U100PLUS 激光碎石治疗仪具有设计紧凑、重量轻、对电源无特殊要求、拥有高效的内置式水冷系统、移动性和稳定性极好等特点；它的操作极其简便，电源接通几秒后就能投入使用，可根据结石部位及大小调整最佳参数；操作过程简单，只要医生能掌握内窥镜技术，经简单培训后就能够使用该设备进行碎石。

优点：可见光准确定位，对软组织无热损伤，操作简便，移动方便，维护成本低。U100PLUS 激光碎石仪适合在医院手术室、内窥镜室、碎石中心以及门诊手术中心使用，完成胆道及泌尿系统结石的碎石。

U100Plus主要技术指标（注册证编号：国械注进20203010019）



激光波长：	532纳米和1064纳米
激光脉冲能量：	120毫焦和160毫焦
	可执行双频双脉冲同时发射
激光脉冲宽度：	1.2微秒
激光脉冲频率：	1,3,5,10,15,20赫兹
峰值功率：	单脉冲133~160千瓦
	双脉冲266~320千瓦
光纤直径：	560微米 × 3.5米
电源：	AC100-240伏/50-60赫兹
尺寸（宽×高×长）：	250×850×600mm

德国W.O.M.公司U100Plus腔内激光碎石系统中国总代理

上海华鲲贸易有限公司

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德国原产：U100Plus激光碎石治疗系统

世界上最安全的无损伤激光碎石系统

2024精编（增订本）



中国大陆独家总代理

上海华鲲贸易有限公司

“FREDDY”专利技术—全世界激光碎石领域的最高技术



德国 W.O.M 公司生产的U100Plus激光碎石治疗仪，具有“FREDDY”专利技术，为结石的腔内治疗提供了一个高效、安全、快速的新标准。

FREDDY（FREQUENCY-DOUBLED DOUBLE PULSE ND:YAG），即双频双脉冲掺钕钇铝石榴石（ND:YAG）激光器。

通过“FREDDY”技术，U100Plus激光碎石治疗仪能够发出两种波长的脉冲激光，绿光（λ=532纳米）和红外光（λ=1064纳米），绿光（约占激光总能量的20%）先在结石表面形成均匀的等离子体，接着等离子体充分吸收红外光（约占激光总能量的80%）的能量，使激光能量瞬间转化为机械冲击波，由于峰值功率极高，形成的机械冲击波足以“崩解”结石。

这是一种非热灼性的激光，如果不小心将激光偏离目标，附近的软组织也不会受到损伤。

在对比实验中，FREDDY激光的碎石效率是热灼性激光的20倍。U100Plus是目前世界上碎石效率最高的激光碎石系统（Germany R. Steke 2009）。



FREDDY Laser是目前世界上最安全、最聪明的激光碎石系统

安全性：人体组织不吸收绿光，不产生等离子体，红光对组织无效，所以碎石过程中对组织不产生伤害。

由于FREDDY激光只对结石产生作用，所以在国外，很多专家喜欢称U100Plus为“Smart Laser”，即聪明的激光。

研究表明：无论体内还是体外实验，U100Plus都是绝对安全的：

1. 对即将切除的输尿管发射300个脉冲，术后对输尿管病理检查，未发现明显损伤。（Santa Cruz J Endo U 1998）
2. 对已经切除的输尿管连续2000个脉冲，输尿管无损伤。（Bazo BAUS 2001）
3. 动物实验中，U100Plus激光对兔膀胱粘膜连续发射2000个脉冲，粘膜无明显损伤。



它可以在您的指尖和掌心完成激光碎石



U100Plus激光碎石机所提供的石英光纤具有很好的柔软度，弯曲直径达到了10毫米，而光纤外径仅550微米，因此可以很好地与各种硬镜、软镜（甚至是超细内镜）相配合，广泛应用于泌尿外科、肝胆外科、消化内科等科室的腔内碎石。结石粉碎后颗粒细小，绝大多数已经在手术中冲出体外，少量在短期内自行排出。

泌尿系结石的治疗：

U100Plus激光碎石机目前常用于以下术式：

膀胱镜下激光碎石术；

输尿管肾镜（软镜、硬镜、半硬性软镜）下激光碎石术；

经皮肾镜下激光碎石术（治疗鹿角形结石）。

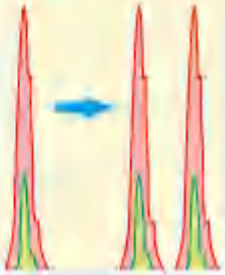
配合超细光纤可对肾脏、输尿管上/下段、膀胱、尿道等各个位置的结石进行高效、安全治疗。





消化道结石的激光碎石治疗：

采用FREDDY技术的U100Plus激光碎石治疗仪，可以通过各种软镜（如术中、术后胆道镜，经皮胆道镜，ERCP子母镜，X光引导下的ERCP，膝胆管镜等）的工作通道，将光纤引到结石表面，发射激光产生机械冲击波，迅速击碎结石，同时对周围的软组织不会造成损伤。碎石后可用取石篮取出碎石颗粒，或经冲洗，由十二指肠乳头自然排出碎石颗粒。



U100 Plus的主要新技术

—更高的碎石效率

- 双脉冲发射的增加：一个激励周期内，同时发射两个脉冲，即一次同时发射两个绿光和两个红光。
- 最大能量增加：单个脉冲的能量由120mJ，提高到160mJ。
- 最大脉冲数的增加：由10Hz，增加到20Hz。
- 绿光能量增加：等离子形成更有效、更快速。

I will not give a lethal drug to anyone ,if I am asked, nor will I advise such a plan .(我要竭尽全力，采取我认为有利于病人的医疗措施，不能给病人带来痛苦与危害。我不把毒药给任何人，也决不授意别人使用它。)



—《希波克拉底誓言》节选



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全世界唯一非热灼性激光

--U100Plus腔内激光碎石系统

胆、胰腺系统腔内碎石的最佳选择

非热灼性,碎石过程中不会造成胆道、胰腺组织的热损伤。



可在X线引导下“盲打碎石”。



可在胆道镜、鼻胃镜、胆道子母镜下直视碎石。



高效碎石，没有近期及远期并发症。

热灼性激光碎石对胆胰系统的巨大危害

高温是所有热灼性激光产生风险的主要因素

所有热灼性激光,其碎石原理都是通过将激光能量转化为高温，以达到融化结石的目的, Oklahoma州立大学Schafer SA 等人的研究表明，热灼性激光可产生高达4700℃的高温。（参考文献:中国科学院声学研究所医用声学实验室，崔杰、肖灵，钬激光碎石机制研究进展［J］，中华腔镜泌尿外科杂志（电子版），2008，2(4)，59-61)

高温对组织可造成直接损伤

高温可对组织造成直接切割效应,德国Zörcher T的实验中，热灼性激光仅仅两个脉冲就可以造成兔子膀胱壁穿孔。需时不到0.1秒，已经超过了人体神经肌肉反应的极限。(Experiences with a New Frequency-Doubled Double-PulseNd:YAG Laser(FREDDY) forthe Treatment of Urolithiasisr，[J]，Lasers in Surgery：Advanced Characterization，2002).

高温可造成组织间接损伤

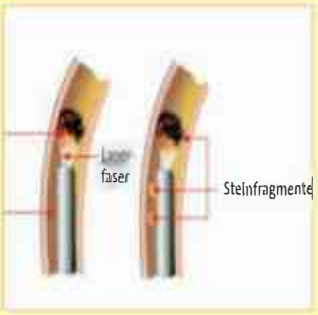
热灼性激光的波长在水的最佳吸收范围内，能量很容易被管腔内的液体吸收，接近沸点的液体(如冲洗液、造影剂、胆汁、胰液等)可对管腔造成持续性伤害，引起水肿、狭窄等严重并发症。



胆道、胰管管径狭小不可能避免热损伤

热灼性激光距离光纤头端直径4mm的范围内，温度可达到700℃，胆道、胰管，特别是肝内胆管直径一般3～5mm，根本没有足够的空间避免激光的直接和间接热损伤。

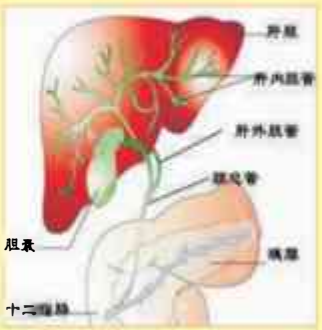
胆道、胰管通过十二指肠乳头与肠道相通，大量冲洗液可致水中毒、腹泻等并发症。高速、高压冲洗还可造成感染扩散等，散热无法达到预期效果，会进一步加重热损伤。(参考文献：中国科学院声学研究所医用声学实验室，崔杰、肖灵，钬激光碎石机制研究进展[J]，中华腔镜泌尿外科杂志（电子版），2008，2(4)，59-61)



胆道、胰管的解剖结构决定了热损伤的不可避免

胆管、胰管系统正常参考值:

胆总管:直径:4～6mm；肝总管:直径为4～6mm；左、右肝管为一级胆管，直径4-6mm；左内叶、左外叶、右前叶、右后叶胆管为二级胆管直径:3-5mm；各肝段胆管为三级胆管，直径:1-3mm；胰腺其管径分别为：头3mm，体2mm，尾1mm。(数据来源:《实用外科杂志》1985年04期《肝内胆管的外科解剖》《超声诊断学》《CT诊断学》等）



“FREDDY”专利技术

激光碎石领域的最领先技术

德国 W.O.M 公司生产的 U100Plus 激光碎石系统，具有世界独家的“ FREDDY ”（FREQUENCY-DOUBLED DOUBLE PULSE ND：YAG）专利技术，即双频双脉冲掺钕钇铝石榴石激光器专利技术。在碎石过程对软组织无热损伤，为腔内结石治疗提供了一个高效、安全、快速的**“金标准”**。是处理复杂、疑难、高危结石病例的**“终极解决方案”**。

U100Plus 激光碎石系统通过“FREDDY ”技术，可以发出波长为 532nm 的绿色激光和 1064nm的近红外激光。532nm 的绿色激光（约占激光总能量的 20%）在结石表面激励产生等离子体，同时等离子体吸收红外激光（约占激光总能量的 80%）的能量，产生机械冲击波，粉碎结石。

对大小不同的结石，设置适当的机器参数，可以完美无损伤解决任何腔内结石的问题。临床数据表明可将患者住院时间缩短至2～3天，无任何术后并发症,因治疗高效、安全无并发症，比较其他治疗方案的7-10天，住院时间显著缩短，完全满足DRG3.0的要求！

德国 U100Plus 激光碎石系统：适用于肝胆外科，消化内科，泌尿外科及颌面外科，只碎结石，不伤软组织，是一种非热灼性的“冷”激光。医生手术几乎零风险，患者手术无损伤！极细极柔软的激光光纤适合各种内窥镜，是治疗腔内各种结石的最佳利器！

注：本书所有英文文献由本公司员工翻译，如有疑问请参照原文。

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· 指南与共识 ·

中国胆道结石双频双脉冲激光碎石专家建议

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【摘要】 胆道结石是消化系统常见疾病,目前主要治疗手段有外科手术、内镜下介入治疗等,但部分困难结石临床上仍面临挑战。双频双脉冲激光碎石术因其安全、高效等特点,是解决困难结石的有效方法。双频双脉冲掺钕钇铝石榴石激光是目前被国家药品监督管理局批准的可用于胆道结石碎石的激光技术,但其适应证、导入方式和操作规范等问题尚未形成共识。为此,国家消化系统疾病临床医学研究中心(上海)、中国医师协会内镜医师分会和中华医学会消化内镜学分会特邀国内消化、内镜与外科等相关领域专家,在参考国内外文献的基础上,经过充分讨论形成本专家建议,以期为国内规范开展胆道结石激光碎石提供指导和参考。

【关键词】 胆石;　激光碎石;　双频双脉冲激光
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Chinese expert opinion on frequency-doubled double pulse laser lithotripsy of biliary stones

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【**Abstract**】 Biliary calculi is one of the common digestive disorders. The major therapeutic options of biliary calculi include surgery and endoscopic intervention, but challenges still exist in the treatment of certain difficult stones. With the advantages of safety and high efficiency, frequency-doubled double pulse laser lithotripsy is considered an effective method to solve difficult stones. The frequency-doubled double pulse neodymium-doped yttrium aluminum garnet laser has been approved by the State Drug Administration for lithotripsy of biliary stones. However, there is no consensus on its indications, introduction methods and operating specifications yet. Therefore, on the basis of reference to literatures, the National Clinical Research Center for Digestive Diseases (Shanghai), Endoscopy Professional Committee of Chinese Endoscopist Association and Chinese Society of Digestive Endoscopy organized domestic experts in relevant fields to formulate this expert opinion after full discussion. This expert opinion may provide some guidance and references for the standard conduction of laser lithotripsy for biliary stones in China.

【**Key words**】 Gallstones;　Laser lithotripsy;　Frequency-doubled double pluse laser
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胆道结石是消化系统常见疾病,起病急、治疗手段复杂、并发症风险高[1]。目前,传统外科手术、腹腔镜手术、经皮经肝胆道镜操作及内镜逆行胰胆管造影术(endoscopic retrograde cholangiopancreatography, ERCP)等是治疗胆道结石的主要手段[1-3]。然而,仍有部分胆道结石由于直径大、数量多、形状特殊或存在复杂解剖因素等原因,不能通过上述常规治疗手段实现结石清除。激光碎石技术最早应用于泌尿系统结石治疗,近年来也逐渐应用于肝内胆道和胆总管困难结石的治疗[4-6]。双频双脉冲掺钕钇铝石榴石(以下简称"双频双脉冲")激光碎石术是指将激光光纤以接触方式对准结石,通过产生强烈的冲击波在短时间内将结石碎裂以利于结石清除的技术。

一、常用设备及原理

1. 设备:双频双脉冲激光碎石设备包括激光的发生与传导设备。激光发生器,可以产生激光,并由控制系统操控激光的频率、能量和脉冲宽度等参数;

激光传导设备，专用激光多模光导纤维利用光的“全反射”原理将激光以极低的能量损耗从激光发生器传送至效应部位。

2. 碎石原理：双频双脉冲激光发生器可同时产生绿激光（λ=532 nm）和近红外激光（λ=1 064 nm），且在一个激励周期内同时发射两个激光脉冲。绿激光（约占激光总能量的20%）先在结石表面形成均匀的等离子体，等离子体充分吸收近红外激光（约占激光总能量的80%）的能量，发生“光能-机械能”转换，使激光能量瞬间转化为超声冲击波，使结石崩解。碎石峰值功率可达133～160 kW。

人体软组织吸收激光产生热量的波长为2 000 nm左右，而双频双脉冲激光的波长为532 nm和1 064 nm，该波长激光软组织几乎不吸收；双频双脉冲激光的脉冲宽度仅为1.2 μs，激光脉冲作用时间短，人体软组织吸收激光产生热效应的响应时间需要100 μs以上，因此，双频双脉冲激光不会引起结石周围的软组织热损伤，又被称为“冷激光”。

二、适应证

双频双脉冲激光碎石术的适应证为传统外科手术、腹腔镜手术、经皮经肝内镜操作及ERCP等常规手段难以取出的胆道结石。

三、操作方法

双频双脉冲激光碎石术可经胆道镜、经口胆道内镜、ERCP子母镜以及非直视X线透视定位下实施。

1. 经胆道镜碎石方法：经皮经肝、开腹、腹腔镜术中或术后应用胆道镜进入胆道行双频双脉冲激光碎石，具有创伤小、效率高、并发症少等优点。置入胆道镜到达结石部位，首先冲洗胆道，形成液体介质和屏障，并保持视野清晰。通过内镜孔道置入光纤，将光纤头端抵住结石，直视下粉碎结石，可注水将碎石冲入肠腔，必要时使用网篮套取较大的碎石。需注意光纤易受损，术中应小心操作以避免对光纤的损伤。

直接经口胆道内镜操作难度较大，非临床常规方法，但如果能将内镜成功送入胆道内，则可按上述方法进行碎石及取石。

2. 经ERCP子母镜碎石方法：十二指肠镜子镜下双频双脉冲激光碎石具有微创优势。操作时先行胆道造影，确认胆道结石的位置与大小，行乳头括约肌切开或小切开联合柱状球囊扩张，以利于子镜进入胆道。预置光纤在子镜内，光纤与子镜头端平齐，插入十二指肠镜工作孔道。发现结石后，光纤伸出子镜5 mm以上，使光纤头端抵住结石，通过子镜注水吸引功能，使光纤、结石均浸润在水中后，在子镜直视下粉碎结石，用取石网篮或取石球囊取石，分段造影证实无结石残留后建议常规置入胆道引流管。

3. 非直视X线透视碎石方法：在无1和2的直视内镜系统情况下，也可采用非直视X线透视定位法，但需要在经验丰富的医疗机构进行。操作时预置光纤于造影导管或取石气囊等附件内，使光纤尖端与导管头端平齐，固定光纤于造影导管尾端。将造影导管插入内镜工作孔道。内镜前端抵达结石附近，对于阳性结石可直接通过X线定位，对于阴性结石注入造影剂后再行X线定位，推动光纤，使光纤伸出导管超过5 mm，抵住结石进行碎石，后续行取石治疗。

四、围手术期管理

1. 术前准备：传统外科手术、腹腔镜手术、经皮经肝胆道镜操作、ERCP及经口胆道内镜各按其术前准备实施。若患者胆道感染严重，需在感染状态控制后再行激光碎石手术。

术者或主要助手应向患者及其家属沟通，告知其胆道结石双频双脉冲激光碎石适应证、目的、替代治疗方案、操作过程及可能存在的风险，详细说明术后可能出现的并发症，并由患者或患者指定的委托

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·共识与指南·

中国胆道结石双频双脉冲激光碎石专家建议

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【提要】 胆道结石是消化系统常见疾病,目前主要治疗手段有外科手术、内镜下介入治疗等,但部分困难结石临床上仍面临挑战。双频双脉冲激光碎石术因其安全、高效等特点,是解决困难结石的有效方法。双频双脉冲掺钕钇铝石榴石激光是目前被国家药品监督管理局批准的可用于胆道结石碎石的激光技术,但其适应证、导入方式和操作规范等问题尚未形成共识。为此,国家消化系统疾病临床医学研究中心(上海)、中国医师协会内镜医师分会和中华医学会消化内镜学分会特邀国内消化、内镜与外科等相关领域专家,在参考国内外文献的基础上,经过充分讨论形成本专家建议,以期为国内规范开展胆道结石激光碎石提供指导和参考。

【关键词】 胆道疾病;　碎石术,激光;　专家委员会
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Chinese expert opinion on frequency-doubled double pulse laser lithotripsy of biliary stones

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【**Summary**】 Biliary stones are common digestive disorders. Main treatment measures for biliary stones include surgery and endoscopic intervention, but treatment of certain difficult stones are still faced with challenges. Due to the safety and high efficiency, frequency-doubled double pulse laser lithotripsy is an effective method to treat difficult stones. The frequency-doubled double pulse neodymium-doped Yttrium Aluminum garnet laser has been approved by State Drug Administration for lithotripsy of biliary stones. However, there is no consensus on its indications, introduction methods and operating specifications. Therefore, on the basis of reference home and abroad, National Clinical Research Center for Digestive Diseases (Shanghai), Chinese Endoscopist Association and Chinese Society of Digestive Endoscopology organized domestic experts in fields of digestion, endoscopy and surgery to formulate this expert suggestion after full discussion, so as to provide guidance and reference for the standard conduction of laser lithotripsy for biliary stones in China.

【**Key words**】 Biliary tract diseases;　Lithotripsy, laser;　Professional staff committees
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一、前言

胆道结石是消化系统常见疾病,起病急、治疗手段复杂、并发症风险高[1]。目前,传统外科手术、腹腔镜手术、经皮经肝胆道镜操作及经内镜逆行胰胆管造

影术(endoscopic retrograde cholangiopancreatography, ERCP)等是治疗胆道结石的主要手段[1-3]。然而,仍有部分胆道结石由于直径大、数量多、形状特殊或存在复杂解剖因素等原因,不能通过上述常规治疗手段实现结石清除[1]。激光碎石技术最早应用于泌尿系统结石治疗,近年来也逐渐应用于肝内胆道和胆总管困难结石的治疗[4-6]。双频双脉冲掺钕钇铝石榴石(frequency-doubled double pulse Nd:YAG, FREDDY,以下简称"双频双脉冲")激光碎石术是指将激光光纤以接触方式对准结石,通过产生强烈的冲击波在短时间内将结石碎裂以利于结石清除的技术。

二、常用设备及原理

1.设备:双频双脉冲激光碎石设备包括激光的发生与传导设备。激光发生器,可以产生激光,并由控制系统操控激光的频率、能量和脉冲宽度等参数;激光传导设备,专用激光多模光导纤维利用光的"全反射"原理将激光以极低的能量损耗从激光发生器传送至效应部位。

2.碎石原理:双频双脉冲激光发生器可同时产生绿激光(λ=532 nm)和近红外激光(λ=1 064 nm),且在一个激励周期内同时发射两个激光脉冲。绿激光(约占激光总能量的20%)先在结石表面形成均匀的等离子体,等离子体充分吸收近红外激光(约占激光总能量的80%)的能量,发生"光能—机械能"转换,使激光能量瞬间转化为超声冲击波,使结石崩解。碎石峰值功率可达133~160 kW。

人体软组织吸收激光产生热量的波长为2 000 nm左右,而双频双脉冲激光的波长为532 nm和1 064 nm,该波长激光软组织几乎不吸收;双频双脉冲激光的脉冲宽度仅为1.2 μs,激光脉冲作用时间短,人体软组织吸收激光产生热效应的响应时间需要100 μs以上。因此,双频双脉冲激光不会引起结石周围的软组织热损伤,又被称为"冷激光"。

三、适应证

双频双脉冲激光碎石术的适应证为传统外科手术、腹腔镜手术、经皮经肝内镜操作及ERCP等常规手段难以取出的胆道结石。

四、操作方法

双频双脉冲激光碎石术可经胆道镜、经口胆道内镜、ERCP子母镜以及非直视X线透视定位下实施。

1.经胆道镜碎石方法:经皮经肝、开腹、腹腔镜术中或术后应用胆道镜进入胆道行双频双脉冲激光碎石,具有创伤小、效率高、并发症少等优点。置入胆道镜到达结石部位,首先冲洗胆道,形成液体介质和屏障,并保持视野清晰。通过内镜孔道置入光纤,将光纤头端抵住结石,直视下粉碎结石,可注水将碎石冲入肠腔,必要时使用网篮套取较大的碎石。需注意光纤易受损,术中应小心操作以避免对光纤的损伤。

直接经口胆道内镜操作难度较大,不是临床常规方法,但如果能将内镜成功送入胆道内,则可按上述方法进行碎石及取石。

2.经ERCP子母镜碎石方法:十二指肠镜子镜下双频双脉冲激光碎石具有微创优势。操作时先行胆道造影,确认胆道结石的位置与大小,行乳头括约肌切开或小切开联合柱状球囊扩张,以利于子镜进入胆道。预置光纤在子镜内,光纤与子镜头端平齐,插入十二指肠镜工作孔道。发现结石后,光纤伸出子镜5 mm以上,使光纤头端抵住结石,通过子镜注水吸引功能,使光纤、结石均浸润在水中后,在子镜直视下粉碎结石,用取石网篮或取石球囊取石,分段造影证实无结石残留后建议常规置入胆道引流管。

3.非直视X线透视碎石方法:在无"1"和"2"的直视内镜系统情况下,也可采用非直视X线透视定位法,但需要在经验丰富的医疗机构进行。操作时预置光纤于造影导管或取石气囊等附件内,使光纤尖端与导管头端平齐,固定光纤于造影导管尾端。将造影导管插入内镜工作孔道。内镜前端抵达结石附近,对于阳性结石可直接通过X线定位,对于阴性结石注入造影剂后再行X线定位,推动光纤,使光纤伸出导管超过5 mm,抵住结石进行碎石,后续行取石治疗。

五、围手术期管理

1.术前准备:传统外科手术、腹腔镜手术、经皮经肝胆道镜操作、ERCP及经口胆道内镜各按其术前准备实施。若患者胆道感染严重,需在感染状态控制后再行激光碎石手术。

术者或主要助手应与患者及其家属沟通,告知其胆道结石双频双脉冲激光碎石适应证、目的、替代治疗方案、操作过程及可能存在的风险,详细说明术后可能出现的并发症,并由患者或患者指定的委托人签署知情同意书。对于预计操作时间长的患者应积极采取预防并发症的措施。

2.术后处理:严密观察患者术后生命体征。传统外科手术、腹腔镜手术、经皮经肝胆道镜操作、ERCP及经口胆道内镜各按其术后处理。

六、临床评价

自 1998 年双频双脉冲激光碎石临床应用于胆道结石以来，碎石成功率高达 88.2%～100%，结石完全清除率达 80.8%～100%。其中经胆道镜碎石成功率达 100%，结石完全清除率达 97.6%～100%[7-11]。ERCP 子母镜系统碎石成功率为 92.3%～97.1%，结石清除率为 80.8%～97.1%，平均需 1.4 次治疗[12-13]。非直视 X 线透视定位法碎石成功率为 88.2%～96.7%，结石清除率为 88.2%～90.0%，平均需 1.4～1.7 次治疗[14-15]。

双频双脉冲激光碎石具有良好的安全性，患者术后可能出现一过性高热，主要并发症为急性胰腺炎、胆道出血、急性胆道炎以及胆瘘，多为轻度，经保守治疗可缓解，极少数需行介入治疗或外科手术治疗[6-15]。

参与本共识意见制定的专家（以姓氏汉语拼音排序）：别平（陆军军医大学第一附属医院），柴宁莉（中国人民解放军总医院），陈卫刚（石河子大学医学院第一附属医院），陈幼祥（南昌大学第一附属医院），党彤（包头医学院第二附属医院），范志宁（江苏省人民医院），郝建宇（首都医科大学附属北京朝阳医院），胡冰（海军军医大学第三附属医院），胡良皞（海军军医大学第一附属医院），冀明（首都医科大学附属北京友谊医院），金震东（海军军医大学第一附属医院），李锐（苏州大学附属第一医院），李文（天津市人民医院），李汛（兰州大学第一医院），李兆申（海军军医大学第一附属医院），刘枫（同济大学附属第十人民医院），罗丁（昆明医科大学第一附属医院），缪林（南京医科大学第二附属医院），施新岗（海军军医大学第一附属医院），王邦茂（天津医科大学总医院），王宏光（吉林市人民医院），王立生（深圳市人民医院），王洛伟（海军军医大学第一附属医院），王拥军（首都医科大学附属北京友谊医院），王云锋（海军军医大学第一附属医院），徐美东（同济大学附属东方医院），张筱凤（杭州市第一人民医院），赵秋（武汉大学附属中南医院），智发朝（南方医科大学附属南方医院），邹多武（上海交通大学医学院附属瑞金医院），邹晓平（南京大学医学院附属鼓楼医院）

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利益冲突　所有作者声明不存在利益冲突

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·专家论坛·

《中国胆道结石双频双脉冲激光碎石专家建议》要点解读

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【提要】 双频双脉冲激光碎石术因其安全、高效等特点，为困难胆道结石的治疗提供了新的选择。为进一步规范和合理应用这一技术，由国家消化系统疾病临床医学研究中心（上海）、中国医师协会内镜医师分会和中华医学会消化内镜学分会牵头，制定了《中国胆道结石双频双脉冲激光碎石专家建议》。本文对困难胆道结石的定义、双频双脉冲激光碎石术的优势、导入方法、围手术期管理、治疗效果等做深入解读，供临床医生参考学习，提高对双频双脉冲激光碎石术的认识。

【关键词】 碎石术，激光；　脉冲；　结石；　胆道；　专家委员会
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Interpretation of *Chinese expert opinion on frequency-doubled double pulse laser lithotripsy of biliary stones*

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困难胆道结石目前在临床上治疗仍面临挑战，双频双脉冲激光碎石术因其安全、高效等特点，为困难结石的治疗提供了新的选择。为进一步规范和合理应用这一技术，由国家消化系统疾病临床医学研究中心（上海）、中国医师协会内镜医师分会和中华医学会消化内镜学分会牵头，在广泛征求了国内消化、内镜与外科等相关领域专家的意见和建议的基础上，结合国内外文献（参考表 1、表 2），制定了《中国胆道结石双频双脉冲激光碎石专家建议》（下文简称《专家建议》），旨在规范双频双脉冲激光碎石技术标准，为进一步提高困难胆道结石清除率提供依据[1-9]。《专家建议》的发表对临床医生规范化使用双频双脉冲激光碎石术治疗困难胆道结石具有重要的指导和借鉴作用，本文对困难胆道结石的定义、双频双脉冲激光碎石术的优势、导入方法、围手术期管理、治疗效果等做深入解读，供各位临床医生参考学习，提高对双频双脉冲激光碎石术的了解和认识。

一、困难胆道结石的定义

胆道结石包括胆囊结石、胆总管结石和肝内胆管结石。传统外科手术、腹腔镜手术、经皮经肝胆道镜手术、经内镜逆行胰胆管造影术（endoscopic retrograde cholangiopancreatography，ERCP）等是目前治疗胆道结石的主要手段，而结石的位

表 1　胆道结石双频双脉冲激光碎石主要研究结果

序号	文献作者（年份，国家）	研究类型	入组人数（男/女）	导入方式	入组标准	首次结石清除率（%）	治疗次数	总结石清除率（%）
1	Li 等[2]（2020，中国）	单中心回顾性研究	79（39/40）	经 LCBDE 术中胆道镜	年龄>18 岁；CBD 结石直径≥2 cm	96.2	1	96.2
			78（42/36）	经 ERCP 子母镜		83.3	1~2	92.3
2	Yang 等[3]（2019，中国）	单中心回顾性研究	42（14/28）	经 LCBDE 术中胆道镜	胆道镜、取石蓝等常规手段无法取出的结石	-	-	100.0
3	Lei 等[4]（2016，中国）	单中心回顾性研究	32（13/19）	经 LTCBDE 术中胆道镜	CBD 结石直径≥8 mm；	-	-	100.0
4	Jiang 等[5]（2013，中国）	单中心回顾性研究	45（19/26）	切肝或保肝外科术中胆道镜	肝内胆管结石	-	-	93.3
5	Liu 等[6]（2011，中国）	系列病例报道	30	非直视 X 线透视联合球囊导管	嵌顿结石或 CBD 结石直径>1.5cm；通过常规手段无法取出的结石	60.0	1.4±0.6	90.0
6	Cho 等[7]（2009，韩国）	单中心回顾性研究	52（20/32）	经 ERCP 子母镜或非直视 X 线透视联合球囊导管	嵌顿结石；CBD 结石直径>1.5 cm；或狭窄上方的结石	80.7	1.4	92.3
7	Kim 等[8]（2008，韩国）	单中心回顾性研究	17（7/10）	非直视 X 线透视联合球囊导管	CBD 巨大结石（>1.5 cm）或伴有壶腹周围憩室；嵌顿结石	-	1.7±0.6	88.2
8	Bayer 等[9]（2001，德国）	单中心回顾性研究	19	ERCP 或 PTC 直视下；非直视 X 线透视	CBD 巨大结石	-	-	89.0

注：LCBDE 指经腹腔镜胆总管探查术；ERCP 指经内镜逆行胰胆管造影术；LTCBDE 指经腹腔镜经胆囊胆总管探查术；PTC 指经皮经肝胆管造影；CBD 指胆总管；“-”指文献未报道

表 2　胆道结石双频双脉冲激光碎石主要研究并发症

序号	文献作者（年份，国家）	整体并发症（%）	出血（%）	穿孔（%）	PEP（%）	胆漏（%）	感染（%）	胆管狭窄（%）	死亡（%）
1	Li 等[2]（2020，中国）	LCBDE 组：10.1	2.6	0	0	2.6	1.3	1.3	0
		ERCP 组：5.1	1.3	0	2.6	0	0	0	0
2	Yang 等[3]（2019，中国）	-	0	0	-	9.5	4.8	0	0
3	Lei 等[4]（2016，中国）	0	-	-	-	-	-	-	0
4	Jiang 等[5]（2013，中国）	11.1	4.4	-	-	-	6.7	-	0
5	Liu 等[6]（2011，中国）	6.7	0	0	6.7	0	0	0	0
6	Cho 等[7]（2009，韩国）	23.0	15.4	-	5.7	-	1.9	-	0
7	Kim 等[8]（2008，韩国）	23.5	11.8	-	5.8	-	5.8	-	0
8	Bayer 等[9]（2001，德国）	6	-	-	6	-	-	-	0

注：LCBDE 指经腹腔镜胆总管探查术；ERCP 指经内镜逆行胰胆管造影术；PEP 指 ERCP 术后胰腺炎；“-”指文献未报道

置、形状、大小及手术方式等因素均可影响结石清除效果。部分结石无法通过上述常规技术实现完全清除，而“困难胆道结石”目前亦无公认、统一的定义。参考《2019 年欧洲消化内镜学会临床实践指南：胆总管结石的内镜治疗》对困难胆道结石进行的定义：（1）结石直径过大（>1.5 cm）；（2）结石数量较多；（3）结石形态特殊（如筒状）；（4）结石位置特殊（胆囊管或肝内胆管）；（5）胆总管解剖结构异常（如胆总管远端狭窄、迂曲、成角<135°等）[10]。这类结石处理难度大，需要进一步行内镜下大球囊扩张术、机械碎石术、液电碎石术（electrohydraulic lithotripsy，EHL）、激光碎石术或体外冲击波碎石术（extracorporeal shock wave lithotripsy，ESWL）等。在已发表的双频双脉冲激光碎石研究中，研究者对困难结石的定义不尽相同，原因可能与采用手术方式、医生临床经验等因素有关[2-4,6-8]。笔者认为，困难胆道结石不应被机械地定义，操作医生应在参考指南共识的基础上结合临床经验，综合评估患者一般情况、影像学表现、手术方式、术中情况等，选择最佳的碎石及取石方式。

二、双频双脉冲激光碎石术的优势

双频双脉冲激光光纤头端必须与结石表面接触，激光束由激光发生器发出，通过光导纤维传送至结石表面，产生碎石效应。研究表明，双频双脉冲激光碎石术主要有以下三大优势[2-4,6-8]：（1）碎石效率高：碎石时间短，碎石峰值功率可达 133~160 kW，通过在结石表面产生冲击波瞬间崩解结石。大多数结石经双频双脉冲“等离子效应”碎石后成为均匀的细小颗粒。（2）安全性好：双频双脉冲激光碎石采用的是一种非灼热性的工作原理，几乎不被结石周围软组织吸收、产

热,不会引起结石周围的软组织热损伤,可以反复击打结石。(3)操作灵活、方便:激光光纤采用具有较高柔韧性的石英光纤,弯曲直径可达 10 mm,可轻松到达高位胆道结石并完成碎石任务,具有明显的临床优势。通过调节激光能量和脉冲频率,可有效、快速地崩解各类胆道结石。但针对不同情况的困难胆道结石,仍需要更多高质量临床研究进一步规范、细化双频双脉冲激光碎石治疗方案与技术标准。

三、适当选择双频双脉冲激光光纤导入方式

双频双脉冲激光的光纤纤细,需通过内镜孔道或内镜附件将光纤头端传送至结石部位,导入方法包括胆道镜、经口胆道内镜、ERCP 子母镜以及非直视 X 线透视定位等,选择适当的导入方式是治疗成功的关键。

1.经胆道镜光纤导入法:经皮经肝、开腹、腹腔镜术中或术后应用胆道镜导入激光光纤,可快速、准确地将光纤头端送至结石表面,直视下粉碎结石,这是外科医生常用的导入方法。胆道镜是胆道结石诊断和治疗的重要技术手段,镜下可观察结石位置及大小、胆管狭窄及扩张程度、胆管黏膜等情况,可有效提高结石清除率、降低结石残留率[11]。Yang 等[3] 回顾性分析了 42 例行腹腔镜联合胆道镜引导下双频双脉冲激光碎石术的困难胆道结石患者,结果显示结石清除率 100%,无术中发生胆管黏膜出血及穿孔病例,无术后死亡病例,且远期随访中也未发现胆管损伤、狭窄及结石复发病例。Jiang 等[5] 回顾性分析 45 例行胆道镜下双频双脉冲激光碎石术治疗的肝内胆管结石患者,与胆道镜下钳除、冲洗、取石篮或肝叶切除术等传统手术方法相比,双频双脉冲激光碎石术组结石清除率为 93.3%,显著高于传统方法组 85.4%。双频双脉冲激光碎石术组有胆道出血 2 例,急性胆管炎 3 例。传统方法组有术中出血 3 例,胆漏 1 例,急性胆管炎 6 例,肝衰竭死亡 1 例。传统方法组手术时间及平均住院日明显长于双频双脉冲激光碎石术组,两组随访期间均未发现肝内胆管结石复发。笔者认为,较传统外科开腹取石手术,经皮经肝、开腹、腹腔镜术中或术后采用胆道镜引导下双频双脉冲激光碎石具有创伤小、效率高、并发症少等优点,但光纤易受损,术中应小心操作。

经皮经肝、开腹、腹腔镜术中或术后应用胆道镜均需先建立进入胆道系统的人工通道,存在非经自然腔道的缺点。近年来,不断有学者探索胃镜或鼻胃镜辅助下直接经口胆道镜激光碎石术在胆道结石中的应用[12-13]。一般情况下,应先行 ERCP,了解十二指肠乳头大小、胆管及结石情况,并决定是否行十二指肠乳头括约肌切开或十二指肠乳头大球囊扩张术,然后换用胃镜或鼻胃镜进行直接经口胆道镜操作。尽管据研究报道,直接经口胆道镜引导下双频双脉冲激光碎石术是安全和可行的,但由于研究样本量较少,其安全性和有效性有待进一步证实。笔者认为,直接经口胆道镜操作流程复杂、难度较大,建议在经验丰富的医疗机构开展,由熟练掌握 ERCP 的高级内镜医师实施。

2.十二指肠镜子镜下光纤导入法:该法遵循传统 ERCP 操作过程,将光纤预置在子镜内并与子镜头端平齐,插入十二指肠镜工作孔道,发现结石后,推出光纤使其头端抵住结石,在直视下粉碎结石。该法具有微创优势,也是临床上 ERCP 操作医生的首选方式。Li 等[2] 开展了 ERCP 子母镜(78 例)与腹腔镜胆总管探查术(laparoscopic common bile duct exploration,LCBDE)联合胆道镜(79 例)引导下双频双脉冲激光碎石术治疗巨大胆总管结石(≥2 cm)效果的回顾性研究,结果显示 ERCP 组首次结石清除率明显低于 LCBDE 组(83.3%比 96.2%),但 ERCP 组首次取石失败后可进行二次手术,最终结石清除率可达 92.3%,与 LCBDE 组差异无统计学意义。两组近期并发症发生率相似,但与 LCBDE 组相比,ERCP 组患者住院时间短,恢复快。

3.造影导管或取石气囊等附件光纤导入法:在无直视内镜系统的情况下,也可通过造影导管或取石气囊等附件导入双频双脉冲激光光纤。该法操作时,先预置光纤于导管内,将造影导管插入内镜工作孔道,内镜前端抵达结石附近,再在 X 线辅助定位下,推动光纤抵住结石进行碎石,因此需要在经验丰富的医疗机构进行。Liu 等[6] 将双频双脉冲激光光纤的头端环形包裹一层不透射线的标记物,在 X 线引导下精准定位光纤位置,在 30 例胆总管结石(>1.5 cm)患者中结石清除率达到 90%,平均治疗(1.4±0.6)次,仅有 2 例患者出现不良事件,且均为急性轻度胰腺炎。Kim 等[8] 探讨了 17 例采用球囊导管对标方法进行非直视下双频双脉冲激光碎石术的疗效和安全性,将激光纤维插入球囊导管,通过十二指肠镜工作孔道到达乳头,在 X 线透视下推进至结石部位,进行激光碎石,结果显示 88%患者结石完全清除,治疗(1.7±0.6)次,3 例患者出现不良反应(胆道出血、胰腺炎和胆管炎),均经保守治疗后好转。

笔者认为,双频双脉冲激光碎石术的光纤导入方法有多种组合方式选择,操作医生应把握每种方法的特点和优势,结合个人手术经验,综合考虑手术设备条件,具体分析患者一般情况、结石特点,充分做好与患者及家属的术前沟通,选择合适的操作方法实现结石完全清除。

四、规范双频双脉冲激光碎石术的围手术期管理

由于双频双脉冲激光光纤导入方法涉及传统外科手术、腹腔镜手术、经皮经肝胆道镜操作、ERCP 及经口胆道内镜等不同手术方式,对于双频双脉冲激光碎石术的围手术期管理应根据手术方式的选择严格遵循各自术前准备、术中及术后处理相关规定,因此《专家建议》中未对每种手术方式的围手术期管理进行详细论述。笔者认为,应该严格把握手术适应证,充分做好术前准备,做好医患沟通,术中操作仔细、轻柔,术后密切观察患者生命体征,积极采取预防并发症措施。

五、双频双脉冲激光碎石术是治疗胆道困难结石的有效手段

当胆道结石被认为是困难结石或经传统治疗方法取石失败时,可采用 EHL、激光碎石术或 ESWL 等辅助技术进一步碎石。近期,一项纳入了 795 项研究的系统综述比较了 EHL、激光碎石术和 ESWL 的有效性和安全性,结果显示,激光碎石术组结石完全清除率显著高于 EHL 组、ESWL 组(95.1%比 88.4%比 84.5%,$P<0.001$),且激光碎石术组碎石成功率较高

(92.5%比 75.5%比 89.3%, $P<0.001$),激光碎石术组术后并发症发生率低于 EHL 组(9.6%比 13.8%, $P=0.04$)[14]。

双频双脉冲激光碎石术和钬激光碎石术是最常用的激光碎石技术。钬激光是一种的单频率单脉冲激光,波长约 2 100 nm,工作介质是包含在钇铝石榴石晶体中的钬,主要通过"钻孔效应"把结石汽化为细小的碎粒。由于钬激光的波长位于水和人体组织吸收范围内,对软组织产生烧灼作用,因此在碎石过程中,需用生理盐水不断冲洗胆管以减轻对周围组织的热损伤[15]。而双频双脉冲激光不被人体正常软组织吸收,其碎石原理为机械能而非热灼式,一项体外实验利用双频双脉冲激光直接照射兔膀胱黏膜,仅引起轻度黏膜水肿,未见黏膜穿孔[16]。两种激光碎石过程中均有可能造成结石上移,体外试验表明双频双脉冲激光比钬激光更能促使结石移位,但上移率差异无统计学意义[17]。

六、结语

双频双脉冲激光碎石具有微创、安全、高效、并发症少的优点,在胆道困难结石中的治疗价值日益突出。虽然双频双脉冲激光碎石术对胆道困难结石病的治疗理念及模式产生了深刻影响,但其在临床应用中还存在诸多不足,且目前仍缺少大规模、前瞻性、随机对照临床研究,更缺乏指南、共识或专家建议等指导性文献。《专家建议》针对双频双脉冲激光碎石术用于胆道困难结石治疗提出了具体的理论和技术指导意见,为进一步推进双频双脉冲激光碎石术的标准化与应用规范化起到了重要的作用。

利益冲突　所有作者声明不存在利益冲突

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双频双脉冲(ND:YAG)激光机和钬(Ho:YAG)激光机在结石上移和碎石效率方面的体外比较

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【摘要】 目的 为了比较 FREDDY 激光机、钬激光机和气压弹道碎石机在结石上移和碎石方面的临床效果。方法 上移的水下试验装置包括一个水平方向放置的硅树脂导管(直径为 1.3 cm),和一个固定支架,使激光机的石英光纤和气压弹道碎石机的撞针可以直接接触石头。将预先称过重的圆柱状 Bego 石头(Bego USA 公司提供)放于该装置中,分别由 FREDDY 激光机、钬激光机和气压弹道碎石机进行碎石。FREDDY 激光机和钬激光机都采用相近的脉冲能量和频率。为了具有可比性,气压弹道碎石机采用了半硬性撞针和单脉冲,在 100、200、300 kPa 各档压力设置下分别对石头进行 30 次撞击。"平均后退距离"定义为直接测得的石头最终静止点到原点的距离(每档设置都记录测试结果)。另外,两台激光机分别对称过重的石头(熟石膏成分)进行碎石,以比较碎石效果。石头固定于一个水下装置(由一个倒置的硅注射器和一个固定装置组成)中。激光光纤(钬激光和 FREDDY 激光的光纤内径分别是 365 μm 和 280 μm)穿过注射器的针头出来抵住石头。总共 24 颗石头被分成 4 组,每组 6 颗,其中两组用 FREDDY 激光分别以 300J 和 400J 的总能量碎石,另两组用钬激光分别以 300J 和 480J 的总能量碎石。"碎石率"定义为石头重量缺失的百分比。结果 FREDDY 激光机在能量设置为 160 mJ 时,分别以 5、10 和 15 Hz 的频率碎石,石头的平均后退距离为 7.6、8.1 和 6.8 cm;钬激光机在能量设置为 0.8 J 时,分别以 5 和 10 Hz 的频率碎石,石头的平均后退距离为 3.3 和 4.9 cm;气压弹道碎石机在压力设置分别为 100、200、300kPa 时,石头的平均后退距离为 8.5、9.9 和 13.8 cm。一般来说,FREDDY 激光机造成的石头后退距离都要少于气压弹道碎石机,尽管这只有在后者处于最高压力设置时才有统计意义($p<0.05$)。而 FREDDY 激光机造成的石头后退距离要多于钬激光机,在临床上常见的设置中有统计意义($p<0.05$)。FREDDY 激光机以 300J 和 400J 的总能量碎石时,石头重量的缺失率分别为 44.9% 和 86.8%,都有统计意义($p<0.05$);钬激光机以 300J 和 480J 的总能量碎石时,石头重量的缺失率分别为 3.3% 和 7.1%,都有统计意义($p<0.05$)。结论 FREDDY 激光机造成的石头后退距离要明显大于钬激光机(在低频设置时),但又明显少于气压弹道碎石机(在所有设置时)。因此我们建议,在进行腔内输尿管镜碎石术,或在输尿管肾盂连接处进行腔内激光碎石术时,于接近结石处使用阻断装置,如 Stone Cone—石椎(Boston Scientific 公司提供)。FREDDY 激光机在体外碎石的效率要明显好于钬激光机,对于结石病人来说,前者是个更优、更经济的选择。

【关键词】 尿路结石;碎石术;激光;钕;钬

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在过去十年间,腔内激光碎石术得到了大力推广,使得尿路结石和肾结石的治愈率获得提高的同时,也降低了手术的死亡率。这就是从早期的脉冲式染料激光机发展到现在的钬激光机和气压弹道碎石机所带来的好处。但是,在所有这些腔内碎石术的过程中,结石上移(结石沿着尿路上漂)始终是个潜在的威胁。

双频双脉冲 Nd:Yag (FREDDY)激光机是一种新型的,相比高功率钬激光机性价比更优越的机器。在我们印象中,此前还没人对这一新型激光机的碎

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石效率和结石上移情况做过研究。我们在本次研究中,就对 FREDDY 激光机、钬激光机和气压弹道碎石机在碎石效率和结石上移方面作一个全面的比较。

1 材料和方法

上移:水下试验装置包括一个水平方向放置的硅树脂导管(直径为 1.3 cm)和一个固定支架,使激光光纤和气压弹道的撞针可以直接接触石头。将预先称过重的圆柱状 Bego 石头(Bego USA 公司提供)放于该装置中。在试验中使用 Bego 石头,是由于其具有高抗张强度,使得观察碎石的后退更方便。分别由 FREDDY 激光机、钬激光机(Lumenis 公司)进行碎石,它们都采用相近的脉冲能量和频率。为了作一个基本的比较,气压弹道碎石机(Swiss Lithoclast 公司)采用了半硬性撞针和单脉冲,在 100、200、300 kPa 各档压力设置下分别对石头进行 30 次撞击。"平均后退距离"是指石头最终位置到最初位置的距离。

碎石:称过重的熟石膏石被用于测试激光机的碎石效果。熟石膏石的抗张强度(破碎力)为 2.0 Mpa,人类的钙结石和炎症性结石的抗张强度在 0.1 ~3.4 Mpa 之间,两者比较接近,而且抗张强度都比 Bego 石头低[1]。水下试验装置包括一个倒置的硅注射器和一个固定装置。激光光纤(钬激光光纤内径是 365μm,FREDDY 激光光纤内径是 280μm)穿过注射器的针头抵住石头。总共有 24 颗石头被分成 4 组,每组 6 颗,其中两组用 FREDDY 激光分别以 300 J 和 400 J 的总能量碎石,另两组用钬激光分别以 300 J 和 480 J 的总能量碎石。直径小于 2 mm 的碎石颗粒从注射器末端掉下,剩余的石头就是最终要称重的部分。

后退试验和碎石试验所获得的数据都通过商业统计软件—ANOVA 进行处理,$p<0.05$ 被认为是有统计意义的。

2 结果

FREDDY 激光采用内径是 280 μm 的光纤,在不同参数设置下获得的石头后退数据显示于表 1 中。ANOVA 软件分析结果都没有统计意义,平均后退距离的均方差±SD 值为 7.1±2.0。

表 2 是 ANOVA 软件对多种比较进行 Tukey 校正的结果。一般来说,气压弹道碎石机造成的平均石头后退距离要多于 FREDDY 激光机和钬激光机。但这只有在前者处于最高压力设置(300kPa)时才有统计意义($p<0.05$)。FREDDY 激光机造成的石头平均后退距离要多于钬激光机,但在钬激光机的输出总能量在 80J 以上时是没有统计意义的,只有在钬激光机的输出处于低能量(临床上更多见)时才有统计意义($p<0.05$)。

表 1 FREDDY 激光机造成的石头后退结果

脉冲能量(J)	频率(Hz)	后退距离(mm)	总的能量(J)
0.120	5	6.6±1.7	6
0.160	5	7.6±2.6	8
0.120	10	5.8±1.0	12
0.160	10	8.1±2.4	16
0.120	15	7.4±1.8	18
0.160	15	6.8±1.2	24

表 2 石头后退的 Tukey 组比较

设备	平均后退距离(mm)	Tukey grouping			
L300kPa	13.8				A
L200kPa	9.9				
L300kPa	8.5	C		B	
F0.16J, 10Hz(16J)	8.1	C		B	
F0.16J, 5Hz(8J)	7.6	C		B	D
F0.12J, 15Hz(18J)	7.4	C		B	D
H1.0J, 5Hz(50J)	7.4	C		B	D
F0.16J, 15Hz(24J)	6.8	C	E	B	D
H1.0J, 10Hz(100J)	6.6	C	E	B	D
F0.12J, 5Hz(6J)	6.6	C	E		D
F0.12J, 10Hz(12J)	5.8	C	E		D
H0.8J, 10Hz(80J)	4.9	C	E	F	D
H0.6J, 10Hz(60J)	4.2		E	F	D
H0.8J, 5Hz(40J)	3.3		E	F	
H0.6J, 5Hz(30J)	1.8			F	

* 以上各种结果都有统计意义($p<0.05$)

当 FREDDY 激光机采用 0.120J/10Hz 的设置,碎石 240 s(总能量为 300J)后,石头重量的平均缺失率为 44.8%;当采用 0.160J/10Hz 的设置,碎石 240 s(总能量为 400J)后,石头重量的平均缺失率提高到 86.8%。三次之后,石头就全被碎成小于 2 mm 的颗粒。而钬激光机则分别采用 0.5J/5 Hz 的设置,碎石 120 s(总能量为 300J),和 0.8J/5 Hz 的设置,碎石 120 s(总能量为 480J)。结果表明,在输出同等能量的情况下,FREDDY 激光机的碎石效率明显高于钬激光机($p<0.0001$)。

3 讨论

腔内碎石已经从早期简单的机械碎石,发展到液电碎石和气压弹道碎石,再到最近的激光碎石。而 FREDDY 激光机在腔内激光碎石领域开创了一个新纪元,它是一个短脉冲、双频

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1064 nm)的固体激光器,能在结石表面形成等离子层,随后产生机械冲击波,达到碎石的目的。FREDDY 激光机能在 1 ~ 1.4 μs 的时间段内发射出长脉冲[2],将部分红外光倍频为绿光,从而形成很高的脉冲强度[3],这就是为什么 FREDDY 激光机以同样的能量输出,比钬激光机有更高碎石效率的原因所在。但在碎石过程中,FREDDY 激光机所产生的机械冲击波,会导致石头从光纤的接触点后退。而钬激光机的工作机理是热灼汽化,只产生小于 8bar 的微弱压力波,并且没有气穴和冲击波现象,因此它造成的石头后退距离就少[3]。在本次研究中将气压弹道碎石机作为比较对象,是由于其具有碎石导致结石后退的特点。

由于碎石机理的不同,钬激光机相比 FREDDY 激光机,更容易对组织造成伤害。在较长的脉冲宽度 300 μs 内,钬激光机输出了高能量(200 ~ 2000 mJ)用于汽化结石,难免直接灼伤尿道上皮的组织[4,5]。而 FREDDY 激光机的脉冲宽度极短,输出的碎石能量仅仅为 120 ~ 160 mJ,根本不会对组织造成热损伤。

本研究是第一次对 FREDDY 激光机和钬激光机在碎石效率和结石后退方面做直接的比较。Zorcher 等首次对 FREDDY 激光机做过体外系列试验的报道[2],从尿路结石患者的体内取出草酸钙(一水化合物和脱水化合物)石、尿酸石、磷灰石、磷酸钙石和鸟粪石,通过 FREDDY 激光机可以成功将它们一一击碎。但 FREDDY 激光机对胱氨酸石是无能为力的。Delvecchio 等应用 FREDDY 激光机,在体外对熟石膏石进行碎石,当总的能量输出为 288J 时,石头重量的缺失率达到了 64.4%[6]。该测试数据尽管与在 300J 时测试的结果不同,但差异在 1 个 SD(标准偏差)内。

此试验中,FREDDY 激光使用的光纤要比钬激光的细(内径分别是 280 μm 和 365 μm)。此前有关钬激光的碎石情况和光纤直径之间关系的论述都不详[7,8]。也没有证据表明 FREDDY 激光的光纤直径和碎石之间有什么关系。

在使用输尿管镜实施腔内碎石术时,结石上移始终是个严重的问题。结石在不经意间从输尿管上移至肾脏区域,会给输尿管镜的操作带来极大的麻烦,提高手术成本(需使用另外的器械),延长手术时间,增加手术并发症。在进行腔内碎石术的过程中,于结石处使用球状导管或 Stone Cone—石椎,就能大大降低结石上移至尿路上端的危险性[9,10]。

尽管熟石膏石在临床试验中很有价值,但人体尿路中的结石毕竟还是与之不同,如胱氨酸石就对 FREDDY 激光发射的波长为 532 nm 和 1064 nm 的光束不吸收,因此也就不能被击碎,需要采取其他的碎石方法。在我们实验室中,正在尝试采用更换冲洗液的办法,试图改变结石的表面特性,以利于其吸收 FREDDY 激光的光束,使之更易被击碎。

4 结论

与流行的钬激光机相比,FREDDY 激光机的碎石效率更高,使用成本更低。但 FREDDY 激光机对少数成分(胱氨酸)的结石无效,没有钬激光机具有的组织切割功能,而且碎石过程中还有相对的结石上移现象。因此我们建议在通过输尿管镜进行激光碎石术,或在通过经皮肾镜进行激光碎石术时,于接近结石处使用阻断装置,如 Stone Cone—石椎(Boston Scientific 公司提供),这样可以大大缓解结石的上移。

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·论著·

U100 倍频双波长脉冲激光对兔膀胱黏膜的损伤效应

郁兆存 谭万龙* 熊林 吴元东 彭红梅 郑少斌

摘要

目的 观察不同频率、不同脉冲的 U100 倍频双波长脉冲激光对家兔膀胱黏膜的损伤效应。

方法 新西兰兔 6 只,避开膀胱三角区随机取四点进行实验,予置激光输出频率分别为 3、10 Hz,脉冲输出 500、1 000 次,垂直接触照射膀胱黏膜,通过肉眼、光镜观察靶组织损伤的形态学改变。

结果 激光照射后,兔膀胱黏膜肉眼未见明显穿孔,光镜下可见激光照射处膀胱黏膜上皮细胞不同程度的脱落,固有层出血等病理改变,无肌层平滑肌细胞断裂等严重损伤;显示脉冲次数为 500 的损伤主要限于膀胱黏膜上皮浅层,脉冲次数为 1 000 的损伤累及上皮全层。

结论 频率为 10 Hz,脉冲 1 000 次的 U100 倍频双波长脉冲激光照射膀胱黏膜不会引起穿孔,但可引起上皮细胞脱落,固有层出血等病理改变。激光损伤程度与照射脉冲次数相关。

关键词 激光; 膀胱; 兔

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Injury of Rabbit Bladder Epithelium Induced by U100 Laser

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ABSTRACT

Objective To study the effect of U100 laser on rabbit bladder epithelium with different frequency and output.

Methods U100 Laser with different frequency (3 Hz and 10 Hz) and output (500 pulses and 1 000 pulses) was acted on rabbit bladder epithelium. Morphological changes of target tissue were observed.

Results There was no perforation observed by eyes. By microscopy, it could be observed that the epithelium desquamated with different degree, and hemorrhage under epithelium. There was no rupture of all the muscle cells. It showed that exterior epithelium desquamated with 500 pulses and interior epithelium desquamated with 1 000 pulses.

Conclusions U100 Laser could not cause muscle cells rupture, but it may cause injury such as epithelium desquamation and hemorrhage. The degree of the injury is related to the dose.

Key Words Laser; Bladder; Rabbit

激光技术自上世纪 60 年代诞生以来,在医学上的应用越来越广泛。激光生物效应非常复杂,目前关于 U100 倍频双波长脉冲激光(frequency-doubled double pulse neodymium:YAG laser, FREDDY)对组织损伤效应的报道较少。本研究通过动物实验,系统观察激光在临床常用剂量下,照射兔膀胱黏膜引

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起损伤的病理变化，为临床应用 U100 激光提供科学的实验依据。

材料与方法

一、实验材料与仪器

1. 实验动物　新西兰兔 6 只，体重（2.5 ± 0.6）kg，由南方医院实验动物中心提供。随机分为 A 组（频率 3 Hz、脉冲次数 500）、B 组（频率 3 Hz、脉冲次数 1 000）、C 组（频率 10 Hz、脉冲次数 500）、D 组（频率 10 Hz、脉冲次数 1 000）。

2. 实验仪器　U100 倍频双波长脉冲激光碎石器，德国威猛（W. O. M.）公司生产。波长为 1 064 nm、532 nm 光纤为石英光纤，芯径 600 μm。

3. 参数设置　1 064 nm 激光占总能量 80%。532 nm 激光占总能量 20%，同时输出。532 nm 激光脉宽为 0.9 μs，1 064 nm 激光脉宽为 1.2 μs，脉冲能量 0.12 J，峰值功率 100 kW。

二、实验方法

腹腔内注射 2.5% 硫喷妥纳 25 ~ 30 mg/kg 麻醉后，将兔仰卧位固定在解剖台上，经腹中线开腹取出膀胱，沿长轴剖开，黏膜面向上平放于弯手术盘中，保持浸泡在生理盐水中。避开膀胱三角区随机取四点进行实验，光纤末端与膀胱黏膜表面垂直接触，开启激光器，设定脉冲激光输出频率，连续照射。照射后立即用过量麻醉药处死动物，观察激光照射点膀胱黏膜的肉眼变化，并以激光照射区为核心，取大小为 1 cm × 1 cm 组织块，10% 甲醛固定，梯度乙醇脱水，石蜡包埋连续切片，HE 染色，于光学显微镜下观察膀胱黏膜损伤的形态学变化。另取不做激光处理的正常膀胱组织两块做为空白对照，制作病理切片，光镜观察兔膀胱黏膜的形态学特点。

三、统计学处理

所有数据应用 SPSS 12.0 统计学软件进行统计学处理，采用两独立样本比率的 χ^2 检验，$P \leqslant 0.05$ 为差异有显著性意义。

结　果

一、兔正常膀胱的形态学特点

正常膀胱黏膜上皮为移行上皮，收缩时增厚，细胞可达 8 ~ 10 层，扩张时只有 2 ~ 3 层。上皮下有一很薄的基膜，光镜下不易分辨。固有层为较疏松的结缔组织，含有胶原纤维和弹性纤维，有丰富的血管，常弥散分布淋巴细胞和淋巴组织。肌层平滑肌肥厚，间有疏松结缔组织和血管，可分为内纵、中环、外纵，浆膜为疏松结缔组织（图 1 见 135 页）。

二、激光照射后膀胱黏膜的肉眼变化

激光照射后，黏膜面仅出现水肿、点状坏死等变化，未见膀胱穿孔等改变。

三、激光照射后组织形态学变化

光镜下可见受照射的部位上皮细胞不同程度的脱落，上皮下固有层小血管破裂、出血，中性粒细胞渗出，小静脉充血、血栓形成，肌层平滑肌细胞水肿、细胞肌间小血管破裂出血等变化，无肌纤维断裂（图 2 ~ 图 4 见 135 页）。

四、组织损伤程度与脉冲频率、照射脉冲数之间的关系

显微镜下观察激光引起的组织损伤程度与激光照射的脉冲数有密切关系，脉冲数为 500 的激光照射区出现上皮细胞脱落，大多为浅层上皮脱落，脉冲次数为 1 000 的激光照射区出现上皮全层缺失。组织损伤的程度与照射脉冲数密切相关（$P < 0.01$），与脉冲频率无关（$P > 0.1$）（见表 1 和表 2）。

表 1　不同照射脉冲数膀胱黏膜损伤的变化

Tab. 1　Changes in bladder epithelium with different dose

照射脉冲数 Pulse number	例数 n	上皮部分脱落 Partial epithelium desquamation		上皮全部脱落 Total epithelium desquamation	
		例数 Case	率(%) Percent	例数 Case	率(%) Percent
500	12	11	91.7*	1	8.3*
1 000	12	2	16.7	10	83.3

注 Note：* 与脉冲 1 000 次比较 *vs* 1 000 pulses，$P < 0.01$

表 2　不同脉冲频率膀胱黏膜损伤的变化（例，%）

Tab. 2　Change in bladder epidermis with different frequency

脉冲频率 Pulse frequency (Hz)	例数 n	上皮部分脱落 Partial epithelium desquamation		上皮全部脱落 Total epithelium desquamation	
		例数 Case	率(%) Percent	例数 Case	率(%) Percent
3	12	8	66.7*	4	33.3*
10	12	5	41.7	7	58.3

注 Note：* 与脉冲频率 10 Hz 比较 *vs* 10 Hz of pulse frequency，$P > 0.01$

讨　论

近年来，激光技术在医学领域得到广泛应用，在外科、妇科、儿科、五官科、皮肤、心血管等医学领域

中成为特别有效的新型诊治手段。德国 W. O. M. 公司于 2000 年上市的 U100 倍频双波长脉冲 Nd:YAG 激光(FREDDY 技术)碎石系统由波长为 1 064 nm 的红外激光(占总能量的 80%)和波长为 532 nm 的绿激光(占总能量的 20%)两个脉冲组成,其作用原理是激光能量经光纤传输到结石表面,532 nm 激光先被结石表面吸收,使结石表面形成均匀的等离子体,等离子体能够充分吸收 1 064 nm 激光的能量,被结石吸收的瞬间转化为机械冲击波将结石粉碎。

激光与生物组织的相互作用非常复杂,既受激光波长、输出方式、功率密度、能量密度和作用时间等影响,亦受组织机械特性、含水量和热弥散等特性的影响[1-3]。U100 双波长激光碎石原理为机械能而非热爆破式,以脉冲形式发射,脉冲宽度仅为 1.2 μs,发射时间极短,输出平均功率仅为 1.2 W,而产生的脉冲峰值功率极高,达到 100 kW,可产生极大的压强效应。一般认为,激光照射产生的压强作用有两种:一种是激光本身的辐射压力所生成的压强,称一次压强;另一种是激光作用于生物组织以后继发而产生的二次压强,是由气流反冲击、热膨胀、超声压和电伸缩等多因素造成[4]。本研究结果表明,U100 双波长激光照射膀胱黏膜致上皮层发生挤压,血管弹力纤维缺失以及小血管充血、出血,损伤效应随激光照射的脉冲数的增加而增强。光镜下组织反应分为 3 层,上皮细胞不同程度脱落,固有层出血,肌层平滑肌细胞水肿,肌间小血管渗出、出血。本实验发现,肌层细胞未见断裂,可能与肌肉组织含水量高,对损伤的耐受性高有关[5]。这些结果与文献报告相符[6,7]。

文献报道靶区组织激光损伤后的愈合过程,与一般外科组织损伤的修复过程大体相似。由于单纯上皮层损伤组织修复快,一般 3 d 就可以修复[8,9],愈合后不会遗留瘢痕、引起管腔狭窄等,因此激光碎石术后患者血尿大多持续 2 ~ 3 d 消失,无远期输尿管狭窄等并发症,这与我们临床观察相符。

文献报道 U100 倍频双波长脉冲激光碎石常用频率为 5 ~ 10 Hz,平均脉冲数为 132(输尿管结石)、530(膀胱结石)、420(尿道结石)[10],与我们临床总结相似。本组实验应用 U100 倍频双波长脉冲激光照射家兔膀胱黏膜,由于输尿管和膀胱组织的光学特性类似[11],因此激光对输尿管的损伤效应也应类似。本实验证实,U100 倍频双波长脉冲激光腔内碎石安全可行,不会引起肌层断裂和穿孔等严重并发症。

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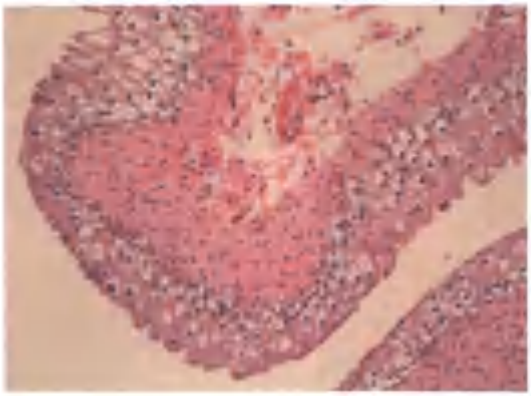


图 1　兔正常膀胱壁组织学所见　HE ×100

Fig. 1　Histology of rabbit normal bladder epithelium　HE ×100

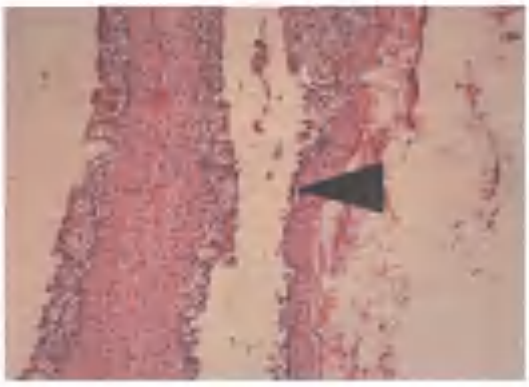


图 2　激光照射区膀胱黏膜上皮细胞部分脱落（箭头）　HE ×40

Fig. 2　Partial bladder epidermis desquamated within laser exposure area　HE ×40

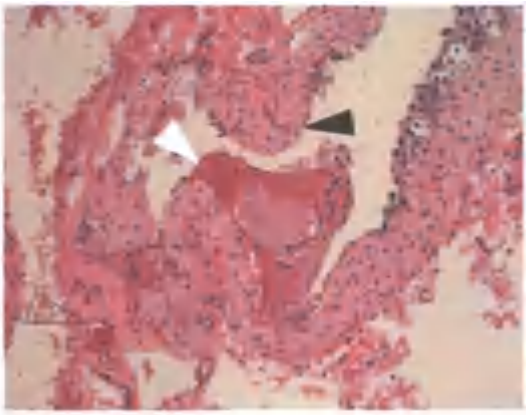


图 3　激光照射区膀胱上皮细胞全层脱落，固有层出血，小血管内血栓形成　HE ×100

Fig. 3　Whole bladder epidermis desquamated，hemorrhage in lamina propria and thrombus is formed in small blood vessels within laser exposure area　HE ×100

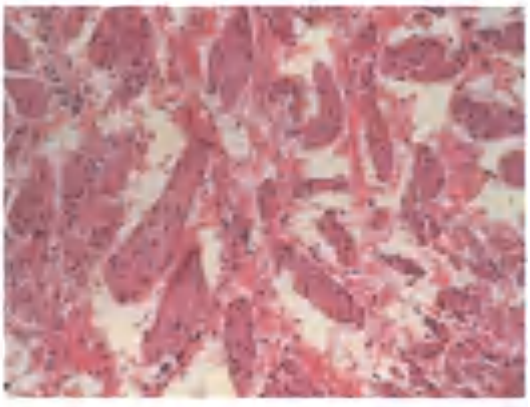


图 4　膀胱肌层平滑肌细胞水肿、细胞肌间小血管破裂出血　HE ×200

Fig. 4　Dropsy in smooth muscle，rupture and bleeding of small blood vessel among bladder muscles　HE ×200

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Efficacy and safety of endoscopic biliary lithotripsy using FREDDY laser with a radiopaque mark under fluoroscopic guidance

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To date no clinic trials have reported on the safety and effectiveness of the use of a frequency-doubled double pulse neodymium YAG (FREDDY) laser with a radiopaque mark under fluoroscopic guidance to treat bile duct stones that are untreatable by conventional endoscopic therapy. We report the cases of 30 patients with impacted or large common bile duct (CBD) stones (> 1.5 cm) treated by endoscopic lithotripsy using FREDDY laser with a radiopaque mark under fluoroscopic guidance. During the procedure, the tip of the laser fiber was packaged with a radiopaque ring mark that was detectable by fluoroscopy. In these patients, complete bile duct clearance was achieved in 27 of the 30 patients (90 %). The majority of patients (18/30) were treated in a single session; the mean number of sessions needed to clear the bile ducts completely was 1.4 ± 0.6. Adverse events were noted in two patients, who both developed acute mild pancreatitis.

Introduction

Endoscopic sphincterotomy for the extraction of stones from the bile duct system is one of the most common endoscopic procedures. However, the procedure fails in 5 % – 15 % of patients with stones in the common bile duct (CBD) because the stones are too large to pass through the sphincterotomy site [1]. In such cases, the stones may be crushed and fragmented by mechanical lithotripsy prior to their removal. However, in some cases, mechanical lithotripsy can be cumbersome, time-consuming, complex or ineffective. When stones grow in size, multiply, and completely obstruct the bile duct, it may not be possible to open the mechanical lithotripsy basket in order to capture the stones. Another difficulty is the presence of distal CBD stricture, which makes it impossible to remove even shattered stones. Furthermore, juxtapapillary diverticula may explain the formation of recurrent biliary stones, which affect bile duct clearance [2]. When mechanical lithotripsy fails to achieve fragmentation in patients with difficult CBD stones, additional methods such as electrohydraulic lithotripsy (EHL), extracorporeal shockwave lithotripsy (ESWL), laser shockwave lithotripsy (LSWL), and palliative therapy (stenting) are required [3 – 5]. However, these procedures require the use of either specialized and costly equipment or high-pulse energy to disintegrate the stones [1].

The frequency-doubled double pulse neodymium YAG (FREDDY) laser is a newly developed economical, short-pulse, double frequency, solid-state laser with wavelengths of 532 nm and 1064 nm. This laser is capable of producing a strong shock wave (the impulse peak power is 133 KW) that fragments the stones in a short time. This system promises to combine the advantages of dye and solid-state lasers, such as reliability, effectiveness, and low cost [6]. However, the laser fiber tip in the bile duct cannot be visualized fluoroscopically; thus, the accurate positioning of the laser fiber on the stone may be inadequate because of the tortuous CBD in patients. Another disadvantage is that the laser fiber is fragile and may be inadvertently broken during the procedures during insertion, because of acute angulations of the CBD. Furthermore, the sharp laser fiber tip may cause trauma of bile duct mucosa and hemobilia.

In the present report, the laser fiber was inserted within a balloon catheter with a radiopaque ring mark on its tip to improve fluoroscopic targeting and to prevent damage to the bile duct. The FREDDY laser was first introduced for endoscopic lithotripsy of urinary stones [7]. However, few studies on fragmentation of difficult CBD stones with the FREDDY laser have been reported [8, 9].

Case report

A total of 30 patients with stones in the CBD (mean age 62.2 years, range 28 – 87) underwent FREDDY laser lithotripsy between June 2006 and December 2009 at a tertiary referral center. The inclusion criteria were the presence of impacted or large CBD stones (> 1.5 cm) that could not be removed after endoscopic sphincterotomy because the stones were not captured in the basket or lithoclast. In all, 18 patients had large stones that could not be grasped, eight patients had impacted CBD stones that failed to pass into the stone basket, and four patients had distal CBD stricturing. The properties of the CBD stones were as follows: one stone (n = 8), two stones (n = 9), and more than two stones (n = 13); the mean diameter of the large stones was 2.0 ± 0.7 cm (range 1.2 – 3.6 cm). The study was approved by our Institutional Review Board, and written informed consent for laser therapy was obtained from each patient.

The FREDDY laser used in this study was the Laser U100 system (World of Medicine, Berlin, Germany). In order to be detectable by fluoroscopy, the tip of the laser fiber (core diameter 280 µm, outer diameter 420 µm, length 3.5 m) was packaged with a radiopaque ring mark (the hydrophilic tip of a zebra guide wire) before being inserted in a triple lumen extraction balloon catheter (Boston Scientific, Natick, Massachusetts, USA) (Fig. 1).

The balloon catheter with the fiber was then passed through the papilla and into the bile duct via the working channel of a standard duodenoscope. Contrast media was infused into another channel to confirm the location of the stones clearly, and then the laser fiber was moved forward by 3 – 5 mm. Under fluoroscopic guidance, the radiopaque tip of the fiber was pushed out of the balloon catheter and positioned on the stone surface (Fig. 2).

Fragmentation of stones was observed simultaneously when the laser emission was obtained. The treatment energy level was 120 mJ per pulse at a repetition rate of 10 Hz. During the laser lithotripsy, the fragmentation effect was monitored by fluoroscopy until the stones were crushed. The bile duct was continuously irrigated with a mixture of contrast media and saline solution in order to transport the laser energy and to monitor fragmentation. After stone disintegration, endoscopic extraction of fragmented stones was performed using a dormia basket or retrieval balloon catheter. If, at that time, the ductal clearance was incomplete, then a nasobiliary catheter was inserted until the next session.

During the procedure, the radiopaque tip of the fiber was visualized clearly under fluoroscopic guidance. The laser lithotripsy treatment failed in one patient who had a history of prior laparoscopic cholecystectomy because the tip of the fiber was unable to be targeted appropriately onto the surface of the stone. The other procedures were successful, and the total success rate was 96.7 %. Complete bile duct clearance was achieved in 27 of the 30 patients (90 %). A total of 18 patients were treated in a single session (60.0 %), and nine patients required two or three sessions. The mean number of sessions per patient that was necessary to clear the bile ducts completely was 1.4 ± 0.6. The median number of laser pulses per procedure was 1050 ± 980 (Table 1). After FREDDY laser lithotripsy, four patients (13.3 %) underwent mechanical lithotripsy to achieve complete clearance of the bile duct (Table 1).

The laser lithotripsy treatment failed in three of these patients: in two patients the stones were only partially fragmented and one of these patients did not want to undergo endoscopic retrograde cholangiopancreatography (ERCP) and instead underwent surgery to clear the bile duct. Another patient, an 88-year-old man with coronary artery disease who had three 2.5-cm CBD stones, did not tolerate the procedure; in this case, the laser lithotripsy procedure was concluded after a plastic stent was inserted into the bile duct to prevent cholangitis. One patient in whom the tip of the fiber was unable to be targeted properly onto the surface of the stone underwent surgery also to clear the bile duct.

No hemobilia was observed. After the first session, two patients suffered acute mild pancreatitis (6.7 %). However, the symptoms were transient and subsided after conservative treatment. No other complications related to the FREDDY laser lithotripsy, such as hemobilia, perforation or bile duct injuries, were found. No complications were observed after the second or third sessions. No laser fiber was broken during the lithotripsy.



Fig. 1 The tip of the laser fiber was packaged with a radiopaque ring mark (black arrow).

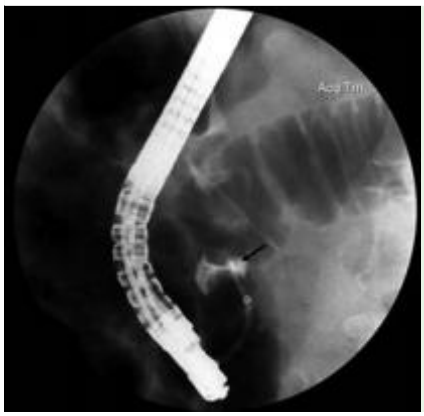


Fig. 2 The tip of the laser fiber was clearly visualized under fluoroscopic guidance (black arrow) on the surface of the impacted stone.

Table 1 Results of lithotripsy using the frequency-doubled double pulse Nd:YAG (FREDDY) laser system.

Procedure	Results (N = 30)
Accurate targeting of the laser on the surface of stones, n (%)	29 (96.7)
Complete clearance of bile duct, n (%)	27 (90.0)
Complete removal of stones in the first endoscopic session, n (%)	18 (60.0)
Number of laser pulses per procedure, median ± SD	1050 ± 980
Number of endoscopic sessions, mean ± SD	1.4 ± 0.6
Combined mechanical lithotripsy required, n (%)	4 (13.3)

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Discussion

ERCP and sphincterotomy are the standard treatments for CBD stones. Endoscopic sphincterotomy for the extraction of stones through dormia basket or balloon catheter is successful in more than 80% of patients. When the stones are too large (> 1.5 cm) to pass through the sphincterotomy site, mechanical lithotripsy is required prior to the removal of the stones [1]. However, complete bile duct clearance is less likely to be achieved in patients with extremely large or impacted stones. In such patients, instead of open surgical exploration of the duct, a variety of other techniques may be employed, such as laser lithotripsy, EHL, and ESWL. The EHL system usually requires direct visualization, which is technically difficult. Transpapillary cholangioscopy with a mother-baby endoscope requires two experienced endoscopists, and ESWL is a time-consuming procedure and stone fragmentation requires a greater number of treatment sessions [10].

Since the first report of successful retrograde laser-induced shockwave lithotripsy of bile duct stones in 1986, various solid-state laser and pulsed-dye laser systems have been developed and introduced for bile duct stone lithotripsy [11 – 13]. These systems require direct visualization of the stone to prevent bile duct injury. The latest development is the introduction of the rhodamine 6G-dye laser with a stone/tissue detection system, which minimizes the risk of possible injury [14, 15]. However, this system is expensive, bulky, requires a high voltage supply, and has a limited use in clinical practice [6]. Recently, a new solid-state laser lithotripter, the frequency-doubled double-pulse Nd:YAG (FREDDY) laser system has taken the place of the rhodamine 6G-dye laser. The FREDDY laser produces two pulses, one at 532 nm and another at 1064 nm, simultaneously. Laser light at 532 nm (green spectrum) initiates plasma formation at the stone surface, while the infrared laser energy boosts this plasma to form a rapidly collapsing bubble, which produces a strong shockwave that fragments the stones.

An initial clinical use of the FREDDY laser for difficult CBD stones was reported by Maiss et al. A study of 22 patients who underwent FREDDY laser lithotripsy showed that complete bile duct clearance was achieved in 91% of the patients [16]. Kim et al. reported the clinical data on laser lithotripsy of CBD stones with the FREDDY system. Bile duct clearance was achieved in 15 of 17 patients (88.2%). The mean number of treatment sessions was 1.7 ± 0.6 [8]. Cho et al. reported that of 52 patients treated via the transpapillary route, complete stone removal was achieved in 48 patients (92.3%). The complete removal of stones required a mean of 1.4 (range 1 – 2) endoscopic sessions [9].

In the current series, complete bile duct clearance was achieved in 27 of 30 patients (90%), with 18 patients being successfully treated in a single session (60%) and nine patients requiring multiple sessions (range 1 – 3). The complete removal of the stones required a mean of 1.4 ± 0.6 endoscopic sessions. After FREDDY laser lithotripsy, four patients (13.3%) underwent mechanical lithotripsy to achieve complete clearance of the bile duct. In this study, multiple sessions were required in some cases because of tortuous CBD. When other techniques failed to achieve duct clearance in these patients with difficult CBD stones, multiple sessions of endoscopic lithotripsy were necessary.

The FREDDY laser lithotriptor with a piezo-acoustic stone/tissue discrimination system may minimize the risk of bile duct injury. When the laser was activated with the fiber in direct contact with the tissues, the histopathological changes were minimal. Zorcher et al. showed that a concentrated, selective laser beam applied to the urothelium of the rabbit only caused light mucosal edemas with hyperemia, as well as light-to-medium grade bleeding in the area of the lamina propria and a punctiform coagulation necrosis of the epithelial layer for all histological preparations, even at maximum parameters of 90 mJ and 2000 pulses. Neither lesions of the tunica muscularis nor perforations were found [17]. Moreover, in comparison with the holmium laser, the FREDDY laser produces no thermal effects. This laser generates very short impulses that are poorly absorbed by soft tissue, and so the tissue sustains virtually no injury, even perforations. Owing to its general safety, direct vision using a choledochoscope is unnecessary when performing FREDDY lithotripsy via the transpapillary route. Instead, the laser fiber was inserted within a balloon catheter to maintain its position in the center of the duct [18].

Unfortunately, a major disadvantage of FREDDY lithotripsy is the inability to fluoroscopically visualize the laser fiber tip in the bile duct. Although the radiopaque tip of the balloon catheter is positioned near the stone, the tip of the fiber itself is not detectable by fluoroscopy. Thus, positioning of the fiber may be unsatisfactory in some cases. Furthermore, when being pushed out of the balloon catheter, the laser fiber may be broken and its sharp tip may cause bile duct wall injury and even hemobilia because of the inability to obtain a visualization under fluoroscopic guidance [19]. Kim et al. [8] and Cho et al. [9] reported that hemobilia occurred in 2/17 and 8/52 patients, respectively. In their studies, broken fibers were observed in some cases. To solve these problems, the tip of the fiber was packaged with a radiopaque ring mark (the hydrophilic tip of a zebra guide wire). As a result, in the current series neither hemobilia nor broken laser fiber were observed. Regarding complications, mild acute pancreatitis was noted in two patients (6.7%). They were treated by conservative management, suggesting that FREDDY laser lithotripsy is safe. The results of these complications were consistent with the report by Maiss et al. [16].

In our experience, when the tip of the laser fiber was packaged with a radiopaque ring mark, the efficiency of successful stone fragmentation appeared higher. In our study, the number of laser pulses needed to disintegrate the stones was 1050 ± 980, whereas in the study by Cho et al. [9] the number was 3580 ± 1450. We assume that this difference was due to the increased accuracy of position on the surface of stones using the laser fiber with a radiopaque mark.

In conclusion, the laser system using FREDDY technology without direct visual control was found to be a safe and very effective method for the treatment of difficult stones in the CBD. The radiopaque tip of the laser fiber enabled the visualization under fluoroscopic guidance, thus ensuring correct positioning and minimizing the risk of bile duct injury.

Competing interests: None

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在 X 光透视引导下使用带放射显影标记的 FREDDY 激光进行内镜胆道碎石术的疗效与安全性

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迄今为止，尚未有临床试验报告关于在透视引导下使用带有不透射线标记的双频双脉冲掺钕钇铝石榴石（FREDDY）激光治疗常规内镜疗法无法处理的胆管结石的安全性和有效性。我们报告了 30 例嵌顿性或较大（>1.5 厘米）胆总管结石患者，在透视引导下采用带不透射线标记的 FREDDY 激光进行内镜下碎石治疗的病例。手术过程中，激光光纤顶端封装有可在透视下识别的不透射线环形标记。这些患者中，30 例中有 27 例（90%）实现了胆管完全清理。多数患者（18/30）通过单次治疗完成；实现胆管完全清理所需的平均治疗次数为 1.4 ±0.6 次。两名患者出现不良事件，均发展为急性轻症胰腺炎。

引言

内镜下括约肌切开术是胆道系统取石最常见的操作之一。然而对于 5%-15%的胆总管结石患者，该手术会因结石过大无法通过括约肌切开部位而失败。此类情况下，可采用机械碎石术将结石粉碎后再行取出。但机械碎石术有时存在操作繁琐、耗时冗长、技术复杂或效果欠佳等问题。当结石体积增大、数量增多并完全堵塞胆管时，甚至可能无法展开碎石网篮进行取石。另一难点在于胆总管远端狭窄的存在，即便结石已被粉碎也难以清除。此外，壶腹周围憩室可能是导致复发性胆管结石形成、影响胆道通畅度的诱因。对于难治性胆总管结石患者，当机械碎石失败时，需采用其他辅助手段如液电碎石术(EHL)、体外冲击波碎石术(ESWL)、激光冲击波碎石术(LSWL)以及姑息性支架置入术等。但这些技术均需依赖专用昂贵设备或高脉冲能量来实现结石崩解。

双频双脉冲掺钕钇铝石榴石（FREDDY）激光器是一种新研发的经济型短脉冲双频固态激光器，其波长为 532 纳米和 1064 纳米。该激光器能产生强大的冲击波（脉冲峰值功率达 133 千瓦），可在短时间内粉碎结石。该系统有望结合染料激光器与固态激光器的优势，如可靠性高、疗效显著且成本低廉。然而，该激光光纤导管尖端无法在透视下显影，加之患者胆总管存在迂曲结构，可能导致激光光纤难以精确定位结石。另一缺点是激光光纤质地脆弱，在胆总管急弯处进行插管操作时易发生意外断裂。此外，尖锐的激光光纤尖端可能造成胆管黏膜创伤并引发胆道出血。

在本报告中，激光光纤被置入带有不透射线环标记的气囊导管内，该标记位于导管尖端，旨在提高透视定位精度并防止胆管损伤。FREDDY 激光最初被引入用于泌尿系结石的内镜下碎石术。然而，关于使用 FREDDY 激光粉碎难治性胆总管结石的研究报道仍较为有限。

病例报告

2006 年 6 月至 2009 年 12 月期间，某三级转诊中心共对 30 例胆总管结石患者（平均年龄 62.2 岁，范围 28-87 岁）实施了 FREDDY 激光碎石术。纳入标准为存在嵌顿性或较大胆总管结石（>1.5 厘米），且经内镜下括约肌切开术后因结石无法被网篮捕获或机械碎石失败而未能取出。其中 18 例患者因结石过大无法抓取，8 例患者存在无法进入取石网篮的嵌顿性胆总管结石，4 例患者伴有胆总管远端狭窄。胆总管结石特征如下：单发结石 8 例，双发结石 9 例，多发结石（≥3 枚）13 例；大结石平均直径为 2.0±0.7 厘米（范围 1.2-3.6 厘米）。本研究经机构审查委员会批准，所有患者均签署了激光治疗知情同意书。

本研究所使用的 FREDDY 激光器为 Laser U100 系统（德国柏林 World of Medicine 公司生产）。为使激光光纤（纤芯直径 280 微米，外径 420 微米，长度 3.5 米）尖端能在透视下显影，在将其置入三腔取石球囊导管（美国马萨诸塞州纳蒂克 Boston Scientific 生产）前，先用不透 X 线的环状标记（斑马导丝亲水头端）进行了封装（图 1）。

随后将带有光纤的气囊导管通过标准十二指肠镜的工作通道，经乳头插入胆管。通过另一通道注入造影剂以清晰确认结石位置，之后将激光光纤向前推进 3-5 毫米。在荧光透视引导下，将光纤的不透射线尖端推出气囊导管，定位于结石表面（图 2）。

在激光发射的同时观察到了结石的碎裂现象。治疗能量设置为每脉冲 120 毫焦，重复频率为 10 赫兹。激光碎石过程中，通过荧光透视监测碎石效果直至结石被粉碎。胆管持续灌注造影剂与生理盐水的混合液，既传导激光能量又便于观察碎石过程。结石分解后，使用取石网篮或回收球囊导管进行内镜下碎石提取。若此时胆管未完全清理，则置入鼻胆管引流至下次治疗。

手术过程中，光纤的不透射线尖端在透视引导下清晰可见。其中一名有腹腔镜胆囊切除术病史的患者因光纤尖端无法准确定位到结石表面，导致激光碎石治疗失败。其余手术均获成功，总成功率达 96.7%。30 例患者中有 27 例（90%）实现了胆管完全清石。单次治疗患者 18 例（60.0%），需要两到三次治疗的患者 9 例。每位患者实现胆管完全清石所需的平均治疗次数为 1.4±0.6 次。每次手术的中位激光脉冲数为 1050±980 次（表 1）。FREDDY 激光碎石术后，4 例患者（13.3%）通过机械碎石术实现了胆管完全清石（表 1）。

激光碎石治疗在三位患者中宣告失败：其中两位患者的结石仅被部分粉碎，其中一位患者不愿接受内镜逆行胰胆管造影术（ERCP），转而选择通过手术清理胆管。另一位 88 岁男性患者，患有冠状动脉疾病并存在三颗 2.5 厘米的胆总管结石，因无法耐受治疗过程；该病例在向胆管植入塑料支架预防胆管炎后，终止了激光碎石手术。还有一位患者因光纤尖端无法准确定位到结石表面，最终同样通过手术清理了胆管。

未观察到胆道出血病例。首次治疗后，两名患者出现急性轻症胰腺炎（6.7%），但症状呈一过性，经保守治疗后消退。未发现与 FREDDY 激光碎石术相关的其他并发症，如胆道出血、穿孔或胆管损伤等。第二、第三次治疗后均未出现并发症。碎石过程中未发生激光光纤断裂情况。



图 1 激光光纤尖端封装有放射不透明环标记（黑色箭头）。

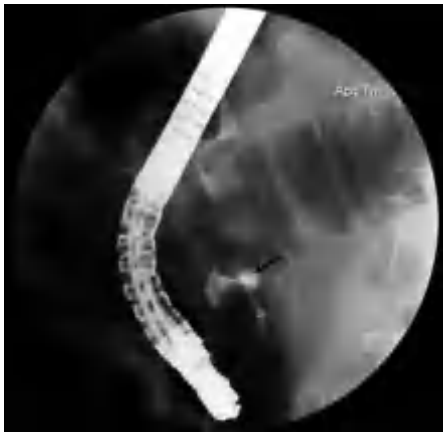


图 2 在荧光镜引导下，激光光纤尖端（黑色箭头）在受冲击结石表面清晰可见。

Procedure	Results (N = 30)
Accurate targeting of the laser on the surface of stones, n (%)	[illegible]
Complete clearance of bile duct, n (%)	27 (90.0)
Complete removal of stones in the first endoscopic session, n (%)	18 (60.0)
Number of laser pulses per procedure, median ± SD	1050 ± 980
Number of endoscopic sessions, mean ± SD	1.4 ± 0.6
Combined mechanical lithotripsy required, n (%)	[illegible]

表 1 使用倍频双脉冲掺钕钇铝石榴石（FREDDY）激光系统进行碎石术的结果

讨论

内镜逆行胰胆管造影术（ERCP）与括约肌切开术是治疗胆总管结石的标准方案。采用 Dormia 网篮或球囊导管通过内镜下括约肌切开术取石的成功率超过 80%。当结石过大（>1.5 厘米）无法通过括约肌切开部位时，需在取石前进行机械碎石。然而对于体积巨大或嵌顿性结石患者，实现胆管完全清石的可能性较低。此类病例中，除开放性胆管探查术外，还可采用多种替代技术，如激光碎石术、液电碎石术（EHL）和体外冲击波碎石术（ESWL）。其中

EHL 系统通常需要直接可视化操作，技术难度较高；子母胆道镜系统需两位经验丰富的内镜医师配合操作；而 ESWL 不仅耗时较长，且往往需要多次治疗才能实现结石碎裂。自 1986 年首例逆行激光冲击波碎石术成功治疗胆管结石的报道以来，已有多种固态激光和脉冲染料激光系统被开发应用于胆管结石碎石。这些系统需直视结石定位以避免胆管损伤。最新进展是引入配备结石/组织识别系统的罗丹明 6G 染料激光，可显著降低组织损伤风险。但该设备价格昂贵、体积庞大、需高压电源支持，临床适用性有限[6]。近期，新型固态激光碎石系统——双频双脉冲掺钕钇铝石榴石激光（FREDDY）已逐步取代罗丹明 6G 染料激光。FREDDY 激光可同步发射 532 纳米（绿色光谱）和 1064 纳米双波长脉冲：532 纳米激光在结石表面引发等离子体形成，而红外激光能量促使该等离子体形成快速坍缩的气泡，由此产生强力冲击波实现碎石效果。

迈斯等人首次报道了 FREDDY 激光在困难胆总管结石中的临床应用。一项针对 22 名接受 FREDDY 激光碎石术患者的研究显示，91%的患者实现了胆管完全清理。Kim 等人报告了使用 FREDDY 系统进行胆总管结石激光碎石术的临床数据，17 名患者中有 15 名（88.2%）实现了胆管清理，平均治疗次数为 1.7±0.6 次。赵等人报道称，在 52 名经乳头途径治疗的患者中，48 名（92.3%）实现了结石完全清除，平均需要 1.4 次（范围 1-2 次）内镜治疗。

在本系列研究中，30 例患者中有 27 例（90%）实现了胆总管完全清石，其中 18 例（60%）通过单次治疗即获成功，另有 9 例需接受多次治疗（治疗次数 1-3 次不等）。完全取石平均需进行 1.4±0.6 次内镜操作。经 FREDDY 激光碎石术后，4 例患者（13.3%）仍需辅以机械碎石术才能实现胆管完全清石。本研究中部分病例因胆总管迂曲而需多次治疗。当其他技术难以清除这些复杂胆总管结石时，多次内镜碎石治疗成为必要选择。

配备压电声波结石/组织识别系统的 FREDDY 激光碎石仪可最大限度降低胆管损伤风险。当光纤直接接触组织激活激光时，组织病理学变化极其轻微。Zorcher 等学者研究表明，聚焦的选择性激光束作用于家兔尿路上皮时，仅造成轻度黏膜水肿伴充血、固有层轻中度出血，以及所有组织学标本上皮层点状凝固性坏死——即使在 90mJ 能量和 2000 次脉冲的最大参数下实施。既未发现肌层损伤，也未出现穿孔。此外，与钬激光相比，FREDDY 激光不产生热效应。该激光产生的超短脉冲几乎不被软组织吸收，因此组织甚至不会发生穿孔等损伤。鉴于其安全性，经乳头途径实施 FREDDY 碎石术时无需胆道镜直视引导。实际操作中，激光光纤通过球囊导管置入，以保持其在胆管中央的位置。

遗憾的是，FREDDY 碎石术存在一个主要缺陷——无法在胆管中通过透视观察到激光光纤尖端。虽然球囊导管的射线不透性尖端靠近结石放置，但光纤尖端本身在透视下不可见，这导致某些病例中光纤定位效果欠佳。此外，当光纤被推出球囊导管时，由于无法在透视引导下实现可视化，可能导致光纤断裂，其尖锐尖端会造成胆管壁损伤甚至胆道出血。Kim 等与 Cho 等分别报告 2/17 例和 8/52 例患者出现胆道出血，部分病例中观察到光纤断裂现象。为解决这些问题，研究者采用斑马导丝亲水尖端作为射线不透性环标记封装光纤尖端。本系列研究中，既未发生胆道出血也未出现激光光纤断裂。并发症方面，两例患者（6.7%）出现轻度急性胰腺炎，经保守治疗痊愈，表明 FREDDY 激光碎石术具有安全性。这些并发症结果与 Maiss 等的报道一致。

根据我们的经验，当激光光纤尖端封装有不透射线标记环时，结石成功碎裂的效率似乎更高。本研究中，粉碎结石所需的激光脉冲次数为 1050±980 次，而 Cho 等学者的研究中该数值为 3580±1450 次。我们认为这种差异源于采用不透射线标记的光纤能更精准地定位结石表面。

综上所述，采用 FREDDY 技术且无需直接视觉监控的激光系统，被证实是治疗胆总管疑难结石安全且高效的方法。激光纤维的不透射线尖端可在透视引导下实现可视化，从而确保准确定位，并将胆管损伤风险降至最低。

·论著·

经皮经肝十二指肠乳头肌扩张顺行排石术联合双频双脉冲激光碎石治疗大直径胆总管结石

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【摘要】 目的　本研究旨在评估经皮经肝十二指肠乳头肌扩张顺行排石术联合输尿管软镜引导双频双脉冲 ND:YAG 激光碎石术（PTPBD-FREDDY）治疗巨大（直径>1.5 cm）胆总管结石的安全性和有效性。**方法**　回顾性分析 2017 年 12 月至 2021 年 10 月在山东大学第二医院和山东颐养健康集团新汶中心医院收治的 26 例大直径困难胆总管结石患者，其中 4 例患者无法耐受外科手术或内镜治疗、6 例患者内镜治疗失败，另外 16 例患者拒绝接受再次手术治疗。所有患者均接受了 PTPBD-FREDDY 治疗，首先在输尿管镜监视下应用 FREEDY 激光将结石粉碎，然后应用球囊将结石推送入十二指肠内。主要研究终点为技术成功率，次要研究终点包括结石复发率以及相关并发症。**结果**　26 例患者均成功完成手术，技术成功率为 100%。胆总管结石直径平均碎石断石和手术时间显著高于混合结石和胆固醇结石（P<0.01）。术后主要并发症包括轻度发热 3 例、腹痛 3 例、恶心 2 例和胰腺炎 1 例，1 例患者出现胆管出血，经保守治疗后好转。未观察到胆漏、胰瘘和胰管狭孔等严重并发症。术后随访 2 年，未观察到结石复发的病例。**结论**　PTPBD-FREDDY 技术对于巨大胆总管结石患者来说是一种安全、有效的治疗方法。它为无法耐受手术、内镜治疗失败的巨大胆总管结石患者提供了一种新的治疗手段，具有良好的前景。

【关键词】 胆总管结石；　放射学，介入性；　输尿管镜；　激光

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Percutaneous transhepatic papillary balloon dilation combined with dual-frequency double-pulse laser lithotripsy for large-diameter common bile duct stones

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[Abstract]　Objective　To evaluate the safety and efficacy of percutaneous transhepatic papillary balloon dilation (PTPBD) combined with flexible ureteroscopy-guided dual-frequency double-pulse ND:YAG (FREDDY) laser lithotripsy (PTPBD-FREDDY) for the treatment of giant (>1.5 cm diameter) common bile duct stones. **Methods**　A retrospective analysis was conducted on 26 patients with large-diameter difficult choledocholithiasis admitted to two medical centers from

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December 2017 to October 2021. Among these patients, four could not tolerate surgery or endoscopic treatment, six experienced failure of endoscopic treatment, and 16 refused to undergo endoscopic or surgical treatment. All patients underwent the PTPBD-FREDDY procedure. The FREDDY laser lithotripsy was performed under ureteroscopic guidance, followed by a balloon to push the stones into the duodenum. The primary endpoint was the technical success rate, and the secondary endpoints included the rate of stone recurrence and related complications. **Results** All 26 patients successfully completed the operation, achieving a technical success rate of 100%. The average lithotripsy frequency and operation time for bilirubin stones were significantly higher than those of mixed stones and cholesterol stones ($P<0.01$). The main postoperative complications included mild fever ($n=3$), abdominal pain ($n=3$), nausea ($n=2$) and vomiting ($n=1$). One patient experienced biliary tract bleeding, which improved after conservative treatment. No serious complications such as pancreatitis, sepsis, or biliary perforation were observed. After 2 years of follow-up, no cases of stone recurrence were observed. **Conclusions** PTPBD-FREDDY is a safe and effective treatment for patients with giant common bile duct stones. It provides a new therapeutic option for patients with giant choledocholithiasis who can not tolerate surgery or have failed endoscopic treatment, demonstrating promising prospects.

[Key words] Choledocholithiasis; Radiology, interventional; Ureteroscopes; Lasers

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胆石症是一种常见的消化系统疾病，胆总管结石(common bile duct stones，CBDS)发病率占胆石症患者的10%–15%，大多胆总管结石为继发性胆管结石，常合并胆囊结石[1]。但有症患者多无临床症状，大多数为查体时发现，部分患者会出现反复发作的胆绞痛、黄疸或发热等症状[2]。目前，内镜逆行胰胆管造影(endoscopic retrograde cholangiopancreatography，ERCP)联合乳头括约肌切开术是胆总管结石的主要治疗手段[3]，但是对于巨大胆总管结石(直径>1.5 cm)，ERCP治疗可能会面临困境[4]。2008年以来，经皮经肝十二指肠乳头肌扩张预行取石术(percutaneous transhepatic papillary balloon dilation，PTPBD)在国内逐渐应用于胆总管结石的治疗并显示出良好的前景[5-6]；激光碎石技术已在泌尿系统结石治疗中成功应用，近年来也逐渐应用于肝内胆管和胆总管困难结石的治疗。双脉双频Nd:YAG激光(frequency-doubled dual pulse Nd:YAG laser lithotripsy，FREDDY)是一种冷激光，其在经皮经肝十二指肠乳头肌扩张预行取石术中的应用鲜有报道。本研究旨在评估PTPBD联合FREDDY激光在治疗大直径困难胆总管结石(直径>1.5 cm)方面的安全性和有效性。

对象与方法

一、对象

1. 患者：本研究为单臂回顾性研究。分析2017年12月至2021年10月在山东大学第二医院和山东颐养健康集团新汶中心医院收治的26例胆总管结石患者，患者年龄为43–83(66±12)岁，其中男性12例，女性14例。最大结石的直径为18.9–25.1(21.8±2.4) mm。9例患者合并胆囊结石。所有患者均未做过胆囊手术。26例患者中，4例患者由于心肺功能不全、麻醉禁忌证、上消化道狭窄等原因不适合手术；6例患者曾尝试行ERCP失败，而另外16例患者拒绝ERCP或手术治疗。研究经医院伦理委员会批准(批文号：LCLL-2019-008)，患者知情同意。

2. 纳入标准：(1)通过腹部超声及增强计算机断层扫描(CT)或磁共振胰胆管成像(MRCP)以及内镜超声(EUS)确诊的胆总管结石患者(图1)；



图1 胆总管结石1例患者的术前影像资料 患者女性，80岁，间歇黄疸，恶心入院，静脉双期增强CT平扫显示胆总管巨大结石(白箭)

(2)胆总管结石直径>15 mm;(3)患者年龄 18~90 岁;(4)卡氏评分不低于 70 分;(5)不耐受或拒绝 ERCP 或外科手术。

3. 排除标准:(1)合并多发肝内胆管结石;(2)严重凝血功能障碍(凝血酶原时间>17 s 和/或血小板计数<60×10⁹/L);(3)恶病质或预期寿命不足 3 个月;(4)严重的心功能衰竭(根据纽约心脏病协会心功能分级标准:Ⅳ级);严重的通气功能障碍(第 1 秒用力呼气容积小于正常预计值的 35%);(5)处于妊娠或哺乳期的女性。

二、方法

1. PTPBD 操作流程:术前根据 CT 值判断结石的性质,CT 值≤40 HU 为胆固醇结石,CT 值>40 HU 为胆色素类结石,混合性结石表现为结石边缘呈环状高密度,中心为低密度的充盈缺损[9]。手术采用静脉麻醉(右美托咪啶)联合局部麻醉(利多卡因)。患者取仰卧位,在 DSA 引导下,于右侧腋中线第 8~9 肋间隙穿刺肝内胆管,穿刺成功后,先置入 8 Fr 鞘进行预扩张,行胆管造影,明确结石位置、大小(图 2A),之后置入 12 Fr 鞘(Olympus,日本),应用推动脉导管配合 150 cm 超滑导丝通过十二指肠乳头,进入十二指肠内,应用 10 mm×40 mm 球囊扩张乳头肌(图 2B)。通过 12 Fr 鞘将 9.8 Fr 输尿管软镜(Olympus,日本)置入胆管内,观察结石形态、位置,将 U100plus 激光纤维(W.O.M, Germain)通过输尿管镜的操作通道进入胆总管内,使其与胆总管结石密切接触,使用 120 mJ 或 160 mJ 单脉冲和 5 Hz 或 10 Hz 频率进行碎石(图 2C)。在激光碎石过程中,持续注入生理盐水以获得清晰的视野,同时提供激光碎石所需的液体环境。直视下发射激光粉碎结石,结石粉碎后,应用球囊将结石推送进入十二指肠内(图 2D)。然后进行镜检和胆管造影,确保所有结石均被清除(图 2E)。术后放置 10.2 Fr 外引流管(图 2F),1 周后重复胆管造影,如未发现残余结石,则移除导管;如有残留结石,则重复 PTPBD。对于合并有急性胆系感染的患者,先行胆管外引流,待 5~7 d,感染纠正后再行排石术。

2. 随访:所有病例自手术当天开始随访,随访至 2023 年 10 月。随访内容包括体格检查、实验室检查和影像学评估(图 3)。观察技术成功率、临床成功率及并发症情况。如胆总管结石完全清除则认为技术成功;无论患者有无残余结石,只要患者症状消失,则认为临床成功。并发症的详细信息按照介入放射学学会(SIR)标准,参见文献[10]。

三、统计学处理

所有数据使用 SPSS 统计 24.0(IBM,美国)进行分析。分类变量以数字和百分比表示。连续变量的正态分布通过 Kolmogorov-Smirnov 检验进行评估。对于正态分布的连续数据,采用 $\bar{x} \pm s$ 表示;对

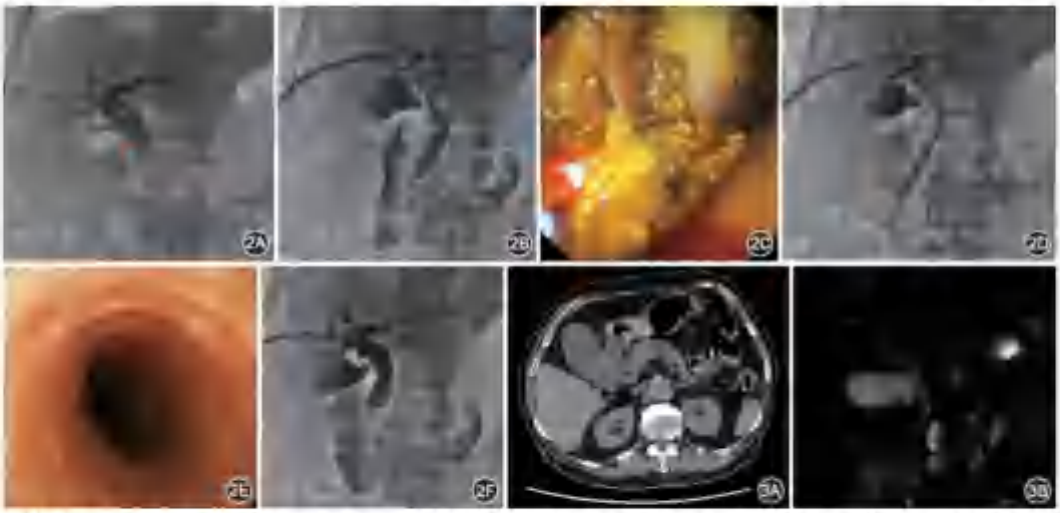


图 2　胆总管结石患者接受手术操作流程　经皮穿刺肝内胆管建立工作通道,胆管造影显示胆总管下大结石(2A,红箭),应用 10 mm×40 mm 球囊扩张十二指肠乳头肌(2B),经输尿管软镜于工作通道进入激光光纤,直视下应用激光粉碎结石(2C),然后应用球囊将结石推进入十二指肠内(2D),镜下查看胆总管内结石消失(2E),置双周径 10.2 Fr 外引流管,造影见胆总管内充盈缺损消失(2F)　图 3　与图 2 同一患者术后随访资料　术后 6 个月复查腹部 CT(仰卧位平扫)(3A),MRCP(3B)显示胆总管结石消失,未见复发

于非正态分布的数据用 $M(Q_1, Q_3)$ 表示。使用配对 t 检验比较术前、术后 1 周和 1 个月的检验数据，$P<0.05$ 为差异有统计学意义。

结　果

一、患者一般资料

26 例患者中，心肺功能不全 2 例，上消化道狭窄 1 例，麻醉禁忌证 1 例。既往病史中，ERCP 失败 6 例，不耐受 ERCP 或外科手术 4 例，拒绝 ERCP 或者外科手术 16 例。患者结石数量，1 个 12 例，≥2 个 14 例。结石类型为胆固醇结石 5 例，混合结石 2 例，胆色素结石 19 例。

二、术后结果

26 例患者均成功完成手术，技术成功率为 100%。最常用的激光碎石模式是 120 mJ 单脉冲和 5 Hz，占比为 69.2%（18/26）。所有类型结石的平均手术时间依次为胆固醇结石（65±9）min，混合型结石（82±4）min，胆红素结石（105±14）min（$t=3.9$，$P<0.05$）。不同类型结石的平均碎石频率依次为胆固醇结石 776（673–848）次，混合型结石 956（924–989）次，胆红素结石 1 550（1 008–3 325）次。患者丙氨酸转氨酶、总胆红素和白细胞计数在手术后逐渐恢复正常。术前和术后血清淀粉酶和血红蛋白水平差异无统计学意义（均 $P>0.05$）（表 1）。

表 1　患者术前术后实验室指标

指标	术前	术后 2 周	t 值	P 值
丙氨酸转氨酶（U/L）	101±51	35±8	13.66	<0.001
总胆红素（μmol/L）	65±19	22±5	12.71	<0.001
淀粉酶（U/L）	75±25	67±18	1.31	0.203
白细胞计数（×10⁹/L）	10.9±3.0	6.2±1.3	8.34	<0.001
血红蛋白（g/L）	122±7	122±6	−0.43	0.667

三、并发症及随访

主要并发症为轻度发热 11.5%（3/26），腹痛 11.5%（3/26），恶心 7.7%（2/26）和呕吐 3.8%（1/26）。未见胆汁性腹膜炎、胆管或十二指肠穿孔以及与手术相关的围手术期死亡。3 例患者在手术后 3 天淀粉酶水平升高，经生长抑素治疗后淀粉酶水平恢复正常。1 例患者术后胆管引流管引流出血性液体，应用止血药物治疗后出血停止。术后 2 年随访，未发现慢性胆管炎和结石复发病例。

讨　论

胆总管结石可引发梗阻性黄疸、胰腺炎、急性梗阻性化脓性胆管炎等严重并发症，特别对于合并心肺等基础疾病的高龄患者风险更大。尽管 ERCP 联合乳头肌切开术是目前胆总管结石的首选治疗方法，但在 10%–15% 的患者中，这一方法可能无法完全清除胆管结石，往往需要联合其他治疗方式[1]。

1986 年，Lux 等[2]就首次成功使用钬激光在人体内进行内镜逆行激光碎石术。随着激光技术的不断发展，激光碎石术已成为难治性胆总管结石的治疗选择之一。但目前已发表的研究中，涉及胆总管结石激光碎石的报道都是应用消化内镜引导，并且有些情况下内镜引导实施该手术十分困难。Verma 等[3]报道了 1 例 91 岁的巨大胆总管结石患者，多次接受 ERCP 治疗均未成功，包括 ERCP 联合钬激光碎石等。最终，介入放射学家经皮向胆管内置入 14 行鞘，应用输尿管软镜直视下钬激光碎石成功。

PTPBD 是近年来新兴的微创治疗技术，尤其对于高龄、合并严重基础疾病等无法手术或内镜治疗失败的胆总管结石患者，PTPBD 具有一定的优势，其疗效及安全性已被大量研究证实[4]。作为一种冷激光，FREDDY 激光波长远低于人体软组织吸收产生热量的波长，所以不会造成结石周围的软组织热损伤[5]。目前临床上双频双脉冲激光主要用于传统外科手术、腹腔镜手术、内镜操作及 ERCP 等常规手段难以取出的胆管结石，而其在 PTPBD 中的应用鲜有报道。本研究在此基础上进一步探索，将 PTPBD 与 FREDDY 相结合，用于处理大直径困难胆总管结石，结果显示此种方法技术可缩短手术时间，提高结石清除率。

结石直径是影响手术成功率的一个主要因素，大直径胆总管结石是胆石症道创治疗的难点之一。直径超过 1.5 cm 的胆总管结石往往需要联合其他碎石手段[6]。Liu 等[7]开展了多中心前瞻性队列研究，对比 ERCP 与 PTPBD 治疗胆总管结石的效果，结果发现对于直径>15 mm 的结石，应用 ERCP 治疗的结石清除率为 90%，术后胰腺炎的发生率为 2%，胆管出血及十二指肠穿孔的发生率为 1%。本研究应用 FREDDY 激光碎石，结石清除率可达 100%，表现出显著的优势。近年来，乳头大球囊扩张术在 ERCP 治疗胆总管大结石中的应用逐渐增多，但大

球囊扩张能可能在一定程度上对十二指肠乳头括约肌的结构和功能造成损伤；同时由于大直径球囊对乳头的作用强烈，可能造成乳头水肿诱发胰腺炎[3]。汪静等[11]回顾性分析46例采用乳头大球囊扩张术治疗的大直径胆总管结石，术后胰腺炎发生率为15.2%，出血发生率为13%。本研究结果显示，PTPBD-FREDDY 治疗大直径胆总管结石胆管出血的发生率较低，而且未出现围手术期死亡、胰腺炎、肠道或胆管穿孔等严重并发症，可能原因为 FREDDY 激光的碎石效率较高，结石粉碎后体积变小，应用小直径球囊就能够将碎石推送入十二指肠内，从而减少了大球囊扩张可能造成的组织损伤。

总结操作的技术要点如下：(1)建立工作通道时需逐级扩张，先置 8 Fr 鞘，应用导丝配合导管通过十二指肠乳头肌，进入肠道内，之后置换送入周径 12 Fr，长度 35 cm 长鞘，远端位于肝总管内。(2)应用球囊扩张十二指肠乳头肌时，应逐渐增加压力，充分扩张。(3)置入输尿管软镜时要轻柔，避免镜头损伤。(4)激光碎石操作过程中，注意保持激光光纤在工作视野内，避免尖端划伤周围组织。

本研究结果表明在传统治疗难以实施或失败的情况下，PTPBD-FREDDY 激光碎石术可以作为一种安全有效的替代治疗方法，不仅技术成功率高，术后并发症也非常轻微，具有良好的前景。

利益冲突 所有作者声明无利益冲突

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作者贡献声明 徐一凡：临床设计、文章撰写；梁涛：临床操作、文章修改；高红刚：临床资料收集及整理；杨旭：临床操作、论文审阅；王雷：数据统计分析、作图；王本正：临床操作；李东亮：研究指导、论文审阅；赵连友：研究总体设计、临床操作、论文修改

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Original Article/Liver

Management hepatolithiasis with operative choledochoscopic FREDDY laser lithotripsy combined with or without hepatectomy

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BACKGROUND: **Hepatolithiasis is very common in East Asia. It is benign in nature, but has a high recurrence rate. It is likely to lead to biliary cirrhosis and increase the risk of cholangiocarcinoma. Hence, the treatment of hepatolithiasis is difficult but vital. In this report, we present a novel approach to manage hepatolithiasis using the choledochoscopic Frequency-Doubled Double pulse Nd:YAG (FREDDY) laser lithotripsy combined with or without hepatectomy.**

METHODS: **Between July 2009 and October 2012, 45 patients underwent choledochoscopic FREDDY laser lithotripsy combined with or without hepatectomy (laser lithotripsy group). Forty-eight patients underwent a traditional operation (traditional method group) from January 2009 to June 2009. Comparative analysis was made of demographic and clinical characteristics of the two groups.**

RESULTS: **The final stone clearance rate of the laser lithotripsy group was 93.3%, whereas that of the traditional method group was 85.4% (*P*=0.22). In the laser lithotripsy group, 2 patients experienced hemobilia and 3 patients had acute cholangitis. In the traditional method group, 3 patients had intraoperative hemorrhage, 1 patient had bile leakage, 6 patients had acute cholangitis, and 1 patient died of liver failure. Moreover, the operative time in the traditional method group was significantly longer than that in the laser lithotripsy group (*P*=0.01). The mean hospital stay of the patients in the traditional method group was longer than that in the laser lithotripsy group (9.8 vs 8.2 days, *P*=0.17). Recurrent intrahepatic bile duct stones were not found during the follow-up period in the two groups.**

CONCLUSION: **Operative choledochoscopic FREDDY laser lithotripsy combined with or without hepatectomy may be an effective and safe treatment for hepatolithiasis.**

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KEY WORDS: **hepatolithiasis; lithotripsy; frequency-doubled double pulse Nd:YAG laser; hepatectomy; choledochoscopy**

Introduction

Hepatolithiasis, also known as "oriental cholangiohepatitis", is quite common in East Asia, with an incidence of 38% in China, 17.0% in Korea, and 2.1% in Japan.[1] It is characterized by the recurrent pyogenic cholangitis which leads to secondary biliary cirrhosis and liver failure,[2] and cholangiocarcinoma represents a long-term unfavorable complication of the disease.[3] The clinical progress of hepatolithiasis is hard-bitten, demanding various surgical or nonsurgical treatments because of a frequent stone recurrence. The main purpose of treatment should be complete removal of the stones, preventing from further attacks of cholangitis and controlling disease progression to biliary cirrhosis. Currently, various treatment options have been available, including liver resection, percutaneous approach, endoscopic approach and laser lithotripsy.[4-24] Usually, stones that are hard and impact or can not be extracted by traditional methods (basket catheters, forceps and irrigation) are considered refractory bile duct stones. Some surveys[7-9] showed that laser lithotripsy may offer a safe and efficacious option

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to manage refractory intrahepatic bile duct stones. In this report, we describe the operative choledochoscopic Frequency-Doubled Double pulse Nd:YAG (FREDDY) laser lithotripsy combined with or without hepatectomy for the management of intrahepatic bile duct stones.

Methods

This retrospective review included 45 patients (19 males and 26 females), with a median age of 53 years (range 36-72), who had undergone choledochoscopic FREDDY laser lithotripsy combined with or without hepatectomy from July 2009 to October 2012 in our Hepatobiliary and Pancreatic Surgery Center. A preoperative assessment was performed for the 45 patients with regard to clinical symptoms, physical examinations, a comprehensive metabolic panel, a complete blood count with differential carcinoembryonic antigen (CEA), CA-199, and right upper quandrant ultrasound, upper abdominal computed tomography (CT) and magnetic resonance cholangiopancreatography (MRCP). Fifteen patients (33.3%) experienced jaundice at the diagnosis of bile duct obstruction. Before surgical intervention, 17 patients (37.8%) had previous hepatobiliary operation, 31 (68.9%) had fever, 30 (66.7%) had upper abdominal pain, and 8 (17.8%) suffered from biliary cirrhosis.

We performed bile duct exploration, except for refractory bile duct stones, for which choledochoscopic FREDDY laser lithotripsy therapy (laser μ100plus, world of Medicine, Berlin, Germany) was feasible. In the 45 patients who received choledochoscopic FREDDY laser lithotripsy therapy, 12 underwent hepatectomy. Laser pulses of 1.2 μs were applied at a repetition rate of 10-15 Hz. As intrahepatic stones were found by a choledochoscope (CHF type P10; Olympus, Tokyo, Japan), a 280 μm flexible fiber was inserted into the working channel of the choledochoscope. The energy of the FREDDY laser system was transmitted by this flexible fiber. Laser wavelengths of 532 nm and 1064 nm as a double pulse was applied with pulse energy of 120 mJ. If bile duct stones fragmented too slowly or were hard enough, the energy was increased to 160 mJ, and there was no relationship between the size of stone and pulse energy. After the disintegration of the stones, a complete clearance of the biliary system was attempted at the same time by irrigation and basket catheters. Generally, hepatectomy is indicative if choledochoscopic insertion in the severely narrowed intrahepatic bile duct is not successful, or patients have atrophy of liver lobe, or clinically suspected cholangiocarcinoma. After bile duct exploration and choledochoscopic FREDDY laser lithotripsy, all of our patients were routinely placed a T-tube in the common bile duct. The T-tube was removed in two months later if the stones were not found in the intrahepatic bile duct.

In order to illustrate the superiority of choledochoscopic FREDDY laser lithotripsy, we made a comparative analysis between the two groups. In our study, this time period was chosen because the FREDDY laser equipment was not available at our hospital before July 2009. The traditional methods included forceps and irrigation lithotripsy, choledochoscopic basket catheter lithotomy, and hepatectomy. The demographic and clinical features of the patients in the laser lithotripsy group and the traditional method group are shown in Table 1.

All patients were followed up after treatment with FREDDY laser lithotripsy and traditional method. The follow-up examinations included T-tube cholangiography, ultrasonography and laboratory tests (hemoglobin, white blood cell count, bilirubin, alanine aminotransferase, aspartate aminotransferase, creatinine, serum urea nitrogen, CEA, CA-199), which were performed every three months. Stones detected in the intrahepatic bile duct within 3 months after therapies were considered as residual stones. The occurrence of any operative complication

Table 1. Demographic and clinical features of patients in laser lithotripsy group and traditional method group

Characteristics	Laser lithotripsy group (*n*=45)	Traditional method group (*n*=48)
Male/Female	19/26	23/25
Mean age (yr)	53	56
History of hepatobiliary surgery (*n*, %)	17 (37.8)	18 (37.5)
Hepatectomy	5 (11.1)	4 (8.3)
Bile duct exploration	12 (26.7)	13 (27.1)
Cholecystectomy	15 (33.3)	17 (35.4)
Symptoms (*n*, %)		
Jaundice	15 (33.3)	17 (35.4)
Fever	31 (68.9)	33 (69.5)
Upper abdominal pain	30 (66.7)	35 (72.9)
Biliary cirrhosis (*n*, %)	8 (17.8)	9 (18.8)
Mean Child-Pugh score	A	A
Biliary strictures (*n*, %)	17 (37.8)	19 (39.6)
Number of stones (*n*, %)		
1	0 (0)	0 (0)
>1	45 (100)	48 (100)
Location of stones (*n*, %)		
Unilateral bile duct	11 (24.4)	13 (27.1)
Left intrahepatic bile ducts	7 (15.6)	9 (18.8)
Right intrahepatic bile ducts	4 (8.8)	4 (8.3)
Bilateral bile duct (*n*, %)	34 (75.6)	35 (72.9)

was assessed by patient visit or telephone interview.

Differences in the characteristics of the laser lithotripsy group and the traditional method group were analyzed by the Chi-square test and Student's *t* test, using SPSS software for Windows (Statistical Product and Service Solutions, version 18.0, SPSS Inc., Chicago, IL., USA). A *P* value of less than 0.05 was considered statistically significant.

Results

Forty-two (93.3%) of the 45 patients in the laser lithotripsy group achieved a complete stone fragmentation and intrahepatic bile duct clearance (Figs. 1 and 2), and 3 patients failed because stones were impacted in the bilateral bile duct and associated with bile duct stricture and biliary cirrhosis. Five of the 45 patients underwent segmental hepatectomy of the right liver, and 7 patients were subjected to left lateral hepatectomy. One patient suffered from cholangiocarcinoma with negative margins, and was still alive 23 months later. In the traditional method group, the final stones clearance rate was 85.4%. Six of 48 patients underwent segmental hepatectomy of the right liver, and 12 patients received left lateral hepatectomy.

The degree of complication was mild in the laser lithotripsy group. During the operation, hemobilia occurred in two patients because of mucosal damage induced by insertion of the laser fiber and was successfully treated by bile duct irrigation of 100 mL normal saline with 8 mg epinephrine. Three patients with acute cholangitis were treated by administration of antibiotics and T-tube irrigation. In the traditional method group, 3 patients had intraoperative hemorrhage because of forceps injury and were treated by bile duct irrigation of 100 mL normal saline with 8 mg epinephrine, 1 patient with leakage was managed by intraperitoneal drainage, 6 patients with acute cholangitis were treated by administration of antibiotics and T-tube irrigation, and 1 patient died of liver failure because of liver cirrhosis and intraoperative lithotomy for a long time on the seventh day after surgery.

The operative time of the traditional method group was significantly longer than that of the laser lithotripsy group (P=0.01). The mean hospital stay of the patients in the traditional method group was longer than that in the laser lithotripsy group (9.8 vs 8.2 days, P=0.17). No postoperative mortality (within 30 days) or recurrence of stones (during follow-up period) was found in the laser lithotripsy group, and the mean follow-up period of the laser lithotripsy group and the traditional method group was 19 and 43 months, respectively (Table 2).

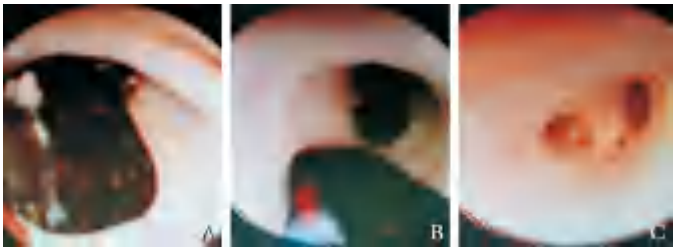


Fig. 1. A: Impacted intrahepatic bile duct stones; **B**: FREDDY laser fragmenting the stones; **C**: cleared intrahepatic bile duct.

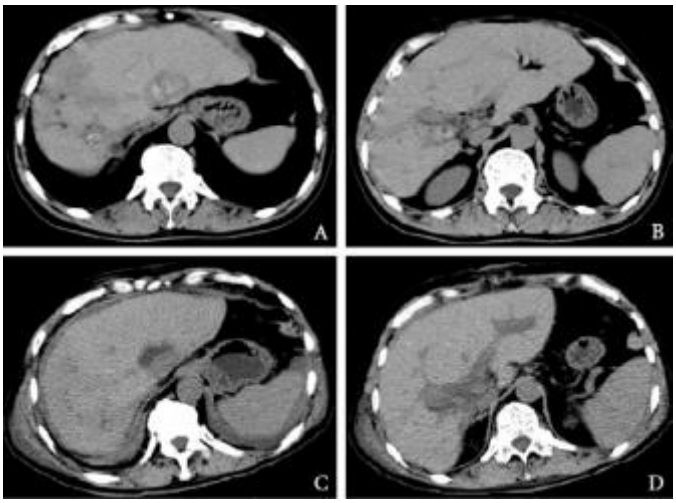


Fig. 2. A, **B**: abdominal CT showing a lot of stones located in the bilateral intrahepatic bile duct before laser lithotripsy; **C**, **D**: abdominal CT showing no intrahepatic bile duct stones after laser lithotripsy.

Table 2. Comparison of the treatment results between the two groups

	Laser lithotripsy group (n=45)	Traditional method group (n=48)	P value
Clerance rate of stones (n, %)	42 (93.3)	41 (85.4)	0.22
Mean operation time (range, min)	112±8.08 (95-137)	145±13.07 (106-185)	0.01
Complication	5 (11.1)	11 (22.9)	0.13
Mean hospitalization time (range, d)	8.2±1.22 (7-12)	9.8±1.63 (7-15)	0.17
Postoperative mortality (within 30 days) (n, %)	0	1 (2.1)	
Mean follow-up (range, mon)	19 (1-40)	43 (41-46)	

Discussion

Hepatolithiasis is characterized by a high rate of treatment failure and recurrence. Intrahepatic bile duct stones can lead to biliary strictures, liver abscess, secondary biliary cirrhosis, liver atrophy and even cholangiocarcinoma.[10-12] To reduce the risk of recurrence

of intrahepatic bile duct stones,[13] surgeons have to remove the intrahepatic and extrahepatic stones as well as bile duct stricture, to establish adequate drainage of the intrahepatic biliary tree, and to resect the lesion of liver lobe. Currently, surgical and nonsurgical procedures are available for hepatolithiasis. The nonsurgical procedures include percutaneous approach and endoscopic approach. Percutaneous transhepatic cholangioscopic lithotomy (PTCSL) is less invasive than surgical approaches, and therefore can be conducted in patients with poor general conditions, difficult anatomy, and bile duct strictures.[12, 14] Nd:YAG laser lithotripsy is often available for disintegrating stones that are too large to be removed using ordinary percutaneous transhepatic cholangioscopy.[7, 8] However, the percutaneous approach is difficult to resolve hepatolithiasis completely when it occurs in both liver lobes. Moreover, PTCSL is more time-consuming and frequently induces intra-abdominal abscess, liver laceration, severe bleedings as well as bile leakage.[7, 8, 12, 14] However, these complications can be avoided by operative laser therapy. Endoscopic retrograde cholangiopancreatography, a routine endoscopic approach, has been used to extract common bile duct stones. However, it is not so efficient in managing hepatolithiasis because of acute angulation of the bile duct, impacted stone or intrahepatic bile duct stricture.[15] And for multiple stones, repeated extraction may increase the risk of complications such as pancreatitis.[16] Comparatively, hepatic resection is the most effective approach for the treatment of hepatolithiasis by removal of intrahepatic stones, stenotic bile duct, and destroyed hepatic parenchyma.[17] This approach is generally considered for patients with unilateral disease, not for those with complicated diseases including stones in both lobes and factors increasing the risk of surgery.[18] Therefore, each patient should undergo preoperative CT and MRCP to demonstrate the precise location of stones, dilated segmental bile ducts, stricture of bile ducts, atrophy of affected lobes, and even concurrent cholangiocarcinoma. According to CT and MRCP, we could judge whether liver resection should be made. In addition to surgical and nonsurgical procedures for intrahepatolithiasis, operative choledochoscopic FREDDY laser lithotripsy combined with or without hepatectomy is a novel approach.

The technological development of FREDDY laser dates back to 1997 and has been developed for endoscopic lithotripsy to disintegrate urinary stones.[19-22] Recent studies[16, 23] have shown that FREDDY laser is efficacious and safe for the billiary system. FREDDY laser initiates plasma formation at the stone surface utilizing the 532 nm green fraction and heats the performed plasma with the infrared portion (1064 nm).[16] The plasma rapidly expands and finally collapses, causing a number of physical phenomena which are responsible for the mechanical fragmentation of the stone.[16] Like the pulsed dye laser it works by generating shockwaves that mechanically break stones without adverse themal effects.[24] *In vivo* studies have clearly shown that direct targeting of the tissue over a prolonged period does not result in structural damage, making inadvertent perforation virtually impossible.[16, 23, 24] Nevertheless, the probe contacting with the bile duct wall may result in perforation or bleeding.[16, 24] For instance, two patients experienced intraoperative biliary tract bleeding in the laser lithotripsy group in our center. Hence we were careful when the flexible fiber was inserted into the intrahepatic bile duct. The FREDDY laser system has the advantage of solid-state and pulse-dye lasers such as lower cost, good reliability, time-saving and excellent effectiveness.[16] We applied this laser on the intrahepatic bile duct stone via the working channel of a choledochoscope during the operation. Some patients underwent liver resection when bile duct stones could not be cleared only by the FREDDY laser approach or the patients had atrophy of liver segment or lobe or clinically suspected cholangiocarcinoma. In our study the final stone clearance rate after choledochoscopic FREDDY laser lithotripsy combined with or without hepatectomy reached 93.3%, compared with that of the traditional method (85.4%). However, there was no significant difference in the final stone clearance rate between the two groups, which may be due to the small sample. The mean operation time and mean hospital stay of the patients in the traditional method group were longer than those in the laser lithotripsy group. Moreover, FREDDY laser was shown to be highly efficient in fragmentation of biliary stones (100%).

Operative choledochoscopic FREDDY laser lithotripsy is a novel treatment of hepatolithiasis. If patients with intrahepatic stones located in the unilateral bile duct and without indications for hepatectomy, choledochoscopic FREDDY laser lithotripsy is effective treatment of choice. But how to manage intrahepatic stones which are distributed bilaterally still needs investigation. In patients with bilateral intrahepatic stones and absence of associated intrahepatic bile duct stricture and liver atrophy, only choledochoscopic FREDDY laser lithotripsy could be used to clear the stones and avoid liver resection. Moreover, choledochoscopic FREDDY laser lithotripsy combined with hepatectomy may be suitable for some patients who have bilateral multiple stones associated with unilateral stenosis of the intrahepatic duct and atrophy of the liver lobe. However,

operative choledochoscopic FREDDY laser lithotripsy combined with hepatectomy is not indicated for patients with biliary cirrhosis associated with bilateral multiple stones and bilateral stenosis of the intrahepatic bile duct. Since hepatectomy may increase the risk of liver failure and a choledochoscope cannot be introduced through the narrowed intrahepatic bile duct, FREDDY laser is no longer used. For these patients, we recommend local bile duct exploration through designated liver capsule or liver transplantation.

In conclusion, given the complicated nature of the disease and various conditions of the patient, a multidisciplinary approach should be considered. The present study suggests that operative choledochoscopic FREDDY laser lithotripsy may be a safe and effective treatment of choice for intrahepatic bile duct stones.

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采用手术胆道镜 FREDDY 激光碎石术联合或不联合肝叶切除术治疗肝胆管结石病

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背景：肝内胆管结石在东亚地区十分常见。该疾病虽属良性，但复发率较高。它容易导致胆汁性肝硬化，并增加胆管癌的发病风险。因此，肝内胆管结石的治疗虽具挑战性却至关重要。本报告提出了一种创新疗法，采用胆道镜联合双频双脉冲掺钕钇铝石榴石（FREDDY）激光碎石术，结合或不结合肝叶切除术来治疗肝内胆管结石。

方法：2009 年 7 月至 2012 年 10 月期间，45 例患者接受了胆道镜 FREDDY 激光碎石术联合或不联合肝叶切除术（激光碎石组）。2009 年 1 月至 2009 年 6 月期间，48 例患者接受了传统手术（传统方法组）。对两组患者的人口统计学特征和临床特征进行了对比分析。

结果：激光碎石组的最终结石清除率为 93.3%，而传统方法组为 85.4%（P=0.22）。在激光碎石组中，2 例患者出现胆道出血，3 例患者发生急性胆管炎。传统方法组中，3 例患者出现术中出血，1 例患者发生胆漏，6 例患者出现急性胆管炎，1 例患者因肝功能衰竭死亡。此外，传统方法组的手术时间显著长于激光碎石组（P=0.01）。传统方法组患者的平均住院时间长于激光碎石组（9.8 天 vs 8.2 天，P=0.17）。两组患者在随访期间均未发现复发性肝内胆管结石。

结论：术中胆道镜 FREDDY 激光碎石术联合或不联合肝叶切除术可能是治疗肝内胆管结石安全有效的方案。

关键词：肝内胆管结石；碎石术；双频双脉冲掺钕钇铝石榴石激光；肝切除术；胆道镜检查

引言

肝内胆管结石症，又称"东方胆管肝炎"，在东亚地区相当常见，其发病率在中国达 38%，韩国 17.0%，日本 2.1%。该病症以反复发作的化脓性胆管炎为特征，可导致继发性胆汁性肝硬化和肝功能衰竭，而胆管癌则是该病的长期不良并发症。肝内胆管结石的临床进展顽固难治，由于结石频繁复发，需要采取多种手术或非手术治疗方案。治疗的主要目的应是彻底清除结石，预防胆管炎再次发作，并控制病情向胆汁性肝硬化发展。目前已有多种治疗手段可供选择，包括肝切除术、经皮途径治疗、内镜途径治疗以及激光碎石术。

通常，坚硬、有冲击力或无法通过传统方法（篮式导管、镊子和冲洗）取出的结石被认为是难治性胆管结石。一些调查显示，激光碎石术可能为治疗难治性肝内胆管结石提供一种安全有效的选择。在本报告中，我们描述了手术胆道镜倍频双脉冲 Nd:YAG（FREDDY）激光碎石术联合或不联合肝切除术治疗肝内胆管结石。

方法

这项回顾性研究纳入了 45 例患者（19 例男性，26 例女性），中位年龄 53 岁（范围 36-72 岁）。这些患者于 2009 年 7 月至 2012 年 10 月期间在我院肝胆胰外科中心接受了胆道镜 FREDDY 激光碎石术联合或不联合肝叶切除术治疗。术前对 45 例患者进行了临床症状评估、体格检查、全套代谢指标检测、全血细胞计数（含癌胚抗原[CEA]分型）、CA-199 检测、右上腹超声检查、上腹部计算机体层摄影（CT）及磁共振胰胆管成像（MRCP）。15 例患者（33.3%）在确诊胆管梗阻时出现黄疸症状。手术干预前，17 例（37.8%）有肝胆手术史，31 例（68.9%）出现发热症状，30 例（66.7%）主诉上腹部疼痛，8 例（17.8%）患有胆汁性肝硬化。

我们实施了胆管探查术，但对于难治性胆管结石病例，则采用胆道镜 FREDDY 激光碎石治疗（使用 laser U100plus 激光设备，生产商：德国柏林 World of Medicine 公司）。在接受胆道镜 FREDDY 激光碎石治疗的 45 例患者中，12 例同时接受了肝叶切除术。治疗采用 1.2 微秒脉宽的激光脉冲，重复频率设定为 10-15 赫兹。当胆道镜（型号 CHF P10，日本东京 Olympus 生产）发现肝内结石时，将 280 微米可弯曲光纤插入胆道镜工作通道，通过该光纤传导 FREDDY 激光系统的能量。激光采用 532 纳米和 1064 纳米双波长脉冲模式，单脉冲能量设置为 120 毫焦。若胆管结石碎裂速度过慢或质地过硬，则能量可提升至 160 毫焦，但结石大小与脉冲能量无明确相关性。 碎石完成后，同步采用冲洗和取石篮技术尝试实现胆道系统完全清理。一般而言，当严重狭窄的肝内胆管无法完成胆道镜置入、或患者存在肝叶萎缩、或临床怀疑胆管癌时，需考虑实施肝叶切除术。在胆管探查和胆道镜 FREDDY 激光碎石术后，我们所有的患者都例行在胆总管内放置 T 型管。若未在肝内胆管发现结石，T 型管将于两个月后拔除。

为阐明胆道镜 FREDDY 激光碎石术的优越性，我们对两组病例进行了对比分析。本研究选择这一时间段，是因为 2009 年 7 月之前我院尚未配备 FREDDY 激光设备。传统治疗方法包括钳夹冲洗碎石术、胆道镜网篮导管取石术以及肝叶切除术。激光碎石组与传统方法组患者的人口学特征和临床特点如表 1 所示。

所有患者在接受 FREDDY 激光碎石术与传统方法治疗后均接受随访。随访检查项目包括 T 管胆道造影、超声检查及实验室检测（血红蛋白、白细胞计数、胆红素、丙氨酸氨基转移酶、天冬氨酸氨基转移酶、肌酐、血清尿素氮、癌胚抗原、糖类抗原 199），这些检查每三个月进行一次。治疗后 3 个月内于肝内胆管发现的结石被视为残余结石。通过患者访视或电话访谈评估任何手术并发症的发生情况。

表 1. 激光碎石组与传统手术组患者的人口统计学及临床特征

Characteristics	Laser lithotripsy group (n=45)	Traditional method group (n=48)
Male/Female	19/26	23/25
Mean age (yr)	53	56
History of hepatobiliary surgery (n, %)	17 (37.8)	18 (37.5)
Hepatectomy	5 (11.1)	4 (8.3)
Bile duct exploration	12 (26.7)	13 (27.1)
Cholecystectomy	15 (33.3)	17 (35.4)
Symptoms (n, %)		
Jaundice	15 (33.3)	17 (35.4)
Fever	31 (68.9)	33 (69.5)
Upper abdominal pain	30 (66.7)	35 (72.9)
Biliary cirrhosis (n, %)	8 (17.8)	9 (18.8)
Mean Child-Pugh score	A	A
Biliary strictures (n, %)	17 (37.8)	19 (39.6)
Number of stones (n, %)		
1	0 (0)	0 (0)
>1	45 (100)	48 (100)
Location of stones (n, %)		
Unilateral bile duct	11 (24.4)	13 (27.1)
Left intrahepatic bile ducts	7 (15.6)	9 (18.8)
Right intrahepatic bile ducts	4 (8.8)	4 (8.3)
Bilateral bile duct (n, %)	34 (75.6)	35 (72.9)

采用卡方检验和学生 t 检验分析激光碎石组与传统方法组的特征差异，使用 SPSS for Windows 统计软件（统计产品与服务解决方案，版本 18.0，SPSS 公司，美国伊利诺伊州芝加哥市）。P 值小于 0.05 被认为具有统计学意义。

结果

在激光碎石组 45 例患者中，42 例（93.3%）实现了结石完全碎裂和肝内胆管清理（图 1 和图 2），3 例治疗失败的原因是结石嵌顿于双侧胆管并伴有胆管狭窄和胆汁性肝硬化。45 例患者中有 5 例接受了右肝段肝叶切除术，7 例实施了左外叶肝叶切除术。1 例患者罹患胆管癌但切缘阴性，术后 23 个月仍存活。传统手术组最终结石清除率为 85.4%，48 例患者中有 6 例接受右肝段肝叶切除术，12 例实施左外叶肝叶切除术。

激光碎石组的并发症程度较轻。术中有两名患者因激光光纤插入导致的黏膜损伤发生胆道出血，通过使用含 8 毫克肾上腺素的 100 毫升生理盐水进行胆道冲洗后成功止血。另有三位急性胆管炎患者通过抗生素治疗和 T 管冲洗获得救治。传统手术组中，3 名患者因钳夹损伤导致术中出血，同样采用含 8 毫克肾上腺素的 100 毫升生理盐水胆道冲洗处理；1 例胆漏患者实施腹腔引流；6 例急性胆管炎患者接受抗生素及 T 管冲洗治疗；另有 1 例肝硬化患者因术中长时间取石，于术后第七天因肝功能衰竭死亡。

传统手术方法组的手术时间显著长于激光碎石组（P=0.01）。传统方法组患者的平均住院时间长于激光碎石组（9.8 天 vs 8.2 天，P=0.17）。激光碎石组未出现术后 30 天内死亡或随访期间结石复发病例，激光碎石组与传统方法组的平均随访期分别为 19 个月和 43 个月（表 2）。

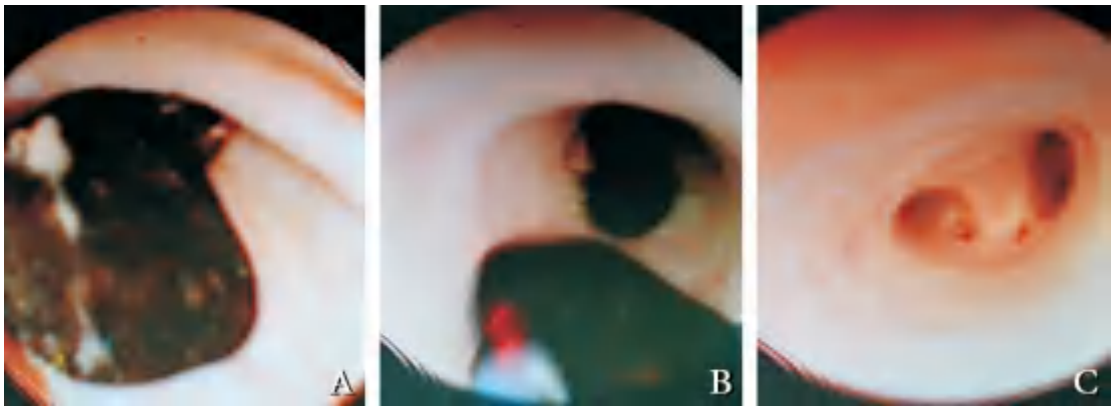


图 1. A：受冲击的肝内胆管结石；B：FREDDY 激光碎石过程；C：清理后的肝内胆管。

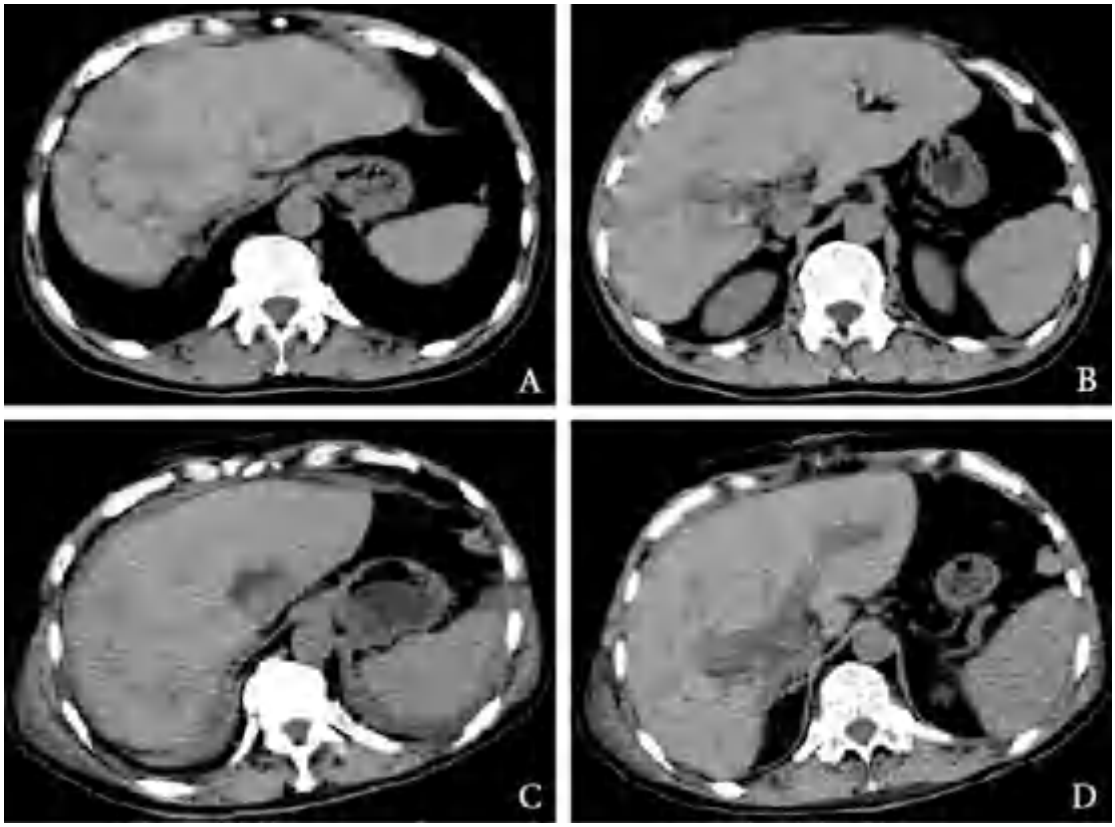


图 2。A、B：激光碎石术前腹部 CT 显示大量结石位于双侧肝内胆管；C、D：激光碎石术后腹部 CT 显示肝内胆管无结石

表 2. 两组治疗结果对比

	Laser lithotripsy group (n=45)	Traditional method group (n=48)	P value
Clearance rate of stones (n,%)	42 (93.3)	41 (85.4)	0.22
Mean operation time (range, min)	112±8.08 (95-137)	145±13.07 (106-185)	0.01
Complication	5 (11.1)	11 (22.9)	0.13
Mean hospitalization time (range, d)	8.2±1.22 (7-12)	9.8±1.63 (7-15)	0.17
Postoperative mortality (within 30 days) (n,%)	0	1 (2.1)	
Mean follow-up (range, mon)	19 (1-48)	43 (41-46)	

讨论

肝内胆管结石症以高治疗失败率和复发率为特征。肝内胆管结石可导致胆道狭窄、肝脏脓肿、继发性胆汁性肝硬化、肝脏萎缩甚至胆管癌。为了降低肝内胆管结石复发的风险，外科医生必须切除肝内和肝外结石以及胆管狭窄，建立充分的肝内胆管引流，并切除肝叶病变。目前，肝胆管结石可采用手术和非手术治疗。非手术疗法包括经皮途径和内镜途径。经皮经肝胆道镜取石术（PTCSL）比外科手术创伤更小，因此适用于全身状况较差、解剖结构复杂以及胆管狭窄的患者。Nd:YAG 激光碎石术常用于粉碎体积过大而无法通过常规经皮经肝胆道镜取出的结石。然而当肝内胆管结石累及双肝叶时，经皮途径往往难以完全清除结石。此外 PTCSL 耗时更长，且易引发腹腔脓肿、肝撕裂伤、严重出血及胆漏等并发症。但通过手术激光治疗可避免这些并发症。内镜逆行胰胆管造影术作为常规内镜手段，已被用于提取胆总管结石。但由于胆管急弯角、嵌顿结石或肝内胆管狭窄等因素，该技术对肝内胆管结石的疗效欠佳。对于多发结石，反复取石可能增加胰腺炎等并发症风险。相较而言，肝切除术通过清除肝内结石、狭窄胆管及毁损肝实质，成为治疗肝内胆管结石最有效的方法。该术式通常适用于单侧病变患者，而不适用于双肝叶结石等复杂病例及存在手术高危因素者。因此术前需通过 CT 和 MRCP 明确结石精确定位、胆管节段性扩张、胆管狭窄、病变肝叶萎缩甚至合并胆管癌等情况，据此判断是否实施肝切除。除传统手术与非手术疗法外，术中胆道镜联合 FREDDY 激光碎石术（配合或不配合肝叶切除）是一种创新治疗方案。

FREDDY 激光技术的发展可追溯至 1997 年，最初开发用于内镜下碎石术治疗尿路结石。近期研究表明，该激光系统在胆道系统中同样安全有效。其工作原理是：通过 532 纳米绿光波段在结石表面引发等离子体形成，并利用红外波段（1064 纳米）加热已形成的等离子体。等离子体急速膨胀后坍缩，产生一系列导致结石机械性碎裂的物理现象。与脉冲染料激光类似，该系统通过产生冲击波实现机械碎石，且不会产生有害热效应。活体研究证实，即使长时间直接照射组织也不会造成结构性损伤，这使得意外穿孔几乎不可能发生。但需注意探头接触胆管壁可能导致穿孔或出血。例如本中心激光碎石组就有两名患者出现术中胆道出血。因此我们在将柔性光纤插入肝内胆管时格外谨慎。该激光系统兼具固体激光与脉冲染料激光的优势：成本较低、可靠性高、省时且疗效显著。我们术中通过胆道镜工作通道对肝内胆管结石实施碎石。对于单纯 FREDDY 激光无法清除的结石，或存在肝段/肝叶萎缩、临床怀疑胆管癌的患者，则联合实施肝叶切除术。本研究显示：胆道镜下 FREDDY 激光碎石（联合或不联合肝叶切除）的最终结石清除率达 93.3%，高于传统方法的 85.4%。但两组最终清除率无统计学差异，可能与样本量较小有关。传统手术组患者平均手术时间和住院天数均长于激光碎石组。值得注意的是，FREDDY 激光对胆道结石的碎裂效率高达 100%。

术中胆道镜 FREDDY 激光碎石术是治疗肝胆管结石的新方法。对于结石局限于单侧胆管且无肝叶切除术指征的患者，胆道镜 FREDDY 激光碎石术是有效的治疗选择。但如何处理双侧分布的肝内结石仍需进一步研究。对于双侧肝内结石但未合并肝内胆管狭窄及肝萎缩的患者，仅采用胆道镜 FREDDY 激光碎石即可清除结石，避免肝切除。此外，对于合并单侧肝内胆管狭窄及肝叶萎缩的双侧多发结石患者，胆道镜 FREDDY 激光碎石联合肝叶切除术可能是适宜的治疗方案。然而，手术胆道镜 FREDDY 激光碎石术联合肝切除术不适用于伴有双侧多发性结石和双侧肝内胆管狭窄的胆汁性肝硬化患者。由于肝叶切除术可能增加肝功能衰竭的风险，且胆道镜无法通过狭窄的肝内胆管导入，FREDDY 激光已不再使用。对于这类患者，我们建议通过特定肝包膜进行局部胆管探查术或实施肝脏移植。

综上所述，鉴于该疾病的复杂性和患者的不同状况，应考虑采用多学科综合治疗方案。本研究表明，手术胆道镜 FREDDY 激光碎石术可能是治疗肝内胆管结石安全有效的首选方法。

Endoscopic laser lithotripsy and lithotomy through the lumen-apposing metal stent for a giant gallstone after EUS gallbladder drainage

Wei Wang, MD, Xingang Shi, MD, Zhendong Jin, MD, Zhaoshen Li, MD

We present the case of a 65-year-old woman who had recurrent cholecystitis for gallstones. However, surgical cholecystectomy was not advisable because of her long history of heart disease. In addition, she refused surgical treatment. She had experienced another severe recurrence of acute cholecystitis after eating greasy food 2 months earlier. CT and magnetic resonance imaging suggested a giant gallstone and acute cholecystitis (Fig. 1). EUS showed that the stone size was 2.6 × 1.9 cm (Fig. 2). After 3 days of anti-infection therapy, no significant improvement appeared. The patient agreed to undergo EUS-guided gallbladder drainage with lumen-apposing metal stents (LAMSs), and she hoped to extract the gallstone. All procedures were performed after she signed an informed consent.

The patient was placed in a horizontal position under single-lumen intubated anesthesia. A linear echoendoscope (GIF-UCT260; Olympus Medical, Tokyo, Japan) was used. EUS-guided transduodenal puncture was performed with a 19G needle (EchoTip Access Needle; Cook Medical, Bloomington, Ind) with color Doppler followed by placement of a 0.035-inch guidewire (Fig. 3). Sterile normal saline solution was used for gallbladder aspiration and

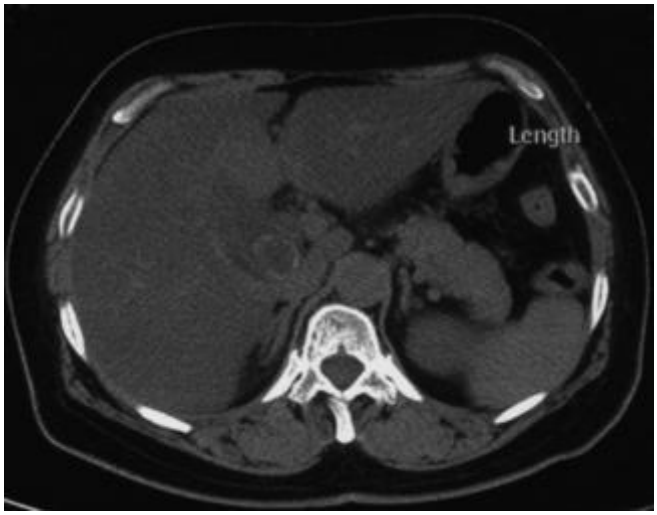


Figure 1. CT image showing gallstone.



Figure 2. EUS image showing the size of gallstone (2.6 × 1.9 cm).



Figure 3. EUS-guided puncture and lavage of gallbladder.

Written transcript of the video audio is available online at www.VideoGIE.org.



Figure 4. Fluid from 5 successive rounds of gallbladder lavage.



Figure 6. The concentration of bile acid and bilirubin was decreased significantly.



Figure 5. Fluoroscopic view showing lumen-apposing stent deployment.



Figure 7. Giant stone broken into small fragments.

lavage to avoid leakage of bile into the peritoneal cavity (Fig. 4). Then the needle was removed, and a cystotome (CST-10; Cook Medical) was applied to set up passage into the gallbladder. The stent delivery system was inserted over the guidewire and advanced into the gallbladder. Deployment of the stent proceeded under EUS and fluoroscopic guidance until the distal and proximal flanges were both expanded and in good position (Fig. 5). No adverse events occurred during the operation.

The patient fasted for 2 days after the procedure and experienced relief of her symptoms such as fever and abdominal pain. Endoscopic lithotomy was attempted 4 weeks later when the cholecystoduodenal tract was intact and firm. A gastroscope with a 2.8-mm work channel (GIF-H-260; Olympus) was used. Various endoscopic devices were experimented with during stone removal, including baskets (MSB-2X4, MB5-2X4-8; Cook Medical), extraction balloon (TXR-8.5-12-15-A; Cook Medical), trielcon (FG-45L-1, Olympus), foreign-body forceps (FG-9L-1, FG-49L-1; Olympus), and disposable bag (AF-D2416GT, Alton, Shanghai). However, none proved to be effective because the stone was so big that none of the conventional

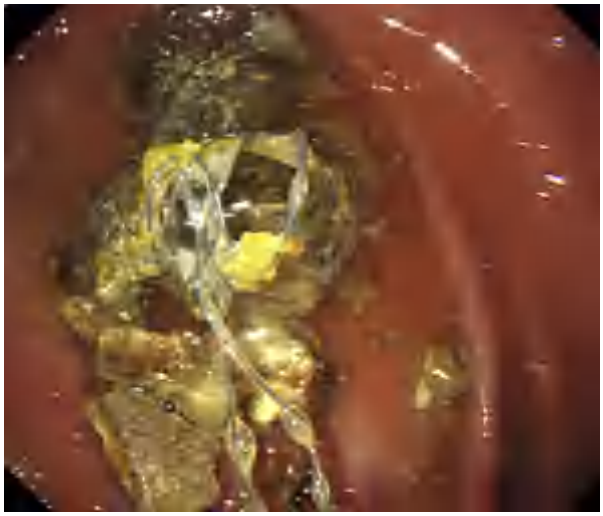


Figure 8. Removal of stent.



Figure 9. Basket extraction of residual stones.



Figure 10. Complete extraction of all stones.



Figure 11. Fluoroscopic view showing no residual stones.



Figure 12. Fistula was put aside.

devices could be used in the small space. Furthermore, the stone was too smooth and hard to grasp.

Finally, U-100 frequency-doubled double-pulse laser (FREDDY, W.O.M., Germany) was used to break down the big stone (Fig. 6). Two hours were spent just for the hard shell. However, the fragments still could not be extracted through the 1.6-cm stent diameter. Therefore, the following 3 remedies were undertaken: (1) changing U100 laser to U100 plus laser, which is more powerful; (2) spending more time on further lithotripsy until all

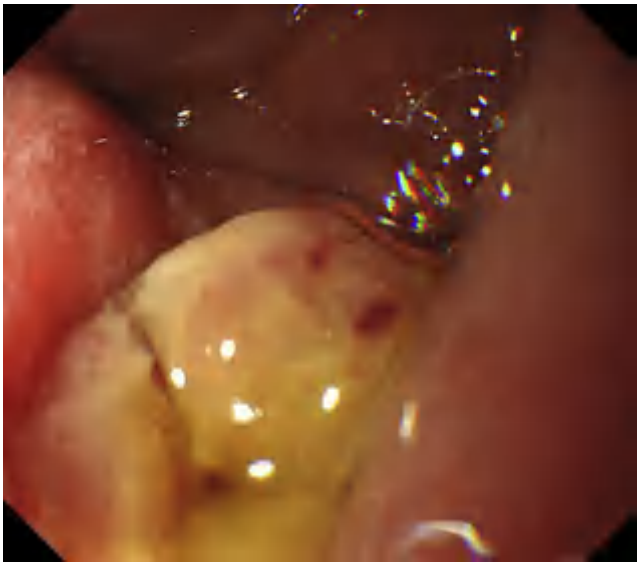


Figure 13. Fistula closed up 2 days after surgery.

pieces were smaller than 1 cm (Fig. 7); and (3) taking out the metal stent to facilitate entry of the gastroscope and manipulation (Fig. 8). Various devices were selected according to the stone shape and size (Video 1, available online at www.VideoGIE.org). The bigger pieces were extracted by basket or trielcon, and the smaller pieces were extracted by rat-tooth forceps (Fig. 9). Washing and suction was effective for sand grains and for stones falling into the cystic duct. In total, 4 hours passed before all visible pieces were extracted, and no retained stones were found by antegrade cholangiography (Figs. 10 and 11). An artificial fistula between the cholecyst and the duodenal bulb was put aside after the operation and was closed up 2 days later (Figs. 12 and 13). No abnormality was found during the 1-month follow-up.

In conclusion, this procedure shows that endoscopic laser lithotripsy and lithotomy is safe and feasible for gallstones through the LAMS. This may be an effective alternative treatment for patients who are not suitable for open surgery. However, further studies are needed to evaluate the long-term results and effectiveness.

DISCLOSURE

All authors disclosed no financial relationships relevant to this publication.

Abbreviations: FREDDY, frequency-doubled double-pulse Neodymium: YAG laser; LAMS, lumen-apposing metal stent.

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经内镜激光碎石取石术通过管腔贴合金属支架治疗超声内镜胆囊引流术后巨大胆结石

Wei Wang, MD, Xingang Shi, MD, Zhendong Jin, MD, Zhaoshen Li, MD

我们报告一例 65 岁女性患者病例，该患者因胆结石反复发作胆囊炎。然而由于长期心脏病史，外科胆囊切除术并不可取。此外患者拒绝接受手术治疗。两个月前食用油腻食物后，她再次出现急性胆囊炎严重发作。CT 与核磁共振成像显示存在巨大胆结石及急性胆囊炎（图 1）。超声内镜检查显示结石大小为 2.6×1.9 厘米（图 2）。经过 3 天抗感染治疗后未见明显改善。患者同意接受超声内镜引导下胆囊引流术（采用管腔对接金属支架），并希望取出胆结石。所有操作均在签署知情同意书后实施。

患者在单腔插管麻醉下取水平卧位。使用线阵超声内镜（GIF-UCT260；奥林巴斯医疗，日本东京）。在彩色多普勒引导下，采用 19G 穿刺针（EchoTip Access Needle；库克医疗，美国布卢明顿）行超声内镜引导经十二指肠穿刺，随后置入 0.035 英寸导丝（图 3）。无菌生理盐水溶液用于胆囊抽吸和灌洗，以避免胆汁漏入腹膜腔（图 4）。随后取出穿刺针，使用膀胱切开刀（CST-10 型；库克医疗）建立胆囊通道。支架输送系统沿导丝插入并推进至胆囊内。在超声内镜和透视引导下逐步释放支架，直至远端与近端法兰盘均充分展开并定位良好（图 5）。手术过程中未发生不良事件。



图 1. 显示胆结石的 CT 影像。



图 2. 超声内镜图像显示胆结石尺寸（2.6×1.9 厘米）。



图 3. 超声内镜引导下的胆囊穿刺与灌洗术



图 4. 连续 5 轮胆囊灌洗后的液体样本。



图 5. 显示管腔对接支架展开的荧光镜视图。



图 6. 胆汁酸和胆红素浓度显著降低



图 7. 巨石碎裂成小碎块。

患者在术后禁食 2 天，其发热、腹痛等症状得到缓解。4 周后，当胆囊十二指肠通道恢复完整且稳固时，尝试进行内镜下取石术。手术采用工作通道为 2.8 毫米的胃镜（型号 GIF-H-260；奥林巴斯）。在结石清除过程中尝试了多种内镜器械，包括取石篮（型号 MSB-2X4、MB5-2X4-8；库克医疗）、取石球囊（型号 TXR-8.5-12-15-A；库克医疗）、三爪钳（型号 FG-45L-1，奥林巴斯）、异物钳（型号 FG-9L-1、FG-49L-1；奥林巴斯）以及一次性取石袋（型号 AF-D2416GT，上海阿尔顿）。然而，没有一种被证明是有效的，因为这块石头太大了，以至于传统的设备都无法在狭小的空间内使用。此外，这块石头太光滑，很难抓。

最终，采用 U-100 双频双脉冲激光器（FREDDY，德国 W.O.M.公司）对大石块进行破碎处理（图 6）。仅坚硬外壳的破碎就耗费了两小时。然而，碎片仍然无法通过 1.6cm 的支架直径取出。因此，采取了以下 3 种补救措施：（1）将 U100 激光改为更强大的 U100plus 激光；（2） 花更多的时间进行进一步的碎石术，直到所有碎片都小于 1 厘米（图 7）；（3）取出金属支架，便于胃镜进入和操作（图 8）。根据结石形态和尺寸（视频 1，详见 www.VideoGIE.org 在线视频），我们选用了多种器械。较大结石碎片采用取石篮或三叶钳取出，较小碎片则用

鼠齿钳清除（图 9）。冲洗吸引法对清除沙粒状结石及落入胆囊管的结石尤为有效。整个取石过程历时 4 小时，经顺行胆管造影确认无残留结石（图 10、图 11）。术中留置的胆囊十二指肠人工瘘管于术后 2 天自行闭合（图 12、图 13）。为期 1 个月的随访未发现异常情况。

综上所述，本研究表明通过管腔内金属支架（LAMS）实施内镜下激光碎石取石术治疗胆结石安全可行。对于不适合开放手术的患者，这可能是一种有效的替代治疗方案。但该疗法的长期疗效和有效性仍需进一步研究评估。



图 8. 支架移除



图 9. 残留结石的篮式提取。



图 10. 所有结石的完整提取。



图 11. 荧光透视视图显示无残留结石。



图 12. 瘘管被搁置一旁。



图 13. 术后 2 天瘘管闭合。

·论著·

X 线监视下激光碎石治疗难治性胆总管结石的效果研究

王拥军　冀明　俞力　牛应林　李鹏　吕富靖　李威　张澍田

【摘要】 **目的**　探讨 X 线监视下激光碎石治疗难治性胆总管结石的效果和安全性。**方法**　将 40 例难治性胆总管结石患者分为两组，分别在子镜监视下（子镜监视组，21 例）及 X 线监视下（X 线监视组，19 例）进行激光碎石治疗，比较两组间结石取净率、并发症发生率。**结果**　子镜监视组共取净结石 19 例（90.5%），X 线监视组取净 17 例（89.5%），两组间结石取净率差异无统计学意义（$P = 0.658$）；两组间并发症发生率差异无统计学意义（19.0% 比 15.8%；$P = 0.559$）。**结论**　治疗难治性胆总管结石子镜监视与 X 线监视两种方法是同样安全有效。

【关键词】 胆总管结石；　激光碎石

Fluoroscopy guided laser lithotripsy for difficult bile duct stones

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【**Abstract**】 **Objective**　To evaluate the efficacy and safety of fluoroscopy guided laser lithotripsy for removing difficult bile duct stones. **Methods**　Patients with difficult bile duct stones in Beijing Friendship Hospital Affiliated to Capital University of Medical Sciences from March 2008 to December 2009 were divided into two groups: cholangioscopy guided group (n = 21) and fluoroscopy guided group (n = 19). The success rate of complete stone removal and the complication rate related to the procedure were compared between the two groups. **Results**　The success rates of complete stone removal in the two groups were not different (cholangioscopy guided group 19/21; fluoroscopy guided group 17/19; $P > 0.05$); The rates of complications related to laser lithotripsy were not different either (cholangioscopy guided group 4/21; fluoroscopic guided group 3/19; $P > 0.05$). **Conclusion**　Frequency-doubled double-pulsed laser lithotripsy guided by cholangioscopy or fluoroscopy seems safe and effective.

【**Key words**】 common bile duct stone;　laser lithotripsy.

胆总管内较大结石、铸型结石以及胆总管狭窄上方的结石内镜下常规方法取石困难，被称为胆总管难治性结石，常规取石技术（取石气囊和取石网篮）失败后，机械碎石是最常用的碎石方法，此外也可应用体外震波碎石和激光碎石等方法[1]。十二指肠镜子母镜联合激光碎石治疗难治性胆总管结石是安全、有效的，但所需设备较多，操作较复杂，子镜易损坏，导致手术成本也较高，临床未能广泛应用。新一代智能激光的出现，使 X 线监视下激光碎石成为可能，本研究通过前瞻性非随机临床试验对两种方法进行比较，探讨 X 线监视下激光碎石治疗难治性胆总管结石的效果和安全性。

资料与方法

一、研究对象

2008 年 3 月～2009 年 12 月首都医科大学附属北京友谊医院胃肠肝胆内科、北京市消化疾病中心、首都医科大学消化病学系住院患者，均经 B 超、CT、磁共振胰胆管造影 ma netic resonance cholan io-

治疗患者。共 40 例患者入选,其中子镜监视组 19 人,X 线监视组 21 人。

二、研究方法

1. 器械:Olympus TJF240 电子十二指肠镜,高频电装置,标准及超滑亲水导丝导丝,切开刀、造影导管,CRE 扩张气囊(直径 12 mm、13.5 mm、15 mm),球囊导管,取石网篮,碎石网篮,鼻胆引流管,应急碎石器,胆管塑料引流支架和推送导管等;U100 双频双脉冲激光器(德国 WOM 公司);电子胆道镜(CHF B20; Olympus)

2. 常规胰胆管造影:确认胆管结石的位置和大小,行乳头括约肌切开,切开长度根据结石大小及乳头形态确定;憩室旁或憩室内乳头、小乳头无法行乳头括约肌足够切开者,乳头小切开后进行 CRE 气囊乳头扩张,扩张直径不超过胆总管直径;然后根据不同情况使用取石气囊、网篮取石。常规取石失败者,签署知情同意书,进行激光碎石,使用子镜监视或 X 线下监视由主治医生根据结石形态、胆管情况及患者意愿选择。

3. X-线监视激光碎石:激光器发射能量设为 120 mJ/pulse,频率 10 HZ,使用时将光纤通过三腔气囊中通过导丝的腔道,乳头切开或小切开联合大气囊扩张,气囊通过十二指肠镜钳道插入乳头前,将光纤伸出 5 mm,可靠标记后退回气囊内,插入胆道,通过气囊另一腔道注入造影剂,清楚显示结石,X 线监视下将激光光纤推出气囊,光纤末端对准结石表面,边碎石边调整光纤位置,直至结石碎裂。

4. 子镜监视下激光碎石:十二指肠乳头切开或小切开联合大气囊扩张后,通过十二指肠镜工作钳道插入子镜,在子镜插入前先将激光光纤由子镜操作管道置入,在直视下将激光光纤触及结石表面,在有水的环境下击碎结石。

5. 取石及术后处理:碎石后,使用取石网篮和取石气囊取石,必要使用机械碎石,取石气囊分段造影证实无残余结石后,常规放置鼻胆引流管;当操作时间超过 1 h 或患者不能耐受时,停止取石操作,置入鼻胆引流管,择日再取;如发生结石嵌顿应急碎石;取石失败内镜下置入胆管支架暂时性引流。3 天后经鼻胆引流管造影复查有无残余结石,有残余结石者再次取石。分别于术后即刻、术后 6 小时及 24 小时查血常规、血淀粉酶,并记录病人腹痛、

三、观察指标

1. 取石取净率:气囊分段造影未见结石征象,3 日后通过鼻胆引流管造影未见残余结石为结石取净。

2. 早期并发症发生率:根据文献[2]定义 ERCP 术后胰腺炎:术后 2 小时血淀粉酶超过正常值上限 3 倍以上,伴腹痛、恶心呕吐、发热或腹膜刺激征等临床症状,影像学检查证实有胰腺形态改变,重症胰腺炎判定参照 Ranson 标准。如确诊为胰腺炎即刻给予禁食、持续静滴生长抑素及抗生素等治疗。ERCP 术后出血:出现呕血、黑便等临床表现,伴有血红蛋白下降,需排除其它原因所致上消化道出血。在操作过程中镜下观察到的出血不作为 ERCP 术后出血的判定标准。胆系感染者应出现体温升高超过 38(C 伴右上腹痛、血常规示白细胞总数及中性粒细胞分类计数升高。穿孔者应有腹痛伴影像学证据。

四、统计学方法

两样本率比较采用 χ^2 检验,早期并发症比较采用四格表确切概率法,两样本均数比较采用两样本 t 检验,计数资料比较采用 χ^2 检验,以 $P<0.05$ 有统计学意义,数据整理统计使用 SPSS 11.5 统计软件。

结　果

一、基线资料均衡性检验

共入组 40 人,其中子镜监视组 19 人,X 线监视组 21 人,基线资料经检验差异无统计学意义,见表 1。

表 1　基线资料均衡性检验

	子镜监视组	X 线监视组	P
男/女	9/12	9/10	0.512
平均年龄(岁)	64.48 ± 13.45	62.16 ± 11.61	0.676
结石数目			0.515
1	6	5	
2	7	5	
3	6	6	
4	0	1	
5	1	1	
6	1	1	
结石最大直径(cm)	1.90 ± 0.72	1.92 ± 0.92	0.135

二、两组间结石取净率比较

统计学意义($P = 0.658$)。子镜监视组及 X 线监视组中分别有两例未能取净结石,均为高龄患者,不能耐受操作,置入胆管塑料支架。

三、两组间早期并发症发生率比较

子镜监视组发生急性胰腺炎 4 例,X 线监视组发生 3 例,两组均无胆道感染、出血、穿孔发生,两组间早期并发症发生率差异无统计学意义(19.0% 比 15.8%;$P = 0.559$)。

讨　论

1974 年,德国的 Classen 等及日本的 Kawai 分别报道了内镜下乳头括约肌切开(Endoscopic sphincterotomy, EST)和胆总管取石技术[3,4],随着 30 多年治疗内镜技术的发展,EST 已经成为治疗胆总管结石的首选方法。90% 的患者通过常规取石技术(使用取石网篮和取石气囊)可以取净胆总管结石,但约 10% 胆总管结石取石困难,需如胆总管充满型或多发结石、直径 > 15 mm 的胆总管结石、胆总管结石坚硬、胆总管石嵌顿、结石下方胆管狭窄使用常规取石篮和取石气囊难以取出, 要采用碎石方法。机械碎石是最常用的碎石方法,但机械碎石除了会遇到套取石困难外,胆管狭窄、结石的硬度也是造成机械碎石失败、发生意外的因素。

1978 年日本学者葛西首先作了利用激光破坏胆总管结石的实验研究,发现激光可以将胆结石击成碎块,1986 年 Lux G[5] 等首先报道了胆总管结石激光碎石的临床应用,此后各种各样的激光器陆续问世,但由于激光可能会误伤胆管壁,通常在经口子母胆管镜下直视碎石,近年来由于胆道子镜的不断更新、完善,只需治疗型十二指肠镜 4.2 mm 的管道即可插入子镜,无需专用母镜,但子镜极易损坏,导致手术成本较高,影响了激光碎石技术的普及推广。以后开发出结石组织自动识别系统,可以避免对组织的损伤,不使用胆道子镜,在 X 线监视下进行碎石,但设备庞大、昂贵,未能在临床广泛应用。

双频双脉冲 U100 Nd:YAG 激光碎石系统是德国 WOM 公司于 2000 年上市的一种先进的腔内碎石装置,由 1 064 μm 的红外光和 532 μm 的绿光组成[6],其作用机制是:激光仪发射出的激光经光纤将激光束能量打到结石表面,绿光先被结石吸收形石击碎,对组织损伤小,安全简单。在动物实验中,U100 激光碎石机对兔子膀胱壁的黏膜发射 2000 次的脉冲激光,无穿孔发生。U100 激光光纤有极大的弯曲度。有学者报道采用不同的方法在 X 线监视下使用 U100 激光进行碎石[7,8]。

本研究通过非随机临床试验比较 X 线监视与子镜监视激光碎石的结石取净率和并发症发生率。两组间结石取净率无显著性差异(子镜监视组 90.5%;X 线监视组 89.5%;$P = 0.658$),两组间取石次数无显著性差异,说明 X 线监视与子镜监视激光碎石是同样有效的。激光光纤不能遮挡放射线,在透视下无法观察光纤的确切位置,本研究使用气囊导管导入激光光纤:1. 气囊充气后,保持激光光纤于胆管中心位置,避免了激光光纤对胆管壁的机械损伤,而且光纤不宜折断。2. 气囊通过钳道进入十二指肠腔,未插入乳头前,先将光纤伸出 5 mm,精确标记后退回,从而确保 X 线监视下光纤与结石准确接触,保证了碎石效果。本研究两组间并发症发生率无显著性差异,均未发生严重胆道出血及穿孔等并发症,说明 X 线监视下使用双频双脉冲激光碎石与子镜监视下激光碎石同样是安全的。

本研究局限:1. 本研究为非随机临床试验,但临床试验以人为研究对象,很多时候由于客观存在的问题及伦理道德因素,无法进行随机对照双盲的临床试验,本研究中接受何种治疗由主管研究的医师决定,方便、简单,容易,依从性较高。缺点是难以保证各组间治疗前的可比性,可能导致研究结果的明显偏倚。本研究基线资料经比较具有可比性。2. 本研究例数较少,尚需进一步扩大样本量。

总之,X 线监视下使用双频双脉冲激光碎石与子镜监视下激光碎石同样是安全有效的。使激光碎石更加简单、方便,不受设备的局限,有利于激光碎石的临床推广,激光光纤的可靠标记是碎石成功的关键。

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RAPID COMMUNICATION

Clinical usefulness of transpapillary removal of common bile duct stones by frequency doubled double pulse Nd:YAG laser

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Abstract

AIM: To study the efficacy and the safety of laser lithotripsy without direct visual control by using a balloon catheter in patients with bile duct stones that could not be extracted by standard technique.

METHODS: The seventeen patients (7 male and 10 female; mean age 67.8 years) with difficult common bile duct (CBD) stones were not amenable for conventional endoscopic maneuvers such as sphincterotomy and mechanical lithotripsy were included in this study. Laser wavelengths of 532 nm and 1064 nm as a double pulse were applied with pulse energy of 120 mJ. The laser fiber was advanced under fluoroscopic control through the ERCP balloon catheter. Laser lithotripsy was continued until the fragment size seemed to be less than 10 mm. Endoscopic extraction of the stones and fragments was performed with the use of the Dormia basket and balloon catheter.

RESULTS: Bile duct clearance was achieved in 15 of 17 patients (88%). The mean number of treatment sessions was 1.7 ± 0.6. Endoscopic stone removal could not be achieved in 2 patients (7%). Adverse effects were noted in three patients (hemobilia, pancreatitis, and cholangitis).

CONCLUSION: The Frequency Doubled Double Pulse Nd:YAG (FREDDY) laser may be an effective and safe technique in treatment of difficult bile duct stones.

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Key words: Bile duct stones; Frequency doubled double pulse Nd:YAG laser; Transpapillary removal; Mechanical lithotripsy; Balloon catheter

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INTRODUCTION

About 90% of all patients with common bile duct stones are currently treated non-surgically using endoscopic sphincterotomy and stone extraction. However, standard endoscopic procedure and mechanical lithotripsy for removal of stones from the bile duct fail in 5% to 10% of patients, because the stones are too large or impacted[1]. In such cases, additional methods such as extracorporeal shockwave lithotripsy (ESWL), laser shockwave lithotripsy (LSWL) or electrohydraulic lithotripsy (EHL) are required[2]. EHL and LSWL need visual control *via* a mother-baby endoscope system or cholangioscopy for safety because of the potential for accidental damage to the bile duct wall. Moreover, a peroral cholangioscope is expensive, fragile and difficult to use. Laser lithotripsy is expensive due to the cost of the cumbersome endoscopic equipment. Although EHL is inexpensive, it uses high-pulse energy to disintegrate stones[3-5].

The Frequency Doubled Double Pulse Nd:YAG (FREDDY) laser (World of Medicine, Berlin, Germany) is a newly developed economical, short-pulse, double frequency, solid-state laser with wavelengths of 532 nm and 1064 nm that cause less tissue damage. It was specifically designed to fragment urinary and biliary calculi[6]. We used a balloon catheter for FREDDY laser lithotripsy (FREDDY LL) in an effort to improve fluoroscopic targeting and to prevent damage to the bile duct. The purpose of this study was to investigate the safety and the effectiveness of using a FREDDY laser to treat bile duct stones that were not amendable to conventional endoscopic therapy.

MATERIALS AND METHODS

Patients

Seventeen patients (7 male and 10 female; mean age 67.8 years, range 55-82 years) with extra-hepatic bile duct

stones were included in this study. The inclusion criterion for this study was extrahepatic bile duct stones that were not amenable to standard endoscopic procedure including endoscopic sphincterotomy and mechanical lithotripsy. Stone removal by using conventional methods failed because the stones were not captured in the basket for mechanical lithotripsy or endoscopic sphincterotomy inadequately was done for large periampullary diverticulum with large CBD stones (> 1.5 cm). The main reasons were the following; large stone (n = 7), impacted stone (n = 3), and large stones with periampullary diverticulum (n = 7).

All patients were diagnosed as having bile duct stones by endoscopic retrograde cholangiography and/or MRCP at our hospital. The data regarding stone size, number, and location was based on the endoscopic retrograde cholangiogram (by using the diameter of the distal end of standard duodenosocpy as a reference). The properties of the CBD stones were as follows: 1 stone (n = 5), 2 stones (n = 7) and more than 2 stones (n = 5); diameter of large stone (18.5 ± 3.2 mm) with 10-20 mm (n = 8) and with 21-30 mm (n = 9). Large stones with periampullary diverticulum were found in 11 of 17 patients. The study was approved by our institutional review board. Written informed consent was obtained from each patient for laser therapy.

Methods

we used the FREDDY laser (frequency doubled double pulse Nd:YAG laser, Laser 100, World of Medicine). Laser wavelengths of 532 nm and 1064 nm as a double pulse were applied with pulse energy of 120 mJ. The laser fiber with a 250 nm core diameter was inserted in a 6.8 Fr standard extraction balloon catheter (Wilson-Cook Medical Inc., Winston-Salem, N.C.) with an 18-mm-diameter balloon and this was then passed through the papilla *via* the working channel of a standard duodenoscope (JF-240; Olympus Optical Co., Ltd. Tokyo, Japan).

As the fiber itself is not detectable by fluoroscopy, the radio-opaque tip of the balloon catheter was positioned near the stone, and the balloon was expanded to fix the position of the catheter and the fiber. The tip of the fiber was advanced a few millimeters beyond the radio-opaque tip of the balloon catheter, under fluoroscopic guidance, to ensure that the fiber was positioned on the stone surface. Only one fluoroscopic plane was used to target the stone and to observe fragmentation. The treatment energy level was 120 mJ per pulse at a repetition rate of 8 to 10 Hz. During the laser treatment, we tried to listen to the fragmentation sound of stone by using stethoscope and the fragmentation effect was monitored by fluoroscopy after instillation of contrast media into the bile duct. During laser lithotripsy, the bile duct was continuously irrigated with a mixture of contrast media and saline solution because fluid is required for the generation of shock waves.

After stone disintegration, endoscopic extraction of stones and fragments was done with a dormia basket and balloon catheter. Laser lithotripsy was limited to a maximum duration of 60 min per session. If, at that time, the ductal clearance was incomplete, then a nasobiliary catheter was inserted. Failure of laser lithotripsy was defined as the inability to achieve complete bile duct clearance after a maximum of three lithotripsy sessions.

All patients were followed for at least two days after the FREDDY LL. Follow-up included simple radiographs and laboratory tests (hemoglobin, white blood cell count, bilirubin, alanine aminotransferase, aspartate aminotransferase, creatinine, serum urea nitrogen, amylase and lipase levels). The occurrence of any complication within one month of the FREDDY LL procedure was assessed by a patient visit or telephone interview.

RESULTS

Lithotripsy

Complete stone fragmentation using FREDDY LL was achieved in 15 of 17 patients without direct visual control (Figure 1). The number of endoscopic retrograde cholangiography sessions per patient that was necessary to totally clear the bile ducts was 1.7 ± 0.6. After FREDDY LL, 3 patients underwent mechanical lithotripsy to achieve complete clearance of the bile duct.

The stone fragmentation failed in two patients, in whom the positioning of the laser fiber on the stone was inadequate due to a huge impacted stone in the tortuous common bile duct and the biliary stricture. One patient was sent to the surgical department to clear the bile duct by laparoscopic surgery. The other patient was treated by percutaneous cholangioscopy with electro-hydraulic lithotripsy.

Complications

The side effects and complications of FREDDY LL were mostly mild. Although acute pancreatitis occurred in one patient, it was treated by conservative management, and there was no pseudocyst. Transient hemobilia was observed in two patients. However, the bleeding stopped spontaneously without any change of the hemoglobin level. The hemobilia may have been caused by mucosal damage from insertion of the guiding catheter or the balloon catheter. A patient with acute cholangitis was treated by administration of antibiotics and nasobiliary tube irrigation. This complication may have been caused by transient obstruction of the nasobiliary tube.

DISCUSSION

Endoscopic retrograde cholangiopancreatography (ERCP) and sphincterotomy have been the standard treatments for choledocholithiasis, yet large stones present a major challenge for the endoscopist. Extending a sphincterotomy increases the risk of bleeding and perforation, and mechanical lithotripters are generally expensive, cumbersome to use, and fragile, and they fail to grasp the stones in a significant number of cases. For treating these patients, the complementary techniques such as extracorporeal shock wave, intracorporeal electrohydraulic, or laser induced lithotripsy are required[2].

Electrohydraulic intracorporeal lithotripsy (EHL) represents an effective treatment option for the endoscopic treatment of difficult bile duct stones. However, EHL requires continuous visual control of the fragmentation procedure because of the high pulse energies that are used.

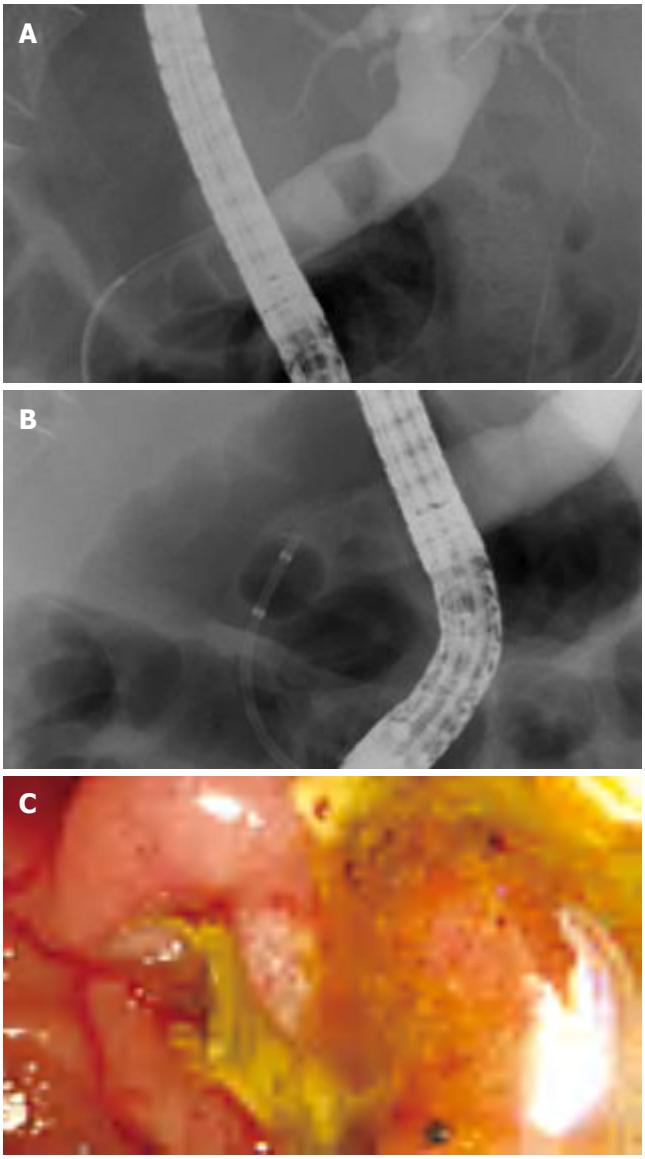


Figure 1 Complete stone fragmentation using FREDDY without direct visual control. **A**: Cholangiogram showing stone impacted in the common bile duct; **B**: Cholangiogram made during FREDDY laser lithotripsy, showing multiple stone fragments; **C**: Endoscopic findings showing the fragmented stones from the bile duct.

The probe contacting with the bile duct wall may result in perforation or bleeding. Cholangioscopy with continuous saline solution irrigation is routinely performed during EHL. Transpapillary cholangioscopy with a mother-baby endoscope requires two experienced endoscopists. In addition, this type of endoscope is so fragile, and its cost is high. Also, EHL is associated with a high level of exposure to ionizing radiation for both the patient and the endoscopist[4,5]. Data on laser lithotripsy for complicated bile duct stones have been reported by several centers. Stone fragmentation rates of about 80%-90% have been reported for the coumarin green and Nd:YAG laser under direct cholangioscopic control. When performing laser lithotripsy under fluoroscopic guidance, the method failed in up to 80% of patients, because positioning of the glass fiber on the stone was difficult. But in 1993, a flash-lamp pulsed laser with a tissue-stone recognition system was introduced that could identify gallstones by analyzing the back-scattered light and the energy pulse was interrupted in case of tissue contact. The visual control of placing the tip of the probe to the surface of the stone is facilitated by a helium-aiming beam. This system allows the treatment to be performed under fluoroscopic control with excellent safety and fragmentation success rates of up to 90%. Fluoroscopic control using a rhodamine 6G laser was effective in clearing the bile ducts in about 80% of patients[2,8].

The FREDDY laser has been developed for endoscopic lithotripsy to disintegrate urinary stones. We applied this laser on the biliary stone that was not amenable to standard endoscopic procedure including endoscopic sphincterotomy and mechanical lithotripsy through the transpapillary route. In our study, stone disintegration through the transpapillary route was achieved in 15 of 17 patients (88%). The FREDDY laser is a short pulsed Q-switched frequency-doubled, double pulse Nd:YAG solid-state laser that allows the emission of long pulses. This laser is capable of producing very high pulse intensity because of the partial frequency doubling of the infrared ray into the green range that works synergistically. Laser light at 532 nm (the green spectrum) initiates plasma formation at the stone surface, while light at a wavelength of 1064 nm heats the preformed plasma, to cause expansion and contraction, which fragments calculi, and the pulse duration is 0.5-1.5 μs[9]. This laser generates very short impulses that are poorly absorbed by soft tissue, and so the tissue is exposed to virtually no thermal effect. *In vitro* experiments show that FREDDY laser is very suitable for performing lithotripsy, and animal model studies have shown little to no effect on normal tissues[10].

Also, in comparison with the holmium laser, the FREDDY laser produces no thermal effect[11]. This laser showed a high degree of fragmentation efficiency (95%) on the urinary stone, but yet any studies of its effect on biliary stones are rare. There was an 88% fragmentation rate in our study, although the number of patient was small. The FREDDY laser system combines the advantage of solid-state and pulse-dye lasers such as lower cost, good reliability, and excellent effectiveness.

The number of ERCP sessions necessary for duct clearance was higher in our study than reported for other study groups. When laser therapy was done as the first line method for difficult cases, additional ERCP sessions were necessary to achieve complete bile duct clearance[12]. A disadvantage of the FREDDY laser system is the high x-ray exposure to patients and the endoscopist. Also, it is difficult and time consuming to target the stone by fluoroscopy because of the positioning of the laser fiber that is inserted through a balloon catheter[13]. A certain level of endoscopic technique is required to contact the balloon catheter with laser fiber on the surface of a stone. Positioning of the balloon may be unsatisfactory in a tortuous angulated bile duct like our cases that laser lithotripsy failed. To ensure that the fiber would target the stone exactly and avoid contact with the bile duct, we monitored stone movement in the bile duct, fragmentation sound by applying stethoscope and hemobilia during this laser treatment.

In conclusion, our results suggest that laser lithotripsy using FREDDY without direct visual control was an effective and safe technique for patients with difficult CBD stones that could not be removed by mechanical lithotripsy. In the future, comparative studies with EHL, ESWL, or other laser systems will be required to assess the utility and efficacy of FREDDY laser.

COMMENTS

Background

Endoscopic papillotomy is successful in more than 90% of the cases of choledocholithiasis. For patients with difficult bile duct stones not responding to mechanical lithotripsy, different methods for stone fragmentation such as laser lithotripsy or electrohydraulic lithotripsy (EHL) with direct visual control have been developed. A major problem in using this device is the requirement of cholangioscopic guidance or the "mother and baby" endoscope.

Research frontiers

Recently, a new laser, the Frequency Doubled Double Pulse Nd:YAG (FREDDY), was developed for endoscopic lithotripsy for urinary stones, and has less tissue damage. The efficacy and safety of laser lithotripsy without cholangioscopy by using the balloon catheter were evaluated in patients with bile duct stones that could not be extracted by standard technique.

Innovation and breakthroughs

The FREDDY laser is a newly developed economical, short-pulse, double frequency, solid-state laser that results in less tissue damage. Fluoroscopically guided laser lithotripsy with a balloon catheter through a peroral duodenoscope appears to be effective treatment for bile duct stones that cannot be extracted by using conventional techniques such as mechanical lithotripsy.

Applications

For the fragmentation of the biliary stone, cholangioscopy guidance is expensive due to the cost of the cumbersome endoscopic equipment and the need for two experienced endoscopists operating the "mother and baby" endoscope. When direct visual control is not available or limited, laser lithotripsy with a balloon catheter may be an alternative. To target the laser fiber accurately on the stone in the bile duct, a new and easier method is required.

Peer review

It is a well-written and interesting paper. The FREDDY laser may be a useful technique in treatment of difficult bile duct stones.

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经乳头途径使用双频双脉冲 Nd:YAG 激光清除胆总管结石的临床实用性

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摘要

目的：研究在无法通过标准技术取出的胆管结石患者中，采用球囊导管进行无直接视觉控制的激光碎石术的疗效与安全性。

方法：本研究纳入 17 例难治性胆总管结石患者（男性 7 例，女性 10 例；平均年龄 67.8 岁），这些患者无法通过常规内镜操作（如括约肌切开术和机械碎石术）进行治疗。采用 532 纳米和 1064 纳米双脉冲激光波长，脉冲能量为 120 毫焦。在透视引导下，激光光纤通过 ERCP 球囊导管推进。持续进行激光碎石术，直至结石碎片尺寸小于 10 毫米。随后使用 Dormia 网篮和球囊导管进行内镜下结石及碎片取出术。

结果：17 名患者中有 15 人（88%）实现胆管清理。平均治疗次数为 1.7±0.6 次。2 名患者（7%）未能通过内镜取石。3 名患者出现不良反应（胆道出血、胰腺炎和胆管炎）。

结论：双频双倍双脉冲掺钕:钇铝石榴石（FREDDY）激光可能是治疗困难胆管结石的一种有效且安全的技术。

关键词：胆管结石；双频双脉冲掺钕钇铝石榴石激光；经乳头切除术；机械碎石术；球囊导管

引言

目前约 90%的胆总管结石患者采用内镜下括约肌切开取石术进行非手术治疗。然而，标准的内镜操作和机械碎石术在 5%-10%的患者中无法成功清除胆管结石，这是由于结石过大或嵌顿所致。此类情况下需采用体外冲击波碎石术(ESWL)、激光冲击波碎石术(LSWL)或液电碎石术(EHL)等辅助疗法。EHL 与 LSWL 因存在意外损伤胆管壁的风险，需通过母子镜系统或胆道镜进行可视化操作以确保安全。此外，经口胆道镜价格昂贵、易损且操作困难。激光碎石术因笨重的内镜设备导致成本高昂。虽然 EHL 费用较低，但其通过高脉冲能量来粉碎结石。

双频双脉冲掺钕钇铝石榴石激光器（FREDDY，德国柏林 World of Medicine 公司研发）是一种新型经济型短脉冲双波长固体激光器，其 532 纳米与 1064 纳米的双波长特性可减少组织损伤。该设备专为泌尿系统及胆道结石碎石术设计。本研究采用球囊导管辅助 FREDDY 激光碎石术（FREDDY LL），旨在提升透视定位精度并避免胆管损伤，主要探讨该激光技术治疗传统内镜疗法难以处理的胆管结石的安全性与有效性。

材料与方法

患者

本研究纳入了 17 名肝外胆管结石患者（7 名男性和 10 名女性；平均年龄 67.8 岁，范围 55-82 岁）。本研究纳入标准为无法通过标准内镜手术（包括内镜下括约肌切开术和机械碎石术）处理的肝外胆管结石病例。采用常规取石方法失败的原因包括：结石无法被网篮捕获进行机械碎石，或因壶腹周围大憩室伴大胆总管结石（>1.5 厘米）导致内镜下括约肌切开术操作不充分。主要失败原因如下：大结石（n=7）、嵌顿结石（n=3）以及壶腹周围憩室伴大结石（n=7）。

所有患者均经我院内镜逆行胆管造影和/或磁共振胰胆管成像确诊为胆管结石。关于结石大小、数量和位置的资料均基于内镜逆行胆管造影结果（以标准十二指肠镜远端直径为参照）。胆总管结石特征如下：单发结石 5 例，双发结石 7 例，多发结石（≥3 枚）5 例；大结石直径（18.5±3.2 毫米），其中 10-20 毫米 8 例，21-30 毫米 9 例。17 例患者中有 11 例发现壶腹周围憩室伴大结石。本研究经我院伦理委员会批准，所有患者均签署了激光治疗知情同意书。

治疗方法

我们使用 FREDDY 激光器（双频双脉冲 Nd:YAG 激光器，Laser 100，World of Medicine 公司）。采用 532 纳米和 1064 纳米双脉冲波长，单脉冲能量为 120 毫焦。将核心直径 250 纳米的激光光纤置入 6.8 Fr 标准取石球囊导管（Wilson-Cook Medical 公司，北卡罗来纳州温斯顿塞勒姆），该导管配备 18 毫米直径球囊，随后通过标准十二指肠镜（JF-240 型；奥林巴斯光学株式会社，日本东京）的工作通道经乳头插入。

由于光纤本身无法通过透视检测，球囊导管的射线不透性尖端被定位在结石附近，球囊扩张以固定导管和光纤的位置。在透视引导下，将光纤尖端推进至超过球囊导管射线不透性尖端数毫米处，以确保光纤准确定位在结石表面。仅采用单一透视平面进行结石靶向定位并观察碎石过程。治疗能量设定为每脉冲 120 毫焦，重复频率 8 至 10 赫兹。激光治疗过程中，我们尝试通过听诊器捕捉结石碎裂声，并在胆管内灌注造影剂后通过透视监测碎石效果。实施激光碎石术时，胆管持续灌注造影剂与生理盐水混合液，因为液体介质是产生冲击波的必要条件。

结石碎裂后，采用 dormia 网篮和球囊导管进行内镜下结石及碎片取出术。每次激光碎石术的最长时限设定为 60 分钟。若此时胆管未完全清理，则置入鼻胆管。激光碎石术失败的定义为：经过最多三次碎石疗程后仍无法实现胆管完全清理。

所有患者均在 FREDDY LL 术后接受至少两天的随访。随访内容包括简易 X 光片检查及实验室检测（血红蛋白、白细胞计数、胆红素、丙氨酸氨基转移酶、天冬氨酸氨基转移酶、肌酐、血清尿素氮、淀粉酶和脂肪酶水平）。通过门诊复诊或电话访谈评估患者在 FREDDY LL 术后一个月内出现的任何并发症。

结果

碎石术

采用 FREDDY LL 激光碎石技术，17 名患者中有 15 人实现了无需直接视觉监控的完全碎石（图 1）。每位患者为彻底清除胆管结石所需的逆行胰胆管造影术平均次数为 1.7±0.6 次。在 FREDDY LL 术后，另有 3 名患者接受了机械碎石术以实现胆管的完全清理。

两名患者的结石碎石术失败，其中一人因胆总管迂曲处存在巨大嵌顿结石及胆道狭窄导致激光光纤定位不当。一名患者转至外科接受腹腔镜手术清理胆道，另一名患者则采用经皮胆道镜联合液电碎石术进行治疗。

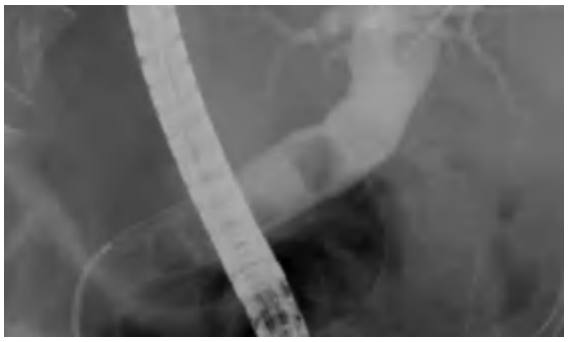
并发症

FREDDY LL 的副作用和并发症大多较为轻微。虽然有一名患者出现急性胰腺炎，但通过保守治疗得到控制，且未形成假性囊肿。两名患者出现短暂性胆道出血，但出血自行停止，血红蛋白水平未见变化。该胆道出血可能由引导导管或球囊导管插入造成的黏膜损伤所致。另有一例急性胆管炎患者通过抗生素治疗和鼻胆管冲洗得到控制，此并发症可能由鼻胆管暂时性阻塞引起。

讨论

内镜下逆行胰胆管造影术（ERCP）与括约肌切开术一直是治疗胆总管结石的标准方案，但大尺寸结石对内镜医师构成重大挑战。扩大括约肌切口会增加出血和穿孔风险，而机械碎石设备通常价格昂贵、操作笨拙且易损，且在相当数量病例中无法有效抓取结石。针对这类患者，需要采用体外冲击波碎石、体内液电碎石或激光碎石等辅助技术。

电液压体内碎石术（EHL）是治疗困难胆管结石的一种有效内镜治疗手段。然而由于采用高脉冲能量，EHL 需要在碎石过程中持续进行视觉监控。



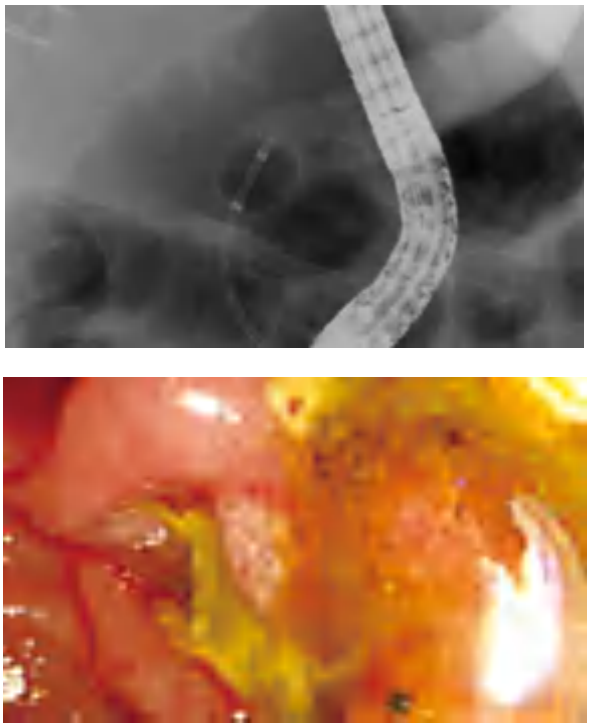


图 1 使用 FREDDY 激光碎石系统在无直接视觉控制下完成结石粉碎。A：胆管造影显示结石嵌顿于胆总管；B：FREDDY 激光碎石术中的胆管造影，显示结石已碎裂成多个片段；C：内镜检查显示胆管内已被粉碎的结石碎片。

探头与胆管壁接触可能导致穿孔或出血。胆道镜检查过程中常规采用持续生理盐水冲洗配合液电碎石术。经乳头母子胆道镜操作需要两名经验丰富的内镜医师配合。此外，这类内镜设备极其精密且成本高昂。值得注意的是，液电碎石术会使患者和术者暴露于高剂量电离辐射。目前多个医疗中心已报道复杂胆管结石的激光碎石数据。在胆道镜直视下，香豆素绿激光和钕钇铝石榴石激光的结石碎裂率可达 80%-90%。而透视引导下的激光碎石术失败率高达 80%，主要因光纤精准定位结石存在困难。1993 年问世的闪光灯脉冲激光配备组织-结石识别系统，可通过分析背向散射光识别胆结石，并在接触组织时自动中断能量脉冲。氦氖瞄准光束有助于直观引导探头尖端定位结石表面。该系统支持透视监控下实施治疗，安全性卓越且碎石成功率高达 90%。若使用罗丹明 6G 激光进行透视监控，约 80%患者的胆管可获得有效清理。

FREDDY 激光器专为内镜下碎石术研发，用于粉碎泌尿系统结石。我们将其应用于经乳头途径难以通过标准内镜操作（包括内镜下括约肌切开术和机械碎石术）处理的胆道结石。在本研究中，17 例患者中有 15 例（88%）成功实现经乳头途径的结石粉碎。FREDDY 激光器是一种短脉冲调 Q 倍频双脉冲 Nd:YAG 固态激光器，可发射长脉冲。该激光器由于能将部分红外线协同转换为绿光范围，从而产生极高的脉冲强度。532 纳米波长（绿光光谱）的激光在结石表面引发等离子体形成，而 1064 纳米波长的光则加热预形成的等离子体，引发膨胀与收缩效应使结石碎裂，脉冲时限为 0.5-1.5 微秒。这种激光产生的超短脉冲被软组织吸收极少，因此组织几乎不受热效应影响。体外实验表明 FREDDY 激光非常适用于碎石术，动物模型研究显示其对正常组织几乎无影响。

此外，与钬激光相比，FREDDY 激光不会产生热效应。该激光在泌尿系结石上展现出高达 95%的碎石效率，但关于其对胆道结石作用的研究仍较为罕见。尽管本研究的病例数量有限，我们仍观察到 88%的碎石成功率。FREDDY 激光系统融合了固态激光与脉冲染料激光的

双重优势，包括较低成本、良好可靠性及卓越疗效。

本研究中所需的 ERCP 操作次数较其他研究组报告的数据更高。当采用激光疗法作为疑难病例的一线治疗方案时，往往需要追加 ERCP 操作才能实现胆管完全清理。FREDDY 激光系统的劣势在于患者与内镜医师需承受较高剂量的 X 射线辐射。此外，由于激光光纤需通过球囊导管置入，在透视条件下精确定位结石靶区存在操作难度大、耗时长等问题。操作者需要具备相当水平的内镜技术，才能使带有激光光纤的球囊导管与结石表面充分接触。在类似本研究中激光碎石失败的迂曲成角胆管病例中，球囊定位效果往往不尽如人意。为确保光纤能精确作用于结石靶区并避免触碰胆管壁，我们在激光治疗过程中实时监测了胆管内结石移动情况、通过听诊器捕捉碎石声响以及观察胆道出血状况。

综上所述，我们的研究结果表明，在无直接视觉控制条件下使用 FREDDY 激光碎石术治疗机械碎石无法清除的困难胆总管结石患者，是一种安全有效的技术。未来需要通过与电液压碎石术、体外冲击波碎石术或其他激光系统的对比研究，来评估 FREDDY 激光的实用性与疗效。

评论

背景

内镜下乳头切开术在 90%以上的胆总管结石病例中取得成功。对于机械碎石无效的难治性胆管结石患者，目前已开发出多种结石破碎方法，如激光碎石术或直视控制下的液电碎石术（EHL）。使用该设备的主要问题在于需要胆道镜引导或"子母"内镜系统。

研究前沿

近期开发出一种新型激光器——双频双脉冲掺钕钇铝石榴石激光(FREDDY)，用于泌尿结石的内镜下碎石术，具有更小的组织损伤。研究人员对无法通过标准技术取出的胆管结石患者，评估了在不使用胆道镜情况下、采用球囊导管实施激光碎石术的疗效与安全性。

创新与突破

FREDDY 激光器是一种新开发的经济型短脉冲双频固态激光器，能减少组织损伤。通过经口十二指肠镜采用球囊导管进行荧光镜引导下的激光碎石术，对于无法通过机械碎石等常规技术取出的胆管结石似乎是有效的治疗方法。

应用领域

针对胆管结石的碎石治疗，胆道镜引导方式因笨重的内窥镜设备成本及需要两名经验丰富的内镜医师操作"子母镜"而费用高昂。当无法获得或受限直接视觉控制时，采用球囊导管进行激光碎石可作为替代方案。为精准将激光光纤定位于胆管内结石靶区，亟需一种更简便的新方法。

同行评审

这是一篇文笔优美且引人入胜的论文。FREDDY 激光技术可能成为治疗疑难胆管结石的有效手段。

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Laparoscopic Transcystic Common Bile Duct Exploration: T-Shaped Incision of Cystic Duct with FREDDY Laser Lithotripsy

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Abstract

Objectives: Optimal laparoscopic techniques for management of gallstones concomitant with common bile duct (CBD) stones remain under debate. The aim of this study was to evaluate a novel approach to managing gallstones concomitant with large or impacted CBD stones through a modified laparoscopic transcystic CBD exploration (LTCBDE) with frequency-doubled double-pulse neodymium:YAG (FREDDY) laser lithotripsy.
Materials and Methods: This retrospective review includes 32 consecutive patients with gallstones concomitant with large or impacted CBD stones who were offered LTCBDE with FREDDY laser lithotripsy between June 2012 and December 2014. Demographic, perioperative, and follow-up data were collected and analyzed retrospectively.
Results: CBD stone clearance was achieved for all patients. There were 13 males and 19 females, among whom there were three patients with a history of abdominal surgery. The diameter of the CBD ranged from 10 to 20 (mean 15.1) mm, and the number of CBD stones ranged from 1 to 5. CBD stones ranged in diameter from 9 to 18 (mean 11.7) mm and 9 patients had stones that were impacted in the CBD. The mean operative time was 123 ± 18 minutes with a range of 72 to 155 minutes. The mean length of postoperative hospital stay was 5.3 (range 4–7) days. All patients recovered normally without morbidity or mortality.
Conclusions: The modified LTCBDE with a T-shaped incision of the cystic duct and FREDDY laser lithotripsy is a safe and effective means of managing gallstones concomitant with large or impacted CBD stones.

Introduction

Common bile duct (CBD) stones occur in up to 15% of patients with symptomatic gallstones or acute cholecystitis.[1] Symptomatic CBD stones can lead to obstructive jaundice, cholangitis, secondary biliary cirrhosis, or pancreatitis. With continual improvement in endoscopic and laparoscopic techniques, endoscopic retrograde cholangiopancreatography (ERCP), along with laparoscopic cholecystectomy (LC), and laparoscopic CBD exploration (LCBDE) with LC are preferred for the majority of patients diagnosed as having concomitant gallstones and CBD stones.[2–5] Randomized clinical trials have concluded that there is no statistically significant difference in the success rate of CBD stone clearance, morbidity, or mortality between ERCP and LCBDE in selected patients.[6–8] However, the short-term and long-term adverse events pertaining to ERCP include post-ERCP pancreatitis, sphincter of Oddi dysfunction, and ERCP-related hemorrhage or perforation.[9] Furthermore, unsuccessful ERCP may cause severe periampullary inflammation that obliterates the papillary orifice or may precipitate iatrogenic complications that lead to higher inpatient mortality.[10–11] LCBDE is safe and effective for the management of bile duct stones without the ERCP-related complications. As a one-stage approach, LCBDE can be performed either through the cystic duct or by choledochotomy. Moreover, laparoscopic transcystic CBD exploration (LTCBDE) has the advantages of protecting the integrity of the CBD, obviating suture repair after choledochotomy, preserving the function of the sphincter of Oddi, faster postoperative recovery, and shorter hospital stay.[7]

However, for clearing large or impacted CBD stones, standard endoscopic or laparoscopic procedures are challenging or impossible. Although multiple studies of LTCBDE

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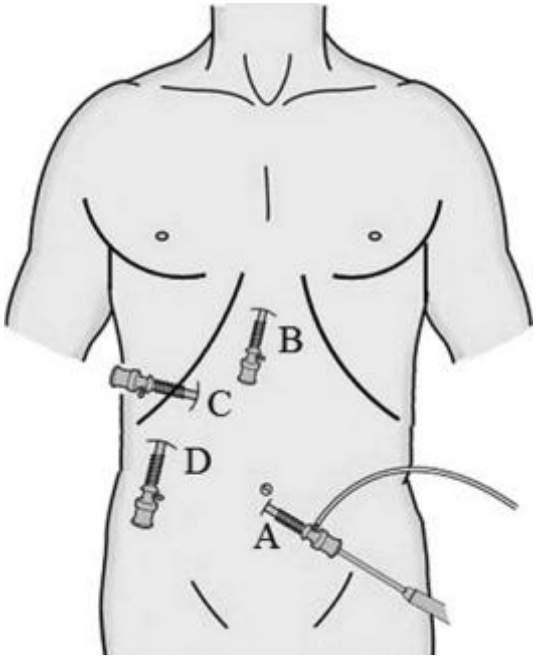


FIG. 1. Diagram of trocar position. LTCBDE was used with a 4-trocar technique; the first (10-mm) trocar (A) was placed below the umbilicus for insufflation of carbon dioxide and laparoscope access, a 12-mm trocar (B) was placed in the epigastric region, a 5-mm trocar (C) was placed in the midclavicular line 1–2 cm below the costal margin, and another 5-mm trocar (D) was placed in the right axillary line 4–5 cm below the costal margin. CBD, common bile duct; LTCBDE, laparoscopic transcystic CBD exploration.

with technical modifications have been reported and applied, the optimal technique has not been determined to date.[3,12,13]

The frequency-doubled double-pulse neodymium:YAG (FREDDY) laser is a newly developed short-pulse, double frequency, and economical laser with wavelengths of 532 nm and 1064 nm. This laser was designed specifically for endoscopic or laparoscopic lithotripsy and has been used successfully for the treatment of difficult bile duct stones in ERCP or open surgery when the traditional methods failed.[14–18] To date, FREDDY laser lithotripsy has yet to be combined with LTCBDE. In this study, we aimed to evaluate the safety and efficacy of a modified LTCBDE with FREDDY laser lithotripsy for management of gallstones concomitant with large or impacted CBD stones.

Materials and Methods

Patients and clinical data

This retrospective review included 32 patients who consecutively underwent LTCBDE combined with FREDDY laser lithotripsy between June 2012 and December 2014 in the Second Affiliated Hospital of Nan Chang University. Patients with gallstones and symptoms or laboratory abnormalities consistent with CBD stones, including obstructive jaundice; raised levels of alkaline phosphatase (ALP) and/or gamma-glutamyl transferase (GGT); CBD diameter of more than 8 mm; CBD stones diagnosed by abdominal ultrasound, CT scan, or magnetic resonance cholangiopancreatography; repeated biliary colic and cholangitis; previous history of obstructive jaundice; and gallstone pancreatitis were included. Patients with hepatolithiasis, Mirizzi syndrome, and suspected bile duct cancer were excluded. Clinical data regarding demographic characteristics and perioperative and follow-up findings were collected and analyzed retrospectively.

Operative techniques

Patients were under general anesthesia in the supine position. Pneumoperitoneum was established. LTCBDE was performed using a 4-trocar technique (Fig. 1). The first 10-mm trocar (A) was introduced below the umbilicus for insufflation of carbon dioxide at 12–14 mm Hg (1 mm Hg = 0.133 kPa) and insertion of the 30° angled laparoscope (Karl Storze, Tuttlingen, Germany). Three more trocars were placed under direct vision: a 12-mm trocar (B) in the epigastric region, a 5-mm trocar (C) in the midclavicular line 1–2 cm below the costal margin, and another 5-mm trocar (D) in the right axillary line 4–5 cm below the costal margin.

After careful dissection and clearance of the triangle of Calot, the cystic artery was clipped and cut off in a standard manner. The cystic duct was dissected close to the gallbladder and clipped to prevent stone or bile migration. After further dissection and sufficient exposure of the cystic duct toward the CBD, a transverse incision of the cystic duct was performed (Fig. 2A). The bile duct anatomy was evaluated, and to facilitate the introduction of the choledochoscope, the cystic duct was dilated with a balloon catheter or occasionally with laparoscopic separation forceps. If the 5-mm flexible choledochoscope (Olympus, Tokyo, Japan) could not be inserted into the cystic duct or if the CBD stone was larger than the diameter of the cystic duct, a T-shaped incision was made 3–5 mm above the confluence of the cystic duct and the CBD (Fig. 2B).



FIG. 2. (A) Transverse incision of the cystic duct. (B) T-shaped incision of the cystic duct and its confluence with the CBD. (C) Introduction of the choledochoscope through the cystic duct.

Next, the choledochoscope was introduced through the cystic duct to the CBD (Fig. 2C), and the CBD stones could be visualized directly (Fig. 3A). Normally, the CBD stones were retrieved individually by a wire basket, irrigation, or a combination of both through the cystic duct. If large or impacted CBD stones could not be extracted by these routine methods, a FREDDY laser fiber (U-100 system, World of Medicine, Berlin Germany) was installed from the working port of the choledochoscope and was used to break the CBD stones into pieces at an energy setting of 120 mJ per pulse and a repetition rate of 5 Hz (Fig. 3B). The tip of the FREDDY laser fiber is armed with a red aiming beam for accurate positioning on the surface of the CBD stones and reducing the risk of injuring the surrounding bile duct wall. The adequately fragmented stones were retrieved through the routine methods (Fig. 3C), and a final choledochoscopy check was performed to confirm complete clearance of the bile duct stone and absence of bile duct mucosal injury (Fig. 3D). After complete clearance of the CBD stones, the cystic duct was closed with clips or suture ligature (3–0 Vicryl). Next, the gallbladder was removed from the hepatic attachments through a standard procedure. Routinely, an abdominal drainage was placed in a subhepatic location. No T-tube or biliary stents were used after successful stone extraction. Patients were relocated to the general wards of the department of hepatopancreatobiliary surgery in a quiet and stable condition after the operation. Oral intake was prohibited during the first 24 hours postoperatively. Postoperative laboratory tests included a complete blood cell count and liver function tests.

Follow-up

Patients were followed up in outpatient visits in the first and third months after release; next, patients were contacted by telephone every 3 months. Each individual patient was followed up for more than 6 months. General conditions, diet, operation-related discomfort, liver function, and radiology examinations were performed to screen for adverse events during follow-up.

Ethics statement

The ethics committee of the Second Affiliated Hospital of Nan Chang University approved this study and the use of clinical data. Informed consent was obtained from all of the patients.

Results

Patient characteristics are summarized in Table 1. Thirteen males and 19 females were recruited; the mean age in the present study was 54.9 years. Three patients (patients 7, 9, and 14) had a history of abdominal operations (Billroth-I gastrectomy, Billroth-II gastrectomy, and splenectomy, respectively). Preoperative liver function tests were obtained the day before the operation. The alanine aminotransferase (ALT) ranged from 9.62 to 306.9 (mean, 91.02) U/L; ALP ranged from 78.1 to 800.1 (mean, 236.35) U/L; GGT ranged from 10.9 to 1110.2 (mean, 331.29) U/L; and total bilirubin (Tbil) level ranged from 18.1 to 230.32 (mean, 79.81) ιM. In terms of bile duct disease characteristics, the diameter of the CBD ranged from 10 to 20 (mean, 15.1) mm, and the number of CBD stones ranged from 1 to 5. CBD stones ranged in diameter from 9 to 18 (mean, 11.7) mm, and 9 patients had stones impacted in the CBD that could not be extracted by a wire basket, irrigation, or a combination of both methods.

Operative outcome is shown in Table 2. The CBD stones were successfully cleared in all patients. The mean operative time was 123 minutes with a range of 72 to 155 minutes. Patient 7 had an impacted stone and abdominal history of Billroth-I gastrectomy and it is likely that these characteristics affected the operative time, which was the longest in this patient. The estimated blood loss during the operation ranged from 10 to 80 mL, and no intraoperative blood transfusion was needed. The mean length of the postoperative hospital stay was 5.3 (range, 4–7) days. All patients recovered normally with no perioperative morbidity or mortality. The mean follow-up duration was 8.5 (range, 6–15) months, and no bile duct injury, stricture, retained or recurrent stones, or other complications were observed during follow-up.

Discussion

LTCBDE is an effective technique and is the least invasive method for managing concomitant gallstones and CBD stones. The LTCBDE for CBD stone clearance has a high success rate, ranging from 85% to 95% in selected patients.[12] This technique has the advantage of protecting the integrity of the major bile duct from choledochotomy and preserving the function of the sphincter of Oddi. Furthermore, LTCBDE is associated

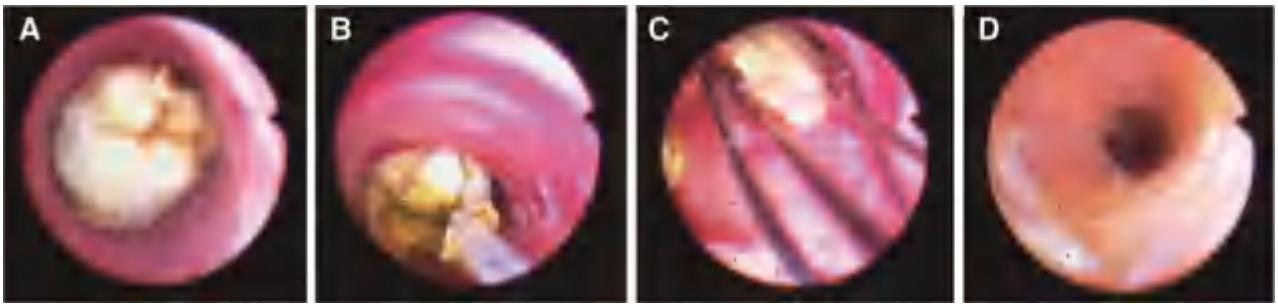


FIG. 3. (A) Common bile duct stone visualized with a choledochoscope. (B) Common bile duct stone under FREDDY laser lithotripsy. (C) Stone basket engagement after laser lithotripsy. (D) Postlithotripsy check with a choledochoscope demonstrating a patent common bile duct.

Table 1. Patient Characteristics

Patient	Sex/Age (years)	ASA class	ALT (U/L)	ALP (U/L)	GGT (U/L)	Tbil (μM)	Abdominal operative history	Diameter of largest CBD stone (mm)	Diameter of CBD (mm)	Impacted CBD stone	No.of CBD stones
1	F/60	II	22.86	133.1	280.7	56.55	—	11	15	No	2
2	M/59	II	32.28	86.4	112.1	32.28	—	12	15	No	4
3	F/60	II	15.5	110.8	23.4	45.2	—	12	15	No	3
4	F/43	I	19.16	78.1	15.6	34.54	—	11	13	No	1
5	F/81	III	73.05	238.9	245.8	69.95	—	16	18	No	3
6	M/75	III	157.56	399.3	495.5	83.07	—	12	16	No	2
7	F/57	II	94.5	120.6	331.2	184.14	Billroth-I gastrectomy	9	15	Yes	3
8	M/36	II	19.67	100.1	221.7	52.31	—	15	20	No	1
9	F/41	II	10.67	82.7	10.9	35.77	Billroth-II gastrectomy	18	20	No	3
10	M/66	II	106.76	477.8	504.5	59.56	—	16	20	No	1
11	F/62	II	9.62	101.7	107.9	31.85	—	11	12	Yes	3
12	F/79	III	129.95	353.8	327	103.6	—	10	16	No	3
13	F/62	II	29.07	89.1	22.3	73.24	—	14	20	No	2
14	M/40	II	172.54	187.4	387.6	86.07	Splenectomy	13	15	No	1
15	M/48	II	139.28	132.3	343.1	36.71	—	10	15	No	2
16	F/64	II	89.3	800.1	1110.2	200.3	—	10	12	Yes	1
17	M/55	II	256.42	255.8	570.4	68.79	—	9	10	No	1
18	F/60	II	119.75	375.1	329.8	143.19	—	10	14	Yes	2
19	F/26	II	306.9	140.2	172.9	105.15	—	9	13	Yes	1
20	F/38	I	11.48	114.9	130.8	18.1	—	12	13	No	2
21	F/68	III	47.8	228	162	27.3	—	10	18	No	1
22	F/76	III	40.73	418.5	640.8	98.42	—	10	18	No	3
23	M/58	II	22.17	290.4	524.1	147.09	—	17	20	Yes	2
24	M/40	II	24.17	136.8	156.6	25.66	—	10	12	No	1
25	F/18	II	220.25	291.1	535.4	95.71	—	12	15	No	1
26	M/60	II	64	224	142.5	31.43	—	12	13	No	5
27	M/53	II	114.95	139.8	671	36.87	—	10	14	No	3
28	M/38	II	179.42	223.7	321	62.14	—	10	11	No	2
29	M/67	III	33.32	181.7	89.2	48.36	—	9	12	No	3
30	F/56	I	214.17	192	422	157.18	—	10	12	Yes	3
31	F/71	III	63.8	657.6	626.1	73.07	—	10	15	Yes	1
32	F/41	II	71.72	201.3	567.2	230.32	—	14	16	Yes	1

F, female; M, male; ASA, American Society of Anesthesiologists; ALT, alanine aminotransferase; ALP, alkaline phosphatase; GGT, gamma-glutamyl transferase; Tbil, total bilirubin; CBD, common bile duct.

with lower morbidity and a shorter hospital stay compared with laparoscopic choledochotomy CBD exploration.[4,12] However, the reported indication for LTCBDE is limited to stones that are smaller than the diameter of the cystic duct, a small number of stones, stones located in the CBD, and a favorable anatomy of the cystic duct-CBD junction.[12] For CBD stones larger than the cystic duct in diameter, the technique of a T-shaped incision in the cystic duct, 3–5 mm from its confluence with the CBD, can be helpful. This method has advantages, including easy access to and exploration of the CBD with a choledochoscope, straightforward retrieval of larger CBD stones, and no requirement for bile duct drainage. However, a T-shaped incision of the bile duct is not effective for impacted or larger CBD stones (more than 5 mm greater than the cystic duct diameter). In this setting, lithotripsy may be employed before stone extraction, including electrohydraulic lithotripsy (EHL) and laser lithotripsy.

EHL is an inexpensive technique used primarily for the fragmentation of difficult-to-remove CBD stones by endoscopy.[19] However, complications occurred in up to 18% of cases: mostly recurrent jaundice, cholangitis, perforation, or bleeding.[20] Recently, laser lithotripsy has been used, and this technique is safer than EHL in general. The FREDDY laser and holmium laser are widely applied for fragmentation of bile duct stones.

The FREDDY laser system is a short-pulse, double-frequency solid-state laser with an 80% infrared component with a wavelength of 1064 nm and a 20% green component with a wavelength of 532 nm.[21] The absorption of the green light causes the formation of a plasma bubble on the stone's surface that completely absorbs the simultaneously emitted infrared light. This combined action is synergistic, raising the intensity of the plasma and producing a more effective mechanical shockwave. Stone fragmentation relies on the generation of a plasma bubble with a final mechanical shockwave without any thermal effect compared with the holmium laser.[21] The FREDDY laser system is safe and effective for the treatment of duct stones. In vitro experiments have demonstrated the application of FREDDY laser to lithotripsy, and animal model tests exhibited little or no effect on normal tissues.[22,23] One investigation of the effect of the FREDDY laser on the human urothelium reported only minimal edema after 300 pulses of 120 mJ each. In addition, 2000 pulses of the FREDDY laser failed to perforate human ureteric tissues ex vivo, while the holmium laser required, on average, only two pulses.[24]

Table 2. Operative Outcome

Patient	Technical success	Function of SOD	Operative time (min)	Estimated blood loss (mL)	Abdominal drainage (days)	Postoperative hospital stay (days)	Adverse event	Follow-up duration (months)
1	Yes	Normal	105	30	5	6	No	10
2	Yes	Normal	140	50	4	5	No	10
3	Yes	Normal	135	60	6	7	No	8
4	Yes	Normal	120	50	4	5	No	7.5
5	Yes	Normal	140	30	4	5	No	7.5
6	Yes	Normal	125	20	4	5	No	7
7	Yes	Normal	155	15	4	5	No	7.5
8	Yes	Normal	145	30	5	6	No	8.5
9	Yes	Normal	150	40	4	5	No	7
10	Yes	Normal	115	40	5	6	No	13
11	Yes	Normal	120	25	5	6	No	6
12	Yes	Normal	115	35	5	6	No	7.5
13	Yes	Normal	140	80	4	5	No	15
14	Yes	Normal	135	80	5	6	No	8
15	Yes	Normal	135	20	5	6	No	6.5
16	Yes	Normal	110	50	4	5	No	11
17	Yes	Normal	115	15	3	4	No	8.5
18	Yes	Normal	130	50	3	5	No	15
19	Yes	Normal	95	40	4	4	No	6.5
20	Yes	Normal	100	25	5	7	No	9.5
21	Yes	Normal	115	15	4	5	No	6
22	Yes	Normal	125	30	5	5	No	8
23	Yes	Normal	130	80	4	5	No	12.5
24	Yes	Normal	72	10	3	4	No	7.5
25	Yes	Normal	100	30	3	4	No	6
26	Yes	Normal	132	40	6	7	No	7.5
27	Yes	Normal	140	80	5	6	No	9.5
28	Yes	Normal	140	30	5	6	No	8
29	Yes	Normal	135	10	4	5	No	6
30	Yes	Normal	130	25	5	6	No	8
31	Yes	Normal	97	20	3	4	No	6.5
32	Yes	Normal	108	20	4	5	No	8

SOD, Sphincter of Oddi.

The FREDDY laser also has demonstrated advantages for treating bile duct stones in patients who could not be handled with a standard endoscopic approach or open surgery. The initial clinical use of the FREDDY laser for difficult CBD stones was reported by Hochberger et al. This study of 19 patients who underwent FREDDY laser lithotripsy with ERCP exhibited a successful bile duct clearance rate of 89%.[14] Kim et al.[15] reported a bile duct clearance rate of 15/17 (88%). These researchers used FREDDY laser lithotripsy with an ERCP balloon catheter under fluoroscopic guidance to fragment difficult CBD stones, which could not be extracted by a standard ERCP. In two patients, the impacted stones failed to fragment because the tortuous CBD and the biliary stricture caused inadequate positioning of the laser fiber. Liu et al.[16] and Cho et al.[17] used FREDDY laser lithotripsy through the transpapillary route, and the bile duct clearance rates were 90% and 92.3%, respectively. Jiang et al.[18] reported FREDDY laser lithotripsy as an effective treatment option for large and impacted intrahepatic stones in open surgery with or without hepatectomy. The final stone clearance rate was 93.3%, and FREDDY laser lithotripsy was shorter in both operative time and hospital stay with a rate of complication no greater than the traditional method.[18]

To the best of our knowledge, this report presents the first clinical description of the clearance of CBD stones with combined LTCBDE and FREDDY laser lithotripsy. In this study, we further validate the usefulness and efficiency of the FREDDY laser system for large or impacted CBD stones. Compared with the aforementioned reports, we achieved 100% bile duct stone clearance for all 32 patients, and no complications occurred. Our patients with large or impacted CBD stones benefited from the modified LTCBDE and FREDDY laser lithotripsy in one operative setting with minimized exposure to anesthesia and shorter hospital stay. The most important point is that we gained access to the CBD with laparoscopy in a transcystic approach and avoided choledochotomy or sphincterotomy, thus freedom from T-tube- or ERCP-related complications.

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Disclosure Statement

No competing financial interests exist.

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腹腔镜经胆囊胆总管探查术：胆囊管 T 形切口联合 FREDDY 激光碎石术

摘要

目的：针对胆囊结石合并胆总管结石的最佳腹腔镜治疗技术仍存争议。本研究旨在评估一种改良腹腔镜经胆囊管胆总管探查术（LTCBDE）联合倍频双脉冲掺钕钇铝石榴石（FREDDY）激光碎石术治疗胆囊结石合并大型或嵌顿性胆总管结石的新方法。

材料与方法：本回顾性研究纳入 2012 年 6 月至 2014 年 12 月期间连续收治的 32 例胆囊结石合并大型或嵌顿性胆总管结石患者，均接受 FREDDY 激光碎石辅助 LTCBDE 治疗。收集并回顾性分析患者人口统计学资料、围手术期及随访数据。

结果：所有患者均实现胆总管结石清除。男性 13 例，女性 19 例，其中 3 例有腹部手术史。胆总管直径 10-20（平均 15.1）mm，结石数量 1-5 枚，结石直径 9-18（平均 11.7）mm，9 例患者存在胆总管嵌顿性结石。平均手术时间 123±18 分钟（范围 72-155 分钟），术后平均住院时间 5.3 天（范围 4-7 天）。所有患者均恢复良好，无并发症及死亡病例。

结论：采用胆囊管 t 形切口改良 LTCBDE 联合 FREDDY 激光碎石术，是治疗胆囊结石合并大型或嵌顿性胆总管结石安全有效的方法。

引言

胆总管结石可见于 15%的有症状胆结石或急性胆囊炎患者。有症状的胆总管结石可导致梗阻性黄疸、胆管炎、继发性胆汁性肝硬化或胰腺炎。随着内镜和腹腔镜技术的持续改进，内镜逆行胰胆管造影术（ERCP）联合腹腔镜胆囊切除术（LC），以及腹腔镜胆总管探查术（LCBDE）联合 LC，已成为同时患有胆结石和胆总管结石患者的主要治疗选择。随机临床试验表明，在特定患者群体中，ERCP 与 LCBDE 在胆总管结石清除成功率、并发症发生率及死亡率方面无统计学差异。然而 ERCP 相关的短期和长期不良事件包括 ERCP 术后胰腺炎、Oddi 括约肌功能障碍，以及 ERCP 相关出血或穿孔。此外，失败的 ERCP 可能导致严重的壶腹周围炎症（致使乳头开口闭塞），或引发医源性并发症从而导致更高的住院死亡率。LCBDE 在治疗胆管结石方面安全有效，且无 ERCP 相关并发症。作为一期手术方案，LCBDE 可通过胆囊管或胆总管切开两种途径实施。其中经胆囊管腹腔镜胆总管探查术（LTCBDE）具有以下优势：保持胆总管完整性、避免胆总管切开后缝合修复、保留 Oddi 括约肌功能、促进术后更快康复及缩短住院时间。

然而，对于清除大型或嵌顿性胆总管结石，标准的内窥镜或腹腔镜手术具有挑战性甚至无法实施。尽管已经报道并应用了对 LTCBDE 进行技术改造的多项研究，但迄今为止尚未确定最佳技术。

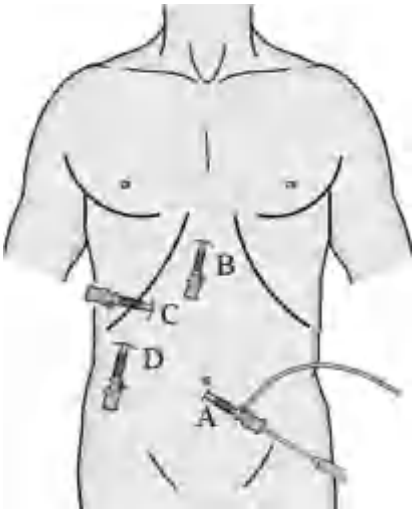


图 1. 套管针位置示意图。腹腔镜经胆囊胆总管探查术采用四孔技术：首个（10 毫米）套管针（A）置于脐下用于二氧化碳气腹和腹腔镜入路，12 毫米套管针（B）位于上腹区，5 毫米套管针（C）置于锁骨中线肋缘下 1-2 厘米处，另一 5 毫米套管针（D）位于右腋前线肋缘下 4-5 厘米处。CBD 指胆总管；LTCBDE 为腹腔镜经胆囊胆总管探查术缩写。

双频双脉冲掺钕钇铝石榴石激光器（FREDDY 激光）是一种新开发的短脉冲双频经济型激光设备，可输出 532 纳米和 1064 纳米两种波长。该激光专为内窥镜或腹腔镜碎石术设计，在传统方法失效时，已成功应用于 ERCP 或开放手术中治疗困难胆管结石。迄今为止，FREDDY 激光碎石术尚未与腹腔镜经胆囊管胆总管探查术（LTCBDE）联合应用。本研究旨在评估改良版 LTCBDE 联合 FREDDY 激光碎石术治疗胆囊结石合并大型或嵌顿性胆总管结石的安全性与有效性。

患者与临床数据

材料与方法

这项回顾性研究纳入了 2012 年 6 月至 2014 年 12 月期间在南昌大学第二附属医院连续接受经腹腔镜胆总管探查术（LTCBDE）联合 FREDDY 激光碎石术的 32 例患者。入选标准包括：伴有胆总管结石相关症状或实验室检查异常的胆结石患者，具体表现为梗阻性黄疸；碱性磷酸酶（ALP）和/或 γ -谷氨酰转移酶（GGT）水平升高；胆总管直径超过 8 毫米；经腹部超声、CT 扫描或磁共振胰胆管造影确诊的胆总管结石；反复发作的胆绞痛和胆管炎；既往有梗阻性黄疸病史；以及胆结石性胰腺炎患者。排除标准为：肝内胆管结石、Mirizzi 综合征及疑似胆管癌患者。研究收集并回顾性分析了患者的人口学特征、围手术期及随访数据。

手术技术

患者取仰卧位行全身麻醉术。建立气腹后，采用四套管技术实施腹腔镜胆总管探查术（图 1）。首个 10 毫米套管（A）于脐下置入，用于灌注 12-14 毫米汞柱（1 毫米汞柱=0.133 千帕）

的二氧化碳气体，并插入 30 度角腹腔镜（德国图特林根卡尔史托斯公司）。在直视下放置另外三个套管：12 毫米套管（B）位于上腹区，5 毫米套管（C）置于锁骨中线肋缘下 1-2 厘米处，另一 5 毫米套管（D）位于右腋前线肋缘下 4-5 厘米处。

在精细解剖并清理 Calot 三角区后，按标准流程夹闭并离断胆囊动脉。紧贴胆囊壁分离胆囊管并施夹，以防止结石或胆汁迁移。进一步分离并充分暴露胆囊管至胆总管后，横向切开胆囊管（图 2A）。评估胆道解剖结构后，为便于胆道镜导入，采用球囊导管或偶尔使用腹腔镜分离钳扩张胆囊管。若 5 毫米柔性胆道镜（奥林巴斯，东京，日本）无法插入胆囊管，或胆总管结石大于胆囊管直径，则在胆囊管与胆总管汇合处上方 3-5 毫米处作 T 形切口（图 2B）。



图 2。(A) 胆囊管横切口。(B) 胆囊管 t 形切口及其与胆总管的汇合处。(C) 胆道镜经胆囊管置入。

随后，胆道镜经胆囊管插入胆总管（图 2C），可直接观察到胆总管结石（图 3A）。通常情况下，胆总管结石可通过取石网篮、冲洗或两者结合的方式经胆囊管逐一取出。若遇体积过大或嵌顿的胆总管结石无法通过常规方法取出时，则从胆道镜工作通道置入 FREDDY 激光光纤（U-100 系统，德国柏林 World of Medicine 公司），以单脉冲能量 120mJ、重复频率 5Hz 的参数将结石击碎（图 3B）。该激光光纤顶端配备红色定位光束，可精确定位结石表面，降低损伤胆管壁的风险。充分粉碎后的结石通过常规方法取出（图 3C），最后行胆道镜复查以确认胆管结石完全清除且无胆管黏膜损伤（图 3D）。胆总管结石完全清除后，采用夹闭或缝扎（3-0 薇乔线）方式处理胆囊管。随后按标准程序将胆囊从肝脏附着处剥离。常规于肝下间隙放置腹腔引流管。成功取石后未使用 T 管或胆道支架。术后患者情况平稳，转至肝胆胰外科普通病房继续观察。术后 24 小时内禁食。术后实验室检查包括全血细胞计数和肝功能检测。

随访安排

患者在出院后第 1 个月和第 3 个月接受门诊随访；此后每 3 个月通过电话进行联系。每位患者的随访时间均超过 6 个月。随访期间通过评估一般状况、饮食情况、手术相关不适、肝功能及影像学检查来筛查不良事件。

伦理声明

南昌大学第二附属医院伦理委员会批准了本研究及临床数据使用。所有患者均签署了知情同意书。

结果

患者特征总结见表 1。共招募 13 名男性和 19 名女性；本研究平均年龄为 54.9 岁。3 名患者（病例 7、9 和 14）有腹部手术史（分别为毕罗特 I 式胃切除术、毕罗特 II 式胃切除术和脾切除术）。术前肝功能检查于手术前一天完成：丙氨酸氨基转移酶（ALT）范围为 9.62-306.9（均值 91.02）U/L；碱性磷酸酶（ALP）范围为 78.1-800.1（均值 236.35）U/L；γ-谷氨酰转移酶（GGT）范围为 10.9-1110.2（均值 331.29）U/L；总胆红素（Tbil）水平范围为 18.1-230.32（均值 79.81）μM。胆管疾病特征方面：胆总管（CBD）直径范围为 10-20（均值 15.1）mm；CBD 结石数量为 1-5 枚；结石直径范围为 9-18（均值 11.7）mm。其中 9 例患者存在嵌顿性 CBD 结石，无法通过网篮取石、冲洗或联合方法取出。

手术结果如表 2 所示。所有患者的胆总管结石均被成功清除。平均手术时间为 123 分钟（范围 72 至 155 分钟）。7 号患者因结石嵌顿及曾接受比尔罗特 I 式胃切除术的腹部手术史，这些特征可能影响了手术时长，该患者手术时间在本组病例中最长。术中估计失血量在 10 至 80 毫升之间，无需术中输血。术后平均住院时间为 5.3 天（范围 4-7 天）。所有患者恢复良好，无围手术期并发症或死亡病例。平均随访时限为 8.5 个月（范围 6-15 个月），随访期间未观察到胆管损伤、狭窄、结石残留或复发及其他并发症。

讨论

腹腔镜胆总管探查术(LTCBDE)是一项有效技术，也是处理胆囊结石合并胆总管结石创伤最小的治疗方法。该技术在胆总管结石清除方面成功率高达 85%-95%（经筛选患者数据）。该技术具有保护胆总管免受胆总管切开术损伤、维持奥狄氏括约肌功能的优势。此外，与腹腔镜胆总管切开术 CBD 探查相比，LTCBDE 的发病率较低，住院时间较短。然而，报道中关于腹腔镜经胆囊管胆总管探查术（LTCBDE）的适应症仅限于：结石小于胆囊管直径、结石数量较少、结石位于胆总管（CBD）内，以及胆囊管与胆总管连接处解剖结构理想的情况。对于直径大于胆囊管的胆总管结石，可在胆囊管与胆总管汇合处 3-5 毫米位置采用 T 形切口技术。该方法具有多项优势：便于使用胆道镜进入和探查胆总管、可轻松取出较大胆总管结石，且无需进行胆管引流。但胆管 T 形切口对于嵌顿性或直径超过胆囊管 5 毫米以上的较大胆总管结石效果不佳。此类情况下，可在取石前采用碎石技术，包括液电碎石术（EHL）和激光碎石术。

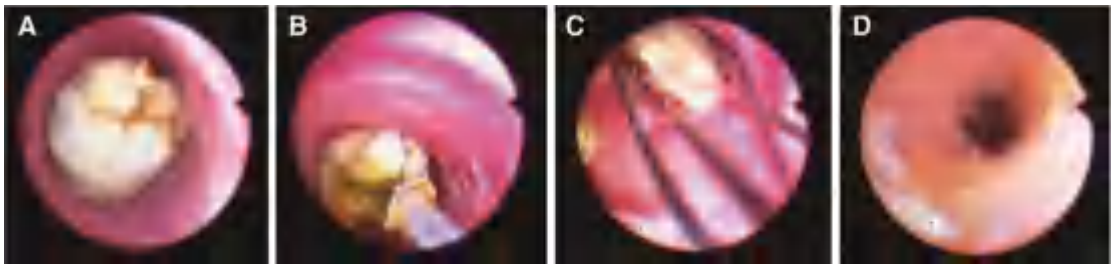


图 3. (A) 胆总管结石经胆道镜可视化成像。(B) FREDDY 激光碎石术中的胆总管结石。(C) 激光碎石术后取石篮抓取。(D) 碎石术后胆道镜检查显示胆总管通畅。

表 1. 患者特征

Patient	Sex/Age (years)	ASA class	ALT (U/L)	ALP (U/L)	GGT (U/L)	Tbil (μM)	Abdominal operative history	Diameter of largest CBD (mm)	Diameter of CBD (mm)	Impacted CBD stone	No. of CBD stone
1	F/60	II	22.86	133.1	280.7	56.85	—	13	19	No	2
2	M/59	II	32.28	86.4	112.1	32.28	—	12	15	No	4
3	F/60	II	15.5	110.8	23.4	45.2	—	12	15	No	2
4	F/43	I	19.16	78.1	15.6	34.54	—	11	13	No	1
5	F/81	III	71.05	238.9	245.8	69.95	—	16	18	No	3
6	M/75	III	152.56	389.3	495.5	83.07	—	12	16	No	2
7	F/57	II	94.5	120.6	331.2	184.14	Billroth-I gastrectomy	9	15	Yes	3
8	M/36	II	19.67	100.1	221.7	52.31	—	15	20	No	1
9	F/41	II	10.67	62.7	103	35.77	Billroth-II gastrectomy	18	20	No	3
10	M/66	II	106.76	477.8	504.5	59.56	—	16	20	No	1
11	F/62	II	9.62	101.7	107.9	31.35	—	11	12	Yes	3
12	F/79	III	129.95	353.8	327	103.6	—	10	16	No	3
13	F/62	II	29.07	89.1	22.3	73.24	—	14	20	No	2
14	M/40	II	172.54	187.4	357.6	86.07	Splenectomy	13	15	No	1
15	M/48	II	109.28	132.3	343.1	36.71	—	10	15	No	2
16	F/64	II	89.3	800.1	1110.2	200.3	—	10	12	Yes	1
17	M/55	II	256.42	255.8	570.4	68.79	—	9	10	No	1
18	F/60	II	119.75	375.1	329.8	143.19	—	10	14	Yes	2
19	F/26	II	306.9	140.2	172.9	105.15	—	9	13	Yes	1
20	F/38	I	11.48	114.9	13018	18.1	—	12	13	No	2
21	F/68	III	47.8	228	162	27.3	—	10	18	No	1
22	F/76	III	40.73	418.5	6401.8	98.42	—	10	18	No	3
23	M/58	II	22.17	290.4	524.1	147.09	—	17	20	Yes	2
24	M/40	II	24.17	136.8	156.6	25.66	—	10	12	No	1
25	F/18	II	220.25	291.1	535.4	95.71	—	12	15	No	1
26	M/60	II	64	224	142.5	31.43	—	12	13	No	5
27	M/53	II	114.95	139.8	671	36.87	—	10	14	No	3
28	M/38	II	179.42	223.7	321	62.14	—	10	11	No	2
29	M/67	III	33.32	181.7	89.2	48.36	—	9	12	No	3
30	F/56	I	234.17	193	422	157.18	—	10	12	Yes	3
31	F/71	III	63.8	657.6	626.1	73.07	—	10	15	Yes	1
32	F/41	II	71.22	261.3	567.2	230.32	—	14	16	Yes	1

F，女性；M，男性；ASA，美国麻醉医师协会；ALT，丙氨酸氨基转移酶；ALP，碱性磷酸酶；GGT，γ-谷氨酰转移酶；Tbil，总胆红素；CBD，胆总管。

电液压碎石术(EHL)是一种经济实惠的技术，主要用于通过内镜粉碎难以清除的胆总管结石。然而该技术并发症发生率高达 18%：主要包括复发性黄疸、胆管炎、穿孔或出血。近年来激光碎石技术得到应用，总体而言该技术比 EHL 更为安全。FREDDY 激光与钬激光被广泛应用于胆管结石的粉碎治疗。

FREDDY 激光系统是一种短脉冲双频固态激光器，其 80%成分为波长 1064 纳米的红外光，20%成分为波长 532 纳米的绿光。绿光的吸收会在结石表面形成等离子气泡，该气泡能完全吸收同步发射的红外光。这种联合作用具有协同效应，可增强等离子体强度并产生更有效的机械冲击波。与钬激光相比，该碎石技术依赖最终机械冲击波产生的等离子气泡，完全不存在热效应。FREDDY 激光系统治疗胆管结石安全有效。体外实验已证实其在碎石术中的应用价值，动物模型测试显示对正常组织几乎无影响。一项关于 FREDDY 激光对人体尿路上皮影响的研究表明，即使施加 300 次 120 毫焦耳的脉冲也仅出现极轻微水肿。此外，离体实验中 2000 个 FREDDY 激光脉冲仍未能击穿人体输尿管组织，而钬激光平均仅需 2 个脉冲即可实现。

表 2. 手术结果

Patient	Technical success	Function of SOD	Operative time (min)	Estimated blood loss (mL)	Abdominal drainage (days)	Postoperative hospital stay (days)	Adverse event	Follow-up duration (months)
1	Yes	Normal	105	40	5	6	No	10
2	Yes	Normal	140	50	4	5	No	10
3	Yes	Normal	135	60	6	7	No	8
4	Yes	Normal	120	50	4	5	No	7.5
5	Yes	Normal	140	30	4	5	No	7.5
6	Yes	Normal	125	20	4	5	No	7
7	Yes	Normal	155	15	4	5	No	7.5
8	Yes	Normal	145	30	5	6	No	8.5
9	Yes	Normal	150	40	4	5	No	7
10	Yes	Normal	115	40	5	6	No	13
11	Yes	Normal	120	25	5	6	No	6
12	Yes	Normal	115	35	3	6	No	7.5
13	Yes	Normal	140	80	4	5	No	15
14	Yes	Normal	135	80	5	6	No	8
15	Yes	Normal	135	20	5	6	No	6.5
16	Yes	Normal	110	50	4	5	No	11
17	Yes	Normal	115	15	3	4	No	8.5
18	Yes	Normal	130	50	3	5	No	15
19	Yes	Normal	95	40	4	4	No	6.5
20	Yes	Normal	100	25	5	7	No	9.5
21	Yes	Normal	115	15	4	5	No	6
22	Yes	Normal	125	30	5	5	No	8
23	Yes	Normal	130	80	4	5	No	12.5
24	Yes	Normal	72	10	3	4	No	7.5
25	Yes	Normal	100	30	3	4	No	6
26	Yes	Normal	132	40	6	7	No	7.5
27	Yes	Normal	140	80	5	6	No	9.5
28	Yes	Normal	140	30	5	6	No	8
29	Yes	Normal	155	10	4	5	No	6
30	Yes	Normal	130	25	5	6	No	8
31	Yes	Normal	97	20	3	4	No	6.5
32	Yes	Normal	108	20	4	5	No	8

SOD，奥狄氏括约肌。

FREDDY 激光系统在治疗胆管结石方面也展现出显著优势，适用于无法采用标准内镜治疗或开腹手术的患者群体。Hochberger 等人首次报道了 FREDDY 激光在复杂胆总管结石中的临床应用：这项涉及 19 例接受 ERCP 联合 FREDDY 激光碎石术的研究显示，其胆管结石清除率达 89%。Kim 研究团队后续报道的清除率为 15/17 例（88%），该团队在 X 线引导下采用 ERCP 球囊导管配合 FREDDY 激光碎石技术处理常规 ERCP 难以取出的复杂胆总管结石。但有两例患者因胆总管迂曲合并胆管狭窄导致激光纤维定位困难，未能成功碎石。Liu 团队与 Cho 团队分别通过经乳头途径实施 FREDDY 激光碎石术，胆管清除率达到 90%与 92.3%。Jiang 研究组证实，对于开腹手术中难以处理的肝内大结石（无论是否联合肝叶切除术），FREDDY 激光碎石术是有效治疗方案，最终结石清除率 93.3%，且手术时间、住院时长均短于传统方法，并发症发生率未见增高。

据我们所知，本报告首次描述了联合应用经胆囊管胆总管探查术（LTCBDE）与 FREDDY 激光碎石术清除胆总管结石的临床案例。本研究进一步验证了 FREDDY 激光系统在处理大型或嵌顿性胆总管结石时的实用性和高效性。与前述研究相比，我们对全部 32 例患者实现了 100%的胆管结石清除率，且无并发症发生。针对大型或嵌顿性结石患者，改良版 LTCBDE 联合 FREDDY 激光碎石术通过单次手术实现了麻醉暴露最小化和住院周期缩短。最关键的是，我们采用腹腔镜经胆囊管入路抵达胆总管，避免了胆总管切开术或括约肌切开术，从而彻底规避了 T 管留置或经内镜逆行胰胆管造影术（ERCP）相关并发症风险。

ORIGINAL ARTICLE

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Clinical role of frequency-doubled double-pulse neodymium YAG laser lithotripsy for removal of difficult biliary stones in laparoscopic common bile duct exploration

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Key words
difficult biliary stones, frequency-doubled double-pulse neodymium YAG laser lithotripsy, laparoscopic common bile duct exploration.

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Abstract

Background: The optimal methods for patients with difficult biliary stones remain under debate. The aim of this study was to evaluate the role of frequency-doubled double-pulse neodymium YAG (FREDDY) laser lithotripsy for removing difficult biliary stones during laparoscopic common bile duct exploration (LCBDE).
Methods: Between March 2013 and January 2015, 42 consecutive patients with difficult biliary stones who underwent LCBDE with FREDDY laser lithotripsy were included in this study. The clinical data of all patients were retrospectively collected and analysed.
Results: Bile ducts were completely cleared in all patients. The complications related to laser lithotripsy were not noted. A total of 38 patients (90.5%) underwent primary closure of common bile duct, and T-tube drainage was applied to four patients (9.5%). No bile duct injury, bleeding and perforation were observed. There were no post-operative surgery-related deaths. Bile leakage occurred in four patients (9.5%) with primary closure procedure, and all of them were managed successfully with conservative therapy. The median follow-up period was 42.8 months, with no evidence of bile duct stricture and stone recurrence in all patients.
Conclusions: The LCBDE combined with FREDDY laser lithotripsy appear to be effective and safe for the treatment of difficult biliary stones.

Introduction

Symptomatic biliary stones can lead to biliary colic, obstructive jaundice, cholangitis, pancreatitis, hepatic abscesses and secondary biliary cirrhosis,[1] which are common complex medical conditions leading to surgical or endoscopic intervention.[2] Traditionally, the preferred approach for patients with biliary stones includes endoscopic retrograde cholangiopancreatography (ERCP) with sphincterotomy and balloon and basket extraction. However, recently, accumulating data showed that laparoscopic common bile duct exploration (LCBDE) is a safer and more effective method for these patients with fewer ERCP-related short-term complications, such as haemorrhage, perforation and pancreatitis, and long-term adverse events caused by the permanent injury of Oddi sphincter, such as papillary stenosis, sine materia cholangitis, recurrent biliary stones and even possible malignant degeneration.[3–7] Moreover, as a one-stage method, LCBDE also has the advantages of faster post-operative recovery, shorter hospital stays and lower costs.[8,9]

Approximately 90% of biliary stones can be managed with conventional techniques; however, stone removal still failed in 10–15% of cases, mostly because of difficult biliary stones, which are commonly defined as large (>15 mm), multiple (>3), intrahepatic duct (IHD), barrel-shaped or impacted stones. For these patients, several methods are currently available to reduce the size of the stone before removal, such as mechanical lithotripsy, electrohydraulic lithotripsy (EHL), extracorporeal shock wave lithotripsy (ESWL), laser lithotripsy, etc. Of these, EHL and ESWL require direct visual control for the risk of damage to the bile duct wall, while laser lithotripsy has the advantage of relatively precise targeting of stones, which can reduce the risk of injury to the surrounding tissue.

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The frequency-doubled double-pulse neodymium YAG (FREDDY) laser is a short-pulse, double-frequency, low-cost laser with wavelengths of 532 and 1064 nm, which was designed specifically for endoscopic or laparoscopic lithotripsy without direct visual control, and it had been used to manage difficult biliary stones in ERCP or surgery where conventional techniques failed.[10–13] In this study, we aimed to evaluate the clinical value of FREDDY laser lithotripsy for the removal of difficult biliary stones in LCBDE.

Methods

Patients selection and clinical data

From 1 September 2011 to 30 December 2016, 542 consecutive LCBDE were performed for patients with biliary stones at the Department of Hepatobiliary and Pancreatic Surgery, Cholelithiasis Treatment Center, Shanghai Tenth People's Hospital, Tongji University of Medicine. Of these, we selected and retrospectively studied 42 patients with complete follow-up data who underwent LCBDE combined with FREDDY laser lithotripsy from March 2013 to January 2015. Patients with biliary stones preoperatively diagnosed by abdominal ultrasound, computed tomography scan, magnetic resonance cholangiopancreatography or ERCP and those with intraoperatively difficult to be managed with conventional stone extraction method were included.

Patients' clinical data regarding demographic characteristics, such as age; gender; body mass index; clinical symptoms; number; size and location of stones; number of impacted stones; American Society of Anesthesiologists scores; and intraoperative and post-operative records including operative time, estimated blood loss, bile duct bleeding or perforation, post-operative hospital stay, post-operative bile leakage, in-hospital morbidity and mortality, retained biliary stones, readmissions and follow-up data including bile duct stricture and stone recurrence, were reviewed and analysed retrospectively. The study was approved by the Institutional Review Board of Shanghai Tenth People's Hospital.

Operative procedures

The operation was performed under general anaesthesia with intravenous prophylactic antibiotic cover in the supine and left lateral position. A 30° angle laparoscope (Karl Storz, Tuttlingen, Germany) was introduced, and surgery was carried out with a standard four-port approach. After successfully dissecting Calot's triangle, the cystic artery was clipped and cut off. The cystic duct was dissected and clipped to avoid further passage of stones from the gallbladder into the common bile duct (CBD). Then, the CBD was confirmed with the needle aspiration of bile, and an approximately 1.0-cm longitudinal supraduodenal choledochotomy was made using hook scissors. The stones were extracted from the bile duct using a 5-mm flexible choledochoscope (Olympus, Tokyo, Japan) and an Anrei basket (AMH-RNBN2018; Anrui, Hangzhou, China).

If the biliary stones could not be extracted using conventional techniques, a FREDDY laser lithotripsy (U-100 system; World of Medicine, Berlin, Germany) was introduced to break the CBD stones into pieces. The tip of the FREDDY laser fibre is armed with a red aiming beam for accurate positioning on the surface of the stones and reducing the risk of the surrounding bile duct wall tissue injury. Then, the fragmented stones were retrieved using a basket or were irrigated with water, and a final choledochoscopy check was performed to again confirm the complete clearance of proximal and distal bile duct stones and the absence of bile duct mucosal injury. After confirming clearance of the bile duct stones, the choledochotomy were then closed with absorbable 4-0 PDS II sutures (Ethicon Inc., Somerville, NJ, USA) in a continuous fashion or using a T-tube drainage. At the end of the procedure, a silicone Jackson-Pratt drainage was routinely placed in the subhepatic space.

Follow-up and definitions

Post-operative mortality was defined as the number of deaths that occurred within 30 days after surgery or in hospital regardless of duration of hospital stay. The primary study outcome was the rate of technical success or effectiveness of the technique, defined as complete ductal clearance. Post-operative morbidity was defined as the number of complications occurring within 30 days of surgery. Complications were grouped according to the Clavien–Dindo classification.[14] The length of hospital stay was defined as the interval from the day of surgery to the day of discharge. Operative time was defined as the interval (minutes) from the first incision to closure of the last skin wound. Follow-up assessment using liver function tests and ultrasound or magnetic resonance cholangiopancreatography was performed at 2 weeks and 3 months after surgery.

Statistical analysis

Data were routinely recorded as mean ± SD. Comparisons between the two groups were made by unpaired two-tailed Student's *t*-tests using SPSS software (SPSS, Chicago, IL, USA). A *P*-value of <0.05 was regarded as significant.

Results

Patient characteristics

A total of 42 patients who underwent LCBDE with FREDDY laser lithotripsy for bile duct stones were identified. The demographic characteristics and clinical presentation of the patients are shown in Table S1. The most frequent presenting symptoms were abdominal pain (85.7%), jaundice (57.1%) and cholecystitis (76.2%). Other symptoms included cholangitis (19.1%); pancreatitis (33.3%); and ardent fever, nausea, vomiting, etc. A few patients had a prior cholecystectomy (16.7%), and 9.5% of patients underwent a prior ERCP attempt with failed ductal clearance. Most of the patients had more than one reason to perform LCBDE with FREDDY laser lithotripsy. These included large stones (>15 mm; 71.4%), multiple stones (≥3; 64.4%), impacted stones (28.6%), intrahepatic stones (4.8%), common hepatic duct (CHD) stones (4.8%), Mirrizi syndrome (4.8%) and other causes, such as operator discretion.

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Perioperative outcome

The operative outcomes are summarized in Table S2. All patients underwent choledochotomy; in all patients, complete ductal clearance was achieved using FREDDY laser lithotripsy, and the complications directly related to laser lithotripsy were not noted. The choledochotomy was primarily closed in 38 patients (90.5%), and a T-tube was inserted in the CBD incision of four patients (9.5%). Of these, 40 patients (95.2%) underwent a laparoscopic method to complete these procedures, and two patients (4.8%) underwent open surgery. The median operation time was appropriately 125 min, and the blood loss was estimated to be 75 mL. The mean post-operative hospital stay was 5.8 days, and mean time of drainage removal was 4.7 days. No cases of bile duct bleeding or perforation occurred, and no cases required further reoperation or readmission with 30 days. For the cases with T-tube placement, the tubes were removed after about 3–4 weeks. In addition, T-tube angiography and/or cholangioscopy through T-tube sinus were routinely performed before tube removal to prevent CBD stone residual. Only one patient was found to have a retained stone and was successfully removed through post-operative ERCP.

Post-operative complications and corresponding management are listed in Tables S2 and S3. There was no post-operative surgery-related death. Four patients (9.5%) experienced post-operative minor bile leakage and were all treated by conservative management, including drainage and intravenous antibiotics, with no further ERCP and other procedures performed, and all patients recovered and were finally discharged. One case of respiratory tract infection occurred, and another patient experienced urinary tract infection; both these patients were given antibiotics and recovered soon.

The median follow-up duration is 42.8 months, and no case is missing; the outcomes are shown in Table S4. No bile duct injury, stricture and stone recurrence were observed in any cases during the follow-up.

Discussion

Difficult biliary stones, including large, multiple and impacted stones; surgically altered anatomy; and strictures, are not unusual, and the clearance of difficult biliary stones is also challenging. In the past 20 years, ERCP has been widely used to clear the biliary stones using a standard extraction balloon or basket, the successful clearance rate of which has been reported to be 86–95%.[15] Recently, increasing studies have demonstrated that there is no statistically significant difference in the success clearance rate of biliary stone, morbidity and mortality between ERCP and LCBDE in such patients.[16–19] In addition, the LCBDE procedure preserves the function of the sphincter of Oddi, which reduces the risk of refluxing cholangitis, pancreatitis and stone recurrence.[5,18] A recent meta-analysis showed that LCBDE had a higher stones clearance rate, lower retained stone rate and lithiasis recurrence rate and lower hospital stays and less total charges than the ERCP procedure. Thus, the LCBDE should be considered the optimal treatment choice for the patient with cholecysto-choledocholithiasis.[20]

Currently, we can clear the biliary stones in LCBDE by using several medical instruments, such as tissue-grasping forceps, Dormia basket and water irrigation. As for the difficult biliary stone cases, including large or impacted stones, it is important to be aware of frequently used techniques, including cholangioscopically directed EHL, laser lithotripsy, ESWL, etc.

Of these, basket retrieval systems may increase the risk of bile duct mucosa injury.[21] EHL is an inexpensive technique used mainly for difficult biliary stones; however, there are many complications, such as recurrent jaundice, cholangitis, perforation and bleeding.[22] In a recent meta-analysis retrospective study on the clinical role of EHL, laser lithotripsy and ESWL in patients with retained biliary tract stones, the results showed that laser lithotripsy appeared to be the most successful advanced endoscopy-assisted lithotripsy technique for retained biliary tract stones. Moreover, a significantly lower post-procedural complication rate was found for laser lithotripsy and ESWL when compared with EHL.[23]

Several previous studies demonstrated that holmium laser lithotripsy was a safe and effective method to manage impacted biliary stones; however, it required continuous visual control of the fragmentation procedure because of the high energies with long pulse durations that are used; the probe contacting the bile duct wall may result in perforation, bleeding, biliary leakage and other serious complications.[21,24] Moreover, because of the inability of the surgeon to visualize the area, holmium laser lithotripsy should be ceased in severe intraoperative haemobilia, which is extremely hard to manage.[25] Furthermore, continuous saline perfusion was needed to ensure that the bile duct is not damaged by heat and also to contribute to the extraction of the gravel. In addition, holmium lasers are invisible and pose a potential hazard to the eyes, and exposure of unprotected skin also may lead to severe burns.[24]

FREDDY is an economical, short-pulsed, double-frequency solid-state laser with wavelengths of 532 and 1064 nm. Laser light at 532 nm (green spectrum) initiates plasma formation at the stone surface, while the infrared laser energy boosts this plasma to form a rapidly collapsing bubble, which produces a strong shockwave that fragments the stones. A recent published study on ERCP or percutaneous transhepatic cholangioscopy combined with FREDDY laser for the patients with biliary stones showed a high success clearance rate and low complication rate.[11] Liu et al. also reported that endoscopic biliary lithotripsy using the FREDDY laser with a radiopaque mark under fluoroscopic guidance be a safe and effective method for the treatment of difficult biliary stones.[13] Moreover, the method of FREDDY laser lithotripsy without direct visual control and low energy could reduce the risk of bile duct mucosa and surrounding tissue injury, which is safe, convenient and effective for patients with difficult biliary stones that could not be removed.[12]

In this retrospective study, 42 patients with difficult biliary stones underwent LCBDE with FREDDY laser lithotripsy; all patients completed bile duct stone clearance, no bile duct mucosa bleeding and perforation cases were observed during the operation, and no post-operative death occurred. Compared with the results of previous meta-analyses,[23] the ductal clearance rate of LCBDE with FREDDY laser lithotripsy (100%) in our study is higher than in those treated with EHL (88.4%) and ESWL (84.5%). However, the complication rate for the cases treated with LCBDE with FREDDY

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laser lithotripsy was lower than for the cases with EHL (13.8%) and ESWL (8.4%). Moreover, during the long-term follow-up, there were no cases with bile duct injury, stricture and stone recurrence in any patient.

Of these patients, 38 patients underwent primary closure, four patients underwent T-tube drainage placement, four patients demonstrated mild bile leakage in the group of primary closure (9.5%), and all patients were given conservation treatment and recovered soon. Bile leakage is a common complication in the LCBDE procedure with primary closure. Previous studies demonstrated that the bile leak rate was appropriately 2.5–6.8%.[4,26–28] To date, the risk factors for bile leakage after primary closure following LCBDE have not been fully discussed. Studies by Liu et al. showed that slender CBD and inexperienced surgeons were the high risk factors for bile leakage after primary closure following LCBDE.[29] Our previous retrospective study demonstrated that the diameter of CBD affected the incidence of bile leakage after primary closure following LCBDE.[7] In this study, we chose cases with difficult biliary stones that could cause bile duct wall oedema and increase the incidence of bile leakage after primary closure following LCBDE. However, all the cases with bile leakage could be managed with conservation treatment, and no serious complications occurred.

A previous retrospective study demonstrated that operative choledochoscopic FREDDY laser lithotripsy combined with or without hepatectomy is an effective and safe treatment for patients with hepatolithiasis.[30] In our study, two cases with CHD stones and two cases with IHD stones were all successfully treated by FREDDY laser lithotripsy, and no cases experienced intraoperative biliary tract bleeding, perforation, hepatectomy or conversion to open surgery. Thus, FREDDY laser lithotripsy was also a good option for the patients with IHD and CHD stones.

Considered together, LCBDE combined with cholangioscopically directed FREDDY laser lithotripsy system is a safe and effective technique for the treatment of patients with difficult biliary stones.

Conflicts of interest

None declared.

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Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Table S1. Patient baseline characteristics.
Table S2. Procedure outcomes.
Table S3. Post-operative complications and their management.
Table S4. Long-term outcomes following operation.

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双频双脉冲掺钕钇铝石榴石激光碎石术在腹腔镜胆总管探查术中治疗难治性胆管结石的临床作用

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摘要

背景：针对难治性胆管结石患者的最佳治疗方案仍存争议。本研究旨在评估倍频双脉冲掺钕钇铝石榴石（FREDDY）激光碎石术在腹腔镜下胆总管探查术（LCBDE）中处理难治性胆管结石的作用。

方法：2013 年 3 月至 2015 年 1 月期间，本研究连续纳入 42 例接受 LCBDE 联合 FREDDY 激光碎石术治疗的难治性胆管结石患者。对所有患者的临床资料进行回顾性收集与分析。

结果：所有患者胆管均实现完全清石。未发现与激光碎石相关的并发症。38 例患者（90.5%）实施胆总管一期缝合，4 例患者（9.5%）采用 T 管引流。未观察到胆管损伤、出血及穿孔病例。术后无手术相关死亡病例。4 例一期缝合患者（9.5%）发生胆漏，均经保守治疗成功控制。中位随访期 42.8 个月内，所有患者均未出现胆管狭窄及结石复发证据。

结论：LCBDE 联合 FREDDY 激光碎石术治疗难治性胆管结石具有显著疗效与安全性。

关键词：难治性胆管结石，双频双脉冲掺钕钇铝石榴石激光碎石术，腹腔镜下胆总管探查术

引言

有症状的胆道结石可引发胆绞痛、梗阻性黄疸、胆管炎、胰腺炎、肝脓肿及继发性胆汁性肝硬化等，这些常见复杂病症往往需要外科或内镜干预治疗。传统上，胆道结石患者的首选治疗方案包括内镜逆行胰胆管造影术（ERCP）配合括约肌切开术及球囊取石、网篮取石。然而最新累积数据显示，腹腔镜胆总管探查术（LCBDE）对此类患者更为安全有效，不仅能减少 ERCP 相关短期并发症（如出血、穿孔和胰腺炎），还能避免因 Oddi 括约肌永久性损伤导致的长期不良事件（如乳头狭窄、特发性胆管炎、结石复发甚至可能的恶变）。此外，作为一期手术方案，LCBDE 还具有术后恢复快、住院时间短和治疗成本低的优势。

约 90% 的胆道结石可通过常规技术处理；然而仍有 10%–15% 的病例取石失败，主要归因于难治性胆道结石——这类结石通常被定义为大结石（>15 毫米）、多发结石（>3 枚）、肝内胆管结石、桶状结石或嵌顿结石。针对这类患者，目前可采用多种方法在取石前进行碎石，例如机械碎石术、液电碎石术（EHL）、体外冲击波碎石术（ESWL）、激光碎石术等。其中

EHL 与 ESWL 因存在胆管壁损伤风险需在直视下操作，而激光碎石术具有相对精确的结石定位优势，可降低周围组织损伤风险。

双频双脉冲钕钇铝石榴石激光（FREDDY 激光）是一种短脉冲、双频、低成本的激光设备，输出波长为 532 纳米和 1064 纳米。该激光专为无需直视控制的内镜或腹腔镜碎石术设计，此前已应用于 ERCP 或手术中处理常规技术难以应对的复杂性胆道结石。本研究旨在评估 FREDDY 激光碎石术在腹腔镜胆总管探查术（LCBDE）中处理复杂性胆道结石的临床价值。

方法

患者筛选与临床数据

2011 年 9 月 1 日至 2016 年 12 月 30 日期间，同济大学医学院附属第十人民医院肝胆胰外科胆石症治疗中心连续为胆道结石患者实施了 542 例腹腔镜胆总管探查术（LCBDE）。其中，我们筛选并回顾性研究了 2013 年 3 月至 2015 年 1 月期间接受 LCBDE 联合 FREDDY 激光碎石术、且具有完整随访资料的 42 例患者。纳入标准包括：术前经腹部超声、计算机体层摄影扫描、磁共振胰胆管造影或 ERCP 确诊为胆道结石，以及术中发现常规取石方法难以处理的病例。

患者临床数据包括人口统计学特征（如年龄、性别、身体肿块指数）、临床症状、结石数量/大小/位置、嵌顿结石数量、美国麻醉医师协会评分，以及术中术后记录（含手术时长、预估失血量、胆管出血或穿孔、术后住院天数、术后胆漏、院内并发症及死亡率、胆道残留结石、再入院情况），并对随访数据（含胆管狭窄与结石复发）进行回顾性分析。本研究经上海市第十人民医院机构审查委员会批准。

手术操作流程

手术在全身麻醉下进行，采取仰卧位及左侧卧位，并静脉预防性使用抗生素。术中采用 30 度角腹腔镜（德国卡尔史托斯公司）实施标准四孔法操作。成功解剖 Calot 三角后，钳夹并离断胆囊动脉。随后分离并夹闭胆囊管，以防止结石从胆囊进一步进入胆总管（CBD）。接着通过针吸胆汁确认胆总管位置，使用钩剪在十二指肠上方纵向切开约 1.0 厘米的胆总管。采用 5 毫米可弯曲胆道镜（日本奥林巴斯公司）配合安瑞取石篮（型号 AMH-RNBN2018，中国杭州安瑞医疗）从胆管中取出结石。

若常规技术无法取出胆道结石，则采用 FREDDY 激光碎石系统（U-100 型，德国柏林 World of Medicine 公司）进行胆总管碎石。FREDDY 激光光纤顶端配备红色瞄准光束，可精确定位结石表面，降低周围胆管壁组织损伤风险。随后使用取石篮或生理盐水冲洗取出碎石，并再次行胆道镜检查以确认近端及远端胆管结石完全清除且无胆管黏膜损伤。确认胆管结石清除后，采用可吸收 4-0 PDS II 缝线（美国新泽西州 Somerville 市 Ethicon 公司）连续缝合胆总管切口或留置 T 管引流。术毕常规于肝下间隙放置硅胶 Jackson-Pratt 引流管。

随访与定义

术后死亡率定义为手术后 30 天内或住院期间发生的死亡人数，不论住院时间长短。主要研究结果是技术成功率或技术有效性，定义为完全清除胆管。术后发病率定义为手术后 30 天内发生的并发症数量。并发症根据 Clavien-Dindo 分类法进行分组。住院时间定义为从手术当天到出院当天的间隔。手术时间定义为从首次切口到最后皮肤伤口闭合的间隔（分钟）。

术后 2 周和 3 个月通过肝功能检查及超声或磁共振胰胆管造影进行随访评估。

统计分析

数据常规记录为均值±标准差。两组间比较采用 SPSS 软件（美国伊利诺伊州芝加哥市 SPSS 公司）进行非配对双尾 Student's t 检验。P 值<0.05 视为具有统计学意义。

结果

患者特征

共纳入 42 例接受经胆总管激光碎石术（LCBDE）联合 FREDDY 激光碎石治疗的胆管结石患者。患者人口学特征与临床表现详见表 S1。最常见症状为腹痛（85.7%）、黄疸（57.1%）和胆囊炎（76.2%）。其他症状包括胆管炎（19.1%）、胰腺炎（33.3%），以及高热、恶心、呕吐等。16.7%的患者曾接受胆囊切除术，9.5%的患者既往尝试 ERCP 取石未成功。多数患者存在多项 LCBDE 联合 FREDDY 激光碎石术的适应证，包括大结石（>15mm；71.4%）、多发结石（≥3 枚；64.4%）、嵌顿结石（28.6%）、肝内胆管结石（4.8%）、肝总管结石（4.8%）、Mirizzi 综合征（4.8%）及其他由术者判断的情况。

围手术期结果

手术结果总结于表 S2 中。所有患者均接受胆总管切开术；通过 FREDDY 激光碎石术实现全部患者胆管完全清理，未发现与激光碎石直接相关的并发症。38 例患者（90.5%）采用胆总管一期缝合，4 例患者（9.5%）在胆总管切口处留置 T 管。其中 40 例患者（95.2%）通过腹腔镜完成手术，2 例患者（4.8%）实施开腹手术。中位手术时间为 125 分钟，预估失血量 75 毫升。术后平均住院天数 5.8 天，引流管拔除平均时间 4.7 天。未发生胆管出血或穿孔病例，30 天内无需要再次手术或再入院的病例。留置 T 管病例在 3-4 周后拔管，拔管前常规进行 T 管造影和/或经 T 管窦道胆道镜检查以防止胆总管残余结石。仅 1 例患者发现残留结石，通过术后 ERCP 成功取出。

术后并发症及对应处理措施详见表 S2 和 S3。全组无手术相关死亡病例。4 例患者（9.5%）出现术后轻度胆漏，均通过保守治疗（包括引流和静脉抗生素）痊愈，未行进一步 ERCP 或其他介入操作，所有患者均康复出院。另发生 1 例呼吸道感染和 1 例尿路感染，经抗生素治疗后均很快康复。

中位随访时限为 42.8 个月，无病例缺失；结果如表 S4 所示。在随访期间，所有病例均未观察到胆管损伤、狭窄及结石复发情况。

讨论

疑难胆道结石（包括巨大结石、多发结石及嵌顿性结石）、术后解剖结构改变以及胆管狭窄等情况在临床上并不罕见，而这类复杂胆道结石的清除也颇具挑战性。过去 20 年间，经内镜逆行胰胆管造影术（ERCP）通过标准取石球囊或取石篮被广泛应用于胆道结石清除，文献报道其结石清除成功率达 86%-95%。最新研究表明，对于此类患者，ERCP 与腹腔镜胆总管探查术（LCBDE）在结石清除成功率、并发症发生率及死亡率方面均无统计学差异。此外，LCBDE 手术能保留 Oddi 括约肌功能，从而降低反流性胆管炎、胰腺炎及结石复发的风

险。近期一项荟萃分析显示，与 ERCP 相比，LCBDE 具有更高的结石清除率、更低的残余结石率及结石复发率，同时住院时间更短、总治疗费用更低。因此对于胆囊合并胆总管结石患者，LCBDE 应被视为首选治疗方案。

目前，我们可以通过使用多种医疗器械清除胆总管探查术中的胆道结石，如组织抓钳、Dormia 取石篮和冲洗水。对于困难的胆道结石病例，包括大结石或嵌顿结石，需掌握常用技术手段，如胆道镜引导下液电碎石术、激光碎石术、体外冲击波碎石术等。

其中，取石篮系统可能增加胆管黏膜损伤的风险。电液压碎石术（EHL）是一种主要用于困难胆管结石的低成本技术；然而该技术存在诸多并发症，如复发性黄疸、胆管炎、穿孔及出血。近期一项关于 EHL、激光碎石术和体外冲击波碎石术（ESWL）在胆道残留结石患者中临床作用的 meta 分析回顾性研究显示，激光碎石术似乎是治疗胆道残留结石最成功的术中镜辅助碎石技术。此外，与 EHL 相比，激光碎石术和 ESWL 的术后并发症发生率显著更低。

先前多项研究表明，钬激光碎石术是处理顽固性胆管结石的安全有效方法；然而由于该技术采用高能量长脉冲持续时间，需要持续视觉监控碎石过程——若探头接触胆管壁可能导致穿孔、出血、胆漏等严重并发症。此外，当术中出现难以处理的严重胆道出血时，因外科医生无法直视术野，必须中止钬激光碎石操作。该技术还需持续生理盐水灌注，既防止胆管热损伤，也有助于碎石颗粒清除。值得注意的是，钬激光具有不可见性，可能对眼睛造成潜在危害，未受保护的皮肤暴露于激光下也可能导致重度烧伤。

FREDDY 是一种经济型短脉冲双频固态激光器，其波长为 532 纳米和 1064 纳米。532 纳米（绿色光谱）的激光在结石表面引发等离子体形成，而红外激光能量则助推该等离子体形成快速坍缩的气泡，从而产生强烈的冲击波使结石碎裂。近期一项关于 ERCP 或经皮经肝胆道镜联合 FREDDY 激光治疗胆道结石患者的研究显示，该技术具有较高的结石清除成功率和较低的并发症发生率。刘等人也报道称，在透视引导下使用带有不透射线标记的 FREDDY 激光进行内镜下胆道碎石术，是治疗困难性胆道结石安全有效的方法。此外，无需直接视觉监控且采用低能量的 FREDDY 激光碎石术可降低胆管黏膜及周围组织损伤风险，对于无法切出的困难性胆道结石患者而言，该方法安全、便捷且有效。

在这项回顾性研究中，42 例难治性胆管结石患者接受了腹腔镜胆总管探查术（LCBDE）联合 FREDDY 激光碎石治疗。所有患者均完成胆管结石清除，术中未观察到胆管黏膜出血及穿孔病例，且无术后死亡发生。与既往荟萃分析结果相比，本研究中采用 FREDDY 激光碎石的 LCBDE 治疗胆管清除率（100%）高于电子液压碎石（EHL）的 88.4% 和体外冲击波碎石（ESWL）的 84.5%。此外，FREDDY 激光碎石治疗的并发症发生率低于 EHL（13.8%）和 ESWL（8.4%）病例。值得注意的是，在长期随访期间，所有患者均未出现胆管损伤、狭窄及结石复发的情况。

在这组患者中，38 例接受了一期关闭手术，4 例实施了 T 管引流置入术。一期关闭组中有 2 例（5.3%）出现轻度胆漏，所有患者经保守治疗后均很快康复。胆漏是胆总管探查术后术（LCBDE）中一期关闭术式的常见并发症。既往研究表明，胆漏发生率约为 2.5%-6.3%。目前关于 LCBDE 术后一期关闭发生胆漏的危险因素尚未充分探讨。刘氏团队研究指出，胆总管纤细和术者经验不足是 LCBDE 术后一期关闭发生胆漏的高危因素。我们前期的回顾性研究证实，胆总管直径会影响 LCBDE 术后一期关闭的胆漏发生率。本研究特别选取了可能引起胆管壁水肿、增加 LCBDE 术后一期关闭胆漏发生率的困难胆管结石病例。但所有胆漏病例经保守治疗均得到有效控制，未出现严重并发症。

先前一项回顾性研究表明，术中胆道镜 FREDDY 激光碎石术联合或不联合肝叶切除术，对肝内胆管结石患者是一种安全有效的治疗方式。本研究中，2 例胆总管结石患者与 2 例肝内胆管结石患者均通过 FREDDY 激光碎石术成功治疗，未出现术中胆道出血、穿孔、肝叶切除术或中转开腹手术病例。因此，FREDDY 激光碎石术同样是治疗肝内胆管及胆总管结石患

者的理想选择。

综合来看，胆总管探查术联合胆道镜引导下的 FREDDY 激光碎石系统，是治疗复杂胆道结石患者安全有效的技术方案。

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Safety and efficacy of laparoscopic common bile duct exploration for the patients with difficult biliary stones: 8 years of experiences at a single institution and literature review

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Abstract

Background Laparoscopic common bile duct exploration (LCBDE) has gained wide popularity for the treatment of choledocholithiasis. However, it remains unclear whether LCBDE is a better alternative option for the patients with difficult biliary stones. Thus, the aim of the present study was to explore the safety and efficacy of LCBDE for these patients by retrospectively analyzing our data and combing with literature review.

Methods Between September 2011 and February 2019, 1064 consecutive patients who underwent LCBDE at Shanghai Tenth People's Hospital were reviewed. The clinical data of patients with difficult biliary stones were selected and retrospectively analyzed.

Results Of these patients, 334 cases were confirmed with difficult biliary stones, and the overall complete stone clearance rate was 98.8% (330/334). 34 cases (10.2%) were performed with laser lithotripsy. A total of 296 patients (88.6%) underwent primary closure of common bile duct, and T-tube drainage was indwelled in 38 patients (11.4%). No bile duct injury, bleeding, perforation and surgery-related deaths were observed. The overall morbidity rate was 6.6%. 16 cases (4.8%) occurred in bile leakage with primary closure procedure, and all of them were managed successfully with conservative therapy. The median follow-up period was 9 months with stone recurrence occurring in 9 patients (2.7%). There was no evidence of bile duct stricture in all cases.

Conclusions The current study suggests that LCBED is a considerable safe and effective option for the patients with difficult biliary stones. A randomized clinical trial is needed to further evaluate the benefit of LCBDE in this subgroup.

Keywords LCBDE · Choledocholithiasis · Difficult biliary stones

Choledocholithiasis is a very common disease in clinic, which accounts for significant morbidity and mortality due to life-threating biliary pancreatitis, cholangitis, cholecystitis, and gallstone ileus [1]. Approximately 15% of symptomatic gallstones or acute cholecystitis occur with choledocholithiasis [2]. At present, endoscopic retrograde cholangiopancreatography (ERCP) is the mainstream method to treat choledocholithiasis and is widely favored by endoscopic expertise [3, 4]. However, in about 10–15% of cases, biliary stones cannot be successfully removed by conventional ERCP, mostly because of difficult biliary stones, which are commonly defined as large (> 15 mm), multiple (> 3), intrahepatic duct (IHD), barrel-shaped or impacted stones [5–7]. Moreover, notably, the sphincter of Oddi can be injured permanently by ERCP, which could cause the reflux of duodenal juice, resulting in recurrence of choledocholithiasis, recurrent episodes of cholangitis, and even biliary malignancies [8–10]. In addition, a series of complications, such as pancreatitis, bleeding, and perforation, can also result from ERCP [11–13].

In recent years, laparoscopic common bile duct exploration (LCBDE) has increasingly been proven to be a safer and more effective method for choledocholithiasis with fewer

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short-term and long-term complications [14–17]. In addition, as a one-stage method, LCBDE also has the advantages of faster postoperative recovery, shorter hospital stays, and lower costs [4]. However, it remains unclear whether LCBDE is safe and effective for the patients with difficult biliary stones, which is rarely reported in the literature. Thus, in this study, we aimed to explore the efficacy and safety of LCBDE for the patients with difficult biliary stones.

Materials and methods

Patients and data collection

The cohort of this retrospective study included 1064 patients who underwent LCBDE at the Department of General Surgery of Shanghai Tenth People's Hospital from January 2011 to February 2019. LCBDE was performed for patients with a diagnosis of choledocholithiasis confirmed by abdominal ultrasonography, computed tomography, magnetic resonance cholangiopancreatography, or ERCP, or intraoperatively by cholangiography ultrasonography. Difficult biliary stones are defined as large (> 15 mm), multiple (> 3), or impacted in the biliary duct, as well as those with Mirizzi's syndrome, any common bile duct (CBD)-associated anatomical abnormality, such as a stricture below the stone, or patients with altered anatomy, such as periampullary diverticulum, Roux-en-Y gastric bypass, Billroth-II anatomy, duodenal stricture, or intrahepatic stones [5, 18–20]. The clinical data, including demographic information, medical history (with particular attention to any biliary pathology), symptoms, morbidity, mortality, and follow-up information were collected and reviewed. Data of patients with difficult biliary stones were selected and retrospectively analyzed. The study protocol was approved by the Institutional Review Board of Shanghai Tenth People's Hospital. Informed consent was waived due to the retrospective nature of this study, and data were analyzed anonymously.

Surgical technique

The LCBDE procedure has been described in detail in our previous articles [17, 21]. Briefly, the patient was placed in the supine position, and the surgery was performed using a "four-port and six-step" approach (Fig. 1A–F). After the Calot's triangle was dissected clearly, the cystic duct was usually clamped. Then, the longitudinal supraduodenal choledochotomy was conducted, a choledochoscope (CHF-V; Olympus Corporation, Tokyo, Japan) was passed through the CBD to detect stones. The stones were most commonly extracted by using a Dormia basket (FG-24X-1; Olympus) and water flushing or irrigation. Choledochoscopy was performed repeatedly to confirm the complete clearance of the proximal and distal ducts. The incision of CBD was primarily closed with absorbable 4–0 PDS® II (polydioxanone) sutures (Ethicon Inc., Somerville, NJ, USA) in a continuous over-and-over locking fashion. And then, the gallbladder resected routinely. At last, an abdominal drainage was placed in subhepatic location.

For the cases with large, multiple, or impacted stones, which might be difficult to extracted with routine methods, the FREDDY (World of Medicine GmbH, Berlin, Germany) laser lithotripsy was usually applied to fragment the stones and make it easier to extract (Fig. 1G–H). A T-tube drainage was selectively placed into the CBD for the cases with severe cholangitis, severe edema of CBD wall, and suspicious stones retain (Fig. 1I). Sometimes, conversion to open surgery was also necessary when encountering severe dense adhesions or an altered anatomy. Thus, in our center, we could take different measures and provide individualized treatment, which called "Tongji Tenth Hospital Solutions" for the patients with choledocholithiasis (Fig. 2).

Outcome definitions and follow-up

The interval between the first incision and closure of the last skin wound was defined as the surgical duration. Postoperative mortality was defined as the ratio of the number of deaths to the total population within 30 days after surgery or during hospitalization. Postoperative morbidity was defined as the ratio of the number of complications occurred within 30 days of surgery to the total population. Complications were grouped and graded according to the Dindo–Clavien classification [22, 23]. Postoperative bile leakage was defined and graded according to the International Study Group of Liver Surgery [24]. Every patient was followed up for more than 6 months after surgery, with the first and second follow-up examinations conducted at 2 weeks and 3 months in the outpatient clinic. Afterward, the patients were contacted by telephone every 3 months. Interviews inquiring about the patient's general condition, diet, surgery-related discomfort, and liver function, as well as radiological examinations were conducted to screen for adverse events and detect possible bile duct stricture or stone recurrence.

Statistical analysis

All data analyses were performed using IBM SPSS Statistics for Windows, version 22.0. (IBM Corporation, Armonk, NY, USA). All continuous values were presented as the mean ± standard deviation (SD). Statistical analysis was carried out by using the independent sample t test for continuous data or the Pearson χ^2 test for categorical data. A probability (p) value of < 0.05 was considered statistically significant.

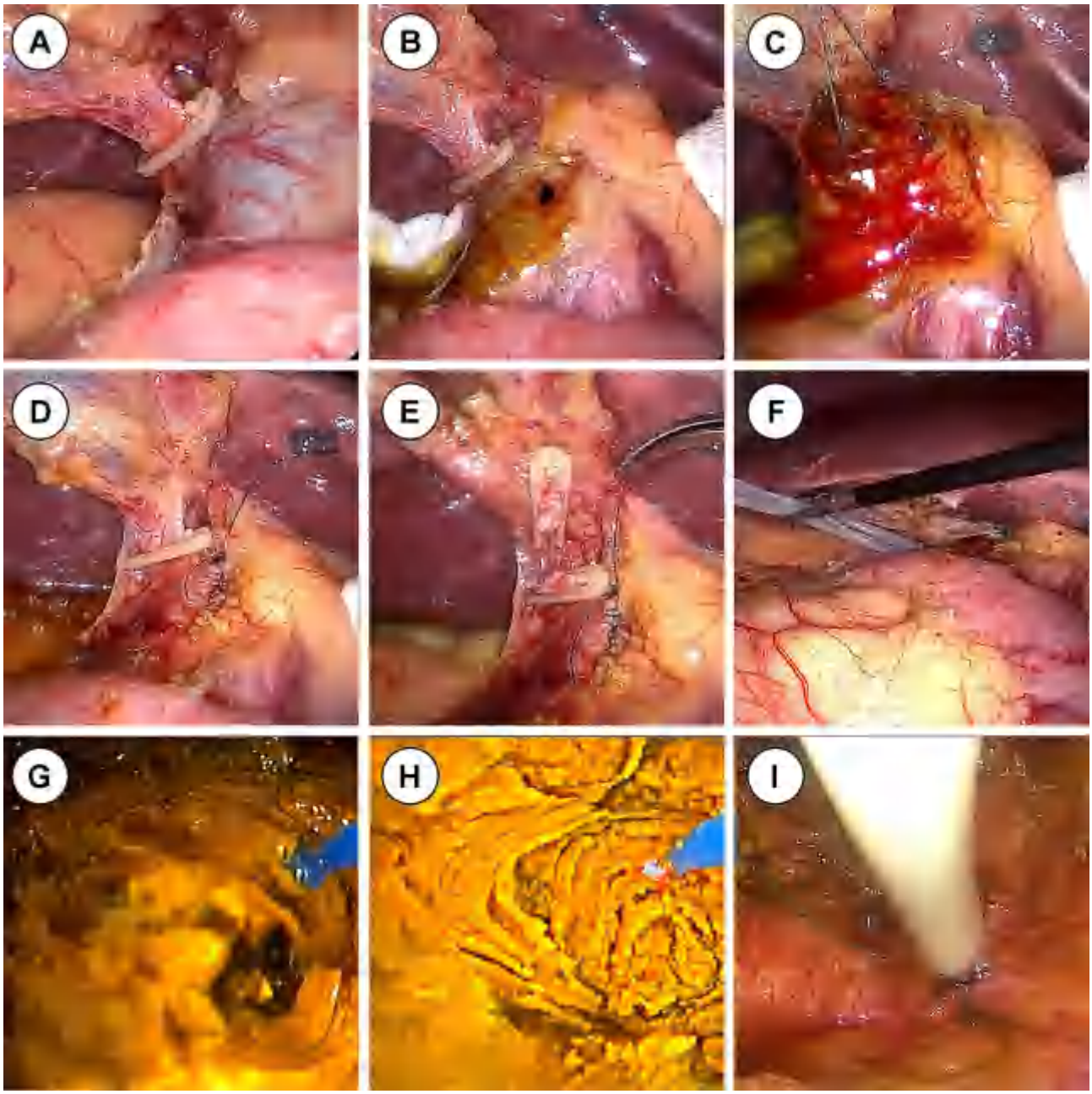


Fig. 1 **A** Dissected and separated the Calot's triangle, the cystic duct was clamped; **B**, **C** longitudinal supraduodenal choledochotomy was conducted, and choledochoscope was passed through the CBD; **D** the small incision to the CBD was primarily closed; **E** the gallbladder and the CBD stones were retrieved; **F** An abdominal drainage was placed in a subhepatic location; **G**, **H** laser lithotripsy was applied to clear difficult biliary stones; **I** A T-tube drainage was selectively inserted into the CBD incision

Results

During the study period, a total of 1064 consecutive patients underwent elective or emergency LCBDE for choledocholithiasis. Difficult biliary stones were confirmed with 334 patients and defined as large (> 15 mm, 17.1%), multiple (> 3, 71.3%), or impacted (22.1%), occurring in the intrahepatic duct (5.1%), cystic duct (5.7%), or in more than one location (9.9%), or with Mirizzi syndrome (3.3%). The demographic characteristics and clinical presentations of the patients with difficult biliary stones are presented in Table 1. The most frequent presenting symptoms were abdominal pain (90.7%), cholangitis (37.7%), jaundice (34.4%), pancreatitis (3.9%), nausea, vomiting, and abnormal liver function tests. About 3.9% of the patients previously underwent cholecystectomy and

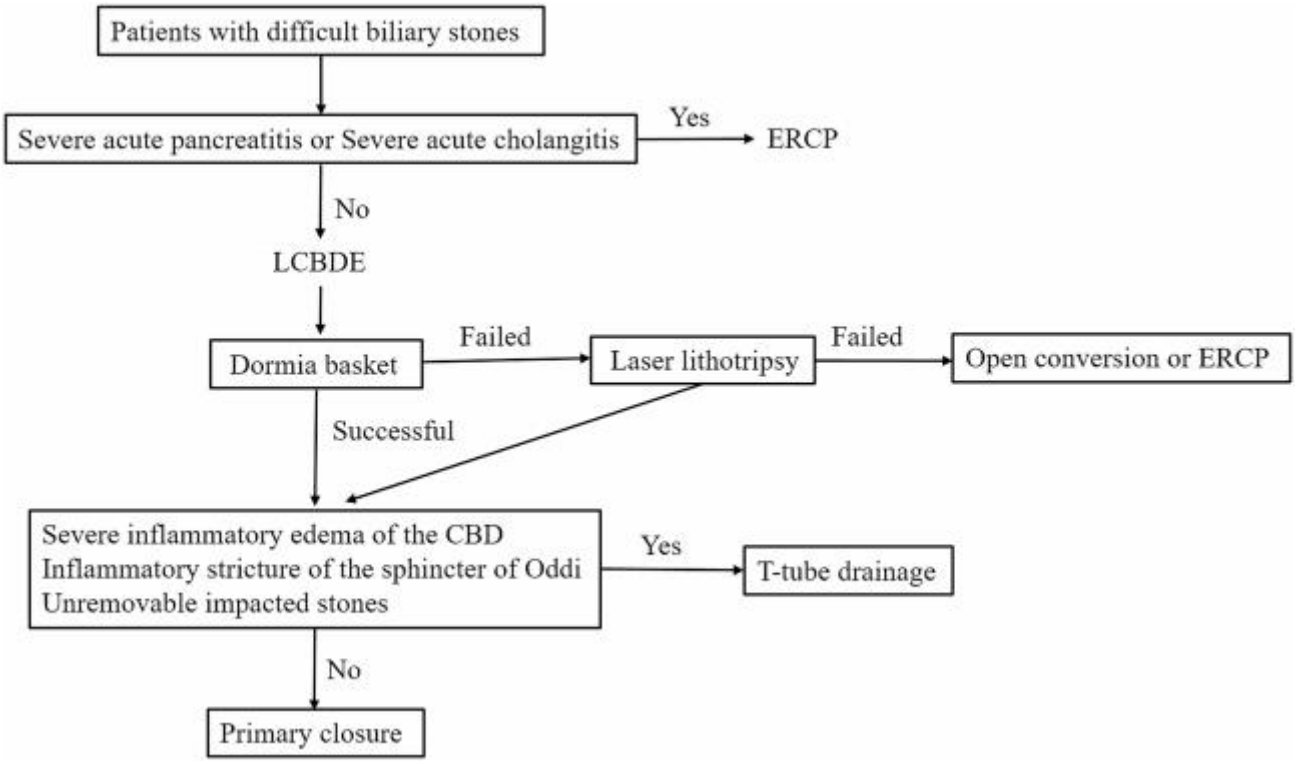


Fig. 2 Algorithm for the management of difficult biliary stones in our institution. *LCBDE* laparoscopic common bile duct exploration; *ERCP* endoscopic retrograde cholangiopancreatography; *CBD* common bile duct

6.6% underwent a prior ERCP attempt, but removal of biliary stones had failed.

The surgical outcomes are summarized in Table 2. In 330 (98.8%) cases, difficult biliary stones were successfully extracted by LCBDE. The procedure was finished with primary closure and a T-tube drainage in 296 (88.6%) patients and 38 (11.4%) patients, respectively. In total, 15 (4.5%) patients were converted to open surgery because of dense adhesions and unclear anatomy, large impacted stones, Mirizzi syndrome, cholecystoduodenal fistula, injury to the subvesical bile duct, or hypercapnia. The mean surgical duration was 150.2 (range, 43–466) min, and the mean blood loss volume was 36.78 ± 33.89 mL. Perioperative bleeding of the bile duct did not occur in any patient, and perioperative bile duct perforation occurred in only one. The overall morbidity rate was 6.6%, and the rate of bile leakage was 4.8%. One patient died from severe infection caused by bile leakage. The mean postoperative hospital stay was 7.668 ± 4.147 days, and the mean time to drain removal was 5.509 ± 3.15 days. Three patients were readmitted within 30 days after surgery and underwent a second operation.

LCBDE with laser lithotripsy was performed for all 34 patients with difficult biliary stones that could not be extracted with the use of a Dormia basket and water flushing or irrigation (Table 2). The successful stone clearance rate was 97.1%. The surgical duration, blood loss, postoperative hospital stay, and time of drain removal were significantly increased in the LCBDE with laser lithotripsy group. The rate of primary closure was significantly decreased after laser lithotripsy, but there was no effect on the morbidity rate, including the rate of bile leakage. Furthermore, there were no significant differences in the occurrences of perioperative bile duct bleeding, perioperative bile duct perforation, conversion to open surgery, readmission within 30 days, mortality, and re-operation between the two groups. Thus, LCBDE with the laser lithotripsy did not increase the morbidity and mortality rates.

As described in Table 3, postoperative complications occurred in 22 patients (6.6%). The rate of bile leakage was 4.8%. For 11 patients with bile leakage, no further action was required, or intravenous and oral antibiotics were administered, and the leakage site had closed spontaneously. Ultrasound-guided peritoneal puncture and drainage combined with administration of intravenous and oral antibiotics were performed for three patients with bile leakage. In these patients, the leakage site had spontaneously closed within 2 weeks. The two patients with severe bile leakage were transferred to the intensive care unit for management of severe infection. Of these two patients, one

Table 1 Patient baseline characteristics

Patient details	Total ($n=334$)
Female Sex, *n* (%)	180 (53.9)
Age, mean (range)	63 (20–91)
BMI (kg/m^2), mean ± SD	23.57 ± 2.957
Symptoms, *n* (%)	
Abdominal pain	303 (90.7)
Jaundice	115 (34.4)
Cholecystitis	243 (72.8)
Cholangitis	126 (37.7)
Pancreatitis	13 (3.9)
ASA Scores, mean (range)	2 (1–3)
Upper abdominal operation history, *n* (%)	38 (11.4)
Post-cholecystectomy, *n* (%)	13 (3.9)
Failed to extract stone with ERCP/sphincterotomy, *n* (%)	22 (6.6)
Biliary stone characteristics	
Large stone (> 15 mm), *n* (%)	57 (17.1)
Stone number > 3, *n* (%)	238 (71.3)
Stone location, *n* (%)	
CHD, *n* (%)	19 (5.7)
IHD, *n* (%)	17 (5.1)
More than 1 location, *n* (%)	33 (9.9)
Stone impaction, n (%)	74 (22.1)
Altered anatomy	13 (3.9)
Roux-en-Y gastric bypass	6 (1.8)
Billroth-II anatomy	7 (2.1)
Mirrizi syndrome, *n* (%)	11(3.3)
Stone size, mm (mean ± SD)	10.44 ± 5.888
CBD diameter (mm) (mean ± SD)	12.39 ± 3.492

SD standard deviation; *CHD* common hepatic duct; *IHD* intrahepatic duct; *ERCP* endoscopic retrograde cholangiopancreatography

was discharge after improvement, and the other one died due to severe infection.

Follow-up outcomes are summarized in Table 4, and 334 (100%) patients were followed up. During the follow-up period, the rate of bile duct stricture was 0, and 9 (2.7%) patients had stone recurrence. Of these patients, stones were successfully removed by ERCP in five and by re-operation in two.

Discussion

Approximately 5–15% of patients undergoing cholecystectomy are diagnosed to have concurrent biliary stones [2, 25–27]. In the past 20 years, with the rapid advances of endoscopic techniques, two-stage endoscopic retrograde cholangiopancreatography (ERCP) stone extraction followed by laparoscopic cholecystectomy has increasingly become the mainstream treatment model for these patients [3]. As reported previously, ERCP is a highly effective method with successful clearance rate of 86–95% for managing biliary stones [19, 20]. However, a variety of reasons, which were defined as difficult biliary stones, make the stone extraction challenging, including large size (> 1.5 cm), multiple number (> 3), irregular shape, difficult location, and altered anatomy [5–7, 19, 20, 28]. Although several additional techniques, such as mechanical lithotripsy (ML), endoscopic papillary large balloon dilation (EPLBD), cholangioscopy-guided lithotripsy (CGL), electrohydraulic lithotripsy (EHL), and laser lithotripsy (LL), have been developed to assist with extraction, the clearance rate of ERCP procedure for these patients was just range from 77 to 90% [19].

In recent years, accumulating data have demonstrated that LCBDE have not only the same clearance rata to ERCP for the patients with biliary stone, but it prevents the Oddi sphincter from injury, which reduces the risk of short-term complications, such as hemorrhage, perforation and pancreatitis, and long-term adverse events, such as papillary stenosis, refluxing cholangitis, stone recurrence, and even possible malignant degeneration [29–31]. In addition, LCBDE also has the advantages of shorter hospital stays and less total costs than ERCP procedure [32–34]. Therefore, the LCBDE has been considered as a safe, effective, and optimal treatment choice for the patients with concomitant gallbladder stones and common bile duct stones. However, at present, it is rarely reported in the literatures on the safety and efficacy of LCBDE for the patients with difficult biliary stones, which are defined as large (> 15 mm), multiple (> 3), or impacted biliary stones, as well as those with Mirizzi's syndrome, biliary stricture, and altered anatomy, such as periampullary diverticulum, Roux-en-Y gastric bypass reconstruction, Billroth-II reconstruction. Thus, we reviewed the data of these patients from our center who underwent LCBDE procedure and analyzed the perioperative safety and the short-term and long-term clinical efficacy. Our data showed that the total clearance rate of LCBDE for the difficult biliary stone is 98.8% (330/334), and the overall postoperative morbidity is 6.6% (22/334). No biliary injury, bleeding, and perforation were observed, and there were no postoperative surgery-related deaths occurred. Of these patients, 296 cases (88.6%) underwent bile duct primary closure procedure, 38 cases (10.4%) underwent indwelling T-tube drainage, and bile leakage occurred in 16 cases (4.8%). The median follow-up period was 8.9 months, with no evidence of bile duct stricture in all patients, and only 9 cases (2.7%) recurred biliary stones.

At present, ERCP is highly effective for treating biliary stones; however, for the cases with difficult stones, conventional techniques such as endoscopic sphincterotomy (EST) with balloon/basket assisted extraction may fail to retrieve stones in 10% to 15% of cases [25]. Recently, overwhelming

Table 2 Operative outcomes of laparoscopic bile duct exploration

Outcomes	Total ($n=334$)	Laser lithotripsy groups ($n=34$)	Routine methods* groups ($n=300$)	P
Operation time, min (mean ± SD)	150.2 (43–466)	221 (60–466)	142.2 (43–357)	< 0.0001
Perioperative bile duct bleeding	0	0	0	1
Perioperative bile duct perforation, *n* (%)	1 (0.3)	0	1 (0.3)	1
Choledochotomy and primary closure, *n* (%)	296 (88.6)	23 (67.6)	273 (91)	< 0.0001
Choledochotomy and T-tube drainage, *n* (%)	38 (11.4)	11 (32.4)	27 (9)	< 0.0001
Conversion to open surgery, *n* (%)	15 (4.5)	1 (3)	14 (4.7)	0.981
Estimated blood loss, ml (mean ± SD)	36.78 ± 33.89	50 ± 39.31	35.1 ± 32.91	0.0148
Complete bile duct clearance, *n* (%)	330 (98.8)	33 (97.1)	297 (99)	0.35
Morbidity, *n* (%)	22 (6.6)	3 (8.8)	19 (6.3)	0.849
Postoperative bile leakage, *n* (%)	16 (4.8)	2 (5.9)	14 (4.7)	1
Postoperative hospital stays, days	7.668 ± 4.147	9.059 ± 4.141	7.512 ± 4.132	0.0394
Time of drainage removal, days	5.509 ± 3.15	6.529 ± 2.873	5.393 ± 3.163	0.0461
Retained CBD stone, *n* (%)	4 (1.2)	1 (3)	3 (1)	0.35
Readmission within 30 days, *n* (%)	3 (0.9)	1 (3)	2 (0.7)	0.276
Re-operation, *n* (%)	3 (0.9)	0	3 (1)	1
Mortality, *n* (%)	1 (0.3)	1 (3)	0	0.102

*Laparoscopic common bile duct exploration with Dormia basket, water flushing or irrigation technique

Table 3 Postoperative complications and clinical management

Dindo–Clavien[a] classification	Number of patients	Complication	Management
1	7	Bile leakage	Conservative*
2	4	Bile leakage	Intravenous and oral antibiotics
	3	Respiratory tract infection	Intravenous and oral antibiotics
	2	Urinary tract infection	Intravenous antibiotics
	1	Wound infection	Surgical dressing change
3a	3	Bile leakage	Ultrasound-guided peritoneal puncture and drainage + intravenous and oral antibiotics
3b			
4a	1	Bile leakage	Intensive care unit management
4b	1	Bile leakage	Intensive care unit management

[a]Clavien classification: Grade I: any deviation from the normal postoperative course without the need for pharmacological treatment or surgical, endoscopic, and radiological interventions. Grade II: requiring pharmacological treatment with drugs other than such allowed for Grade I complications. Grade III: requiring surgical, endoscopic, or radiological intervention: IIIa, intervention not under general anesthesia; IIIb, intervention under general anesthesia. Grade IV: life-threatening complications requiring intensive care unit management. *SSSI* skin and skin structure infection

*Conservative management: no antibiotics or further action were required and the leakage site had closed spontaneously

results of studies have demonstrated that endoscopic papillary large balloon dilation (EPLBD), which was first described by Ersoz et al. in 2003, has been utilized to dilate the papillary orifice following partial EST in order to facilitate large stone extraction, with a success rate of 90% in retrieving large stones after one session [20, 35]. Although EPLBD has an outstanding stone clearance rate for difficult biliary stones, and the international consensus guideline has recommended it as a first-line therapy for large bile duct stones, the complication rate is still high with 0–16% that included pancreatitis, perforation, and bleeding [36–39]. Multivariate analysis in a cohort included 946 cases underwent EPLBD revealed that cirrhosis, full-length EST, and stone size greater than 16 mm were a risk factor for bleeding, whereas common bile duct stricture was an independent predictor for perforation [40]. In our study, the clearance rate of

Table 4 Long-term outcomes of following operation

Outcomes	Total ($n=334$)
Number of patients followed up, *n* (%)	334 (100)
Median follow-up time, months, mean ± SD	8.919 ± 10.13
Bile duct stricture, *n* (%)	0
Stone recurrence, *n* (%)	9 (2.7)
Management of stone recurrence	
ERCP extraction	5
Re-operation extraction	2

the patients with stone diameter large than 15 mm underwent LCBDE in one session is 100%. 51 cases (51/57) underwent primary closure procedure, and bile leakage occurred in 3 cases (5.3%), which suggesting that LCBDE is a more safe and effective treatment for these patients (Table 5).

For those cases with large stones greater than 2 cm or impacted stones, cholangioscopy-guided lithotripsy (CGL) is an alternative technique to fragment and remove stones [19]. Currently, a new single-operator catheter-based digital cholangioscope (SCBC) system that inserts through the duodenoscope is widely used for intraductal visualization [41]. Additionally, electrohydraulic lithotripsy (EHL) and laser lithotripsy (LL) are also useful tools that can help fragment large stones inside the biliary duct and facilitate their extraction. A large multicenter study involving 407 patients with difficult biliary stones using the digital cholangioscope system was recently reported, and the data showed that the overall biliary clearance rate is 96.7% in EHL and 99% in LL, and the overall adverse events are 3.7% [5]. Although CGL has a high effect and more efficient procedure for those patients with difficult biliary stones, biliary complications, such as hemobilia, perforation, and cholangitis, remain a concern, especially if this procedure is done with inexperienced operators [19]. In addition, the possible limitation of CGL is the higher costs of the device, particularly SCBC, compared with conventional ERCP stone extraction techniques [42]. In our study for these population, 74 cases (22.1%) have the impaction stones. Of these, 34 cases utilized frequency-doubled double-pulse neodymium YAG (FREDDY) laser, which is a short-pulse, double-frequency, low-cost laser with wavelengths of 532 and 1064 nm, and is designed specifically for endoscopic or laparoscopic lithotripsy without direct visual control [43–45]. The overall clearance rate is 97.3%. 63 cases (85.1%) underwent primary closure procedure, and bile leakage occurred in 3 cases (4.1%). Thus, the LCBDE combined with FREDDY laser lithotripsy is an effective and safe option for difficult biliary stones, especially large and impaction stones (Table 5).

Despite the increasing advance of endoscopic device and techniques, it remains a challenging procedure for ERCP in patients with altered anatomy, such as Roux-en-Y gastric bypass and Billroth-II anatomy. Recently, a large multicenter study included 579 patients with Roux-en-Y gastric bypass underwent laparoscopy-assisted transgastric ERCP (LA-ERCP) is reported, which showed that although the total success rate was 98% for biliary intervention, the adverse events rate was high of 18%, whereas 8% were severe events [46]. Another report involving 133 patients with Billroth-II anatomy demonstrated that the successful stone extraction rate was 86% with a complication rate of pancreatitis and perforation of 8% and 2%, respectively [47]. Therefore, for the patients with these altered anatomy, especially with difficulty biliary stones, ERCP remains to be considered as a considerable difficult and challenging method. In our study, 40 cases underwent upper abdominal operation with 6 cases of Roux-en-Y gastric bypass and 7 cases of Billroth-II anatomy. Our data showed that the overall clearance rate is 100%. 37 cases (37/40) underwent primary closure procedure and bile leakage occurred in 1 cases (2.5%). Thus, the LCBDE with or without primary closure is also safe and effective for the altered anatomy cases with difficult biliary stones (Table 5).

Although the results of our study showed that, regardless of the clearance efficacy, complication rate, and even cost effectiveness, LCBDE takes good advantages for these patients with difficult biliary stones, we would recommend

Table 5 The clearance rate and adverse events in LCBDE from our study and ERCP-related technique reported in the literature

	Clearance rate (%)				Adverse events (%)			
	LCBDE	EPLBD	CGL	ERCP	LCBDE	EPLBD	CGL	ERCP
Stone diameter > 15 mm	100	88–100 [36–40]	–	–	5.3	0–16 [36–40]	–	–
Impacted stone	97.3	–	87–100 [48–50]	–	4.1	–	0–18 [48–50]	–
Altered anatomy	100	–	–		2.5	–	–	
Roux-en-Y	100	–	–	33–99 [51–53]	0	–	–	0–7 [51–53]
Billroth-II	100	–	–	86–90 [47, 54]	0	–	–	4.3–10 [47, 54]

LCBDE laparoscopic common bile duct exploration; *CGL* cholangioscopy-guided lithotripsy; *EPLBD* endoscopic papillary large balloon dilation; *ERCP* endoscopic retrograde cholangiopancreatography

that a high-quality, multicenter, randomized clinical trial is developed specifically to further evaluate the safety and effective in this enriched population.

Compliance with ethical standards

Disclosures Zhilong Ma, Jia Zhou, Le Yao, Yuxiang Dai, Wangcheng Xie, Guodong Gong, Hongbo Meng, Bin Xu, Ti Zhang, Bo Zhou, Tingsong Yang, and Zhenshun Song have no conflict of interest or financial ties to disclose.

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腹腔镜下胆总管探查术在困难胆管结石患者中的安全性与有效性：单中心8年经验及文献综述

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摘要

背景：腹腔镜下胆总管探查术（LCBDE）已成为治疗胆总管结石的广泛选择。然而，对于困难胆道结石患者，LCBDE 是否更优尚不明确。本研究旨在通过回顾性分析临床数据并结合文献综述，探讨 LCBDE 对此类患者的安全性与有效性。

方法：回顾 2011 年 9 月至 2019 年 2 月期间上海市第十人民医院连续收治的 1064 例 LCBDE 手术患者，筛选困难胆道结石病例的临床资料进行回顾性分析。

结果：334 例确诊为困难胆道结石，总体结石清除率达 98.8%（330/334）。34 例（10.2%）采用激光碎石术治疗。296 例（88.6%）实施胆总管一期缝合，38 例（11.4%）留置 T 管引流。未观察到胆管损伤、出血、穿孔及手术相关死亡。总体并发症发生率为 6.6%。16 例（4.8%）一期缝合患者出现胆漏，均经保守治疗成功处理。中位随访 9 个月，9 例（2.7%）出现结石复发，所有病例均未发现胆管狭窄。

结论：本研究表明，LCBDE 对困难胆道结石患者是安全有效的治疗选择。未来需开展随机临床试验进一步评估 LCBDE 对该亚组患者的获益。

关键词：LCBDE，胆总管结石，难治性胆道结石

胆总管结石是临床上十分常见的疾病，由于可能引发危及生命的胆源性胰腺炎、胆管炎、胆囊炎及胆石性肠梗阻，其发病率和死亡率均不容忽视。约 15%的有症状胆结石或急性胆囊炎病例伴随胆总管结石。目前，内镜逆行胰胆管造影术（ERCP）是治疗胆总管结石的主流方法，深受内镜专家的青睐。然而约 10%-15%的病例中，传统 ERCP 无法成功清除胆管结石，主要归因于困难胆管结石——通常定义为大结石（>15 毫米）、多发性结石（>3 枚）、肝内胆管结石、桶状结石或嵌顿结石。值得注意的是，ERCP 可能永久性损伤 Oddi 括约肌，导致十二指肠液反流，进而引发胆总管结石复发、胆管炎反复发作，甚至胆道恶性肿瘤。此外，ERCP 还可能引起胰腺炎、出血、穿孔等一系列并发症。

近年来，腹腔镜胆总管探查（LCBDE）越来越被证明是治疗胆总管结石的一种更安全、更有效的方法，短期和长期并发症较少。此外，作为单阶段手术方法，腹腔镜胆总管探查术(LCBDE)还具有术后恢复更快、住院时间更短以及治疗成本更低的优势。然而，对于疑难胆管结石患者群体，LCBDE 是否安全有效目前仍不明确，相关文献报道也较为罕见。因此，本研究旨在探讨 LCBDE 治疗疑难胆管结石患者的疗效与安全性。

材料与方法

患者与数据收集

这项回顾性研究的队列包括 1064 名患者，他们于 2011 年 1 月至 2019 年 2 月期间在上海市第十人民医院普外科接受了胆总管探查术（LCBDE）。手术对象为经腹部超声、计算机断层扫描、磁共振胰胆管造影或 ERCP 确诊为胆总管结石的患者，或术中经胆道造影超声确诊者。难治性胆管结石定义为：大结石（>15 毫米）、多发结石（>3 枚）、嵌顿性结石，以及合并 Mirizzi 综合征、胆总管解剖异常（如结石下方狭窄）、或存在解剖结构变异（如壶腹周围憩室、Roux-en-Y 胃旁路术、Billroth-II 式吻合、十二指肠狭窄或肝内胆管结石）的患者。研究收集并分析了包括人口统计学资料、病史（重点关注胆道病史）、症状、并发症、死亡率及随访信息在内的临床数据。研究方案经上海市第十人民医院机构审查委员会批准，基于研究回顾性特征免除知情同意，所有数据均经匿名化处理。

手术技术

胆总管探查术(LCBDE)的操作步骤在我们既往文献中已有详细描述。简言之，患者取仰卧位，采用"四孔六步法"实施手术(图 1A-F)。清晰解剖 Calot 三角后，通常先行胆囊管夹闭。随后实施十二指肠上纵行胆总管切开术，经胆总管插入胆道镜(CHF-V；日本东京奥林巴斯公司)探查结石。最常采用 Dormia 取石篮(FG-24X-1；奥林巴斯)配合生理盐水冲洗取石。反复进行胆道镜检查以确保肝内外胆管结石清除彻底。胆总管切口主要采用 4-0 可吸收 PDS®II 缝线(Ethicon Inc., Somerville, NJ, USA)以连续锁边方式进行一期缝合。随后按常规切除胆囊。最后于肝下间隙放置腹腔引流管。

对于结石体积大、数量多或嵌顿严重等常规方法难以取出的病例，通常采用 FREDDY 激光碎石系统（德国柏林 World of Medicine 公司）进行碎石以方便取出（图 1G-H）。针对合并严重胆管炎、胆总管壁重度水肿或可疑结石残留的病例，会选择性放置 T 管引流（图 3I）。当遇到严重致密粘连或解剖结构变异时，有时还需中转开腹手术。因此，我院可采取多种措施为胆总管结石患者提供个体化治疗方案，即"同济十院解决方案"（图 2）。

结果定义与随访

手术时限定义为首次切口至最后皮肤伤口缝合的间隔时间。术后死亡率采用手术 30 天内或住院期间死亡人数与总病例数的比值表示。术后发病率则定义为术后 30 天内发生并发症的病例数与总病例数的比值。并发症根据 Dindo-Clavien 分级系统进行分组与评级。术后胆漏则依据国际肝脏外科研究组的定义与分级标准进行判定。所有患者术后均接受超过 6 个月的随访：首次和第二次随访检查分别于术后 2 周和 3 个月在门诊进行。此后每 3 个月通过电话进行随访。随访内容包括询问患者一般状况、饮食情况、手术相关不适及肝功能，并通过影像学检查筛查不良事件，检测可能出现的胆管狭窄或结石复发情况。

统计分析

所有数据分析均使用 IBM SPSS Statistics for Windows 22.0 版（IBM Corporation, Armonk, NY, USA）完成。所有连续变量均以均值±标准差（SD）表示。对连续数据采用独立样本 t 检验，对分类数据采用 Pearson X^2 检验进行统计分析。概率值（p）<0.05 视为具有统计学显著性。

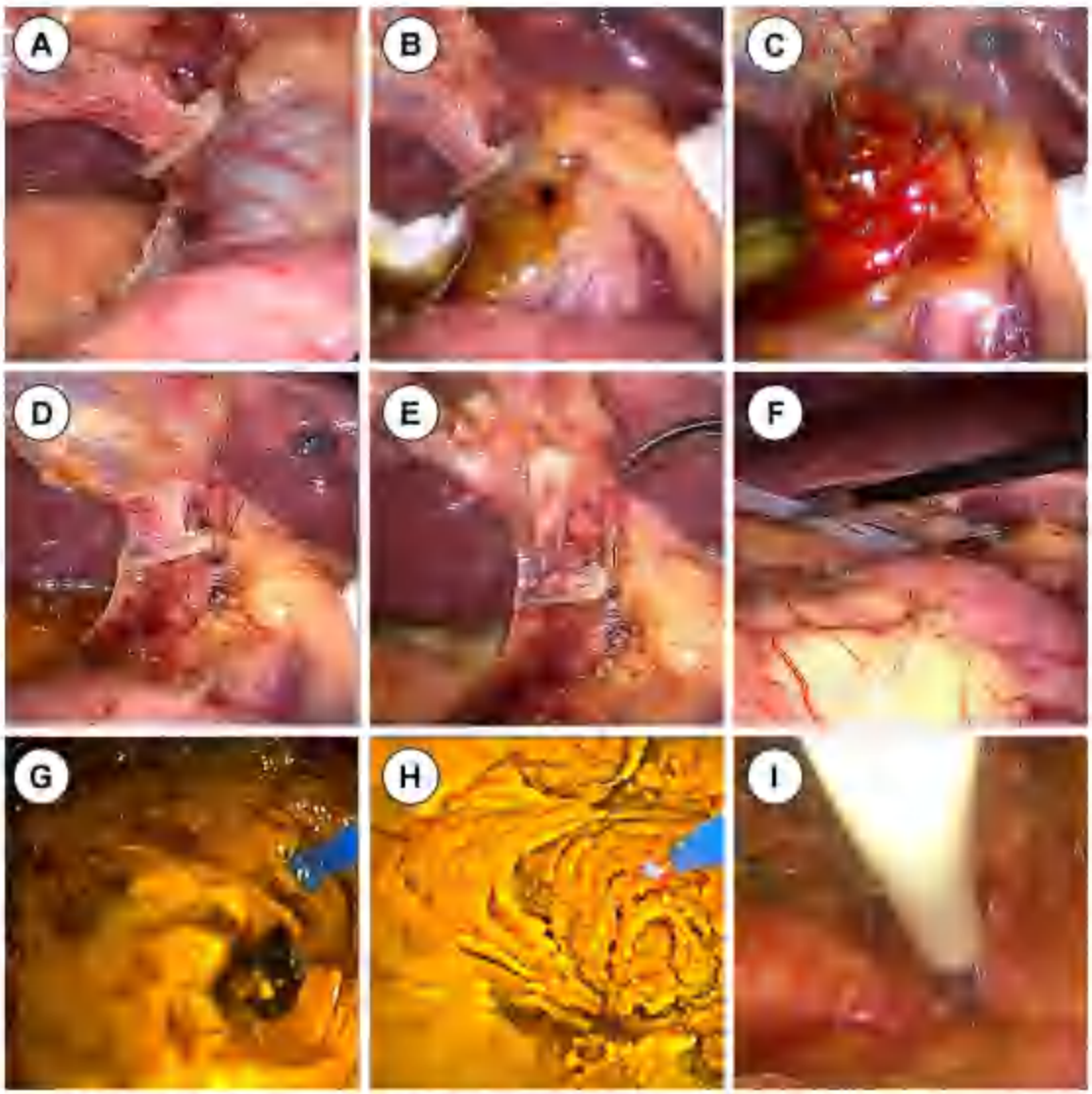


图 1　A 解剖分离胆囊三角区，钳夹胆囊管；B、C 实施十二指肠上胆总管纵向切开术，经胆总管置入胆道镜；D 对胆总管小切口进行一期缝合；E 取出胆囊及胆总管结石；F 于肝下位置放置腹腔引流管；G、H 应用激光碎石术清除难取性胆道结石；I 选择性在胆总管切口处置入 T 管引流

研究结果

在研究期间，共有 1064 例连续患者因胆总管结石接受了择期或急诊腹腔镜胆总管探查术（LCBDE）。其中 334 例患者被确诊为难治性胆道结石，其定义为：大结石（>15 毫米，占 17.1%）、多发结石（>3 枚，占 71.3%）或嵌顿性结石（22.1%），结石位于肝内胆管（5.1%）、胆囊管（5.7%）或多部位分布（9.9%），或合并 Mirizzi 综合征（3.3%）。表 1 展示了难治性

胆道结石患者的人口学特征和临床表现。最常见的症状包括腹痛（90.7%）、胆管炎（37.7%）、黄疸（34.4%）、胰腺炎（3.9%），以及恶心、呕吐和肝功能检查异常。约 3.9%的患者之前接受过胆囊切除术，6.6%的患者曾接受过 ERCP 检查，但胆道结石清除失败。

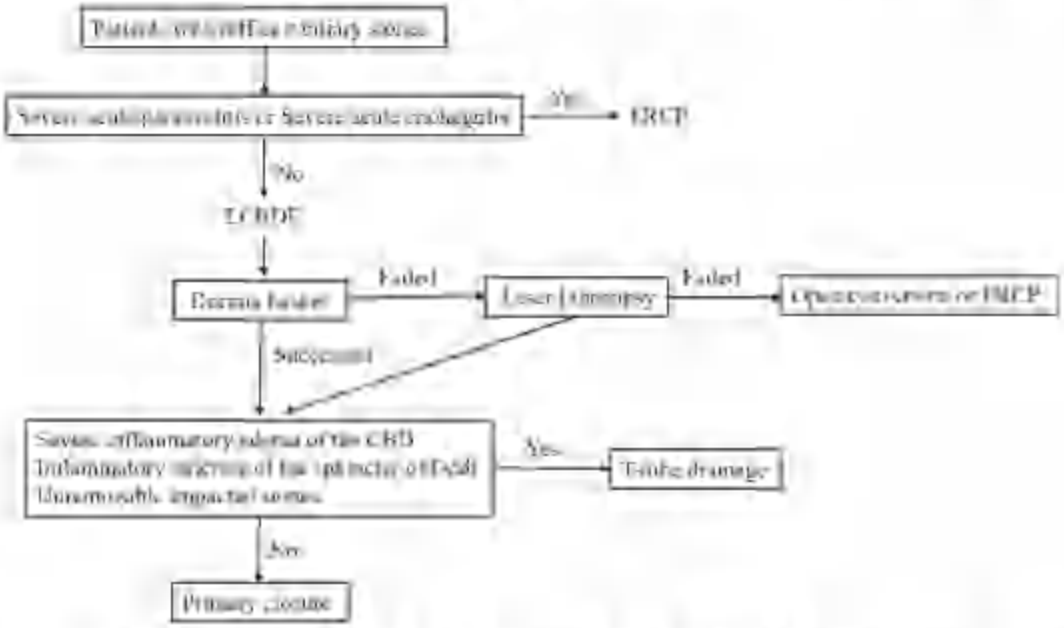


图 2 本机构处理困难胆管结石的诊疗流程。LCBDE：腹腔镜下胆总管探查术；ERCP：内镜下逆行胰胆管造影术；CBD：胆总管

手术结果总结见表 2。在 330 例（98.8%）病例中，困难胆管结石通过腹腔镜胆总管探查术（LCBDE）成功取出。其中 296 例（88.6%）患者采用一期缝合，38 例（11.4%）患者采用 T 管引流。共有 15 例（4.5%）患者因致密粘连和解剖结构不清、巨大嵌顿结石、Mirizzi 综合征、胆囊十二指肠瘘、胆囊下胆管损伤或高碳酸血症而中转开腹手术。平均手术时长为 150.2 分钟（范围 43-466 分钟），平均失血量为 36.78±33.89 毫升。所有患者均未发生围手术期胆管出血，仅 1 例出现围手术期胆管穿孔。总体并发症发生率为 6.6%，胆漏发生率为 4.8%。1 例患者因胆漏导致严重感染死亡。术后平均住院时间为 7.668±4.147 天，平均引流管拔除时间为 5.509±3.15 天。3 例患者在术后 30 天内再次入院并接受二次手术。

所有 34 例难以通过 Dormia 网篮取石联合水冲洗/灌注清除的胆道结石患者均接受了激光碎石联合腹腔镜胆总管探查术（表 2）。结石清除成功率达 97.1%。激光碎石组的术中时间、失血量、术后住院时间和引流管拔除时间均显著增加。激光碎石术后一期缝合率显著降低，但对胆汁漏等并发症发生率无影响。此外，两组在围手术期胆管出血、围手术期胆管穿孔、中转开腹手术、30 天内再入院、死亡率和再次手术发生率方面均无显著差异。因此，激光碎石术并未增加并发症发生率和死亡率。

如表 3 所示，22 例患者(6.6%)出现术后并发症。胆漏发生率为 4.8%。在 11 例胆漏患者中，无需进一步处理或仅需静脉及口服抗生素治疗，漏口即自行闭合。另有 3 例胆漏患者接受超声引导下腹腔穿刺引流联合静脉及口服抗生素治疗，这些患者的漏口均在 2 周内自行闭合。2 例严重胆漏患者被转入重症监护室处理严重感染。在这两名患者中，一名在好转后出院，另一名因严重感染而死亡。

表 1 患者基线特征

Patient details	Total (n=334)
Female Sex, n (%)	180 (53.9)
Age, mean (range)	63 (20–91)
BMI (kg/m^2), mean ± SD	23.57 ± 2.957
Symptoms, n (%)	
Abdominal pain	303 (90.7)
Jaundice	115 (34.4)
Cholecystitis	243 (72.8)
Cholangitis	126 (37.7)
Pancreatitis	13 (3.9)
ASA Scores, mean (range)	2 (1–3)
Upper abdominal operation history, n (%)	38 (11.4)
Post-cholecystectomy, n (%)	13 (3.9)
Failed to extract stone with ERCP/sphincterotomy, n (%)	22 (6.6)
Biliary stone characteristics	
Large stone (> 15 mm), n (%)	57 (17.1)
Stone number > 3, n (%)	238 (71.3)
Stone location, n (%)	
CHD, n (%)	19 (5.7)
IHD, n (%)	17 (5.1)
More than 1 location, n (%)	33 (9.9)
Stone impaction, n (%)	74 (22.1)
Altered anatomy	13 (3.9)
Roux-en-Y gastric bypass	6 (1.8)
Billroth-II anatomy	7 (2.1)
Mirrizi syndrome, n (%)	11(3.3)
Stone size, mm (mean ± SD)	10.44 ± 5.888
CBD diameter (mm) (mean ± SD)	12.39 ± 3.492

标准差（SD）；胆总管（CHD）；肝内胆管（IHD）；内镜下逆行胰胆管造影术（ERCP）

随访结果汇总于表 4，334 例（100%）患者完成随访。在随访期间，胆管狭窄发生率为 0，9 例（2.7%）患者出现结石复发。其中 5 例患者通过 ERCP 成功取石，2 例通过再次手术取石。

讨论

约 5%-15%接受胆囊切除术的患者被诊断出同时存在胆道结石。过去 20 年间，随着内镜技术的快速发展，采用两阶段治疗模式——先行内镜逆行胰胆管造影术（ERCP）取石，再行腹腔镜下胆囊切除术——已成为这类患者的主流治疗方案。既往研究表明，ERCP 治疗胆道结石具有高效性，取石成功率可达 86%-95%。但存在多种被定义为"困难胆道结石"的情况会使取石操作极具挑战性，包括结石体积过大（>1.5 厘米）、数量过多（>3 枚）、形态不规则、位置特殊以及解剖结构变异等。虽然目前已发展出机械碎石（ML）、内镜下乳头大气囊扩张（EPLBD）、胆道镜辅助碎石（CGL）、液电碎石术（EHL）和激光碎石（LL）等辅助取石技术，但 ERCP 对此类患者的结石清除率仍仅维持在 77%-90%。

近年来，越来越多的数据表明，对于胆道结石患者，腹腔镜胆总管探查术（LCBDE）不仅具有与内镜逆行胰胆管造影术（ERCP）相同的结石清除率，还能避免 Oddi 括约肌损伤，从而降低短期并发症（如出血、穿孔和胰腺炎）以及长期不良事件（如乳头狭窄、反流性胆管炎、结石复发甚至恶性病变）的风险。此外，与 ERCP 相比，LCBDE 还具有住院时间更短、总费用更低的优势。因此，LCBDE 已被视为胆囊结石合并胆总管结石患者安全、有效且最优的治疗选择。然而，目前关于 LCBDE 治疗困难胆道结石（定义为结石直径>15mm、多发结石（>3 枚）或嵌顿性结石，以及合并 Mirizzi 综合征、胆管狭窄或解剖结构异常如壶腹周围憩室、Roux-en-Y 胃旁路重建术、Billroth-II 重建术的患者）的安全性和有效性的文献报道较少。为此，我们回顾分析了本中心接受 LCBDE 治疗的这类患者的围手术期安全性及短期、长期临床疗效。数据显示，LCBDE 对困难胆道结石的总清除率达 98.8%（330/334），术后总并发症发生率为 6.6%（22/334）。未观察到胆管损伤、出血及穿孔病例，也无手术相关死亡病例。其中 296 例（88.6%）患者行胆管一期缝合，38 例（10.4%）留置 T 管引流，16 例（4.8%）发生胆漏。中位随访时间 8.9 个月，所有患者均未出现胆管狭窄，仅 9 例（2.7%）患者结石复发。

目前，内镜逆行胰胆管造影术（ERCP）在治疗胆管结石方面疗效显著；然而，对于疑难结石病例，采用内镜下括约肌切开术（EST）联合球囊/取石篮辅助取石等常规技术时，仍有 10%至 15%的病例无法成功取出结石。最近，大量研究结果表明，内镜乳头大球囊扩张术（EPLBD）是 Ersoz 等人首次描述的。

表 2 腹腔镜下胆道探查术的手术结果

*腹腔镜下胆总管探查术配合 Dormia 取石篮、水冲洗或灌洗技术

表 3 术后并发症及临床处理方案

Dindo–Clavien* classification	Number of patients	Complications	Management
I	7	Bile leakage	Conservative†
II	4	Bile leakage	Intravenous and oral antibiotics
	3	Respiratory tract infection	Intravenous and oral antibiotics
	2	Urinary tract infection	Intravenous antibiotics
	1	Wound infection	Surgical dressing change
IIIa	1	Bile leakage	Ultrasound-guided percutaneous puncture and drainage + intravenous and oral antibiotics
IIIb			
IVa	1	Bile leakage	Intensive care unit management
IVb	1	Bile leakage	Intensive care unit management

‡Clavien 分级系统：I 级：术后病程出现任何异常，但无需药物治疗或手术、内镜及放射学干预。II 级：需使用超出 I 级并发症允许范围的药物进行治疗。III 级：需手术、内镜或放射学干预——IIIa 级指无需全身麻醉的干预；IIIb 级指需全身麻醉的干预。IV 级：危及生命的并发症，需重症监护治疗。SSSI 皮肤及皮肤结构感染。
*保守治疗：未使用抗生素或采取进一步措施，渗漏部位已自行闭合。

2008 年，该技术被用于在部分 EST 术后扩张乳头开口以便于大结石取出，单次治疗的大结石清除成功率可达 90%。虽然 EPLBD 对疑难胆道结石具有出色的清除率，且国际共识指南已推荐其作为大胆管结石的一线治疗方案，但并发症发生率仍高达 0-16%，包括胰腺炎、穿孔和出血。一项纳入 946 例 EPLBD 手术病例的多变量分析显示，肝硬化、全程 EST 及结石直径大于 16 毫米是出血的危险因素，而胆总管狭窄则是穿孔的独立预测因子。在我们的研究中，结石直径大于 15mm 的患者在一次治疗中接受 LCBDE 的清除率为 100%。51 例患者（51/57）接受了一期关闭手术，其中 3 例（5.3%）发生胆漏，这表明 LCBDE（腹腔镜胆总管探查术）对这些患者而言是更为安全有效的治疗方式（表 5）。

表 4 术后长期疗效

Outcomes	Total (n=334)
Number of patients followed up, n (%)	334 (100)
Median follow-up time, months: mean±SD	8.919±10.13
Bile duct stricture, n (%)	0
Stone recurrence, n (%)	9 (2.7)
Management of stone recurrence	
ERCP extraction	5
Re-operation extraction	2

对于结石直径大于 2 厘米或嵌顿性结石的病例，胆道镜引导下碎石术（CGL）是一种可选的碎石取石技术。目前，一种新型单人操作导管式数字化胆道镜（SCBC）系统通过十二指肠镜插入，广泛应用于胆管内可视化检查。此外，液电碎石术（EHL）与激光碎石术（LL）同样是有效工具，能粉碎胆管内大体积结石并便于取出。近期一项涉及 407 例难治性胆管结石患者的大型多中心研究显示，采用数字化胆道镜系统治疗的总胆道清除率达 96.7%（EHL）

与99%（LL），总体不良事件发生率为3.7%。尽管CGL对难治性胆管结石患者疗效显著且操作高效，但胆道出血、穿孔及胆管炎等并发症仍值得关注，尤其当操作者经验不足时风险更高。此外，与传统ERCP取石技术相比，CGL设备（特别是SCBC）成本较高可能构成应用限制。本研究中，74例（22.1%）患者存在结石嵌顿，其中34例采用FREDDY激光（频率倍增双脉冲钕钇铝石榴石激光）治疗。这种短脉冲、双频、低成本的532/1064纳米波长激光专为无直接视觉控制的内镜/腹腔镜碎石设计，总体清除率达97.3%。63例（85.1%）实施一期关闭术式，3例（4.1%）发生胆漏。因此，LCBDE联合FREDDY激光碎石术是处理难治性胆管结石（尤其是大结石及嵌顿结石）安全有效的治疗方案（表5）。

尽管内窥镜设备和技术不断进步，但对于解剖结构改变的患者（如Roux-en-Y胃旁路术和Billroth-II术后解剖）实施ERCP仍具挑战性。近期一项纳入579例Roux-en-Y胃旁路术患者的多中心研究显示，虽然腹腔镜辅助经胃ERCP（LA-ERCP）的胆道干预总成功率高达98%，但不良事件发生率仍达18%，其中8%为严重事件。另一项涉及133例Billroth-II术后患者的研究表明，取石成功率为86%，胰腺炎和穿孔并发症发生率分别为8%和2%。因此对于这类解剖变异患者，尤其是合并困难胆管结石者，ERCP仍被视为极具难度的手术方式。本研究中40例上腹部手术患者包含6例Roux-en-Y胃旁路术和7例Billroth-II术后病例，数据显示总体结石清除率达100%。37例（37/40）实施一期关闭术式，仅1例（2.5%）发生胆漏。这表明无论是否采用一期关闭，LCBDE对于解剖变异合并困难胆管结石病例都具有安全性和有效性（表5）。

表5 本研究中腹腔镜胆总管探查术的结石清除率及不良事件与文献报道的内镜逆行胰胆管造影相关技术对比

LCBDE 腹腔镜下胆总管探查术；CGL 胆道镜引导下碎石术；EPLBD 内镜下乳头大气球扩张术；ERCP 内镜下逆行胰胆管造影术

尽管我们的研究结果表明，无论从清除效果、并发症发生率乃至成本效益来看，腹腔镜胆总管探查术（LCBDE）对治疗疑难胆管结石患者都具有显著优势，我们建议专门开发一项高质量、多中心、随机的临床试验，以进一步评估该富集人群的安全性和有效性。

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CLINICAL REPORT

Fluoroscopy-guided percutaneous lithotripsy using FREDDY laser for giant gallstones: Preliminary experience

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Abstract

Objectives: Percutaneous treatment of symptomatic cholelithiasis with large gallstones remains a challenge. We aimed to evaluate the efficacy and safety of a new method for the removal of giant gallstones with percutaneous lithotripsy using a frequency-doubled double-pulse neodymium: YAG (FREDDY) laser.

Materials and Methods: This study included 16 patients (7 males, 9 females; mean age, 63.4 ± 14.9 years) with giant gallstones who experienced the recurrence of cholecystitis and were not eligible for operation. The percutaneous transcystic approach was established using an 8-French sheath. A 6-French steerable sheath were inserted through the sheath. FREDDY laser lithotripsy was performed to break the stones into fragments. The stone fragments were extracted through the 6-French sheath or pushed into the duodenum using a balloon catheter. Cholecystography was performed before removing the catheter. Follow-up ultrasound or computed tomography examination were performed.

Results: Gallstone clearance was accomplished in 16 (100%) patients at the initial assessment. Eleven patients underwent one session, and five patients underwent two sessions. Residual stones were found in 3 (18.8%) patients during the follow-up period. Peritonitis was found in two (12.5%) patients and hemocholecyst was detected in one (6.3%) patient. No procedure-related deaths occurred.

Conclusion: Percutaneous lithotripsy using a FREDDY laser may be an effective and safe alternative choice for treating giant gallstones, especially for patients who are not eligible for cholecystectomy.

KEYWORDS

fluoroscopy-guided, FREDDY laser, giant gallstones, percutaneous lithotripsy

INTRODUCTION

Gallstone disease is a prevalent, worldwide occurring disease. The incidence of gallstones is 10%–20% in the adult population, and adverse events including cholangitis and cholecystitis, arise in 5% of the people who are diagnosed with cholelithiasis.[1] Cholecystectomy is the first choice for the treatment of symptomatic gallbladder stones.[2] Approximately 700,000 laparoscopic cholecystectomies (LC) are performed in the United States every year, costing about $9.9 billion[3]; therefore, it is a high financial burden for the national economy. Additionally, several complications, including duodenum gastric reflux, diarrhea, and choledocholithiasis, may occur in the absence of the physiological function of the gallbladder,[4,5] and increased incidence of gastrointestinal tumors, such as liver cancer, pancreas carcinoma, and esophagus cancer have also reported.[6–8] On the other hand, some patients with comorbidities are not suitable for operations due to high risk. Recently, percutaneous transhepatic balloon dilation and percutaneous transcystic papilla balloon dilation were developed as alternative techniques to manage gallstones and common bile duct (CBD) stones, and both approaches are associated with high success rates and rare complications.[9,10] However, the treatment of symptomatic cholelithiasis with large gallstones (i.e., larger than 20 mm) using a minimally invasive method while preserving the gallbladder function remains a challenge.

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Several lithotripsy techniques, including electrohydraulic lithotripsy (EHL), mechanical lithotripsy, extracorporeal shock wave lithotripsy, have been used to break the gallstones into fragments before percutaneous cholecystolithotomy.[11,12] EHL usually requires the aid of an endoscopic system to protect the gallbladder wall from injury. As with EHL, a large working passage of at least 12F is also needed for mechanical lithotripsy to grab and remove the stones.[13] The newly designed frequency doubled, double pulse Nd:YAG (FREDDY) laser has the advantages of being cost effective and causing minimal injury to normal tissue based on its unique working principle.

Although previous studies have demonstrated that this is an effective and safe method for difficult CBD stones,[14,15] the FREDDY laser fiber cannot be visualized under fluoroscope, and it is difficult to target the stones in the gallbladder. Due to these limitations, we have developed a new method able to circumvent these problems. In this study, we aimed to evaluate the efficacy and safety of this new method for the removal of giant gallstones with percutaneous lithotripsy using a FREDDY laser.

MATERIALS AND METHODS

Patients

This retrospective study was approved by the ethics committee of our hospital. Written informed consent was obtained from all patients.

Sixteen consecutive cases (7 males, 9 females) of fluoroscopic guided percutaneous cholecystolithotomy were performed between June 2018 and September 2019 at our hospital using a FREDDY laser for giant gallstones. The flow chart of the enrolled patients is shown in Figure 1. The mean age of the participants was 63.4 ± 14.9 years (range, 23–81 years). All of the 16 patients had symptomatic gallstones and were diagnosed by ultrasound or/and computed tomography (CT) scans (Figure 2). Three of the patients underwent this novel procedure with the aim of preserving the cholecyst; the remaining 13 patients were considered unsuitable for surgery after a multidisciplinary consultation that was conducted by a gastrointestinal surgeon, gastroenterologist, and anesthetist. Contraindications included cardiac diseases in six patients, poor lung function in six patients, and renal failure in one patient. Gallbladder function was assessed before the procedure in 11 patients with steady situation at the time of admission. Five patients who suffered from acute cholecystitis did not undergo assessments of cholecyst function before the procedure. Gallbladder function was defined as the ratio of gallbladder shrinkage 1 h after eating two fried eggs as measured by ultrasound.[16] Baseline characteristics of the 16 patients are shown in Table 1.

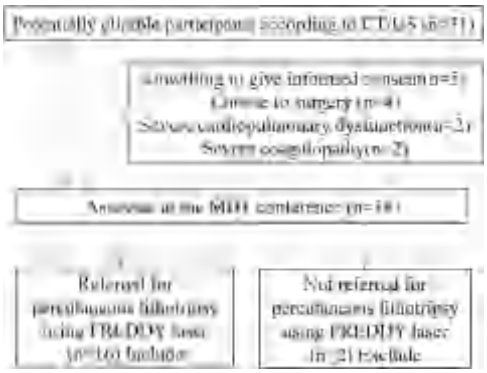


FIGURE 1 Flow chart of patients inclusion/exclusion. CT, computed tomography; MDT, multidisciplinary therapy; US, ultrasound

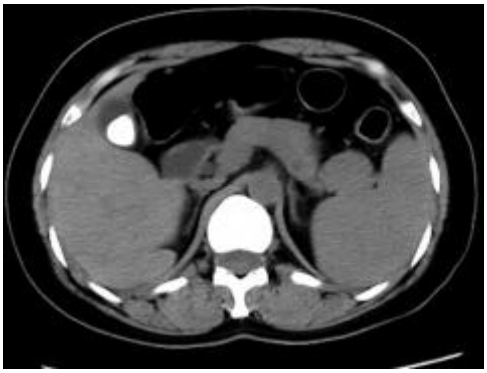


FIGURE 2 A 45-years female underwent fluoroscopy-guided percutaneous lithotripsy using a FREDDY Laser. Computed tomography scan of a giant gallstone within the gallbladder

FREDDY laser

The U100 PLUS Laser system (World of Medicine) was used in this study. The laser fiber was 0.73 mm in diameter. Two laser pulses were simultaneously emitted during one excitation cycle. Each laser pulse contained a 532 nm visible green light and a 1064 nm invisible infrared light that accounted for 20% and 80% of the total energy output of the laser, respectively. Plasma was created on the stone surface when it absorbed the energy of the visible green light. The plasma absorbed and magnified the infrared laser energy. After the laser energy was magnified, it produced a strong shock wave that penetrated and shattered the targeted stone into pieces. The energy output and pulse rate were set to 120 mJ/pulse and 5 Hz, respectively.

Procedure

All procedures were performed by two interventional radiologists with more than 10 years of experience.

TABLE 1 Baseline characters of the patients and stones

No	Sex	Age (year)	Size (mm)	ASA	CBD stones	No. of sessions	Gallbladder function (%)		Initial Results	Follow-up ultrasound	Complications
							Preoperative	Postoperative			
1	F	23	28	1	No	1	65	83	Clear	Sludge	None
2	F	53	22	1	Yes	1	54	61	Clear	Normal	None
3	F	45	24	3	No	1	53	56	Clear	Normal	None
4	M	70	28	3	Yes	2	61	65	Clear	Normal	None
5	M	59	25	1	No	1	N/A	65	Clear	One 3-mm fragment	None
6	F	69	27	3	No	1	49	53	Clear	Normal	Peritonitis
7	F	74	30	3	Yes	1	N/A	52	Clear	Normal	None
8	M	56	31	4	No	2	59	58	Clear	Normal	Hamocholecyst
9	M	73	25	3	No	1	N/A	50	Clear	Normal	None
10	F	80	23	3	Yes	1	N/A	46	Clear	Normal	skin infection
11	M	58	24	3	No	1	65	63	Clear	Sludge	None
12	F	65	23	3	No	1	49	55	Clear	Normal	Peritonitis
13	F	73	27	3	Yes	2	51	54	Clear	Normal	None
14	M	59	25	3	No	2	59	60	Clear	Normal	None
15	M	77	22	3	No	1	46	51	Clear	Normal	None
16	F	81	28	4	No	2	N/A	47	Clear	Normal	None

Abbreviations: ASA, American Society of Anesthesiologists classification; CBD, common bile duct.

Emergent transhepatic percutaneous cholecystostomy was performed under local anesthesia for patients with acute cholecystitis. Sensitive antibiotics were selected for anti-infection treatment according to the results of the culture. Percutaneous lithotripsy was performed after the infection was subsided, which typically took 6–7 days.

The procedure of percutaneous lithotripsy was performed under intravenous anesthesia using dexmedetomidine. First, a core 18-Gauge needle was used to puncture the gallbladder in a transhepatic way under ultrasound guidance. Said transhepatic approach was used for the patients with original cholecystostomy tube. Cholecystography was performed under fluoroscopy (Figure 3A). A 150-cm-long guidewire with a diameter of 0.035 inches (Radifocus Guidewire M; Terumo Medical Corporation) was inserted into the gallbladder through the needle.

Next, the needle was retreated and an 8-French introducer sheath was inserted into the gallbladder cavity along with the guidewire. A 5-French catheter was first introduced through the sheath; then, it was introduced through the cystic duct and CBD into the duodenum using the 150-cm-long guidewire. The 150-cm-long guidewire was eventually replaced with a 260-cm-long stiff guidewire with a 0.035-inch-diameter (Radifocus Guidewire M, Terumo Medical Corporation) after this step was completed in the 16 patients. This 260-cm-long guidewire was kept in place as safety wire during the procedure (Figure 3B). Percutaneous transcystic balloon dilation of the ampulla and stone removal were performed for patients with concomitant CBD stones or gallstones that shifted to the CBD. Detailed information about this step was described in our prior study.[9]

Then, a 6-French, 55-cm-long steerable introducer sheath (FuStar; Lifetech Scientific Inc.) was inserted into the gallbladder cavity through the 8-French introducer sheath. The tip of the steerable sheath was easily angled with a range of 0°–180°. The sheath tip was adjusted to the right angle to ensure that the sheath tip was targeted onto the stones. The laser fiber of the FREDDY laser system was assembled with a 4-French single-angle catheter, and the fiber tip was exposed 1 cm beyond the catheter tip. The combination of the laser fiber and 4-French catheter were inserted through the 6-French sheath. Laser lithotripsy was performed to break the stones into fragments

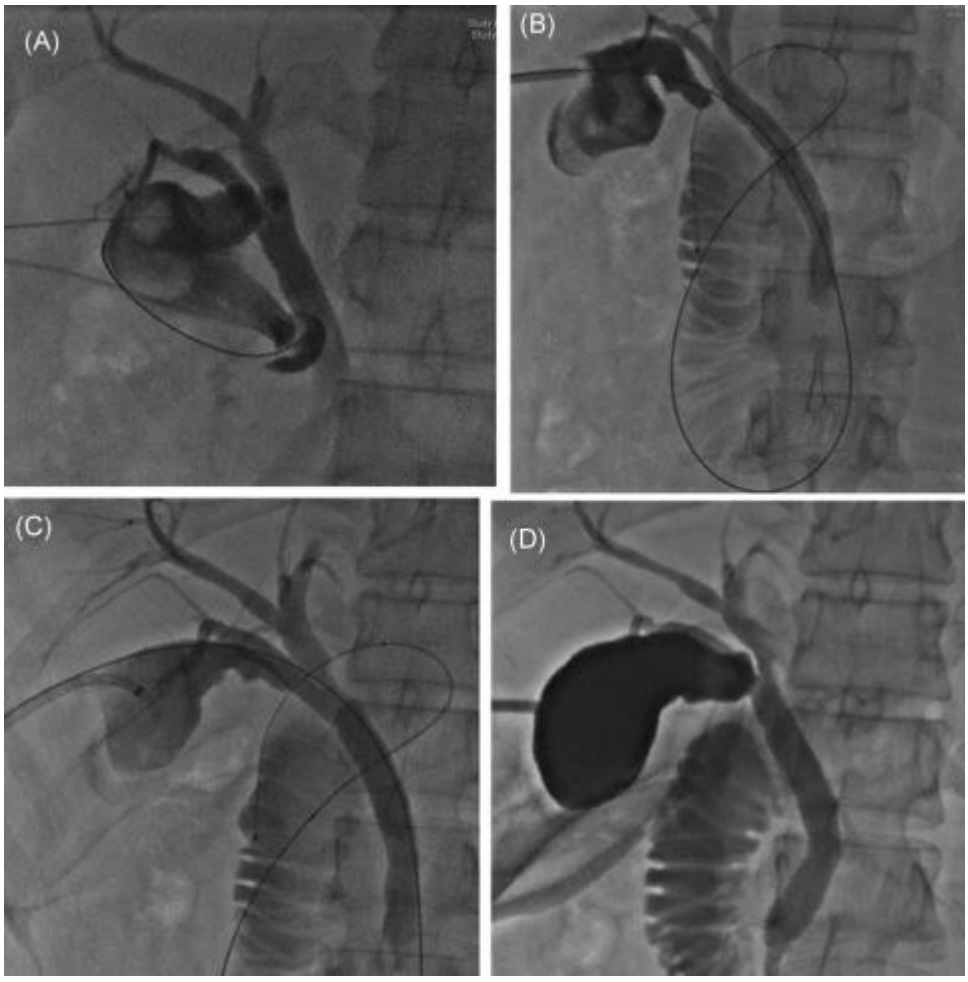


FIGURE 3 (A) Giant stone observed during cholecystography under fluoroscopy. (B) A 260-cm-long guidewire was inserted into the cystic duct into the duodenum as a safety wire during the procedure. (C) The package of the laser fiber and 4-French catheter were inserted through the 6-French sheath. The sheath tip was adjusted to the right angle to ensure that the sheath tip targeted the stone. FREDDY laser lithotripsy was performed to break the stones into fragments. (D) Final cholecystography. There were no filling defects in the gallbladder

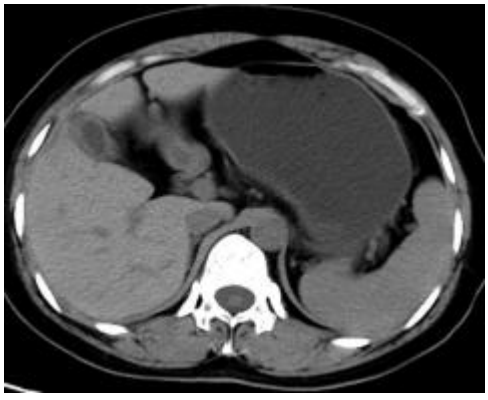


FIGURE 4 Computed tomography scan of the gallbladder three months after the procedure. The gallbladder was free of stones

(Figure 3C). The stone fragments were extracted through the 6F sheath or pushed into the duodenum through the cystic duct and CBD using a balloon catheter if any of the stones shifted to the CBD during the procedure. The procedure ended when no filling defects were detected in the gallbladder under fluoroscopy (Figure 3D).

Next, a 8.5-French (Cook Medical) drainage catheter was placed into the gallbladder cavity. The patients were discharged 3–4 days later with the catheter in the gallbladder. The catheter remained in the gallbladder for one month to avoid choleperitonitis after catheter removal. Cholecystography was performed to ensure that there were no filling defects in the gallbladder before the catheter was removed. Follow-up ultrasound or CT examinations were performed over an interval of 3 months after the drainage catheter was removed for 2 years (Figure 4), and gallbladder function was assessed through sonography after fatty meals at the first interval. Ursodeoxycholic acid capsules (Dr. Falk Pharma GmbH) were administered to patients at a dose of 10 mg/kg for 6 months after the procedure. Patients were encouraged to eat a low-fat diet that included vegetables and fruits and walking 8000–10,000 steps per day.

RESULTS

Results from the initial cholecystography before the drainage catheter was removed revealed that the giant gallstones and fragments were successfully removed from all of the 16 patients (100%) (Table 1). We found recurrent stones during the follow-up ultrasound examination in three (18.8%) of these 16 patients. Stone sludge was found in two patient at 9 and 12 months, respectively, and small fragments were identified in another patient at 15 months (Table 1). During the follow-up period, 13 (81.3%) of the 16 patients had no stones detected in their gallbladders upon ultrasound examination. Relief of symptoms was achieved in all of the 16 patients through the follow-up. The gallbladder function was stable 3 months after the procedure according to ultrasound results.

The procedure of stone fragmentation with FREDDY laser and removal was achieved in 11 patients with one session. The average time of the procedure was 145 min. A second session was required for the other five patients to complete the clearance of the gallstones. The median and mean times of laser pulses needed to disintegrate the stones into "dust" fragments were 2532 and 2471 ± 672 per patient, respectively. Shifted stones were not observed during the procedures.

Hemocholecyst was detected in one (6.3%) patient that manifested as bleeding fluid drainage from the catheter after the procedure. Hemocoagulase was dispensed and the bleeding stopped within 2 days. Peritonitis was found in 2 (12.5%) patients, but it was quickly resolved using antibiotics. Skin site infection occurred in one patient which was controlled easily with local disinfection. The 81-year-old patient was transferred to intensive care unit for one day after the procedure due to delayed resuscitation. Blood gas analysis revealed mild respiratory acidosis, and the patient woke up within 6 h with increased alveolar ventilation on a noninvasive ventilator. These four patients recovered without further incidents. No procedure-related deaths occurred.

DISCUSSION

To our best knowledge, the present study is the first clinical study to evaluate the efficacy and safety of percutaneous lithotripsy using FREEDY laser for giant gallstones. Unlike previous studies that used percutaneous lithotripsy, we performed this procedure using an 8-French outer sheath tube, which is much smaller than that used in other endoscopy-assisted lithotripsy studies.[17] The success rate, measured as the cholecystographic findings showing no gallstones, was a 100% (16/16). This method may be a new minimally invasive method for the treatment of giant gallbladder stones.

Cholecystectomy has been traditionally used for the treatment of symptomatic gallbladder stones. However, this procedure is not always suitable for elderly or high-risk patients. Additionally, the criteria for selecting patients for cholecystectomy remains controversial,[18] and different indications are followed globally.[19]

In addition, several prospective studies reported that multiple symptoms, especially persistent postoperative pain, occurred in up to 41% of patients who received cholecystectomy.[20] The risk of malignant carcinoma also increased after cholecystectomy.[6–8] A recent multicenter randomized parallel-arm study indicated that the current treatment for symptomatic gallbladder stones was not nearly optimal and the use of cholecystectomy should be reconsidered and carefully advised for patients. Cholecystectomy might not be the solution for symptomatic gallstones. Further investigation is needed regarding the relationship of gallstone and functional gastrointestinal problems.[21]

Percutaneous cholecystolithotomy is an alternative option for high-risk patients and patients who desire to preserve gallbladder function. This technique was first reported by Kerlan et al. in 1985.[22] This technique offers a wide-range of applications in most patients. Many studies have reported the safety and efficacy of this method for treating gallstones with high success rates.[12,23] Several lithotripsy techniques, such as EHL, mechanical lithotripsy, extracorporeal shock wave lithotripsy, and laser lithotripsy were used to break the stones into fragments. Laser lithotripsy is considered to be an advanced lithotripsy technique as compared with the other techniques.[17]

Various laser systems, such as pulsed Nd:YAG laser, Q-switched Nd:YAG laser, and pulsed-dye laser, were investigated and introduced for gallstones lithotripsy after Orii et al. performed the first choledocholithotomy using a YAG laser with a choledoscope in 1981.[24–27] Unlike these previous laser systems, no thermal effects were generated by the FREDDY laser, and the laser impulses were not easily absorbed by the mucosa of the gallbladder and other soft tissue; therefore, tissue injury caused by laser energy was avoided. This advantage made it possible to safely perform laser lithotripsy under fluoroscopy without direct visualization of the stones using endoscopy. Thus, the requirement of a large sheath (i.e., at least 18-French) and long tract maturation time (i.e., about 10–14 days) for endoscopy was no longer needed.[28] In this study, we performed percutaneous lithotripsy under fluoroscopy alone with an 8-French sheath which reduced the hospital stay, tissue damage, and pain of the patients compared with larger sheaths. On the other hand, the emergence of new thin endoscopes (i.e., 8.7F) has been applied, which overcomes the necessity for large sheaths in recent years.[29]

Another advantage of the FREDDY laser its ability to effectively and powerfully fragment stones. Two laser pulses, which consisted of green light and infrared light in each pulse, worked on the stones simultaneously. The shock wave used to shatter the stones was very strong

after energy magnification by the plasma. Marguet et al. compared the fragmentation ability of FREDDY laser with that of the holmium laser in vitro and found that the two laser systems resulted in 86.8% and 4.1% weight loss, respectively. The stone fragmentation ability of the FREDDY laser was significantly greater than that of the holmium laser.[30] Additionally, Young et al.[14] used a FREDDY laser on 52 patients with large CBD stones under endoscopic guidance, and the success rate was 92.3%. We achieved a 100% success rate in the present study owning to the high effectiveness of the FREDDY laser. This outcome was better than one obtained in the study performed by Young et al. who used a Wittich nitinol stone basket and metallic cannula to fragment the gallstones. In said study, a success rate of 94% was achieved.[13] In another study, neodymium-yttrium aluminum garnet (Nd-YAG) laser was applied for biliary calculi in 69 patients and the complete clearance of the stones were accomplished in 67 patients (97.1%)[31] which is comparable with the results in the present study. However, a main limitation of the FREDDY laser system is that the laser fiber is invisible under fluoroscopy. To overcome this disadvantage, we assembled the laser fiber with 4-French single-angle catheter with the fiber tip exposed 1 cm beyond the catheter tip. The package of the laser fiber and 4F catheter were inserted through a 6-French steerable introducer sheath to target the stones. The steerable sheath acted like the endoscope when adjusting the direction of the tip. The mean times of laser pulses needed to disintegrate the stones in this study (2471 ± 672) were shorter than those in the study conducted by Young et al. (3580 ± 1450).[14] We attributed this difference to the application of the steerable sheath and package of laser fiber and catheter that increased the position accuracy to target the stones. To our knowledge, no previous studies have used a steerable introducer sheath to treat gallbladder stones.

A high relapse incidence is the main concern of percutaneous lithotripsy. A previous study that included 439 patients who received percutaneous lithotripsy reported that the recurrence rate was 41.46% at the 10-year follow-up,[32] and Donald et al.[33] reported that the cumulative recurrence rate was 44% at the 4-year follow-up. Gallstones were detected in 3 (18.8%) patients in this study during the short-term follow up in the current study. However, percutaneous lithotripsy still played an important role in treating high-risk and elderly patients. Moreover, no symptoms were caused by the recurrent gallstones.[34] We also encouraged the patients to adjust their diet and increase aerobic exercise after the procedure. We assumed that these measures would reduce the recurrence rate of stones.

Hemocholecyst was detected in one (6.3%) patient in this study. This may have been due to injury to the wall of gallbladder by the sharp tip of the laser fiber. However, the injury was controlled by administering drugs. Minor hemobilia was reported by Young et al.[14] at a rate of 15.4% when FREDDY was used to treat CBD stones. Routine blood tests showed no change in hemoglobin, and the bleeding stopped automatically. Peritonitis due to minor bile leak during the procedure was found in 2 (12.5%) patients who recovered quickly following treatment with antibiotics, and no percutaneous drainage was needed. However, Young et al.[13] reported two patients who underwent percutaneous drainage for bile peritonitis due to tract loss during stone removal when using a basket to perform cholecystolithotomy.

There were several limitations of this study. First, the sample size was small and follow-up period was short; therefore, the results should be interpreted with caution. Second, it is possible that tiny fragments of stones were neglected with the sole guidance of fluoroscopy due to a two-dimensional fluoroscopy view as compared to endoscopy guided lithotripsia, which provides a real time view of residual stones.

In conclusion, percutaneous lithotripsy using a FREDDY laser may be an effective and safe alternative for treating giant gallstones, especially for patients who are not eligible for surgical cholecystectomy. The application of the steerable sheath and package of laser fiber and catheter increased the position accuracy to target the stones.

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CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

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X 光透视引导下经皮碎石术采用 FREDDY 激光治疗巨大胆结石：初步经验

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摘要

目的：经皮治疗伴有大块胆结石的症状性胆石症仍具挑战性。本研究旨在评估采用新型钕:YAG 双频双脉冲激光(FREDDY)进行经皮碎石术清除巨大胆结石的有效性与安全性。
材料与方法：本研究纳入 16 例(男性 7 例，女性 9 例；平均年龄 63.4±14.9 岁)因胆囊炎复发且不适合手术的巨大胆结石患者。采用 8-French 鞘管建立经胆囊穿刺通路，通过鞘管置入 6-French 可转向鞘管。应用 FREDDY 激光碎石术将结石粉碎后，通过 6-French 鞘管取出碎石或用球囊导管推入十二指肠。拔管前行胆囊造影术，术后随访采用超声或计算机体层摄影检查。
结果：初次评估时 16 例(100%)患者均实现胆结石清除，其中 11 例接受单次治疗，5 例接受两次治疗。随访期间 3 例(18.8%)发现残余结石，2 例(12.5%)出现腹膜炎，1 例(6.3%)发生胆囊积血。无手术相关死亡病例。
结论：对于不适合行胆囊切除术的患者，FREDDY 激光经皮碎石术可能是治疗巨大胆结石安全有效的替代方案。

关键词
透视引导、FREDDY 激光、巨大胆结石、经皮碎石术

引言

胆结石疾病是一种全球范围内普遍发生的疾病。成人群体中胆结石的发病率为 10%–20%，其中 5%的确诊胆石症患者会出现包括胆管炎和胆囊炎在内的不良事件。胆囊切除术是治疗有症状胆囊结石的首选方案。美国每年约实施 70 万例腹腔镜胆囊切除术（LC），耗资约 99 亿美元，这对国民经济构成重大财务负担。此外，在胆囊生理功能缺失的情况下，可能出现十二指肠胃反流、腹泻和胆总管结石等并发症，且已有报道显示胃肠道肿瘤（如肝癌、胰腺癌和食管癌）发病率上升。另一方面，部分合并症患者因高危因素不适合手术。近年来，经皮肝穿刺球囊扩张术和经皮经胆囊乳头球囊扩张术作为替代技术被开发用于处理胆结石和胆总管结石，这两种方法均具有高成功率和低并发症的特点。然而，如何在保留胆囊功能的同时采用微创方法治疗大尺寸胆结石（即大于 20 毫米）的有症状胆石症，仍是一个挑战。

多种碎石技术已被应用于经皮胆囊取石术前将胆结石粉碎成碎片，包括电液压碎石术（EHL）、机械碎石术和体外冲击波碎石术。电液压碎石术通常需要借助内窥镜系统保护胆囊壁免受损伤。与电液压碎石术类似，机械碎石术也需要至少 12F 的大工作通道来抓取并移除结石。新设计的双脉冲钕:钇铝石榴石（FREDDY）激光碎石系统基于其独特的工作原理，具有成本效益高且对正常组织损伤极小的优势。

尽管先前研究已证实这是处理困难胆总管结石的有效安全方法，但 FREDDY 激光光纤在荧光镜视野下不可见，且难以精确定位胆囊内结石。鉴于这些局限性，我们开发了一种能规避这些问题的新方法。本研究旨在评估这种采用 FREDDY 激光经皮碎石术清除巨大胆结石的新方法的有效性与安全性。

材料与方法

患者

本回顾性研究经我院伦理委员会批准。所有患者均签署了书面知情同意书。

2018 年 6 月至 2019 年 9 月期间，我院连续实施 16 例（男性 7 例，女性 9 例）荧光镜引导下经皮胆囊取石术，采用 FREDDY 激光治疗巨大胆结石。入组患者流程图如图 1 所示。参与者平均年龄为 63.4 ± 14.9 岁（范围 23-81 岁）。所有 16 例患者均存在症状性胆结石，并通过超声和/或计算机体层摄影（CT）扫描确诊（图 2）。其中 3 例患者接受这项新术式旨在保留胆囊功能；其余 13 例患者经胃肠外科医师、胃肠病学家及麻醉医师多学科会诊后被认为不适合传统手术。禁忌症包括：6 例患者存在心脏疾病，6 例患者肺功能不良，1 例患者存在肾衰竭。11 例入院时病情稳定的患者在术前接受了胆囊功能评估，其功能定义为通过超声测量进食两枚煎蛋 1 小时后胆囊收缩率。另有 5 例急性胆囊炎患者术前未进行胆囊功能评估。16 例患者的基线特征详见表 1。

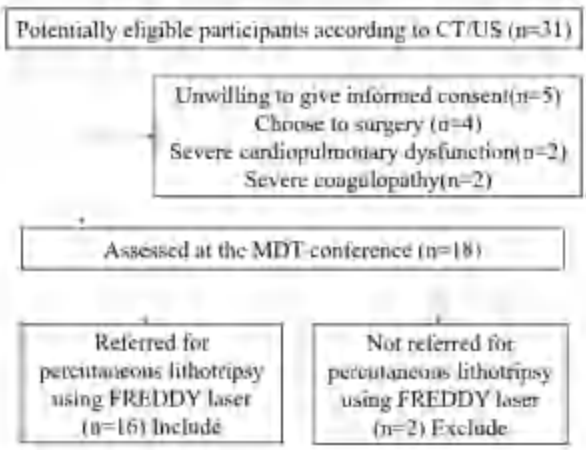


图 1 患者纳入/排除流程图。CT，计算机体层摄影；MDT，多学科综合治疗；US，超声检查



图 2 一名 45 岁女性接受荧光镜引导下经皮激光碎石术，采用 FREDDY 激光治疗。计算机断层扫描显示胆囊内存在巨型胆结石

FREDDY 激光

本研究采用了 U100 PLUS 激光系统（World of Medicine）。激光光纤直径为 0.73 毫米。每个激发周期会同时发射两束激光脉冲，每束脉冲包含 532 纳米可见绿光和 1064 纳米不可见红外光，分别占激光总能量输出的 20%和 80%。当结石表面吸收可见绿光能量时会产生等离子体，该等离子体会吸收并放大红外激光能量。经过能量放大后，会形成强大的冲击波穿透目标结石并将其粉碎。能量输出和脉冲频率分别设置为 120 毫焦/脉冲和 5 赫兹。

手术流程

所有手术操作均由两位具有 10 年以上经验的介入放射科医师执行。

表 1 患者基线特征与结石情况

No	Sex	Age (year)	Size (mm)	ASA	CBD stones	No. of session	Gallbladder function (%)		Initial Results	Follow-up ultrasound	Complications
							Preoperative	Postoperative			
1	F	23	25	1	No	1	65	83	Clear	Sludge	None
2	F	53	22	1	Yes	1	54	61	Clear	Normal	None
3	F	45	24	3	No	1	53	56	Clear	Normal	None
4	M	70	28	3	Yes	2	61	65	Clear	Normal	None
5	M	59	25	1	No	1	N/A	65	Clear	One 3-mm fragment	None
6	F	69	27	3	No	1	49	53	Clear	Normal	Peritonitis
7	F	74	30	3	Yes	1	N/A	52	Clear	Normal	None
8	M	56	31	4	No	2	59	58	Clear	Normal	Hemocholecyst
9	M	73	25	3	No	1	N/A	50	Clear	Normal	None
10	F	80	33	3	Yes	1	N/A	46	Clear	Normal	skin infection
11	M	58	24	3	No	1	65	63	Clear	Sludge	None
12	F	65	23	3	No	1	49	55	Clear	Normal	Peritonitis
13	F	73	27	3	Yes	2	51	54	Clear	Normal	None
14	M	59	25	3	No	2	59	60	Clear	Normal	None
15	M	77	32	3	No	1	46	51	Clear	Normal	None
16	F	83	28	4	No	2	N/A	47	Clear	Normal	None

Abbreviations: ASA, American Society of Anesthesiologists classification; CBD, common bile duct

对急性胆囊炎患者实施了急诊经皮肝穿刺胆囊造瘘术，手术在局部麻醉下完成。根据细菌培养结果选用敏感抗生素进行抗感染治疗。待感染消退后（通常需要 6-7 天）进行经皮碎石术。

经皮碎石术的操作过程在右美托咪定静脉麻醉下进行。首先，在超声引导下使用 18 号薄壁针经肝途径穿刺胆囊。对于原有胆囊造口术导管的患者，采用上述经肝入路方式。在 X 线透视下实施胆囊造影（图 3A）。随后通过穿刺针将直径 0.035 英寸、长度 150 厘米的导丝（Radifocus 导丝 M 型；Terumo 医疗公司）置入胆囊内。

随后退出穿刺针，沿导丝将 8F 导入鞘置入胆囊腔。首先经鞘管引入 5F 导管，随后借助 150 厘米长的导丝将导管经胆囊管和胆总管送入十二指肠。在 16 例患者完成该步骤后，最终将 150 厘米导丝更换为直径 0.035 英寸的 260 厘米硬质导丝（Radifocus Guidewire M，泰尔茂医疗公司）。术中全程保留这根 260 厘米导丝作为安全导丝（图 3B）。对于合并胆总管结石或移位至胆总管的胆囊结石患者，实施经皮经胆囊壶腹球囊扩张取石术。该步骤的详细操作方法在我们先前的研究中已有阐述。

随后，将一根 6-French（55 厘米长）的可操控导引鞘（FuStar，Lifetech Scientific Inc.）通过 8-French 导引鞘插入胆囊腔。该可操控鞘的尖端可在 0° 至 180° 范围内轻松弯曲。调整鞘管尖端至合适角度，确保其对准结石。将 FREDDY 激光系统的激光光纤与 4-French 单腔导管组装，使光纤尖端超出导管尖端 1 厘米；激光光纤与 4-French 导管的组合体通过 6-French 鞘管置入。进行了激光碎石术，将结石击碎成碎片（图 3C）。术中若发现结石移位至胆总管，则通过 6F 鞘管取出结石碎片，或用球囊导管将结石推入十二指肠。当胆囊在透视下未再发现充盈缺损时（图 3D），手术即告结束。

随后，将一根 8.5 法式（Cook Medical）引流导管置入胆囊腔。患者 3-4 天后携带导管出院。该导管在胆囊内留置一个月，以避免拔管后发生胆汁性腹膜炎。拔管前通过胆囊造影确认胆囊内无充盈缺损。在引流导管拔除后的 3 个月间隔期内进行超声或 CT 随访检查（持续 2 年）（图 4），并在首个间隔期通过脂肪餐后超声评估胆囊功能。术后 6 个月内，患者每日服用 10 毫克/公斤体重的熊去氧胆酸胶囊（Dr. Falk Pharma GmbH）。建议患者保持低脂饮食（多摄入蔬菜水果）并每日步行 8000-10000 步。

结果

引流导管拔除前的初始胆囊造影结果显示，26 名患者（100%）的巨大胆结石及碎片均被成功清除（表 1）。随访超声检查发现其中 3 例（18.8%）患者出现结石复发：2 例分别在 7 个月和 11 个月时发现胆泥沉积，另 1 例在 15 个月时检出细小碎片（表 1）。随访期间，16 名患者中有 13 例（81.3%）超声检查未发现胆囊结石。所有 16 名患者症状均通过随访获得缓解。根据术后 3 个月超声评估，胆囊功能保持稳定。

使用 FREDDY 激光碎石并清除的手术在 11 名患者中单次完成。手术平均时长为 145 分钟。其余 5 名患者需进行第二次手术以实现胆结石完全清除。将结石粉碎成"粉尘"状碎片所需激光脉冲次数的中位数和平均数分别为 2532 次和 2471±672 次/患者。手术过程中未观察到结石移位现象。

一名患者（6.3%）检出胆囊积血，表现为术后导管引流出血性液体。经注射蛇毒血凝酶后，出血在 2 天内停止。2 例（12.5%）患者出现腹膜炎，但通过抗生素治疗迅速缓解。另有一例发生穿刺部位皮肤感染，经局部消毒后得到控制。其中 81 岁高龄患者因术后复苏延迟转入重症监护室观察一天，血气分析显示轻度呼吸性酸中毒，经无创呼吸机增加肺泡通气量后 6 小时内恢复意识。这四例患者均未出现后续并发症，无手术相关死亡病例发生。

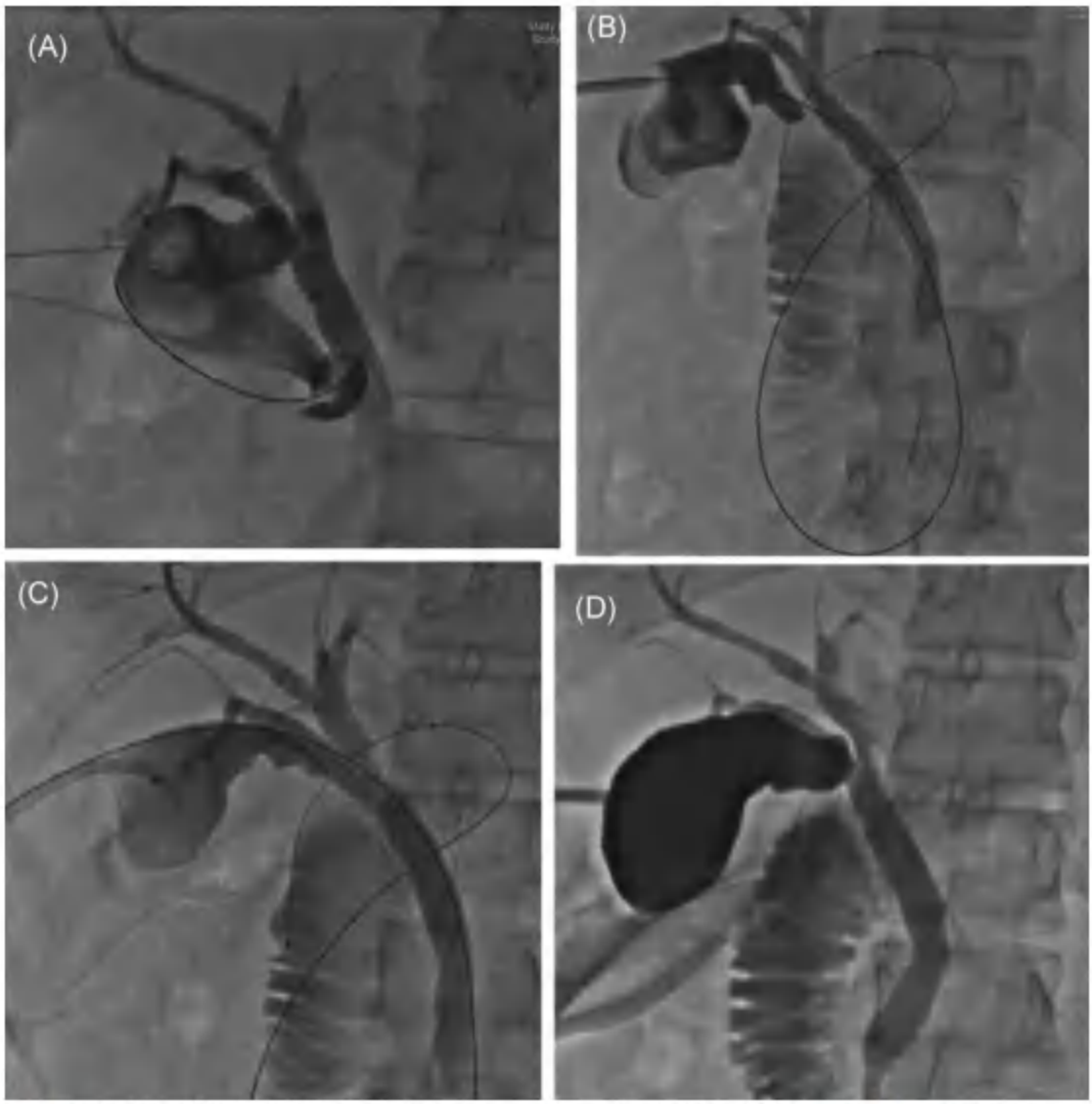


图 3　(A) 胆囊造影透视下观察到的巨型结石。(B) 术中向胆囊导管插入一根 260 厘米长的导丝延伸至十二指肠作为安全导丝。(C) 激光光纤组件与 4-French 导管通过 6-French 鞘管置入。调整鞘管尖端呈直角以确保其对准结石。采用 FREDDY 激光碎石术将结石击碎成碎片。(D) 最终胆囊造影显示胆囊内未见充盈缺损。



图 4 胆囊术后三个月计算机断层扫描影像。胆囊内未见结石。

讨论

据我们所知，本研究是首个评估 FREEDY 激光经皮碎石术治疗巨大胆囊结石有效性与安全性的临床研究。与既往采用经皮碎石术的研究不同，我们使用 8-French 外鞘管实施该手术，其尺寸远小于其他内镜辅助碎石术研究采用的器械。以胆囊造影显示无结石为标准的成功率高达 100%（16/16）。该方法可能成为治疗巨大胆囊结石的新型微创术式。

胆囊切除术传统上用于治疗有症状的胆囊结石。然而该手术并不总是适合老年或高风险患者。此外，胆囊切除术的患者选择标准仍存在争议，全球范围内遵循的适应证也不尽相同。

此外，多项前瞻性研究报道显示，在接受胆囊切除术的患者中，高达 41% 会出现多种症状，尤其是术后持续性疼痛。胆囊切除术后罹患恶性肿瘤的风险也有所增加。近期一项多中心随机平行对照研究表明，当前针对症状性胆囊结石的治疗方案远未达到理想效果，应当重新评估胆囊切除术的临床应用，并为患者提供审慎的治疗建议。胆囊切除术可能并非症状性胆结石的最佳解决方案。关于胆结石与功能性胃肠问题之间的关联性，仍需开展进一步研究。

经皮胆囊取石术是高危患者及希望保留胆囊功能患者的替代选择方案。该技术由 Kerlan 等人于 1985 年首次报道。这项技术在大多数患者中具有广泛适用性。多项研究证实该方法治疗胆结石具有较高成功率和良好安全性。临床采用多种碎石技术如电子液压碎石、机械碎石、体外冲击波碎石及激光碎石将结石粉碎。与其他技术相比，激光碎石被视为更先进的碎石技术。

多种激光系统，如脉冲 Nd:YAG 激光、调 Q Nd:YAG 激光和脉冲染料激光，在 Ori 等人于 1981 年首次使用 YAG 激光配合胆道镜实施胆总管切开取石术后，被研究并应用于胆结石碎石治疗 [24-27]。与这些早期激光系统不同，FREEDY 激光不会产生热效应，其激光脉冲不易被胆囊黏膜及其他软组织吸收，从而避免了激光能量造成的组织损伤。这一优势使得在透视引导下无需内镜直接观察即可安全实施激光碎石术成为可能。因此，不再需要为内镜操作准备大尺寸鞘管（即至少 18Fr）及长通道成熟时间（约 10-14 天）[28]。本研究中，我们仅使用 8Fr 鞘管在透视下实施经皮碎石术，与较大鞘管相比显著缩短了住院时间、减少了组织损伤并降低了患者疼痛。另一方面，近年来新型细径内镜（8.7Fr）的应用也消除了对大尺寸鞘管的需求。

FREEDY 激光的另一优势在于其高效碎石能力。该激光系统采用双脉冲同步作用机制——每个脉冲同时包含绿光与红外线成分。经等离子体能量放大后，用于碎石的空化冲击波强度极高。Marguet 等人通过体外实验比较了 FREEDY 激光与钬激光的碎石能力，发现两种激光系统分别造成 80.89% 和 4.13% 的重量损失。FREEDY 激光的碎石能力显著优于钬激光。此外，Yang 等人在内镜引导下对 52 例胆总管大结石患者使用 FREEDY 激光，成功率高达 53.8%。本研究得益于 FREEDY 激光的高效性，取得了 100% 的成功率。该结果优于 Yang 团队使用 Wilrich 镍钛合金取石篮联合金属套管进行碎石的研究（成功率 94%）。另一项研究中，钕-钇铝石榴石（Nd-YAG）激光治疗 69 例胆道结石患者，67 例（97.1%）实现结石完全清除，与本研究结果相当。然而 FREEDY 激光系统的主要局限在于激光光纤在透视下不可见。为解决这一问题，我们将激光光纤与 6F 单弯导管组装，使光纤头端外露 1 厘米。通过 6F 可控导引鞘将组装体送达靶区结石部位，该鞘管在调整头端方向时可发挥类似内镜的功能。本研究中结石完全粉碎所需的平均激光脉冲次数（2471±672 次）显著少于杨团队报道的数据（3581±1450 次），我们认为这种差异源于可控鞘管与光纤导管组装体提高了结石定位精度。据我们所知，这是首个应用可控导引鞘治疗胆囊结石的研究。

高复发率是经皮碎石术的主要问题。一项纳入 459 例接受经皮碎石术患者的研究显示，10 年随访期的复发率达 26%；Donald 等报告 4 年随访期的累积复发率为 4.2%。本研究长期随访发现 3 例（18.8%）患者出现胆结石。然而经皮碎石术在治疗高风险老年患者中仍

具重要价值，且复发性胆结石未引发临床症状。我们建议患者术后调整饮食结构并加强有氧运动，这些干预措施可能有助于降低结石复发率。

本研究中在一名患者（6.3%）体内检测到胆囊积血。这可能是由于激光光纤尖端对胆囊壁造成的损伤所致。不过通过药物控制住了伤势。Young 等学者 14 报告称，在使用 FREDDY 治疗胆总管结石时，轻微胆道出血的发生率为 15.4%。常规血液检查显示血红蛋白无变化，且出血自动停止。术中因轻微胆漏导致的腹膜炎见于 2 例患者（12.5%），经抗生素治疗后迅速康复，无需经皮引流。然而 Young 等学者曾报道，在使用取石篮进行胆囊结石切除术时，有两名患者因取石过程中胆道损伤导致胆汁性腹膜炎而接受了经皮引流治疗。

本研究存在若干局限性。首先，样本量较小且随访周期较短，因此研究结果需谨慎解读。其次，在仅依靠二维透视引导的情况下，可能存在结石微小碎片被遗漏的情况，这与内镜引导下碎石术能实时观察残留结石形成对比。

综上所述，使用 FREDDY 激光进行经皮碎石术可能是治疗巨大胆结石的一种有效且安全的替代方案，尤其适用于不适合手术胆囊切除术的患者。可操纵鞘管及激光光纤与导管组合的应用显著提高了定位结石靶区的精确度。

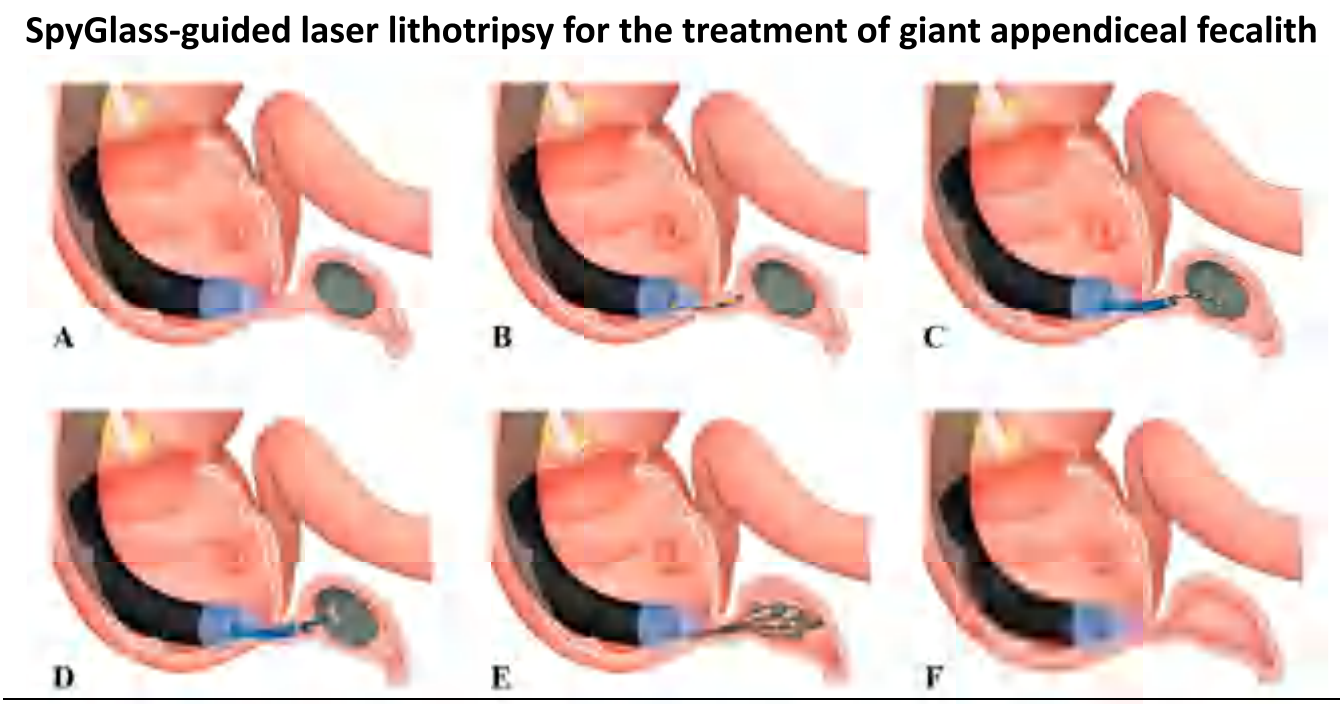
Video

SpyGlass-Guided Laser Lithotripsy for the Treatment of Giant Appendiceal Fecalith: First Human Case Report

Ling-Jian Kong, PhD[1], Ji-Yu Zhang, MD[1], Saif Ullah, MD[1] and Bing-Rong Liu, MD, PhD[1]

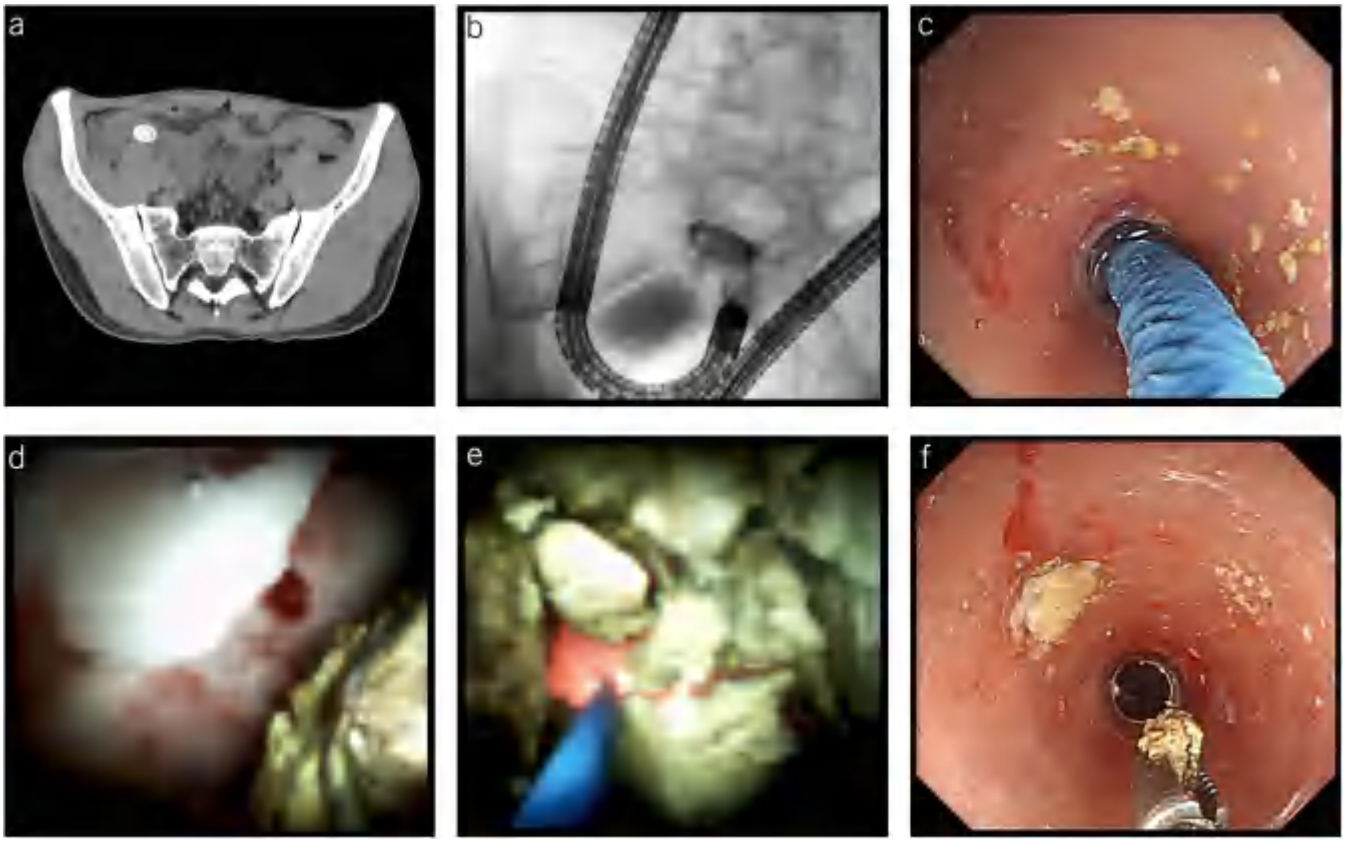
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Kong et al. *Am J Gastroenterol.2021*. doi:10.14309/ajg.0000000000001409
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Appendectomy remains the first selectivity for adult appendicitis with appendiceal fecalith. However, the risk of appendiceal fecaliths falling into the peritoneal cavity resulting in serious postoperative complications remains high. In addition, the appendix, which believed to have significant immune functions, is also removed. Here, we report our experience of the SpyGlass-guided laser lithotripsy for the treatment of a giant appendiceal fecalith.

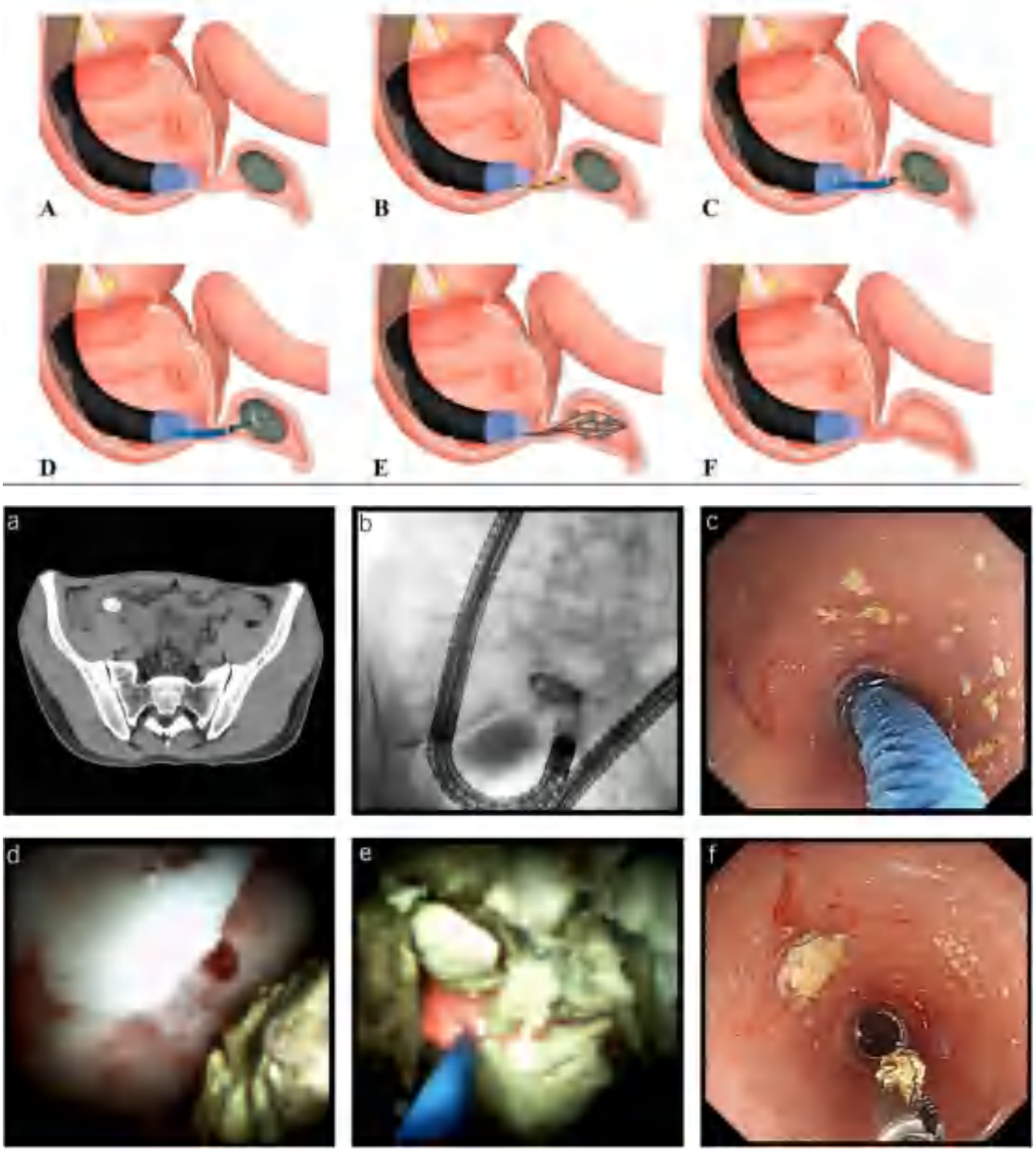
A 40-year-old man was admitted to our hospital with intermittent right lower abdominal pain without fever for 15 days. The computed tomography scan showed thickened wall of the appendix and a nondense fecal stone shadow in the appendiceal cavity (a). An endoscope with a transparent cap attached on the tip was advanced into the cecum where edema of the opening of appendix was clearly seen. A guide wire was inserted into the appendix under fluoroscopic guidance showing a huge oval 1.5 * 1.2-cm filling defect (b). A balloon dilation catheter with a diameter of 10 mm was used to expand the appendiceal cavity, and Spyglass laser lithotripsy using U100 excitation was performed (c, d, e). A large amount of yellow and white hard fecal stones were removed with a stone basket extractor and foreign body forceps (f). The appendix cavity was repeatedly washed with normal saline. A plastic stent (8.5 Fr, 6-cm length, COOK) was then placed along the guide wire. The total procedure time was 53 min. Abdominal pain was relieved immediately after the procedure. The stent was removed 1 month after the procedure. No recurrence or any other adverse event had been noted during the 3-month follow-up. Spyglass-guided laser lithotripsy using endoscopic retrograde appendicitis therapy has the ability to solve the problem of huge hard stones within the appendix. This technique provides a feasible new alternative treatment for patients who are unwilling or unable to undergo appendectomy. This minimally invasive organ-sparing procedure both relieved the obstruction and preserved the physiological function of the appendix. (Watch the Video, Supplementary Digital Content 1, http://links.lww.com/AJG/C148.) (Informed consent was obtained from the patient to publish these images.)

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《SpyGlass 引导激光碎石术治疗巨大阑尾粪石：首例人类病例报告》

Ling-Jian Kong, PhD, Ji-Yu Zhang, MD, Saif Ullah, MD and Bing-Rong Liu, MD, PhD

SpyGlass 引导下激光碎石术治疗巨大阑尾粪石



阑尾切除术仍是成人阑尾炎伴阑尾粪石的首选治疗方案。然而，粪石坠入腹腔导致严重术后并发症的风险仍然较高。此外，被认为具有重要免疫功能的阑尾组织也将被切除。本文报道一例采用 SpyGlass 引导下激光碎石术治疗巨大阑尾粪石的经验。

一名 40 岁男性患者因间歇性右下腹疼痛 15 天（无发热）入院。计算机体层摄影扫描显示阑尾壁增厚，阑尾腔内可见非致密性粪石影（图 a）。将配备透明帽的内镜推进至盲肠后，可清晰观察到阑尾开口处水肿。在透视引导下将导丝插入阑尾，显示 1.5*1.2 厘米的巨大椭圆形充盈缺损（图 b）。使用直径 10 毫米的气囊扩张导管扩张阑尾腔后，实施 SpyGlass 激光碎石术（采用 U100 激发源）（图 c、d、e）。通过取石篮和异物钳取出大量黄白色坚硬粪石（图 f）。随后用生理盐水反复冲洗阑尾腔，并沿导丝置入塑料支架（8.5Fr，6 厘米长，COOK 品牌）。手术总时长 53 分钟，术后腹痛立即缓解。支架于术后 1 个月取出，3 个月随访期间未发现复发或其他不良事件。

采用内镜逆行阑尾炎治疗技术的 SpyGlass 引导激光碎石术，能够有效解决阑尾内巨大坚硬结石问题。该技术为不愿或无法接受阑尾切除术的患者提供了可行的新治疗方案。这种保留器官的微创手术既解除了梗阻，又保留了阑尾的生理功能。（观看视频，补充数字内容 1，http://links.lww.com/AJG/C148。）（已获得患者知情同意发布相关影像资料。）

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胆道镜 U100 双频激光治疗胆肠吻合术后残留结石

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摘要：目的 探讨电子胆道镜结合双频激光碎石仪治疗胆肠吻合术后胆道残留结石的治疗效果及体会。方法 2008 年 9 月～2010 年 9 月经腹壁窦道采用胆道镜治疗胆肠吻合术后胆道残留结石 46 例，对其治疗效果进行分析，其中 38 例使用 U100 双频激光碎石。结果 取石取净率为 95.7%(44/46),1 次取净结石者 21 例(45.7%),2 次取净结石 13 例(28.3%),3 次取净结石 8 例(17.36%),4 次以上者 2 例(4.34%),2 例为远端肝内结石,胆管段状狭窄,胆道镜无法进入而取石失败。结论 电子胆道镜结合双频激光碎石仪能有效地治疗胆肠吻合术后胆道残留结石。

关键词： 胆道镜;双频激光碎石仪;胆肠吻合术;胆管结石
中图分类法： R657.3 文献标识码： B

肝内胆管结石和胆道术后残余结石的处理至今仍是胆道外科的难题之一,常需多次手术治疗,随着胆道镜技术的发展和激光碎石技术的应用，开辟了治疗上述结石较理想的方法，甚至可以起到外科手术起不到的作用。2008 年 9 月～2010 年 9 月我院对 46 例行胆肠 Roux- en- Y 吻合术后胆道残余结石患者应用电子胆道镜取石，并使用 U100 双频激光碎石,取得了满意的效果。现报道如下：

1 资料与方法

1.1 临床资料

本组患者 46 例。其中,男 26 例,女 20 例;年龄 28～78 岁,中位年龄 53.2 岁。结石分布:左肝内胆管结石 20 例,右肝内胆管结石 14 例,左右肝胆管结石 12 例。结石直径 0.6～2.0 cm。所有患者术中均在胆肠吻合口处空肠段放置 T 管，并于术后 6 周拔除 T 管,经窦道行胆道镜取石或双频激光碎石取石治疗。6 例患者术前使用安定、度冷丁镇静止痛，其余 40 例患者均不需麻醉与禁食,术后常规给予抗感染、补液治疗。

1.2 治疗器械

德国 WOM 公司的 U100 双频激光碎石机,Pentax 电子胆道镜及其电视监视系统,Microvasiv 胆管扩张球囊、导丝,取石网篮,内镜逆行胰胆管造影造影胆管及 20 mL 注射器。

1.3 治疗方法

①常规消毒、铺巾后拔除 T 管,直视下经窦道口插入电子胆道镜,调整先端弯曲部,经窦道进入肠腔后,沿肠腔寻找到肝内胆管,发现小结石可用网篮套取至肠腔。②嵌顿结石或结石直径 >1.0 cm 者,于体外自胆道镜活检孔插入光导纤维，再次进入胆道找到结石后,光纤头超出胆道镜 1.5 cm,使其顶端轻轻接触结石显露面的中心区域,直视下激发激光。操作过程中持续送水，以保持视野清晰，直至结石粉碎。用取石网篮取出碎石后送至肠腔。③胆管结石合并该支胆管狭窄者可用胆道镜镜身扩张狭窄的胆管,若胆道镜先端部不能通过者,经胆道镜活检孔插入导丝,退出胆道镜,保留导丝并沿导丝导入胆管扩张球囊,充气扩张,扩张后直视下激光碎石。④激光碎石术后常规放置 16- 20 号去短臂 T 管,如一次结石不能取尽,隔 5～7 d 后再次取石。

2 结果

通过胆道镜、B 超、窦道造影共同确认无结石则确定为成功取石。本组结石取净率 95.7%,其中 1 次胆道镜取净结石者 21 例 (45.7%),2 次胆道镜取净

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图 1　X 线引导下胆道镜进入胆管

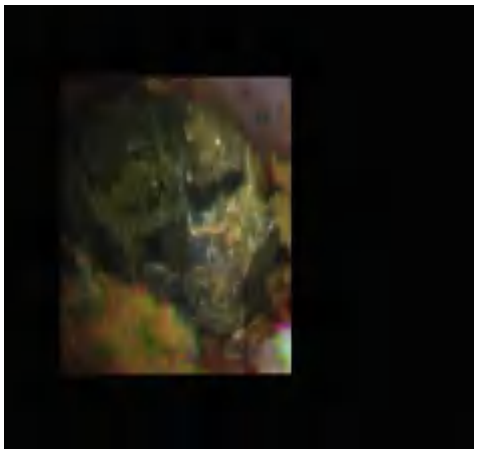


图 2 肝内大结石

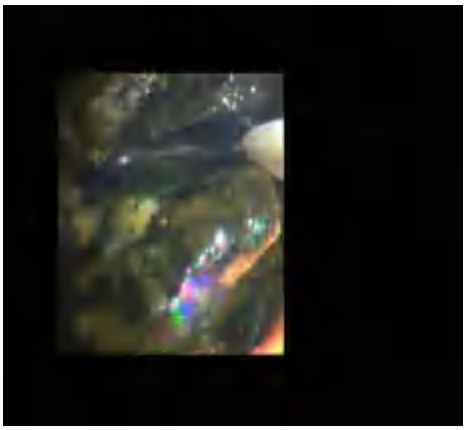


图 3　激光碎石

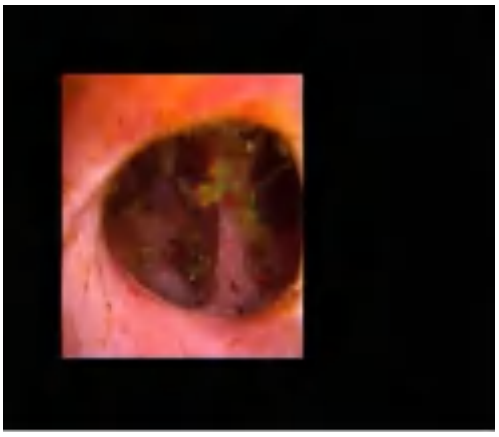


图 4 取净结石后

结石 13 例（28.3%），3 次胆道镜取净结石 8 例（17.36%），4 次以上者 2 例（4.34%），2 例为远端肝内结石，胆管段状狭窄，胆道镜无法进入而取石失败。

对合并胆管狭窄者，经胆道镜或气囊扩张后，狭窄均解除。术中均有轻、中度但尚能忍受的上腹部胀痛，未诱发循环、呼吸系统意外。术中胆管少量渗血 5 例，经灌注 1∶10 000 去甲肾上腺素盐水溶液数分钟出血停止。术后呕吐、腹泻 5 例，术后胆管炎 3 例，经对症治疗均治愈。碎石过程见图 1～4。

3　讨论

原发于肝内胆管系统结石病情复杂，并发症发生率高，手术后复发率高，病死率高，一直是外科治疗的难题，目前仍以手术治疗为主，外科治疗的原则是取尽结石、解除狭窄、去除病灶、胆汁引流通畅和防止感染[1]。胆管空肠 Roux- en- Y 吻合术常作为附加治疗方式。由于肝内胆管结石分布广、位置深、形成铸型结石及胆管狭窄等因素，术后容易残留结石和结石复发。对于后期再发结石、吻合口狭窄以及肝内胆管再狭窄，仍然尚难解决，特别是行胆肠吻合术后，再次手术更为困难，甚至需要多次手术，而且开腹手术一次更比一次困难。胆道镜技术的发展开辟了治疗肝内外结石较理想的途径，绝大多数结石可在胆道镜下通过篮网套取出，但对于结石直径>1.0 cm、嵌顿型结石内镜下取石很难成功，常需碎石治疗[2-4]。目前临床上常用的碎石方式有超声碎石、液电碎石、等离子碎石、机械碎石及钬激光碎石等，O-GAWA 等[5-6]报道经皮经肝胆道镜结合液电碎石对于不能手术或逆行胰胆管造影治疗失败的胆总管结石有一定疗效，但由于水产生的高压冲击波易造成胆道出血及损伤，术后部分患者可出现腹胀不适、胆汁性腹膜炎等并发症。文献报道[7-9]钬激光碎石肝内胆管残石具有一定疗效，但也有引起胆道出血和胆道穿孔的危险。目前的各种碎石方法均因各种原因在临床使用受限。笔者通过应用 U100 双频激光碎

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石仪碎石后取石,取得了极佳的效果。

U100 双频激光碎石仪是德国 W0F 公司生产的一种双频双脉冲掺钕钇铝石榴石 (Nd:YAG) 激光器。其原理是通过"FREDDY"技术产生激光脉冲,包括绿光 (A=532 nm) 和红外光 (A=1 064 nm) 两种波长的脉冲。人体正常组织由于不吸收这两种波长激光。不会导致正常组织损伤,并且能在短时间内准确高效地击碎结石,对结石推动力极小,可避免胆道壁穿孔危险。动物实验中,U100 激光碎石视对兔子膀胱壁黏膜发射 2 000 次的脉冲激光,无穿孔发生[10-11]。本研究结果显示,U100 双频激光具有碎石效果好、穿孔、出血等并发症发生率低的优点,其不足之处主要表现在于:①光纤的脆性太大,增加了其在肝内胆管碎石中操作的难度。②激光在激发前发出的光造成内镜视野"苍白"而影响操作。③成本较高,主机的抗震性较差,易损坏且维修费用较高。故使用时应注意:①因为光纤易折断,所以在插入胆道镜时可以先将其插入塑料导管,然后再将导管插入胆道镜,为了防止损伤胆道镜光纤远端应露出胆道镜 l.5 cm 以上。②双频激光碎石时,应将光纤远端接触结石同一部位,反复击打,当结石出现裂缝或破裂口时就容易粉碎。③光纤远端尽量不要接触胆管壁,以免损伤胆管。

胆道镜在胆肠吻合术后残余结石患者的操作难点在于快速准确寻找到肝内胆管,笔者的处理方法是:①采用肠镜拉镜法:通过持续注水,在空肠的舒张期进镜,可以避免肠管的收缩导致视野不清。②观察胆汁的流向,沿着肠管中胆汁排出的方向去寻找肝内胆管。③注意插镜的深度,若进入很深仍未找到胆管,则退出重新寻找。④结合造影在 X 线引导下寻找。⑤放置引流管时最好在导丝引导下置放,可以为下次取石提供便利。取石时对于直径 <1.0 cm 的结石,可以用取石网篮直接套取,但 >1.0 cm 的结石,先将结石用双频激光击碎后再分别用网篮取石,不应粗暴拉拽,以免损伤胆道和窦道或损坏了取石工具[12]。胆管结石合并该支胆管管状狭窄者,可用胆道镜镜身扩张狭窄的胆管,仍未使胆道镜前端部通过者,经胆道镜活组织检查孔插入导丝,退出胆道镜,保留导丝并沿导丝导入胆管扩张球囊,球囊充气扩张即可观察到结石,直视下激光碎石。

笔者通过临床实践认为,经电子胆道镜结合 U100 双频激光碎石为肝内胆管结石和胆道术后残余结石提供了较好的治疗方法,避免了患者再次手术,有着广阔的应用前景,值得推广应用。

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· 临床论著 ·

经胆囊管超细胆道镜联合双频激光碎石治疗胆道结石*

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【摘要】 目的 探讨腹腔镜下经胆囊管超细胆道镜(管径 3.7 mm)联合双频激光碎石术治疗胆道结石的安全性和可行性。 方法 2011 年 8 月~2013 年 6 月,治疗胆囊结石合并胆道结石 63 例。行腹腔镜胆囊切除术,经胆囊管通过胆道镜工作通道,用双频双脉冲激光碎石技术将结石击碎,注水冲出或用取石网篮套出。 结果 63 例胆道结石均一次清除取出。无胆道损伤、胆漏。全组术后 3 个月复查 B 超或 MRCP,未发现胆道残余结石、胆道狭窄。 结论 腹腔镜下经胆囊管超细胆道镜联合双频激光碎石术直观,准确,方便,疗效确切,是治疗胆囊合并胆道结石的安全、有效的新方法。

【关键词】 腹腔镜; 超细胆道镜; 双频激光; 经胆囊管胆道探查; 胆道结石

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Laparoscopic Transcystic Common Bile Duct Exploration Combined with Superfine Choledochofiberscopy and Double-frequency Laser Lithotripsy for Biliary Stones *Liu Jun, Jin Lan, Han Wei, et al. Department of General Surgery, Beijing Friendship Hospital, Capital Medicine University, Beijing* 100050, *China*

【Abstract】 **Objective** To evaluate the safety and feasibility of laparoscopic transcystic common bile duct exploration combined with superfine choledochofiberscopy and double-frequency laser cholelithotripsy for patients with complicated biliary calculus. **Methods** A total of 63 patients with cholelithiasis received laparoscopic transcystic common bile duct exploration combined with superfine choledochofiberscopy and double-frequency laser cholelithotripsy from August 2011 to June 2013. The patients with both hepatic duct and gall bladder stones received laparoscopic cholecystectomy followed by superfine choledochofiberscopy and double-frequency laser cholelithotripsy. The stones were then removed by irrigation or a basket. **Results** All the stones in the total of 63 cases were removed completely in one operation without bile duct injury or biliary leakage. In the reexamination (B-ultrasonography or MRCP) of all the cases 3 months after the surgery, no residual stones or bile duct stricture was observed. **Conclusion** Laparoscopic transcystic common bile duct exploration combined with superfine choledochofiberscopy and double-frequency laser cholelithotripsy is a safe, effective, and accurate approach for complicated cholelithiasis.

【Key Words】 Laparoscopy; Superfine choledochofiberscope; Double-frequency laser; Transcystic common bile duct exploration; Cholelithiasis

随着微创外科技术的发展,腹腔镜胆囊切除术(laparoscopic cholecystectomy,LC)加腹腔镜下经胆囊管胆道探查术(laparoscopic transcystic common bile duct exploration,LTCBDE)成为胆囊结石合并胆道结石的首选治疗方式[1~3]。但由于 LTCBDE 操作相对复杂,术者需掌握熟练的腹腔镜和胆道镜技术,且对胆囊管解剖条件要求高,LTCBDE 的开展受到一定限制。超细胆道镜(管径 3.7 mm)置入胆囊管更容易,但对于胆管内质硬、较大结石(直径 > 6 mm)或嵌顿结石,单纯胆道镜难以取出,一是套石篮不能套入结石,另外即使套入了结石,也难以经胆囊管取出,易造成胆囊管、胆总管交汇部撕裂。2011 年 8 月~2013 年 6 月,我院对需行 LC 联合 LTCBDE 患者应用双频激光碎石技术结合超细胆道镜经胆囊管治疗胆道结石 63 例,效果满意,现报道如下。

1 临床资料与方法

1.1 一般资料

本组 63 例,男 35 例,女 28 例。年龄 31~75 岁,平均 52.6 岁。32 例有腹痛、黄疸、发热,保守治

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疗缓解后 2 ~ 3 个月手术; 6 例急性胆囊炎、胆管炎, 2 ~ 6 天内手术, 其中 3 例先行鼻胆管引流术; 25 例体检发现胆囊、胆总管结石, 无临床症状。术前 B 超或胆道 MRCP 明确 50 例胆总管结石, 结石直径 0.2 ~ 1.3 cm, 单发结石 33 例, 17 例 2 ~ 5 枚结石, 均位于胆总管中下段; 3 例肝管、胆管结石, 结石直径 0.3 ~ 0.8 cm, 2 ~ 4 枚, 2 例在肝总管、胆总管, 1 例在胆总管和左肝Ⅱ级肝管。7 例因体内有金属物, 未做 MRCP 检查, B 超未提示胆管结石, 其中 3 例胆总管增宽(直径 > 8 mm), 2 例有胆源性胰腺炎史, 1 例有黄疸史, 1 例肝功能异常[丙氨酸氨基转移酶(ALT) 135 U/L(正常值 0 ~ 40 U/L), 天门冬氨酸氨基转移酶(AST) 173 U/L(正常值 0 ~ 40 U/L), GGT 226 U/L(正常值 8 ~ 55 U/L)]。3 例 B 超及 MRCP 未发现异常, 其中 2 例有胆源性胰腺炎史, 1 例有黄疸史。均符合胆道探查指征。

病例选择标准: 胆囊结石合并胆管结石需行 LC 及胆管探查取石术者; 一般状况评分(KPS) ≥70; 接受 LC + LTCBDE 术式; 无手术禁忌证。

排除标准: 单纯应用胆道镜即可取净胆管结石; 不能经胆囊管完成胆道探查; 腹腔镜下胆总管切开行胆道探查; 中转开腹手术。

1.2　方法

应用 Olympus CHF-XP20 胆道镜和德国 WOM U100 Plus(FREDDY) 双频双脉冲激光, 420 μm 光纤。静吸复合全麻, 头高足低位, 左倾右侧高 15° ~ 20°。Veress 气腹针穿刺建立 CO_2 气腹, 压力 12 mm Hg(1 mm Hg = 0.133 kPa), 常规四孔法放置 trocar, 右锁骨中线肋下处 5 mm trocar 较单纯 LC 手术更接近肋缘, 以利于胆道镜探查。解剖分离 Calot 三角, 暴露胆囊动脉、胆囊管、胆总管。夹闭胆囊动脉后切断, 靠胆囊侧夹闭胆囊管, 牵拉胆囊, 使胆囊管呈平直状。距胆总管约 6 mm, 将胆囊管前壁剪开周径的 1/2, 再向胆总管侧沿胆囊管长径剪开 2 ~ 3 mm, 使切口呈"T"字状。于切开的胆囊管前下壁缝合一针牵引, 分离钳沿切开处深入胆囊管向胆总管方向适度扩张胆囊管。右上腹 trocar 深入腹腔, 尽量靠近胆囊管切开处, 插入胆道镜经胆囊管行胆道探查。从胆道镜操作孔置入激光光纤, 光纤超出胆道镜约 1 cm, 持续生理盐水冲洗。尽量将结石抵住一侧胆管壁或靠近乳头, 减少结石的运动, 光纤对准结石中心击发。激光能量设定为 0.12 J, 脉冲宽度 1.2 μs, 脉冲频率 10 Hz。每次接触结石间断发射 2 次激光。可多次击发, 将结石击碎(一般 < 5 mm), 利于取石网篮套入结石并自胆囊管取出。细小结石可通过乳头冲入十二指肠。常规尝试胆道镜通过 Oddi 括约肌进入十二指肠, 扩张十二指肠乳头, 利于胆管内冲洗。如条件允许, 均翻转胆道镜探查肝总管和肝内胆管。退出胆道镜, 夹闭胆囊管, 切除胆囊。均不放置引流管。术后治疗同单纯 LC。

2　结果

63 例均手术成功。其中 10 例术前检查未发现胆总管结石, 术中胆道探查发现胆管结石直径 0.4 ~ 0.7 cm, 1 ~ 3 枚, 9 例位于胆总管下段, 1 例位于肝总管和胆总管内。碎石后取出胆总管内结石 59 例, 胆总管和肝总管内结石 3 例, 胆总管和左肝管内结石 1 例。54 例胆道镜可以通过十二指肠乳头 Oddi 括约肌进入十二指肠, 9 例取石网篮可进入十二指肠。手术时间 75 ~ 140 min, 平均 118 min。出血 10 ~ 60 ml, 平均 17 ml。无胆道损伤、胆漏、胆道出血等并发症。59 例术后第 1 天即进食、出院, 无其他治疗; 2 例术后第 1 天肝脏转氨酶升高(ALT 66、114 U/L, AST 71、125 U/L), 1 例胆红素增高[直接胆红素(DBIL) 9.67 μmol/L(正常值 0 ~ 6.84 μmol/L), 间接胆红素(IBIL) 23.6 μmol/L(正常值 0 ~ 12 μmol/L)], 保肝利胆解痉治疗 2 天后上述指标降至正常, 术后第 3 天出院。2 例术后血白细胞计数明显升高(13.4×10^9/L、15.8×10^9/L) 伴发热(37.8、38.3 ℃), 予抗生素治疗后血白细胞计数和体温恢复正常。所有患者术后 3 个月复诊, 无临床症状, B 超或 MRCP 检查未发现胆道残余结石。43 例术后 1 年 B 超检查, 其中 19 例行 MRCP, 均未见胆道结石。

3　讨论

Fletcher[4] 于 1991 年首次报道腹腔镜下经胆囊管胆道探查术。之后这一技术得到认可并推广, 创伤小, 术后患者恢复快, 手术创伤近乎于 LC。充分利用胆囊管这一自然腔道, 完成胆道探查后能够可靠地夹闭胆囊管; 避免了胆总管切开所造成的医源性损伤及可能的不良后果, 无须放置 T 管; 保持了胆道的完整及正常生理功能。同时也避免了有胆道探查指征的患者行 ERCP + EST 等有创治疗的创伤和痛苦, 并保留 Oddi 括约肌的功能。超细胆道镜管径细, 易于在胆囊管和胆总管内活动、扭转。有利于翻转探查肝总管及肝内胆管。LTCBDE 术后恢复快, 住院时间短, 目前已成为治疗胆囊结石合并胆管结石的首选方式[1~3]。

LTCBDE 虽有巨大优势, 但因其对患者胆囊管局部解剖条件和手术者的操作技术要求高, 限制了其大范围推广, 不同单位报道的成功率也不同[3,5,6]。以下情况都会造成胆道镜难以进入胆囊管: 多种原因引起的胆囊管管腔过小、扭曲或阻塞; 炎症反应使管壁增厚, 管腔狭窄; 胆囊管内 Heister 瓣影响; 胆囊管与胆总管交汇部的解剖变异(胆囊管与胆总管并行过长, 交汇过低或交汇于胆总管后方、左侧方等); 粘连严重, 难以分离出明确的胆囊

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管和胆总管交汇部。此外，胆管内结石过大、铸型或嵌顿于十二指肠乳头部，网篮难以张开、套入结石；或网篮虽能套入结石，但难以经胆囊管取出，强行拉出易造成胆囊管、胆总管撕裂，增大损伤，也形成胆囊管夹闭困难。我院自 2006 年开始行 LTCBDE，已完成近千例，积累了较丰富经验。尤其是超细胆道镜的运用，LTCBDE 成功率达 90% 以上[7]。实际工作中，我们体会超细胆道镜能提高胆囊管进入的成功率，但对于较大结石或嵌顿结石取出困难，有时强行取石也会造成胆囊管胆总管汇入部撕裂。若用常规镜身直径 4.9 mm 胆道镜取石虽然方便些，但经胆囊管进入胆总管困难，往往需做汇入部微切开，切口延至胆总管侧壁，增加了胆管损伤几率，且闭合困难。

胆道镜结合碎石技术治疗胆管结石已有报道[8]。20 世纪 90 年代发展起来的双频双脉冲激光碎石现已超过钬激光成为最佳的激光碎石技术，尤其在胆道结石治疗方面有广阔的发展前景[9,10]。双频双脉冲激光碎石系统是脉冲 Nd: YAG（钕：钇铝石榴石）激光发生器，实质是脉冲激光等离子体冲击波碎石技术，是机械能量的作用，而非热爆式。作用原理是短波长激光（波长为 532 nm 绿光，占能量 20%）照射结石，先在结石表面形成等离子区，然后长波长激光（波长为 1064 nm 红外光，占能量 80%）照射先期形成的等离子区，充分吸收红外光能量，迅速扩大该区的离子和电子容积，产生机械性冲击波，使结石碎裂。除胱氨酸结石外，对人体大多数结石如钙石、尿酸石、胆固醇和胆色素结石均有效，适用于胆道碎石。正常人体软组织不吸收这 2 种波长的激光；激光发射是脉冲式，避免了连续激光照射碎石对周围组织的热损伤；同时术中连续生理盐水冲洗，进一步避免了对胆管壁等周围组织的冲击损伤。Zorcher 等[11]进行了试验，将激光光纤直接对准兔膀胱黏膜击发，仅引起黏膜轻度充血、水肿，未造成穿孔，也无肌层损伤。双频激光光纤直径 420 nm，柔软，易弯曲，可很好地与胆道镜配合，易于通过管径 1.2 mm 的胆道镜操作孔。常用的液电微爆破碎石导线不能通过超细胆道镜操作孔。钬激光光纤可顺畅进出胆道镜，也有好的碎石效果，但对胆管壁的损伤大，易造成出血、穿孔。

我们联合应用超细胆道镜和双频双脉冲激光碎石术，腹腔镜下经胆囊管治疗胆道较大结石和难取性结石，取得了满意的治疗效果。63 例 LTCBDE 均取得成功，一次手术治愈胆囊、胆道结石。常规 Olympus CHF-P20 胆道镜不能通过胆囊管，需行胆囊管胆总管汇入部切开，不能做到真正意义上的 LTCBDE。而且大部分患者胆道内大结石或嵌顿结石仍难以取出，还要碎石。

术中注意事项：①激光光纤要超出胆道镜 1 cm 左右，避免损坏胆道镜。②将结石推至胆管下段或使之与胆管壁相对固定，减少漂移活动，光纤易于抵住结石，提高碎石效果。③直视下光纤对准结石中心击发，对准一点连续冲击，易于碎石；不宜击发结石侧壁，易损伤胆管壁。④结石碎裂分解为 4、5 mm 为宜，方便取出即可，不宜碎石过小，否则网篮套入结石困难。⑤肝管结石用生理盐水冲入或网篮带入胆总管后再碎石、取石。⑥胆道镜均应尝试通过十二指肠乳头进入十二指肠，扩张 Oddi 括约肌，利于胆管冲洗和细小结石碎屑排出。我们的经验，只要十二指肠乳头无明显偏斜，胆管下端或 Oddi 括约肌没有炎性狭窄，胆道镜都可通过。

腹腔镜、超细胆道镜结合双频双脉冲激光碎石微创手术治疗胆囊、胆道结石，尤其是难取性胆道结石，效率高，创伤小，恢复快，有非常好的临床效果，是安全、可行的，值得大力推广。

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临床报道

逆行性胰胆管造影胆总管巨大结石激光碎石术治疗老年急性梗阻化脓性胆管炎126例

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摘要：目的探讨十二指肠镜下乳头切开术+胆总管巨大结石激光碎石术+取石术治疗老年急性梗阻化脓性胆管炎的临床效果。**方法**2012年1月-2015年5月采用经十二指肠镜下乳头切开术+胆总管巨大结石激光碎石术+取石术，治疗126例60岁以上急性梗阻化脓性胆管炎，且胆总管结石直径>2.0cm，对其临床治疗情况进行分析。**结果**老年急性梗阻化脓性胆管炎采用经内镜下乳头切开术+胆总管巨大结石激光碎石术+取石术治疗疗效满意。**结论**内镜下乳头切开术+胆总管巨大结石激光碎石术+取石术治疗老年急性梗阻化脓性胆管炎，成为胆总管巨大结石首选治疗方法，大部分患者不需要外科手术。

关键词：内镜下乳头切开术；激光碎石术；胆总管巨大结石；老年急性梗阻化脓性胆管炎
中图分类号：R657.4 **文献标识码：**B

急性梗阻化脓性胆管炎是胆道梗阻并发化脓性感染的肝胆系急症，起病急，病情重，进展迅速，死亡率高。内科保守治疗效果差，急症外科手术对患者全身状况影响大，术后并发症多。本科于2012年引进胆道镜SpyGlass，该胆道镜与激光联合取石已成为美国消化内镜取石的主流方法[1]。本科自2012年1月-2015年5月同期开展十二指肠镜下乳头切开术3175例，其中60岁以上急性梗阻化脓性胆管炎且胆总管结石直径>2.0cm应用激光碎石者126例，疗效满意。现报道如下：

1 资料和方法

1.1 一般资料

男69例，女57例，年龄60～98岁，平均（66.3±4.4）岁。临床表现有腹痛、寒战、高热和黄疸，体温38.5～39.5℃，白细胞数（11.0～21.9）×10^9/L，25例收缩压<90mmHg，11例有精神症状。影像学检查：本组126例均经彩超及磁共振胰胆管成像（magneticresonancecholangipoancreatography，MRCP）及超声胃镜证实为胆总管结石，直径2.～04.0cm，胆总管直径1.5～3.3cm。术前合并高血压10例，慢性气管炎14例，冠心病15例，糖尿病6例，水电解质紊乱11例，其中两种合并症以上者16例。手术前告知所有患者和家属可能出现的术后并发症，并签署知情同意书。

1.2 治疗方法

常规进PENTAXED34-i10T十二指肠镜（PENTAX，日本）至十二指肠降段，寻找乳头，进造影导管行逆行性胰胆管造影（endoscopicretrogradecholangiopancreatography，ERCP）判断结石位置及大小，在导丝引导下应用TRI-20M弓式切开刀（COOK，美国）沿11点方向切开十二指肠乳头奥狄氏括约肌约0.3～0.5cm，应用COOK公司扩张球囊（QBD-10X3）扩张胆总管，在SpyGlass胆道镜或ERCP球囊导管引导下，采用德国U100激光碎石后，用取石网篮将粉碎后的结石取出。手术结束前再次行ERCP证实有无残留结石。对病情严重合并休克者，先升压再行内镜下乳头切开术，置入双猪尾支架引流脓性胆汁，待病情稳定后再择期行激光碎石+取石术。术后常规留置胃肠减压、抑制胰液分泌药物、抗生素控制感染，保护各器官功能。观察治疗1周左右出院。

2 结果

2.1治疗结果

一次手术取石成功118例，二次取石成功8例，

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其取石成功率为100.0%，术后胆系感染迅速控制，合并休克者休克迅速纠正。1例出现胆道出血，经保守治疗好转。4例出现急性胰腺炎，其中3例经内科治疗痊愈，1例转入外科手术引流。

2.2随访

随访3个月，2例出现结石性胆囊炎，经应用抗生素治疗好转后，腹腔镜手术切除胆囊。

3 讨论

胆囊结石和胆管结石是常见病，其发病率在我国约占8.0%左右，其中胆管结石约占1/5[2]。胆总管结石引起梗阻性黄疸、急性胆囊炎、急性胰腺炎和急性胆管炎等一系列临床疾病，随年龄增长，其患病风险也随之加大[3]。

胆总管结石会引发寒战发热、恶心呕吐和神情抑郁等症状，严重者会并发胆道感染、胆道出血、胆源性肝硬化，甚至是胆管癌。老年人由于对疾病的反应差，临床症状和体征不典型，就诊时间晚，病情危重复杂，基础疾病多，合并症多，各器官生理代偿能力差，加上麻醉、手术创伤，极易出现肾、心血管、呼吸系统多器官功能衰竭，以急性肾功能衰竭最为常见。传统手术的风险较大，手术病死率较高。十二指肠乳头切开取石术是通过人体的自然生理通道，用内镜器械切开十二指肠乳头，借助各种内镜器械取石。胆总管结石，经过多年的临床努力，90.0%以上的胆总管结石可得以治疗，内镜下取石已是技术最成熟，远期疗效最好的诊治胆总管结石的方法，可以作为胆总管结石首选的治疗方法[4-6]。经验丰富的内镜医师取石成功率可达98.0%。该法不用开腹即可取出结石，不需放置T管，对腹腔内干扰少，且不受腹腔粘连和老年体弱因素限制[7]，但对胆总管巨大结石、铸型结石等内镜取石也有一定困难，由于激光胆总管碎石技术的迅速发展，国外也总结了大量经验[8]。

双频双脉冲U100激光碎石机能发出1064nm长的红外光和532nm的绿光，故称为双频激光机。碎石过程中，绿光（约占激光总能量的20.0%）先被结石吸收形成等离子体，等离子体再充分吸收红外光（约占激光总能量的80.0%）的能量，产生机械冲击波使结石粉碎[9]。人体正常组织由于不吸收这两种波长的激光，因而不会损伤正常组织。由于U100产生的冲击波峰值功率极高（最高达100kW），短时间内能准确高效地击碎结石。因此，碎石时间短，效率高，且对结石产生的推动力小，不会因碎石导致结石移动而不好控制。U100激光碎石采用的是非热灼性的碎石，使用时输出的功率仅1.2W，对周围软组织不产生热效应，无穿孔危险。本组126例中111例（88.1%）单击2～5次就达到碎石目的，另15例激光碎石5～10次将结石击碎。

本组应用内镜下乳头切开术+胆总管巨大结石激光碎石术+取石术，治疗老年急性梗阻化脓性胆管炎126例疗效满意，患者病情恢复迅速，具有创伤小、并发症少、疗效确切和恢复快等特点，大部分患者不需要外科开腹手术，成为老年胆总管巨大结石治疗方法之一，这与国内部分激光碎石报道相似[10]。

现对诊治老年胆总管巨大结石有以下几点体会：①术中做好心电监护，心动过缓者可应用阿托品或654-2。由于老年人耐受性差，手术不能超过1h。有冠心病或心衰可术中静点单硝酸异山梨酯扩冠及西地兰强心；②病情较重，结石较大者，采用小切口联合气囊行乳头括约肌扩张，乳头开口必须足够大，否则胆道镜不能顺利进入，结石取出过程中有困难。SpyGlass胆道镜微调很重要，上下左右调整幅度不要过大，注水要连续充分，不能无水碎石。激光光纤要准确对准结石，一般1～5次可激裂，但有的结石多、硬，击碎后结石仍较大，需反复发射激光，最多需要10次。应用激光碎石后用碎石网篮取石，因结石有的只是击裂，不能完全变成粉末，需再次用碎石网篮机械碎石。如有出血发生，可静脉推注立止血2支，必要时静点奥曲肽24h，配合局部氩气刀止血；③对于急性梗阻性化脓性胆管炎，如生命体征平稳，应尽早内镜治疗，否则患者出现全身多脏器功能衰竭将失去治疗机会；④对于肝胆管结石合并胆总管狭窄者、憩室内乳头、凝血机制严重障碍者慎用，做好术前评估；术后联合应用抗生素，注意保护肾肝心等重要脏器功能，及时纠正水、电解质紊乱，维持酸碱平衡，及时处理各种并发症及合并症；⑤无痛麻醉过程中碎石需要注水较多、注气也较多，应及时内镜抽水抽气，防止返呛和过度腹胀；⑥术前签字也非常重要，向患者家属交待手术的风险、费用等。

综上所述，应用内镜下乳头切开胆总管巨大结石激光碎石术+取石术治疗老年急性梗阻化脓性胆管炎，既可以达到治愈，又减轻外科手术的创伤，术后恢复快、住院时间短，显著地提高患者的生存质量，值得推广。

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（曾文军　编辑）

·病例报告·

应用 Freddy 激光技术对胃巨大结石进行腔内碎石 1 例

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[关键词]　巨大胃结石；　胃镜；　Freddy 激光
[中图分类号]　R573.8　　[文献标识码]　B　　doi：10.3969/.issn.1674-3245.2014.03.023

1　临床资料

患者，男性，45 岁，长途运输司机，上腹部疼痛 1 个月余，加重伴腹胀、恶心、纳差 1 周。在当地医院经胃镜检查见胃巨大结石（直径达 6 cm）伴胃溃疡，在我院门诊诊断为“胃结石、胃溃疡”，给予口服雷尼替丁加碳酸氢钠片，1 周后行胃镜检查及治疗。常规咽喉部黏膜浸润麻醉，插入 Olympus 260 型胃镜，吸尽胃液，适度注气，调节镜端的弯角旋转镜身，使胃结石置于视野中最佳位置后将活检钳内送，在胃石表面抓取尝试软硬度，未能抓取到胃结石表面任何物质；撤出活检钳，放入注射针，试图往胃结石内注入 5%碳酸氢钠，因胃结石较硬进针未成功；撤出注射针，放入圈套器，因胃石表面光滑，无法套住勒紧套圈；撤出圈套器，从活检孔放入德国 WOM 公司 U-100 Freddy 激光（Frequency-double double pulse Nd：YAG laser）光纤，直接抵住胃结石，在胃结石上打出一圈凹槽，用圈套器勒紧胃结石，仍未能切割开。继续用 Freddy 激光光纤在胃结石上进行多点碎石，然后抽取 20 ml 5% 碳酸氢钠液体通过注射针多点注入胃结石内，使胃结石膨胀、松软；再次放入圈套器勒住胃石，收紧圈套器后成功切开胃石。注入 5% 碳酸氢钠液 20 ml 浸泡胃结石 3 min，继续以上过程反复进行碎石，最终将胃结石切碎，使之能通过幽门口随着胃肠蠕动排出体外。1 周后复查胃镜，胃结石消失。观察数日，无肠梗阻现象，患者自觉症状消失。

2　讨论

胃结石是消化系统常见病，是进食某种物质后在胃内形成的石性团块状物，按其组成成分不同可分为植物性、毛发性和混合性 3 种。国内临床上最多见的是植物性胃结石，尤以胃柿石、胃山楂石多见[1]。有研究表明，胃结石的硬度与成分相关[2-4]。本例患者曾在空腹时食用半斤黑枣，并饮浓茶。黑枣中鞣酸浓度较高，在胃酸作用下，与蛋白结合成分子较大且不溶于水的鞣酸蛋白，并缠绕植物纤维，经胃的机械作用形成胃结石，不易排出。

诊断胃结石后可先尝试药物治疗 1 周。雷尼替丁是一种 H_2 受体抑制药，具有抑制胃酸分泌的作用，可使胃液 pH 提高到 5 ~ 6，改变胃结石的形成环境，破坏胃石的鞣酸成分，促使胃结石变小、疏松或溶解，同时可治疗伴随的局部溃疡；碳酸氢钠可以中和胃酸，与鞣酸形成二氧化碳、水和脆而易碎的鞣酸钠，促使胃结石逐渐溶解变小。本例患者病程较长，结石形成较大且凝结时间长，表面形成了坚硬的硬壳，药物不容易渗入结石内，故药物疗效较差，只能缓解胃溃疡症状。

胃镜下激光碎石技术可在直视下操作，视野清晰，大大减少了传统取石方法造成的出血等风险。U-100 Freddy 激光是德国 WOM 公司生产的一种新型钕 YAG 激光，其作用原理是激光机发射出两种不同波长的激光打到结石表面，绿光先被结石表面吸收，使结石表面形成均匀的等离子体，等离子体再充分吸收红外光能量，瞬间转化为机械冲击波将结石粉碎。黄旭元等[5]报道，其碎石效能是普通激光的 6 倍，结石粉碎程度高，而对结石周围软组织的作用较小。人体的大多数结石（除胱氨酸结石外）均容易吸收 Freddy 激光。所以，胃镜下激光碎石是高效、安全的方法。

应用圈套器切割胃结石的方法简单实用，可将胃结石切割成小块，从幽门口排出。在药物作用后，应用胃镜直视下 U-100 Freddy 激光碎石，是治疗胃巨大结石的好办法。

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·论著·

胃镜引导下双频双脉冲掺钕钇石榴石激光治疗难治性胃石

吴诚 付永和 王志强

【摘要】 **目的** 探讨胃镜下U-100双频双脉冲掺钕钇石榴石（Nd:YAG）激光对难治性胃石的治疗的安全性和有效性。**方法** 应用U-100双频双脉冲掺钕钇石榴石（Nd:YAG）激光经胃镜治疗难治性胃石。**结果** 总碎石成功率100%，激光平均工作时间：10787 J能量，碎石时间在94 min。**结论** 双频双脉冲掺钕钇石榴石（Nd:YAG）激光治疗难治性胃石，是一种高效、安全、操作简便，组织损伤甚微的手术方法。

【关键词】 碎石术，激光； 激光，固体； 难治病； 胃肠结石

Frequency-doubled double-pulse Neodymium YAG laser in the treatment of refractory gastric bezoar

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【Abstract】 Objective We aimed to find a new way to manage the gastric bezoar which polypectomy snare and other management does not work. **Methods** U-100 frequency-doubled double-pulse Neodymium: YAG (Nd:YAG) laser was used to disrupt the refractory gastric bezoar shell through the upper gastrointestinal endoscopy. **Results** All bezoar shell was disrupt by U-100 frequency-doubled double-pulse Nd:YAG laser. **Conclusion** U-100 frequency-doubled double-pulse Nd:YAG laser is a safe efficient and useful way to manage refractory gastric bezoar.

【Key words】 Lithotripsy, Laser; Lasers, Solid-State; Refractory diseases; Bezoars

胃石是由于摄入某种植物成分或吞入毛发或某些矿物质如碳酸钙、钡剂、铋剂等在胃内凝结而形成的异物，称为胃石症（gastric bezoar）。按胃石症的组成内容物可分为植物石、毛石、乳酸石、医源性胃石等类型，其中以植物石最为常见。进食大量柿子、黑枣等[1]。胃石症的治疗包括药物治疗、内镜下碎石及外科腹腔镜取石等。本文探索了利用掺钕钇石榴石（Nd:YAG）激光治疗药物及内镜下套圈器治疗无效的胃石症的安全性和有效性。

资料与方法

一、临床资料

2013年1月至2013年12月解放军总医院门诊6例胃石患者，均为男性，年龄48~65岁，平均年龄57岁；胃石，均为1枚，形态均为椭圆形、黑色、质地硬（图1A），口服药物治疗无效，内镜下采用圈套器圈套治疗无效，胃石大小5.0~7.0 cm。所有患者均并发有胃内的溃疡。

二、手术方法

采用咽部麻醉，胃镜检查见胃石，采用U-100双频双脉冲Nd:YAG激光仪（WOM公司，德国），激光设置140MJ/5Hz，激光纤维探头对准胃石表面，

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将胃石表面坚硬的外壳逐步击碎（图1B），胃石表皮脱落后，采用圈套器将胃石切割成小块，术后嘱咐患者口服抑酸药物（耐信，口服，20 mg，2/d）及苏打水，1个月后复查。

结　果

6例患者胃石均在激光下碎去胃石坚硬外壳，后予以圈套器圈套后切除，平均使用能量10787 J能量，碎石时间在94 min，无并发症。碎石时间和胃石大小呈正向相关。胃石经激光治疗去除坚硬外壳，再辅以圈套器圈套后，加抑酸药物治疗，1个月后复查，均已恢复正常。

讨　论

胃石治疗多先予以抑酸药物或者碱性溶液，如可口可乐，可使胃石溶解或变小，排除体外。对于药物治疗无效，内镜下网篮取石及圈套器圈套、包括使用大钳道内镜吸引、内镜下激光爆破、腹腔镜下治疗都有效[1-4]。

U-100双频双脉冲激光碎石系统是2000年上市的一种新型的腔内碎石装置，其原理是波长532 nm绿光先被结石吸收后使其形成等离子体，继而再吸收波长为1064 nm红外光能量，产生机械冲击波使结石崩解。由于所产生的冲击波峰值极高，很短时间内就能准确高效地将结石击碎[5]。U-100双频双脉冲激光碎石系统最先被用于泌尿管结石[6]，随后被用于胆道结石的治疗[7]。然而这一技术在胃石诊治过程中既往无应用。

本研究中选取病例为药物治疗无效，内镜下圈套器无法圈套，又希望于内镜下微创治疗的胃石症患者。采取U-100双频双脉冲激光碎石系统击碎胃石坚硬外壳后辅以圈套器及药物治疗。激光光纤能有效的破碎胃石坚硬外壳，并且光纤即使对着胃黏膜（不直接接触，排除机械损伤），不会造成胃黏膜损伤，这一技术在胃石治疗中应用，属首创。

但U-100双频双脉冲激光治疗仅对于难治、质地硬、黑色的胃石破碎外壳，破碎后仍需对于质地软的胃石，用圈套器及胃石切割器治疗，并辅助内镜治疗后的药物治疗；对于无坚硬外壳胃石其无效（图2）。

（本文图1~2见光盘）

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吴诚，付永和，王志强. 胃镜引导下双频双脉冲掺钕钇石榴石激光治疗难治性胃石[J/CD]. 中华胃肠内镜电子杂志，2014，1(1)：33-35.

Resolution of ampullary stone impaction with duodenoscopy-guided direct frequency-doubled double-pulse Nd:YAG laser lithotripsy after the failure of rescue lithotripsy

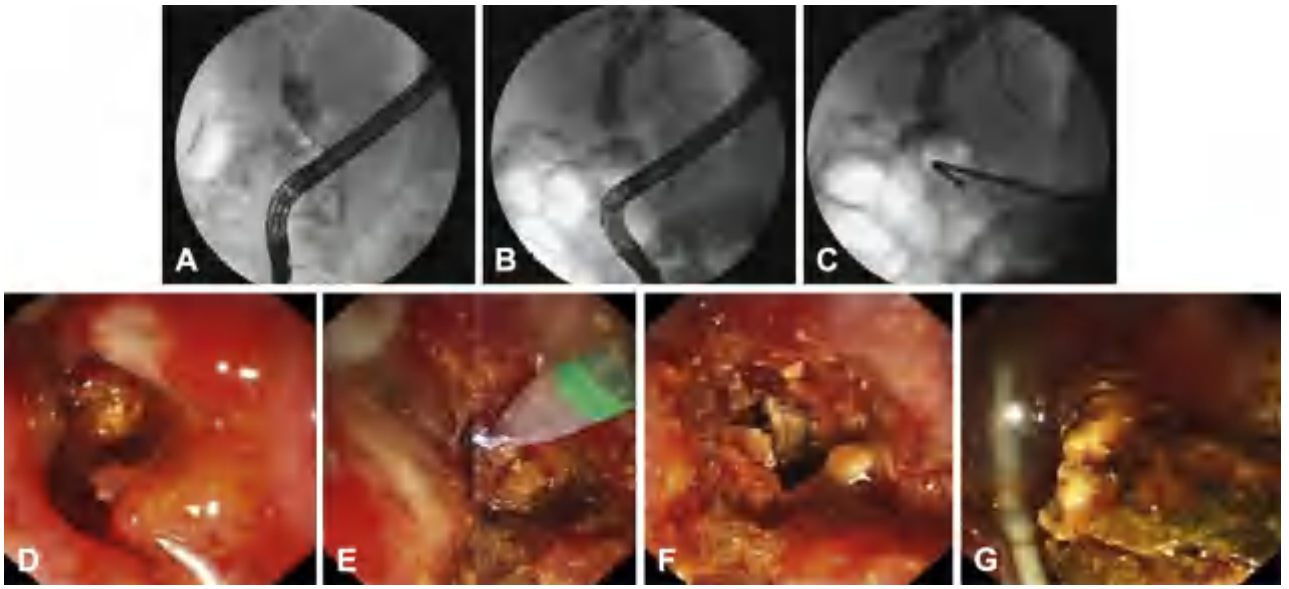


Figure 1. A, Cholangiographic view showing multiple large stones in the CBD. B, The stone was drawn into the basket but could not be extracted. C, Application of Soehendra rescue lithotriptor to crush the stone. D, After failed lithotripsy, impaction of stone in the CBD, as seen from the opened papilla. E, Direct laser lithotripsy under duodenoscopy. F, After laser lithotripsy, the stone was fractured. G, Successful extraction of stone by a balloon. CBD, common bile duct.

An 84-year-old woman received a diagnosis of large common bile duct (CBD) stones and experienced failed endoscopic stone extraction half a year previously. Two plastic stents were temporarily placed into the CBD for biliary drainage. Currently, the patient was admitted for endoscopic stone extraction. The cholangiogram demonstrated a maximal diameter of 1.5 cm of the CBD, with multiple large stones. The largest stone (1.4 $\times$ 2.5 cm) was impacted in the upper part of the CBD (Fig. 1A).

After endoscopic sphincterotomy and papillary balloon dilation to a 15-mm diameter, most stones, except the largest one, were successfully extracted with a 3-cm diameter lithotriptor basket. However, because of the large size and limited space, the stone in the upper part of the CBD could not be drawn into the basket. Therefore, a larger extraction basket (3 $\times$ 6 cm) was used to grasp the stone (Fig. 1B). Unfortunately, the stone and the basket were impacted in the CBD, and a Soehendra rescue lithotriptor (BML-110A-1, Olympus Optical Company, Tokyo, Japan) was applied to crush it (Fig. 1C). Owing to only a partial grasp, the lithotripsy failed, and the stone was so tightly impacted in the ampulla that the basket and guidewire could not enter the CBD.

The stone could be seen from the opened papilla under duodenoscopy, which inspired a direct application of frequency-doubled double-pulse Nd:YAG laser lithotripsy (Fig. 1D). The optical fiber was guided through a 4.4F sphincterotome that touched the stone under duodenoscopy with a 4.2-mm working channel (Fig. 1E). The laser lithotripsy was carried out, and the stone was fractured after about 10 minutes (Fig. 1F). A 15-mm

Written transcript of the video audio is available online at www.VideoGIE.org.

diameter balloon catheter was then introduced into the CBD, and the fractured stones were successfully extracted (Fig. 1G) (Video 1, available online at www.VideoGIE.org). This technique is simple and easily performed without the assistance of cholangioscopy.

DISCLOSURE

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十二指肠镜引导下直接双频双脉冲掺钕:钇铝石榴石激光碎石术在抢救性碎石失败后解决壶腹结石嵌顿

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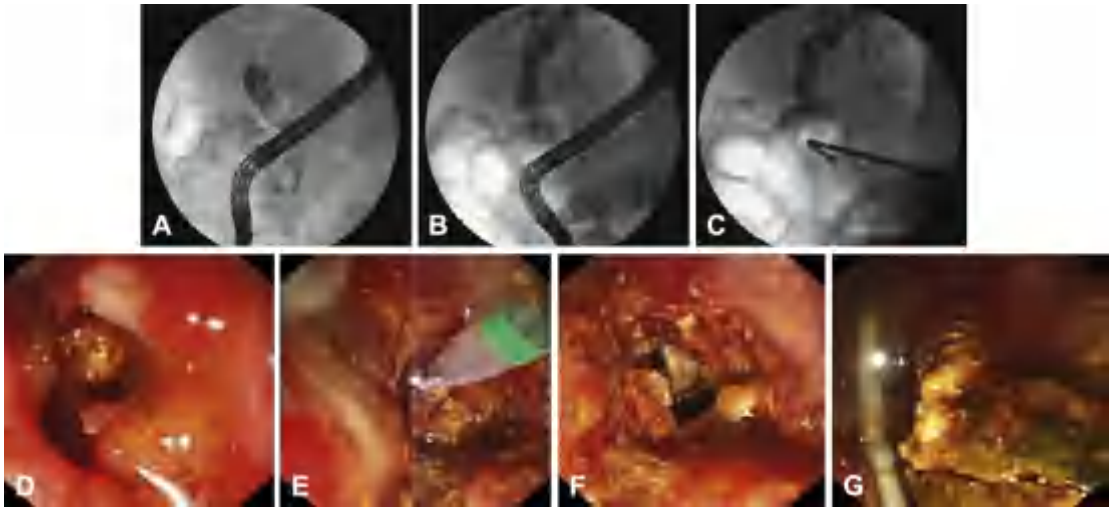


图 1. A，胆管造影显示胆总管内有多个大结石。B，结石被套入取石篮但无法取出。C，使用 Soehendra 碎石救援器进行碎石。D，碎石失败后，结石嵌顿在胆总管内，从切开的乳头处可见。E，十二指肠镜直视下进行激光碎石。F，激光碎石后结石碎裂。G，通过球囊成功取出结石。CBD，胆总管。

一位 84 岁女性患者被诊断为胆总管大结石，半年前曾接受内镜取石术但未成功。当时在胆总管内临时放置了两根塑料支架进行胆汁引流。此次患者因内镜取石术再次入院。胆管造影显示胆总管最大直径为 1.5 厘米，内含多枚大结石。其中最大结石（1.4×2.5 厘米）嵌顿于胆总管上段（图 1A）。

在内镜下括约肌切开术和乳头球囊扩张至 15 毫米直径后，除最大的一颗外，多数结石已成功用 3 厘米直径的碎石网篮取出。然而由于结石体积过大且空间受限，位于胆总管上段的结石无法被网篮套取。因此改用更大尺寸的取石网篮（3×6 厘米）进行抓取（图 1B）。不幸的是，结石与网篮在胆总管内形成嵌顿，遂采用 Soehendra 救援碎石器（型号 BML-110A-1，奥林巴斯光学株式会社，日本东京）实施碎石（图 1C）。由于仅能部分抓持，碎石操作失败，且结石在壶腹部嵌顿过紧，导致网篮与导丝均无法重新进入胆总管。

通过十二指肠镜检查可见乳头开口处的结石，这启发了我们直接应用倍频双脉冲掺钕钇铝石榴石激光碎石术（图 1D）。将光纤引导通过一个 4.4F 括约肌切开刀，在具有 4.2 毫米工作通道的十二指肠镜下接触结石（图 1E）。实施激光碎石术后，约 10 分钟结石即被粉碎（图

1F）。随后，将直径为 15mm 的球囊导管引入 CBD，并成功取出破裂的结石（图 1G）（视频 1，可在线访问 www.VideoGIE.org）。该技术操作简单，无需胆道镜辅助即可轻松完成。

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腹腔镜联合胆道镜微创治疗复杂性肝胆管结石 32 例

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【摘要】探讨腹腔镜联合胆道镜微创技术治疗复杂性肝胆管结石的价值。应用腹腔镜联合胆道镜胆管切开取石术(LCTD)治疗复杂性胆总管结石患者 32 例,必要时联合腹腔镜肝切除术(LH)及胆道镜下微创技术,如双频双脉冲 U100 YAG 激光碎石(FREDDY)、内镜下狭窄胆管球囊扩张及术后辅助胆道镜治疗等。32 例患者均行 LCTD,其中 2 例Ⅱb 型结石由于左半肝硬化同时行腹腔镜下左半肝切除术。23 例第一次手术时结石全部取净,25 例第一次手术时狭窄彻底解除。9 例第一次术后三级胆管内仍有结石残留的患者,经多次辅助性胆道镜治疗后 5 例成功解除胆管狭窄并取净结石,其余 4 例由于狭窄、结石复发给予再次手术治疗。28 例(87.5%)患者取净结石、解除狭窄,实现胆道自净。腹腔镜联合胆道镜微创技术治疗复杂性肝胆管结石创伤小,安全可行,效果良好。

【关键词】肝胆管结石·微创技术·腹腔镜·胆道镜
【中图分类号】R575.6+2
【文献标识码】B doi:10.3969/j.issn.1009-9905.2018.06.012
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由于结石残余率、复发率高且常合并严重并发症,复杂性肝胆管结石的治疗一直是肝胆外科的难点和热点。所谓复杂性肝胆管结石即同时出现以下 4 种情况的任意两种:(1)二级以上肝内胆管弥漫性结石;(2)伴有胆管狭窄或局部肝萎缩;(3)伴有肝硬化、门脉高压症、重症胆管炎或肝脓肿等肝内炎性病灶;(4)既往有过至少一次胆道手术[1]。我院 2013 年 6 月—2016 年 6 月应用腹腔镜联合胆道镜胆管切开取石术(laparoscopic choledocholithotomy and T -tube drainage,LCTD)治疗复杂性胆总管结石 32 例,必要时联合腹腔镜肝切除术 (laparoscopic hepatectomy, LH) 及胆道镜下微创技术如双频双脉冲 U100 YAG 激光碎石(U100 Frequency-doubled double pulse Nd:YAG laser,FREDDY)、内镜下狭窄胆管球囊扩张及术后辅助胆道镜治疗等,效果显著,总结报道如下。

1 资料与方法

1.1 一般资料 32 例患者中男 14 例,女 18 例,年龄 37~86 岁,平均 65 岁。根据术前超声、CT、MRI 及术中胆道镜探查等明确诊断。结石均累及二级以上肝内胆管。根据结石在肝内的分布、相应肝管和肝脏的病变程度分型[2]:Ⅰ型 26 例,其中肝右叶胆管弥漫性分布 2 例,局限于肝右后胆管 6 例,局限于肝右前胆管 4 例,肝左叶胆管弥漫性分布 2 例,局限于肝左内胆管 3 例、局限于肝左外胆管 9 例,均无肝段纤维化或萎缩;Ⅱ型 6 例,其中Ⅱa 型 4 例、Ⅱb 型 2 例。术中证实所有患者均有一、二级胆管狭窄,膜状狭窄(狭窄长度<2 mm)20 例,管状狭窄 8 例,混合狭窄 4 例。其中合并三级胆管开口狭窄者 9 例,狭窄部以上均有嵌顿性结石。所有患者均无上腹部手术史。

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1.2 方法 依据术前影像学资料及术中探查对结石分布、胆管狭窄及肝脏情况进行评价。首先用胆道镜探查胆道情况，明确有无胆管狭窄及狭窄部位、程度，以取石网篮将狭窄部以下结石尽量取净。对于二级胆管狭窄采取球囊扩张，通过胆道镜引导置入导丝，沿导丝向狭窄胆管插入扩张球囊，成功后用带压力表的注射泵向扩张器球囊注入生理盐水，使球囊内压力达(4~10)×10⁵Pa，实际扩张压力根据狭窄段的厚度及狭窄后方胆管的扩张程度选择，每次扩张时间持续2~3 min，必要时可重复扩张。胆道镜通过狭窄胆管后对狭窄部以上嵌顿性结石可采取FREDDY激光碎石，将激光光纤经胆道镜工作孔道导入胆管中，其末端超出胆道镜约1 cm，使目标光束(红色光标)接触结石中心，以1~10次/s的速率脉冲进行发射(通常为5次/s)，击碎结石后再用生理盐水脉冲加压冲洗胆道，以取石网篮尽量取净结石。对于三级胆管开口处狭窄患者采取球囊扩张、FREDDY激光碎石后，若胆管开口处角度适宜且狭窄部以上胆管扩张较明显，应尽量以胆道镜直视下取净结石；若胆管扩张不明显或胆管成角太大导致胆道镜无法进入，可最后再次加压冲洗胆道后行引流术。对于肝门部及一级胆管管状狭窄，常多次球囊扩张后才能取出其内结石。术后应放置支撑管保留3~6个月，待狭窄处的溃烂创面慢慢修复后方可拔出。拔除T管前行胆道造影检查，如果发现胆管内有结石或狭窄，均应经T管窦道行胆道镜取石并扩张狭窄部位，然后沿该窦道插入1根T管固定，经B超、造影证实无胆管狭窄、结石残留且胆道镜直视下看到胆管内无残余结石、胆管狭窄后方可拔管[3]。如果胆管狭窄合并肝脏严重纤维化，腹腔镜镜下见肝脏颜色发暗、表面有结节的行LH。术后常规按疗程口服利胆排石的中药制剂。

1.3 随访 所有患者通过电话、门诊进行随访，行肝功能、彩超或CT检查。随访时间12~30个月。随访截至2017年6月。

2 结果

32例患者均行LCTD，其中2例左肝管管状狭窄合并肝右后叶胆管膜状狭窄的Ⅱb型结石患者由于左半肝硬化同时行腹腔镜下左半肝切除术。23例第一次手术时结石全部取净，25例第一次手术时狭窄彻底解除。2例Ⅱa型结石合并一级胆管膜性狭窄患者由于结石分布广，数量多，术后经胆道镜经T管窦道取石后取净结石；1例Ⅱa型结石合并一级胆管管状狭窄，三级胆管膜性狭窄患者及2例Ⅰ型结石合并二级胆管管状狭窄患者术后胆道镜检查发现胆管狭窄解除不完全，狭窄上段仍有残余结石，给予胆道镜经T管窦道胆管扩张并取石后解除狭窄、取净结石(表1)。共28例(87.5%)患者取净结石、解除狭窄、实现胆道自净。

本组共发生暂时性胆瘘1例，胆道出血2例，均经保守治疗后痊愈；无腹腔出血、T管脱落、窦道破裂等并发症。

表1 32例患者LTCD治疗后结石取净率及狭窄解除率[%]

组别	结石取净	狭窄解除
第一次手术(n=32)	71.88(23/32)	78.13(25/32)
术后辅助性胆道镜治疗(n=9)	55.56(5/9)	42.66(3/7)
合计	87.50(28/32)	87.50(28/32)

所有患者均获随访，术后6~12个月复查CT、B超及肝功能，必要时复查MRCP，对疗效作出初步评价。28例治愈患者随访期间无胆管炎发作症状，B超检查未见结石复发。由于狭窄胆管纤维化较重，3例Ⅰ型结石合并三级胆管管状狭窄和1例Ⅱa型结石合并左肝管管状狭窄患者术中狭窄解除不完全，术后经多次胆道镜辅助治疗后仍反复出现发热、寒战、黄疸，经MRCP确诊肝胆管狭窄、结石复发而再次手术，手术方式为肝段切除术和胆管空肠吻合术。

3 讨论

早在30多年前黄志强院士就指出：反复发作的化脓性胆管炎是肝胆管结石病的主要原因；同时，由于相同的原因亦导致肝胆管炎性狭窄，结石和狭窄是复杂性胆管结石的两个方面，二者又相互加重，故取净结石、解除狭窄、恢复胆道生理状态是治愈复杂性肝胆管结石的关键。肝切除术是肝胆管结石的传统治疗手段，然而复杂性肝胆管结石分布广泛，且常合并肝内胆管狭窄，肝切除术无法完全切除病灶，也无法精准去除肝内胆管狭窄，容易导致术后残留结石或结石复发；且手术创伤较大，限制了其在复杂性肝胆管结石治疗中的广泛普及[4]。为从根本上改善复杂性肝胆管结石的预后，降低再手术率，必须采用多种措施联合序贯治疗。随着胆道镜下各种微创技术的不断发展，多技术联合微创治疗复杂性肝胆管结石的效果逐渐得到肯定[5]。

传统胆道外科在治疗复杂性肝胆管结石具有一定的盲区和局限性，即使手术技术不断提高，肝内胆管结石复发率仍达30%~93%，再次手术率高达37.1%~74.4%[6]。胆道镜为外科医师提供了直观的肝内胆管病变情况，既可在术中应用以降低胆管残石率，也可在术后辅助诊断和治疗，是微创治疗肝内胆管结石的基础平台。但嵌顿性结石常导致常规网

篮取石失败，限制了胆道镜的应用，影响了手术治疗效果。激光碎石技术的临床应用为解决这一棘手问题带来了希望。胆道镜下激光碎石技术即可避免传统盲法取石带来的胆管壁损伤、残石率高等弊端，也可有效解决嵌顿结石带来的内镜下"碎石兴叹"的难题，有效降低结石残余率的同时避免了手术对于正常胆管的副损伤[7-8]，为最大程度发挥"胆道自净"奠定了基础。

目前，影像学检查对胆管狭窄的诊断准确率仍较低，严重限制了传统胆道外科治疗复杂性肝胆管结石的效果。黄志强[9]认为忽视对胆管狭窄的有效处理常是影响肝胆管结石病外科治疗效果的主要原因。朱成林等[10]报道胆管狭窄是结石残留或复发的独立危险因素。胆道镜探查在胆管狭窄诊断及治疗方面的价值无可替代，是根治复杂性胆管结石和预防复发的重要保障。大多数胆管狭窄是局部炎症刺激形成的膜状狭窄，胆管壁黏膜完好，未受破坏，胆道球囊适当扩张后，狭窄较容易解除[11]。管状狭窄的病理基础是胆管炎发作后胆管黏膜溃疡愈合过程中胆管壁纤维层及周围组织的增生[12]。球囊扩张的治疗目标即破坏增生的胆道壁纤维层，促进胆道壁各层组织重塑。球囊扩张后狭窄部位多有出血，扩张成功后不要急于撤出球囊，需重新充盈在较低压力压迫5~10 min以止血。本组5例Ⅰ型结石合并二级胆管管状狭窄患者经术后多次球囊扩张后狭窄成功解除，术后胆道恢复正常生理状况，随访无胆管狭窄、结石复发。3例Ⅰ型结石合并三级胆管管状狭窄和1例Ⅰ型结石合并左肝管管状狭窄患者经多次球囊扩张后仍未完全解除狭窄，胆道镜见胆道炎性改变无明显好转，随访中患者结石复发、胆管炎反复发作，行二次手术时取狭窄部胆管行病理检查见黏膜层明显变薄，各纤维层比例明显升高。笔者考虑胆管壁各层组织变化是影响胆管狭窄预后的重要因素，由于缺乏大样本对照研究，关于狭窄胆管病理变化对复杂性胆管结石手术方式选择、判断预后的意义尚有待探讨。

胆管梗阻解除后，完整的胆管黏膜细胞增生活跃，胆汁量可增加至正常值的5~6倍，促进胆道系统沉积成分的排泄，有效避免结石发生的同时可预防胆管狭窄复发，逐步恢复胆道生理状况。对肝胆管结石患者的术后胆道镜检查中我们观察到"胆道自净"现象：术中可见梗阻上端胆管壁黏膜水肿、颜色发白，胆管内可见絮状漂浮物，取净结石、解除梗阻后6周行胆道镜检查时可见胆管壁黏膜颜色恢复红润，胆道恢复正常生理状况。基于这一认识，笔者认为复杂性肝胆管结石病的治疗应该是对病变胆管进行必要处理的同时，最大限度地保存正常胆管，以胆道自身的生理功能恢复胆道生理状态。胆道镜技术结合球囊扩张、碎石等措施，可在直视下反复多次扩张狭窄并取石，弥补肝切除术无法兼顾广泛病变且易损伤正常肝脏的不足，符合微创时代胆道外科精准操作的要求[13]，最大范围保护"胆道自净"作用，对改善复杂性胆管结石预后具有重要意义。

综上所述，复杂性肝胆管结石的治疗原则是取净结石；解除胆管狭窄，恢复胆道生理状态。微创胆道外科在克服传统胆道外科的盲区和局限性的同时，其直观、精准、可序贯的优势在复杂性肝胆管结石的治疗中受到肯定。笔者认为，应用微创技术早期、合理地治疗复杂性肝胆管结石，能够达到治愈复杂性肝内胆管结石病、降低再手术率的目的。

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胆总管困难结石经内镜激光碎石治疗的有效性和安全性探讨

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摘要：[目的]探讨经口直接胆道内镜对困难结石激光碎石的有效性和安全性。[方法]对经内镜逆行胰胆管造影(ERCP)并网篮取石或机械碎石篮碎石失败的 21 例胆总管困难结石患者进行乳头开口小切开联合 15 mm 大球囊扩张后，插入经口直接胆道内镜至胆总管，治内镜活检孔插入双频双脉冲(Nd:YAG)激光探头至结石部位直视下激光碎石，研究其插入成功率、并发症发生率、碎石成功率。[结果]21 例中 17 例(80.95%)达到肝门部并发现结石，其中直接插入 5 例(23.81%)，导丝辅助者 9 例(42.86%)，外套管辅助 3 例(14.29%)；失败 4 例。15 例碎石成功(71.43%)，其中 6 例胆道镜清理结石，9 例更换十二指肠镜清理，失败 4 例(19.05%)转外科开腹手术。4 例胆道感染，无严重并发症如出血，穿孔，胰腺炎等，也无手术相关死亡。[结论]经口直接胆道内镜介导的困难结石激光碎石是安全有效的，但内镜插入技术有一定困难，需进一步研究。

关键词：胆总管结石；胆道镜；经口直接胆道内镜；激光碎石
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Common bile duct stones treated by endoscopic laser lithotripsy

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Abstract: [**Objective**]To explore the effectiveness and safety of the direct biliary endoscopy in difficult stone lithotripsy. [**Methods**]The 21 patients who had lost chisel by means of ERCP and net basket or mechanical gravel were named choledocholithiasis cases. The patients were treated with small incision of the nipple and the expansion of 15 mm diameter balloon, insert person ultra fine endoscope(The out diameter of 5.6 dishes can be inserted through the nasal cavity into the digestive tract for diagnosis and treatment. It was also named transnasal) to bravery manager. Along the endoscopic biopsy channel, we insert double-frequency (Nd:YAG) laser probe-stone parts under the direct laser lithotripsy. Its insertion success rate and the incidence of gravel success rate were investigated. [**Results**]The 17 of 21 cases(80.95%) were reached the hepatic portal and found stones, among which 5 cases(23.81%) were inserted directly and 9 cases (42.86%) were assisted by guide wire, 3 cases(14.29%) were assisted by outer casing and 4 cases failed. 15 cases were sussessful(71.43%), 6 cases of biliary tract were removed and 9 cases were replaced with duodenoscope. 4 cases(19.05%) failed and accepted surgery. There were 4 cases of biliary tract infection, no serious complications such as bleeding, perforation, pancreatitis as well as surgical related death. [**Conclusion**]It

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万方数据

is safe and effective for the difficult calculus lithotripsy to be mediated by oral direct biliary endoscopy. But the endoscopic insertion technology has certain difficulties. Further study is needed.

Key words: choledocholithiasis; choledochoscope; viaoral direct biliary endoscopy; laser lithotripsy

从1968年首次报道乏特氏壶腹插管成功以来[1]，经内镜逆行胰胆管造影（encoscopic retrograde cholangio-pancreatography，ERCP）取得了巨大的进步，已经成为诊断和治疗胆胰疾病的首选和主要方式。通过乳头切开、扩张或联合2种技术，利用取石网篮、取石球囊、机械碎石70%～90%的结石可以顺利取出[2]，具有创伤小、并发症低、痛苦轻、康复快、住院时间短、结石残留率低、并发症少等优点。10%～15%的结石由于过大（>1.5 cm）、过多、不规则或合并胆总管扭曲、狭窄，导致常规十二指肠镜下取石非常困难或手术失败[3]，有报道采用液电碎石或激光碎石，成功率在90%以上[4]。但2种碎石技术均对胆管上皮可能造成损伤，需要胆道镜直视下操作以提高安全性。目前无论双人操作的母子胆道镜系统还是单人操作的套管为基础的SpyGlass都存在着明显缺陷，如价格昂贵、脆性较大、图像质量差、工作通道小等，限制其临床广泛应用。经口直接胆道内镜（peroral direct cholangioscopy，PODC）即外径5～6 mm可通过鼻腔插入上消化道进行诊治的一类内镜，又称为经鼻内镜。近年来PODC介导技术又引起国外内镜学者的重视，即在常规十二指肠镜乳头开口扩大后直接插入胆道以观察和治疗胆道疾病的一种新技术[5]，可以提供更优质的内镜图像、并有更宽的工作管道以满足治疗器械插入。目前PODC应用于困难胆管结石碎石治疗的报道较少，本研究主要就其可行性和安全性进行初步评估。

1 对象与方法

1.1 对象

从2014-01-05—2016-12-27期间行常规取石患者1 082例中人选符合以下条件的21例为研究对象。纳入标准：均为机械碎石网篮无法圈套结石导致常规取石失败，结石数目超过3枚，结石最大横径超过15mm，乳头解剖异常无法大切开，大球囊扩张风险较高者[6]，合并胆管狭窄；排除标准：有ERCP禁忌证，有心肺等脏器功能不全，既往行胃肠道改道术者。21例中男6例，女15例，年龄55～82（67.8±18.6）岁。大结石13例（15～20 mm 7例，20～30 mm 4例，>30 mm 2例），憩室内乳头且结石最大横径超过15 mm 4例，合并胆管狭窄2例，多发结石2例（3枚结石1例，充满性结石1例）。研究对象均为术前行腹部超声和磁共振胰胆管造影（magnetic resonance cholangiopancreatography，MRCP）发现结石并观察数目、最大直径、位置，且无如凝血功能异常等ERCP及十二指肠镜下乳头括约肌切开术（EST）禁忌证。

1.2 研究设备

日本富士能公司十二指肠镜（ED-530 XT）、PODC（EG-530 N），德国爱尔博公司高频电发生器（VIO 300 S）；德国富莱克斯公司乳头切开刀、5 Fr鼻胆汁引流管；日本泰尔茂超滑导丝（RF * GA35263 M）；美国库克公司胆道取石网篮、取石球囊；外套管（本课题组开发，专利号：ZL2013 2 0663151 6，已通过本院伦理委员会批准临床试验）；美国库克公司斑马导丝（0.035"和0.022"）；美国波士顿公司胆道逐级扩张球囊（扩张直径10～12与12～15 mm）；常州市久虹公司超细内镜专用取石网篮及取石球囊（JHY-BAS-18-180-10-N4-C与JHY-BAL-20-200-8.5-B）、激光碎石器FREDDY laser（frequency doubled double pulse Nd：YAG laser 100，World of Medicine，波长分别为532 nm、1064 nm，能量120 mJ，术中调整碎石时间，直至结石粉碎）。

1.3 操作方法

1.3.1 术前、术后处置和麻醉方法 术前准备及麻醉方法同ERCP；术前0.5 h、术后4 h及第2、3天连续使用抗生素4次；全部病例均由麻醉医师在丙泊酚加芬太尼静脉复合麻醉下进行。

1.3.2 ERCP 常规ERCP插管成功并造影确定结石大小、数目、位置，2例小乳头或憩室旁乳头尽可能切至乳头根部，3例憩室内乳头无法切开的行球囊扩张，余16例行小EST（切开缩头皱褶），以结石最大直径加2 mm为标准选取10～15 mm球囊行球囊扩张术，至"腰部"消失后立即撤压，随以10 mm取石球囊顺利进出为乳头开口扩大标准。

1.3.3 PODC进入胆总管 退出十二指肠镜，保留胆管导丝，插入PODC，经十二指肠球部、乳头，反复尝试进入胆总管。安装套管后再次进镜，在X线监视下拉直镜身，沿镜身插入外套管至十二指肠球部，充气远端球囊固定于十二指肠球部，沿外套管插入内镜可以避免镜身在胃腔中成襻，直接进入降段，直视下通过乳头进入胆总管。发现结石后开始反复

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注水、吸引，直至胆总管内液体清亮。直视下使用双频双脉冲激光（波长分别为 532 nm、1 064 nm，能量为 120 mJ）反复将浸没于液体中的结石击碎成碎块或糊状。激光碎石过程需要反复注水、吸引，保持视野清晰，同时可将击碎的糊状结石排出，碎片结石可直视下用取石网篮取出，碎块过多者可再次更换十二指肠镜清理。整个手术时间以 1 h 为界，以降低手术时间过长导致并发症的风险。术后处理同常规 ERCP。

2 结果

21 例经 PODC 均能越过扩大的乳头开口进入胆管，17 例（80.95%）达到肝门部并发现结石，其中直接插入 5 例（23.81%），导丝辅助者 9 例（42.86%），外套管辅助 3 例（14.29%），平均插入时间 7～17（4.9±2.9）min；4 例未到达胆总管中上段。15 例内镜到达肝门部接近结石被碎成数块甚至糊状，其中 6 例胆道镜清理结石（4 例直接在 PODC 直视下网篮捕获已经破碎的结石并拖出胆管外，2 例结石成糊状通过内镜冲洗、球囊清理完全清理），余 9 例因大量糊状结石残渣，不能排除其内有较大或成角残留结石，因此更换十二指肠镜网篮和球囊清理胆道，并放置鼻胆管，3 d 后鼻胆管造影均未发现残留结石拔出鼻胆管。2 例碎石失败转外科手术。成功碎石后未发生如出血，穿孔，胰腺炎等严重并发症。4 例术后发烧，右上腹痛并压痛，白细胞增高，降钙素原升高，以胆道感染给予抗生素治疗后好转。

通过对 21 例经 PODC 介导激光碎石取石的过程分析，表明其难易度与性别和年龄无明确相关性。失败 4 例均为胆囊切除术后，合并胆总管中上段良性迂曲狭窄（占 19.05%）。21 例中，成功碎石 15 例（71.43%），碎石失败 2 例，因结石过大过多造成。PODC 进入胆总管不仅需要操作医师娴熟内镜操作技巧，同时辅助导丝及外套管必不可少，由于胆总管生理病理性狭窄会造成镜身通过困难，从而无法进行碎石操作，内镜直视下发现结石并行激光碎石成功率高并发症少，导致碎石失败原因主要为结石过大过多过硬，耗时过长。

3 讨论

目前，通过十二指肠镜对胆胰疾病诊断及治疗已成为临床首选。通过乳头切开和球囊扩张，尤其内镜下乳头小切开联合大气囊扩张术（ESLBD），利用取石网篮、取石球囊及机械碎石，70%～90%的结石可以结合顺利取出[4]。但 10%～15%的结石由于过大（>1.5 cm）、过多（>3 枚）、质地坚硬的钙化结石，不规则或合并胆总管扭曲、狭窄，导致常规十二指肠镜下取石非常困难或手术失败。扩张球囊直径过大增加了出血和穿孔的风险，有时导致网篮嵌顿。对机械碎石失败者采用激光或液电碎石，成功率目前报道在 90%以上[6,7,9]。但液电或激光碎石治疗时可诱发胆道出血、胆管炎，需要胆道镜直视下操作以提高安全性。

自 1977 年，Urakami[10]首次报道了 1 例将普通胃镜通直接进入胆总管下段。近年来工业技术的革命使得内镜具有更细的直径、更高的分辨率和更大的工作通道。由于超细胃镜镜身较软，易在胃腔内打弯，通过未充分扩张的胆管壶腹部较为困难，无疑需要较高的操作技巧，即使进入胆总管也很难达到目标位置进行下一步操作。文献报道如果不使用一些辅助工具，插管成功率不足 50%[6]。因此，以下方法或设备得到应用。①导丝辅助法；②小肠镜气囊外套管；③活检钳辅助；④锚定球囊。虽然上述各种方法可以辅助进镜，使成功率由 45.5%上升至 95%[11]，但无论超硬导丝抑或锚定导管，都无法阻止 PODC 通过胃腔在大弯侧成襻而使得内镜到达乳头周围前即从胆总管脱出，尤其在胆管广泛扩张时极难起到支撑内镜或“锚定”作用。而目前使用的用于小肠镜的外套管，相对 PODC 粗且硬，内镜进退仍有明显阻滞感。锚定球囊由于存在气体栓塞等严重并发症，生产商已退出市场[12]。笔者认为 PODC 插入的关键在于乳头开口扩大和胆管扩张的程度，常用的 PODC 直径为 5～6mm，故需要较大的乳头切开和（或）球囊扩张。

本研究对象胆总管直径均在≥10 mm，虽然有少数研究对象为憩室旁或憩室内乳头，但可采用小切开加大球囊扩张技术（按结石最大横径加 1～2mm，至少 10 mm），保证了内镜均能顺利通过乳头进入胆总管。对部分胆总管直而短者可直接插入，而部分手术后胆管迂曲者直接插入有困难，内镜在胃和十二指肠成袢，本组 3 例由于胃内盘曲过大，反复尝试仍无法将胃内袢解除，抽出气体使胃腔尽量缩小，加用外套管将球囊充气后固定十二指肠球部，使套管内的内镜离开胃体实大弯避免胃内成袢。失败 2 例均曾行胆囊切除术，内镜虽然越过乳头开口成功，但难以深插到肝门部，考虑胆总管走形异位。笔者使用的德国产 U100 plus 激光碎石装置[13-15]，该新型激光对胆管内皮几乎无损伤，但其因纤维硬而细，有可能造成机械伤害。本组 17 例结石硬度不同，碎石时间略有差别但均被碎成碎块甚至糊状，再更换十二指肠镜较容易用网篮抓住已经破碎的结石并取出胆管，小的碎块可通过内镜冲洗、网篮或球囊清理。失败 4 例随后均接受开腹手术，2 例是由

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于结石过大过硬，反复碎石超过预定时间(1 h)；另2例为胆囊切除术后合并胆管狭窄，内镜难以抵近结石，增加了靶向碎石的难度。能否将狭窄段支架扩张后再碎石，目前未见相关报道。本研究中碎石均在内镜直视下进行，安全性高，未发生严重并发症，但文献报道发生率为3%～15%[16]，包括胆瘘、胆道出血、胆管炎等，尚待进一步增加病例数量。在迄今为止发表的最大的系列研究中，尽管使用预防性抗生素，术后胆管炎的发生率为10%[7]，虽然未放置鼻胆引流管，但胆汁也能通畅排泄。本研究中仅4例发生胆道感染，其原因可能与术中直视下0.9%氯化钠溶液清理胆道有关。此技术也保证术后胰腺炎发生率低，避免了严重出血和穿孔的发生。应当高度警惕的是有PODC发生罕见而严重不良事件的报道[17]，特别是由于空气进入门静脉或肝静脉系统引起的栓塞。这可能与内镜堵塞乳头开口，当胆管内注气使胆管内压增高，空气可通过内镜创伤造成的黏膜破损口进入门脉或肝静脉有关。为了降低这种严重并发症的风险，最好使用二氧化碳或0.9%氯化钠溶液代替空气来清除胆管；在直接胆管镜检查时切忌沿导丝盲插以避免黏膜损伤。

综上所述，PODC对困难性胆管结石的激光碎石，在图像质量和工作通道方面较其他胆道镜有一定的优势，但插入技术有一定困难，需要较高的操作技巧，采用辅助工具可以提高成功率，先进的碎石装置是完成本课题的关键，因此无论从设备和技术上均有待探索和发展。

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万方数据

·论　著·

内镜下双频双脉冲激光碎石与传统机械碎石在胆总管结石患者中的疗效比较



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【摘要】 目的 比较内镜下双频双脉冲激光碎石与内镜下传统机械碎石治疗胆总管结石患者的疗效差异。**方法** 回顾性分析2009年3月至2019年3月期间在上海交通大学医学院附属第九人民医院普外科行ERCP治疗并碎石的207例胆总管结石患者的临床资料，其中71例患者采用双频双脉冲激光碎石术（激光组），136例患者采用机械碎石（机械组），比较2组患者的取石成功率、手术时间、术后住院时间、住院费用、耗材费用、并发症等情况。**结果** 2组患者一般情况、术前临床资料等基线资料基本一致（$P>0.05$）。激光组和机械组均无围术期死亡患者。2组患者术后常规实验室生化指标、耗材费用、住院费用及出血、术后胰腺炎、穿孔和胆管感染并发症率比较差异均无统计学意义（$P>0.05$）。虽然激光组的手术时间明显长于机械组（$P<0.05$），但是与机械组相比，激光组的取石成功率更高（$P<0.05$）、术后住院时间更短（$P<0.05$）、总并发症率和结石残留率更低（$P<0.05$）。**结论** 双频双脉冲激光碎石治疗胆总管结石具有比传统手术机械碎石更好的疗效及更低的并发症率，但手术时间仍有改进的空间。

【关键词】 胆总管结石；双频双脉冲激光碎石；机械碎石；疗效

Comparison of therapeutic effects of endoscopic frequency-doubled double pulse neodymium yttrium aluminium garnet laser and traditional mechanical lithotripsy in patients with common bile duct stones

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【Abstract】 Objective To compare difference of therapeutic effects between endoscopic frequency-doubled double pulse neodymium yttrium aluminium garnet (FREDDY) laser and endoscopic traditional mechanical lithotripsy in treatment of common bile duct stones (CBDs). **Methods** The clinical data of 207 patients with CBDs treated with ERCP and lithotripsy in the Ninth People's Hospital Affiliated to Shanghai Jiaotong University School of Medicine from March 2009 to March 2019 were analyzed retrospectively, of which 71 cases treated by FREDDY (FREDDY group) and 136 cases treated by mechanical lithotripsy (mechanical group). The success rate of stone removal, operation time, postoperative hospitalization time, hospitalization cost, consumables cost, and complications were compared between the two groups. **Results** There were no significant differences in the general condition and the preoperative clinical data between the two groups ($P>0.05$). There was no perioperative death in the two groups. There were no significant differences in terms of the postoperative routine laboratory biochemical indexes, consumables cost, hospitalization cost, and rates of the bleeding, postoperative pancreatitis, perforation and biliary tract infection between the two groups ($P>0.05$). Although the operation time of the FREDDY group was significantly longer than that of the mechanical group ($P<0.05$), the success rate of stone removal was significantly higher, the postoperative hospitalization time was shorter, the total complications rate and stone residual rate were significantly lower in the FREDDY group as compared with the mechanical group ($P<0.05$). **Conclusion** Endoscopic FREDDY laser lithotripsy has a better curative effect and less complications in treatment of large CBDs than mechanical lithotripsy, but operation time needs further to be improved.

【Keywords】 common bile duct stones; frequency-doubled double pulse neodymium yttrium aluminium garnet laser lithotripsy; mechanical lithotripsy; therapeutic effect

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胆总管结石为消化系统的常见疾病之一[1]，以黄疸、寒战、高热、上腹绞痛等为主要症状，还可能出现多脏器功能障碍、感染性休克、呼吸衰竭等表现，有一定病死率[2-4]。因此，患者一旦明确诊断胆总管结石，大部分均需手术治疗。随着内镜技术的发展，内镜逆行胰胆管造影术（ERCP）在胆总管结石的治疗中已成为首选治疗方式。现有研究[5-6]表明，相比传统外科手术，ERCP 具有较强的操作性、较小手术创伤及较少的并发症。但部分患者由于胆总管结石巨大，内镜下治疗需碎石后方能安全取石，传统机械碎石虽能基本达到治疗效果，但有少数患者结石较硬、机械手段无法碎石甚至发生碎石网篮导丝断裂和嵌顿的情况，给治疗带来巨大的风险。因此，内镜下激光碎石相对较为安全的。本研究回顾分析了上海交通大学医学院附属第九人民医院（简称“我院”）普外科内镜下碎石患者的临床病理资料，对比研究了采用内镜下双频双脉冲激光技术碎石与机械碎石治疗的效果，以期为胆总管结石患者采用安全、有效的治疗方法提供更多选择。

1 资料与方法

1.1 一般资料

回顾性分析 2009 年 3 月至 2019 年 3 月期间在我院普外科行 ERCP 治疗并碎石的 207 例胆总管结石患者的临床资料，其中 71 例患者采用双频双脉冲激光碎石术治疗（激光组），136 例患者采用机械碎石治疗（机械组），2 组患者的一般情况及术前临床资料比较差异无统计学意义（P>0.05），见表 1。

1.2 方法

① 主要设备有 Olympus JF-260 十二指肠镜、爱尔博 200D 电刀、U100 plus 双频双脉冲激光胆道碎石机、BML-3 机械碎石网篮、取石网篮、气囊导管、超滑导丝、鼻胆管、各种塑料支架等。② ERCP 手术过程：术前禁食 12 h，均在利多卡因咽喉部麻醉下行 ERCP+内镜下乳头括约肌切开术（endoscopic sphincterotomy，EST），先插管、造影、切开后再行球囊扩张。术前常规注射盐酸哌替啶和阿托品（有禁忌证者不用），术前不常规给予抗生素。治疗过程中必要时吸氧，同时行氧饱和和心电监护。结石取出后均放置鼻胆管引流，再行胆总管造影，以确认结石彻底清除。若结石一次难以取净或取石失败者置入胆管塑料支架，3 个月后再次行 ERCP 取石或行手术治疗。术后暂禁食，给予二代头孢预防感染，术后第 1 天查血尿淀粉酶，若正常则第 2 天进食，若异常则监测至正常后进食。③ 对于术前影像检查（图 1a）明确且胆总管结石较大（结石超过胆总管直径或直径超过 2 cm）者术中采用激光碎石后取出，其具体操作为：插管成功后造影（图 1b）以明确结石位置，在光纤头部放置可在 X 射线下显影的标记（取自斑马导丝头部），光纤从取石球囊导丝通道并通过十二指肠镜进入胆总管，打开球囊与胆总管直径一致，顶住结石防止结石移位，并在 X 射线透视下明确光纤顶住结石后碎石（图 1c）；对于术前影像学检查（图 1d）或术中造影（图 1e）显示胆总管内结石可能无法用网篮一次性取出者则术中用机械碎石网篮套住结石后，用加压手柄碎石后取出至十二指肠腔内（图 1f）。两种方法碎石后，使用取石网篮和取石球囊取出胆总管内结石。

1.3 观察指标

2 组患者均在术前 48 h 时及术后第 1 天清晨在空腹状态抽取外周静脉血检测 TBIL、GGT、ALT、AMS、WBC、C 反应蛋白（CRP）。记录术后取石情况、手术时间、术后住院时间、住院费用、耗材费用、并发症［包括术后出血（主要指 Oddi 括约肌出血）、术后胰腺炎（术后 24 h 时的 AMS>正常值上限的 3 倍，同时伴有腹痛或腹部 CT 提示胰腺周围有渗出）、穿孔（经影像学证实）、胆管感染（腹痛、腹胀、黄疸、发热、白细升高）］情况等。

1.4 统计学方法

采用 SPSS 24.0 统计学软件，符合正态分布的计量资料以均数±标准差（$\bar{x}\pm s$）表示，2 组独立计量资料采用独立样本 t 检验；计数资料采用交叉表格[2]

表 1 2 组患者一般情况及术前临床资料比较结果

基线资料	激光组（n=71）	机械组（n=136）	χ 或 t 值	P 值
男/女（例）	38/33	67/69	0.579	0.638
年龄（$\bar{x}\pm s$，岁）	68±18	66±14	1.137	0.317
胆总管结石（例）				
单发	26	51	0.015	0.512
多发	45	85		
胆总管直径（$\bar{x}\pm s$，cm）	2.31±0.72	2.14±0.54	0.176	0.440
结石数量（$\bar{x}\pm s$，枚）	2.35±1.18	2.24±1.06	0.242	0.429
结石直径（$\bar{x}\pm s$，cm）	2.03±0.78	1.97±0.86	0.237	0.626
TBIL（$\bar{x}\pm s$，μmol/L）	19.43±7.88	18.71±6.98	0.239	0.218
GGT（$\bar{x}\pm s$，U/L）	540.63±126.44	533.71±151.73	0.289	0.329
ALT（$\bar{x}\pm s$，U/L）	134.34±73.12	123.54±81.69	0.433	0.571
AMS（$\bar{x}\pm s$，U/L）	45.21±11.33	38.48±12.25	1.388	0.624
WBC（$\bar{x}\pm s$，×10 /L）	6.88±1.55	6.42±1.63	0.186	0.376

TBIL：总胆红素；GGT：谷氨酰转肽酶；ALT：丙氨酸转氨酶；AMS：血清淀粉酶；WBC：白细胞计数

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卡方（χ）检验。检验水准 α=0.05。

2　结果

2.1　2 组患者术后实验室生化指标比较

结果见表 2。从表 2 可见，2 组患者术后常规实验室生化指标比较差异无统计学意义（P>0.05）。

2.2　2 组患者取石成功率、手术时间、术后住院时间、住院费用及耗材费用比较

结果见表 3。从表 3 可见，2 组患者的住院费用和耗材费用比较差异无统计学意义（P>0.05），虽然激光组的手术时间明显长于机械组（P<0.05），但是与机械组比较，激光组取石成功率更高（P<0.05）、术后住院时间更短（P<0.05）。

2.3　2 组患者的死亡及并发症情况

2 组均无围术期死亡患者。2 组患者的术后并发症情况见表 4。从表 4 可见，激光组的总并发症率和结石残留率均明显低于机械组（P<0.05），而 2 组间术后出血、术后胰腺炎、穿孔和胆管感染率比较差异无统计学意义（P>0.05）。激光组术后胰腺炎患者复查 CT 影像结果显示可见胰头及十二指肠周围渗出明显（图 1g），所有并发症均通过保守治疗后痊愈；机械组碎石后复查 CT 可见腹腔内大量积液，术中证实为胆汁样液体，并在肝左外叶找到胆管穿孔（图 1h），1 例肝左外叶穿孔和 1 例胆总管穿孔患者均通过手术治疗后好转，有 1 例术后出血患者通过输血、止血治疗后好转，有 2 例坏死性胰腺炎患者通过外科手术治疗后好转，13 例结石残留患者均置入胆总管塑料支架后通过二次或多次手术后取出胆总管结石，其余患者的并发症均通过保守治疗后好转。

3　讨论

胆总管结石的形成与代谢障碍、慢性胆管感染、胆管解剖异常及功能异常有关。胆总管结石不仅容易复发，还可以引起多种并发症，包括梗阻性黄疸、胆管炎、肝脓肿、胰腺炎、继发性胆汁性肝硬化等 。

手术为胆总管结石的主要治疗方法，但对于急性发作期手术难以明确胆管系统、结石数量及位置，增加二次手术的可能性，因此，临床上多在炎症控制后进行择期手术 。手术治疗主要以取出结石解除胆管梗阻为主，而对于部分胆总管结石因

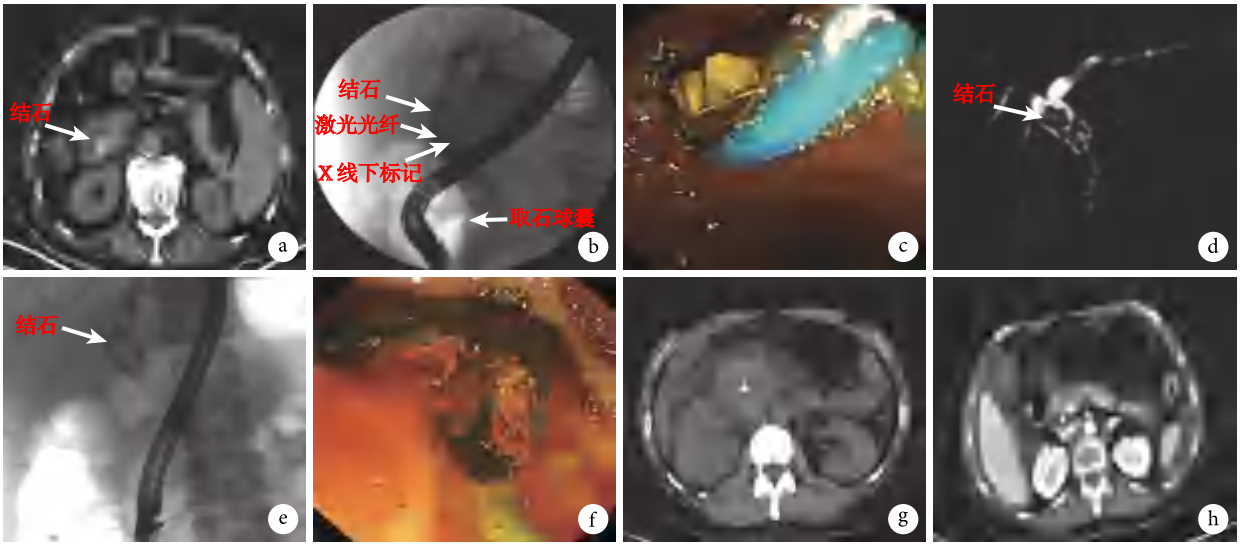


图 1　示激光组和机械组术前、术中及术后影像学检查结果

a–c：激光组术前腹部 CT 检查（a）、ERCP 术中影像（b）、ERCP 镜下影像（c）；d–f：机械组术前腹部 CT 检查（d）、ERCP 术中影像（e）、ERCP 镜下影像（f）；g、h：激光碎石（g）后胰腺炎 CT 影像结果和机械碎石（h）后肝内胆管穿孔的 CT 影像结果

表 2　2 组患者术后第 1 天实验室生化指标比较结果（$\bar{x}\pm s$）

组别	n	TBIL（μmol/L）	GGT（U/L）	ALT（U/L）	AMS（U/L）	WBC（×10 /L）	CRP（mg/L）
激光组	71	25.34±9.14	280.90±83.32	89.23±67.62	149.13±33.23	7.41±1.43	13.60±2.48
机械组	136	24.93±8.31	282.53±93.14	90.33±54.63	260.92±32.79	7.82±1.68	17.14±3.62
t 值		0.281	0.173	0.158	2.433	0.319	0.743
P 值		0.304	0.472	0.517	0.552	0.219	0.146

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表 3　2 组患者取石成功率、手术时间、术后住院时间、住院费用及耗材费用比较

组别	n	取石成功[例(%)]	手术时间($\bar{x}\pm s$, min)	术后住院时间($\bar{x}\pm s$, d)	住院费用($\bar{x}\pm s$, 万元)	耗材费用($\bar{x}\pm s$, 万元)
激光组	71	70(98.6)	65.12±25.76	2.30±0.76	2.28±0.13	0.67±0.13
机械组	136	123(90.4)	42.52±21.77	4.50±1.58	2.45±0.24	0.72±0.21
χ 或 t 值		3.707	1.364	0.895	0.534	0.663
P 值		0.027	0.014	0.027	0.272	0.568

表 4　2 组患者术后并发症情况比较[例(%)]

组别	n	总并发症	术后出血	术后胰腺炎	穿孔	胆管感染	结石残留
激光组	71	4(5.6)	0(0)	2(2.8)	0(0)	1(1.4)	1(1.4)
机械组	136	29(21.3)	2(1.5)	8(5.9)	2(1.5)	4(2.9)	13(9.6)
χ 值		7.501	0.078	0.403	0.078	0.042	3.707
P 值		0.004	0.305	0.271	0.305	0.440	0.027

结石直径较大(直径≥10 mm)在内镜下取石均较为困难，既往首选开腹胆总管探查术或腹腔镜胆总管探查术治疗，但该手术方式创伤大、住院时间长。[8] 随着微创技术的发展，内镜下取石技术发展迅速，其具有可反复多次取石、创伤小、术后恢复快等优势，仍是治疗胆总管结石首选的手术方式。

EST 是目前治疗胆总管结石最主要的方式之一[9]，但仍有 5% ~ 15% 的患者因胆总管内结石较大而无法通过切开的十二指肠乳头，从而导致治疗失败[10-12]。因此，当遇到此类患者时则需要采用碎石技术，但机械碎石可能很麻烦，费时、费力、复杂且可能无效，其主要原因一是胆总管内结石巨大，而胆总管内空间较小，碎石网篮无法张开而无法套住结石进行碎石；二是远端胆总管存在狭窄，无法清除大块的碎裂结石。因此，当机械碎石无法取出胆总管结石时则需要考虑采用其他方法，如电液压碎石、体外冲击波碎石、激光冲击波碎石或姑息治疗(置入胆总管支架)[13]。

双频双脉冲激光 U100 plus 是一种新开发的经济、短脉冲、双频固态激光器，波长在 532 nm 和 1 064 nm。532 nm(绿色光谱)的激光在结石表面引发等离子体形成，而红外激光能量使该等离子体增强以形成快速塌陷的气泡，从而产生强烈的冲击波，使结石破碎，目前该技术已经成熟应用于 ERCP 等内镜手术中处理困难的胆总管结石[14-15]。最近发表的有关 ERCP 或经皮经肝穿刺胆道镜检查结合双频双脉冲激光治疗胆总管结石的研究[16] 显示，其结石成功清除率高，并发症发生率低。Liu 等[17] 也报道，在荧光镜引导下使用带有不透射线标记的双频双脉冲激光内镜胆道碎石术是治疗困难的胆管结石的一种安全、有效的方法。此外，不用直视下控制和低能量的双频双脉冲激光碎石术可以减少胆管黏膜和周围组织损伤的风险，对于难以清除的难治性胆管结石患者是安全、方便和有效的[14]。Yang 等[7] 报道采用双频双脉冲激光碎石术也明显优于其他碎石技术治疗的患者，并且在长期随访中未见患者出现胆管损伤、狭窄和结石复发的情况。

本研究通过使用双频双脉冲 U100 plus 激光碎石技术，取得了明显优于机械碎石的治疗效果。在机械碎石组内发生了术后出血，可能与机械碎石网篮套住结石后没有完全碎石从切开的乳头拉出后造成乳头括约肌撕裂有关；其术后胰腺炎发生率也明显高于激光碎石组，这与碎石网篮反复进入胆管或误入胰管有关；同时，由于碎石网篮较长且头端较硬，在进入胆管后打开过程中使用暴力，则有可能造成肝内胆管或胆总管穿孔可能，且在反复碎石操作过程中造成胆管黏膜内壁损伤，造成术后胆管感染及术后胆管出血可能；另外，在本研究中，有部分患者由于结石极为坚硬，碎石网篮无法使其碎裂，从而造成网篮导丝断裂而取石失败，只能采用胆总管内植入支架二次甚至多次取石。但在激光碎石组则不存在这类问题，往往坚实的结石在激光下更容易碎石，采用在激光光纤头部放置不透射线标记，通过取石球囊在 X 射线直视下固定在胆总管中间，光纤顶住结石而进行碎石，可以取得较好的碎石效果，然后通过取石网篮或取石球囊取净胆总管内结石。

总之，在内镜下通过双频双脉冲激光碎石较传统的机械碎石在治疗胆总管结石具有更安全、更经济、更效率的优势，但在手术时间上仍有进步的空

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间，一旦技术完全掌握或提前把 U100 plus 激光碎石器准备充分，则在手术时间上也可大大缩短。

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· 经验交流 ·

腹腔镜、胆道镜联合 U100 激光处理胆总管末端嵌顿性结石

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【摘要】 目的 探讨腹腔镜胆道镜联合 U100 激光治疗胆总管末端嵌顿性结石的效果。 方法 回顾性分析 2014 年 9 月~2019 年 9 月 11 例胆囊结石合并胆总管末端嵌顿结石行腹腔镜胆囊切除(laparoscopic cholecystectomy, LC)+胆总管探查(laparoscopic common bile duct exploration, LCBDE)+U100 激光碎石术资料。 结果 手术均成功,无大出血、胆漏、胰漏、肠漏等严重并发症,术后 4~6 周 T 管造影无残余结石。 结论 LC+LCBDE+U100 激光碎石术治疗胆囊结石合并胆总管末端嵌顿结石,直观,准确,疗效确切。

【关键词】 胆总管末端结石; 腹腔镜; 胆道镜; 激光碎石

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Laparoscopy and Choledochoscopy Combined With U100 Laser Lithotripsy in the Treatment of Incarcerated Stones at the End of Common Bile Duct *Azhatijiang Ainiwaer*, Aisaiti Ainiwaerbeki, Yu Wenqing, et al. (Department of Minimally Invasive Surgery, Xinjiang Uygur Autonomous Region People's Hospital, Urumqi 830001, China)*

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【Abstract】 **Objective** To investigate the clinical experience and value of laparoscopy and choledochoscopy combined with U100 laser lithotripsy in the treatment of incarcerated calculi at the end of common bile duct. **Methods** From September 2014 to September 2019, 11 cases of gallbladder stones with incarcerated calculi at the end of common bile duct were treated with LC (laparoscopic cholecystectomy) + LCBDE (laparoscopic common bile duct exploration) + U100 laser lithotripsy. **Results** All the operations were successful, and there were no serious complications such as massive hemorrhage, biliary leakage, pancreatic leakage, or intestinal leakage. No residual calculi were detected by T-tube angiography at 4-6 weeks after the operation. **Conclusion** LC + LCBDE + U100 laser lithotriptic technique for the treatment of cholecystolithiasis combined with common bile duct end incarcerated calculi is a direct, accurate, and effective surgery.

【Key Words】 Calculi at the end of common bile duct; Laparoscope; Choledochoscope; Laser lithotripsy

胆囊结石中 10%~15% 合并胆总管结石[1],有症状胆囊结石中 10%~20% 有继发胆总管结石,及时取出胆总管结石有助于避免并发症[2]。胆总管结石可因自行掉落或医源性取石而嵌顿于 Oddi 括约肌,此类 Oddi 括约肌结石较隐匿,胆道镜检查时若括约肌开口收缩,将完全隐匿在括约肌内,容易漏诊。胆总管下段嵌顿性结石在胆总管探查术中有时取石较困难,处理不当可引起胆胰肠结合部位损伤,甚至造成大出血、胆漏、胰漏、肠漏等严重并发症。临床上常用的碎石技术包括超声碎石、液电碎石、等离子碎石及机械碎石等,均有其局限性[3]。我科 2014 年 9 月~2019 年 9 月对 11 例胆总管下段嵌顿结石行腹腔镜胆囊切除(laparoscopic cholecystectomy, LC)+胆总管探查(laparoscopic common bile duct exploration, LCBDE)+U100 激光碎石术,均获成功,现进行回顾性分析,报道如下。

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万方数据

1　临床资料与方法

1.1　一般资料

本组 11 例，男 7 例、女 4 例。年龄 50 ~ 61（54.5 ± 3.7）岁。均有不同程度上腹痛，黄疸 10 例。病程 2 ~ 9（5.5 ± 2.3）d。均行 B 超、CT 平扫 + 增强、MRCP 和超声胃镜，显示胆囊结石合并胆总管结石，胆囊壁 3 ~ 9（5.1 ± 2.0）mm，胆总管直径 8 ~ 14（11.1 ± 1.9）mm，肝内外胆管明显扩张，胆总管结石均为胆总管末端及 Oddi 括约肌内结石，结石单发 7 例，多发 4 例，结石大小 1.3 ~ 6.0（3.96 ± 1.78）mm。直接胆红素 6.6 ~ 126.4（76.6 ± 38.0）μmol/L（正常值 0 ~ 8.55 μmol/L，1 例正常）；总胆红素 86.7 ~ 185.6（117.7 ± 32.3）μmol/L（正常值 < 21 μmol/L，均升高）；γ-谷氨酰转肽酶 39.4 ~ 248.7（110.5 ± 69.8）U/L（正常值 7 ~ 45 U/L，3 例正常）；碱性磷酸酶 136.2 ~ 306.4（186.5 ± 52.1）U/L（正常值 45 ~ 125 U/L，均升高）；天门冬氨酸氨基转移酶 51.35 ~ 76.80（51.68 ± 22.5）U/L（正常值 13 ~ 40 U/L，均升高）；丙氨酸氨基转移酶 55.7 ~ 124.5（85.6 ± 21.8）U/L（正常值 7 ~ 45 U/L，均升高）。合并急性梗阻性化脓性胆管炎 5 例，胆源性胰腺炎 7 例。超重和肥胖 6 例，糖尿病 4 例，高血压病 2 例。

病例选择标准：腹腔镜胆总管探查手术中胆总管末端结石其他取石方法无法取石时用 U100 激光碎石。

1.2　方法

术前禁食 12 小时，禁饮 6 小时。全身麻醉，仰卧位。CO_2 气腹压力 12 ~ 15 mm Hg，四孔法行 LC。先解剖胆囊三角，分离出胆囊管后远端上钛夹，确定近端胆囊管是否有胆囊管结石，用电钩钳和分离钳解剖分离胆囊管、胆囊动脉，切除胆囊，用标本袋将胆囊取出。打开十二指肠韧带，识别胆总管（穿刺抽出胆汁确认）并显露，于胆总管前壁做 0.5 ~ 1.2 cm 纵行切口，切开胆总管前壁，切口长度以能通过最大结石或胆道镜能进入为宜。取胆汁做细菌培养 + 药敏、胆汁生化。对较松脆胆总管结石，用网篮的金属头部或活检钳反复撞击，使结石外周部分松动脱落，钳夹结石，用网篮套出或取石钳取出。如胆总管末端及 Oddi 括约肌内结石较硬，用各种活检钳或网篮取石钳无法张开及取出结石，球囊管无法通过结石远端，结石嵌顿牢固，用 U100 激光碎石（U100 双频双脉冲激光碎石机 FRDDY Nd:YAG）。经胆道镜看到结石后，将 U100 光纤从胆道镜的工作通道送入胆总管末端结石区，根据结石的大小、硬度调节 U100 激光的参数，初始脉冲频率 5 ~ 10 Hz，能量 120 mJ，直视下将光纤末端抵近结石中央，采取间断发射激光脉冲的方法粉碎结石。碎石过程中持续冲水保持视野清晰，光纤接触结石中心开始击碎结石，反复数次，以取石网将结石取净。胆道镜反复探查胆总管近端、远端，确定无出血、残余结石，留置 T 管，3-0 吸收线胆总管近端、远端间断缝合各 1 ~ 2 针，针距 1.5 mm，边距 1.5 mm。Winslow 孔留置 19 号腹腔引流管 1 根从腋前线肋缘下切口引出，T 管从锁骨中线肋缘下切口引出。

2　结果

11 例手术均成功，无中转开腹。手术时间 93 ~ 186 min，平均 128 min。无出血、胆漏、胰漏、肠漏。术后 2 周胆道造影，胆汁引流通畅，无残余结石，顺利进入十二指肠，夹闭 T 管，术后 4 ~ 6 周再次行胆道造影、彩超和肝功检查，无残余结石及其他异常，拔除 T 管。11 例随访 15 ~ 56 个月，平均 21.5 月，术后每半年复查 B 超和肝功能，未见异常。

3　讨论

继发性胆总管结石是胆囊内的结石通过扩张的胆囊颈管进入胆总管，国外文献报道 4% ~ 15% 的胆囊结石患者合并胆总管结石[4,5]。该疾病好发于 35 ~ 50 岁人群，且有年轻化的趋势[6]。胆总管下段（多为壶腹部）结石嵌顿造成胆道完全梗阻，常出现 Charcot 三联征（腹痛、寒战高热、黄疸），严重者可发展为急性梗阻性化脓性胆管炎、急性重症胰腺炎，应积极手术治疗，如未能及时解除梗阻，病死率可达 15%[7]。

U100 激光是双频双脉冲激光，由一束占总能量 80% 的红外光（波长 1064 nm）与一束占总能量 20% 的绿激光（波长 532 nm）组成，脉冲时间 1 ~ 2 μs。碎石时，结石先吸收其中的绿光，在结石表面形成均匀的等离子体气泡，充分吸收红外光的能量形成空化气泡，并通过空化气泡破裂产生机械冲击波以击碎结石。由于所产生的冲击波峰值功率高，在很短的时间内就能准确高效地将结石击碎，对组织损伤小，直观，准确，方便，疗效确切。本组 11 例均用上述方法顺利碎石取石，无并发症发生。胆总管末端结石大且硬，嵌顿在十二指肠乳头括约肌内，取石钳

万方数据

或活检钳无法夹住钳碎，网篮亦无法通过结石，或被结石挤在一边无法张开，难以套住结石，这时可采用胆道镜下 U100 激光碎石后取石。胆总管下段嵌顿性结石取石困难、费时，本组均用 U100 激光碎石，手术时间最长 186 min。对于合并急性梗阻性化脓性胆管炎及 Oddi 括约肌内结石，应快速安全地解除梗阻，取出结石，通畅引流，联合用 U100 更加重要，本组均一期取净结石。我们认为要注意以下方面：①严格按术前辅助检查个体化治疗，是否适合做 LCBDE（是否黄疸、结石大小及来源、合并症、胆总管壁情况等）；②熟练掌握胆道镜和 U100 操作步骤及腔镜下缝合技术；③切开胆总管时少用电刀，或电刀改为 20 kHz 左右；④U100 激光光纤头端应超出胆道镜 1 ~ 1.5 cm，以避免损坏胆道镜；⑤光纤头不要直接接触胆管壁，并保持向胆管内冲水（我们用 3000 ml 生理盐水连在胆道镜上），以免引起胆管损伤；⑥胆总管结石取完后，胆道镜反复查看肝内外胆管，确认无残留结石，无出血，无黏膜损伤等，胆总管远端乳头功能正常；⑦用 3-0 可吸收线间断缝合 T 管上下端。

综上，腹腔镜、胆道镜联合 U100 治疗胆总管末端嵌顿结石安全可行，符合快速康复的观念。

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万方数据

[12] 陈庆永，陈立波. 一期行肠切除术及无张力疝修补术治疗急性绞窄性腹股沟疝合并肠坏死58例[J].中华普通外科杂志,2015,30(8):620-622.

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腹腔镜联合胆道镜下 U-100 双频激光治疗复发肝内结石继发胆总管结石体会

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本研究比较复发肝内胆管结石继发胆总管结石患者行腹腔镜联合胆道镜下 U-100 激光碎石治疗或传统开放手术的治疗效果,总结报道如下。

1　资料与方法

1.1　一般资料　选择我院普外科 2013年 3 月至 2018 年12 月收治的156例复发肝内胆管结石继发胆总管结石患者，按手术方式分为两组。实验组78例,男32例,女46例,平均年龄58.8±4.3岁,其中双侧肝内胆管结石59例,左侧8例,右侧11例;对照组78例,男26例,女52例,平均年龄57.6±3.7岁,其中双侧肝内胆管结石51例,左侧12例,右侧15例。所有患者既往均有1次以上胆管结石手术史,且经B超和CT/MRI明确肝内胆管结石并胆总管结石,胆总管直径>1 cm,术前肝功能为Child A级。

1.2　方法　实验组行腹腔镜联合胆道镜下U-100双频激光碎石,胆总管一期缝合或T管引流(二期经窦道胆道镜取石);对照组行传统开放胆总管切开+术中胆道镜取石+一期缝合或T管引流(二期经窦道胆道镜取石)。本地患者术后接受定期门诊随访,外地患者电话或微信群随访。随访时间1年。

1.3　统计学处理　所获数据经SPSS17.0软件进行统计分析。计量资料以$x\pm s$表示,行单因素t检验;计数资料行χ^2检验。$P<0.05$为差异有统计学意义。

2　结果

患者均顺利完成手术出院。两组观察指标比较见表1。

表1　两组观察指标析比较

观察指标	实验组(n=78)	对照组(n=78)	t/χ^2 值	P 值
手术时间(min)	128.9±42.7	136.3±47.3	0.42	0.519
住院时间(d)	6.5±3.7	14.3±5.8	7.82	<0.01
平均住院费用(元)	27582±725.8	32427±827.5	9.25	<0.01
术后留置 T 管(例)	12	58	12.68	<0.01
胆漏(例)	5	4	0.14	0.786
胆道出血(例)	4	3	0.86	0.472
切口感染(例)	0	11	12.53	<0.01
术后结石残留(例)	6	21	7.08	<0.01

实验组5例和对照组3例术后胆漏患者经充分引流均痊愈。实验组术后3例T管引出血性胆汁患者经保守处理治愈;1例术后1周出现呕血,介入诊断为胃十二指肠动脉瘤破裂,行栓塞治疗治愈。对照组3例胆道出血患者经保守治疗出院,11例切口感染患者经换药处理治愈。

3　讨论

复发肝内胆管结石继发胆总管结石目前治疗方式主要是传统开放手术和腹腔镜微创手术。由于手术风险大,术后并发症多,手术方式的选择具有重要意义[1]。

U100 双频激光碎石仪通过“FREDDY”技术产生不被人体吸收的激光脉冲,既能高效击碎肝胆内胆管结石,又不会损伤胆管[2]。本研究结果显示,两组手术时间总体无差异而分布阶段不同,实验组分离术中粘连时间比对照组长而取石时间短,并且节省关闭缝合时间。两组在术后胆漏、胆道出血方面差异无统计学意义;对照组切口感染率、术后留置T管再取石比例更高,住院时间和平均住院费用增加。两组术后结石残留率比较差异有统计学意义($P<0.05$)。我们认为原因可能有以下几点:(1) 实验组使用U-100激光碎石成功率高,可以解决铸型、嵌顿型巨大结石;对照组取石钳和取石网篮效率低;(2)实验组碎石后主要分支胆管通畅,即便远端末梢胆管结石术中无法探及取尽，亦可导致结石松动为术后T管窦道取石带来方便,提高取石效率。

胆管一期缝合适应证:(1)胆总管直径>1 cm,胆管壁瘢痕水肿不明显;(2)胆道镜探查肝内无结石残留,胆总管下端通畅;(3)年龄<65岁,无糖尿病、肝硬化腹水、长期服用激素病史等。个人认为术后发生胆漏可能与缝合技术、胆管壁条件、胆总管下端通畅性等因素有关。潘峥等[3]认为放置T管并不能减少胆瘘的发生,且增加了拔T管后胆瘘的风险。

本研究表明腹腔镜联合胆道镜下U-100双频激光治疗复发肝内结石继发胆总管结石在术后结石残留、留置T管、住院时间、平均住院费用等方面有近期优势。由于收集数据样本少,随访时间短,远期效果尚待进一步观察。

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万方数据

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Original Article

Comparative study of the effect of U100 laser and pneumatic ballistic combined with percutaneous transhepatic cholangioscopic lithotomy in the treatment of intra-and extrahepatic bile duct stones and its effect on liver function

Zhongliang Yin[1], Bin Shen[2]

ABSTRACT

Objectives: To compare the efficiency of U100 laser and pneumatic ballistics combined with percutaneous transhepatic cholangioscopic lithotripsy (PTCSL) in the treatment of intra-and extrahepatic bile duct stones and their effects on liver function.

Methods: Medical records of 97 patients with intra-and extrahepatic bile duct stones treated in our hospital from May 2020 to May 2021 were selected for retrospective analysis. Of them, forty-three patients received pneumatic ballistic lithotripsy combined with PTCSL (Group-I), and 54 patients received U100 laser lithotripsy combined with PTCSL (Group-II). The therapeutic effects of the treatment in two groups and its effect on liver function were compared and analyzed.

Results: There was no significant difference in the operation time and intraoperative bleeding (P>0.05) between the two groups. The postoperative pain duration and hospital stay of patients treated with U100 laser lithotripsy combined with PTCSL (Group-II) were shorter than those treated with pneumatic ballistic lithotripsy combined with PTCSL (Group-I), P<0.05. The biliary bleeding rate of patients in Group-II was lower (3.70%) than those in Group-I (16.27%, P<0.05), and the stone residue rate of patients in Group-II was also lower (1.85%) than those in Group-I (11.63%, P<0.05). The levels of total bilirubin (TBIL), alanine aminotransferase (ALT) and albumin (ALB) in Group-II patients were higher than in patients in Group-I.(P<0.05).

Conclusion: Compared with pneumatic ballistics, U100 laser lithotripsy combined with PTCSL in the treatment of intra and extrahepatic bile duct stones has the advantages of less postoperative pain, shorter hospital stay, less biliary bleeding and stone residue, and less damage to liver function.

KEYWORDS: U100 laser lithotripsy; Percutaneous transhepatic cholangioscopic lithotripsy; Intra-and extrahepatic bile duct stones; Operation; Liver function.

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INTRODUCTION

The high residual stone rate, high recurrence rate and high reoperation rate of intrahepatic and extrahepatic bile duct stones are still difficult problems in biliary surgery.[1,2] The intrahepatic bile duct is curved, narrow and complex. Most intra-and extrahepatic bile duct stones are grouped and sporadic and can cause hepatobiliary stricture. These stones can also block the bile duct, which can easily cause recurrent cholangitis, resulting in fever, abdominal pain and other symptoms.[3]

Additionally, if biliary obstruction is not removed in time, it can lead to the accumulation of a large number of bacteria in the biliary tract, resulting in the continuous increase of biliary pressure, which promotes the diffusion of infectious substances in the biliary tract. Bacteria and toxins can enter the hepatic sinuses and arteries, leading to systemic infection and further complications, such as obstructive suppurative cholangitis and liver abscess that may endanger the lives of patients.[4]

The traditional and more conservative treatment in cases of intrahepatic and extrahepatic bile duct stones involves anti-inflammatory agents and liver protection. However, these methods have limited effectiveness, and can often result in surgery to treat intra-and extrahepatic bile duct stones. Percutaneous transhepatic cholangioscopic lithotripsy (PTCSL) is a common surgical procedure which can effectively remove these stones, relieve the obstruction, and promote unobstructed drainage.[5]

There are many lithotripsy methods used for the treatment of intra-and extrahepatic bile duct stones. Pneumatic ballistic lithotripsy is the most common and can effectively crush stone. However, it is associated with stone residues and is not that efficient in case of granulation tissue.[6] U100 laser lithotripsy converts the laser power into shock waves which can "disintegrate" the stone from the center, causing less driving force. This reduces the damage to the bile duct and liver tissue.[7] In recent years, the combination of U100 laser lithotripsy with percutaneous transhepatic cholangiolithotomy has been used in our hospital to treat patients with intra-and extrahepatic bile duct stones. The main goal of this study is to compare the efficiency of U100 laser and pneumatic ballistics combined with percutaneous transhepatic cholangioscopic lithotripsy in the treatment of intra-and extrahepatic bile duct stones and their effects on liver function.

METHODS

The records of 97 patients (51 males and 46 females) with intra-and extrahepatic bile duct stones, treated in our hospital from May 2020 to May 2021, were analyzed retrospectively. Of them, 43 patients that were treated with pneumatic ballistic lithotripsy combined with PTCSL comprised Group-I, and 54 patients that were treated with U100 laser lithotripsy combined with PTCSL were defined as Group-II.

The inclusion criteria: Meets the diagnostic criteria of intra-and extrahepatic bile duct stones based on the results of the ultrasound, CT and other imaging examinations;[8] Intrahepatic bile duct dilatation >4mm; No history of previous laparotomy or biliary surgery; Aware of the study and cooperate with informed consent.

Exclusion criteria: Severe basic diseases, organ dysfunction and malignant tumour; Contraindications of PTCSL; Incomplete medical records. The medical ethics Association of our college approved the study (No. JXFY-L20210311, Date: 2021-March-10).

Following anesthesia, the percutaneous transhepatic puncture path was determined according to the preoperative examination. The puncture point, was located in the abdominal wall of the lower right edge of the xiphoid process or between the right 8th~10th ribs. The percutaneous transhepatic puncture was completed using ultrasound real-time monitoring. After the puncture needle entered the target bile duct, the inner core was pulled out, and the bile was withdrawn. After the successful puncture was confirmed, the guide wire was injected into the puncture needle tube and the fistula was dilated through the 8F fascia expander in the direction of the guide wire.

After no bleeding was observed, the matching sheath sleeve was sleeved on the 16F or 18F expander and delivered to the target intrahepatic bile duct. The expander was pulled out and the sheath tube was left. One end of the sheath tube was in the intrahepatic bile duct and the other end was left in vitro to place the fistula between the intrahepatic bile duct and the outer surface of the body. The choledochoscope was placed into the target bile duct through this channel. Saline was flushed through, which allowed the small stones to flow out of the body or be removed with a blue net.

Pneumatic ballistic lithotripsy was done using pneumatic ballistic lithotripter (EMS SA CH21260 NYON, Switzerland). The air pressure was set to 2×100kPa, which broke up the stone using a continuous pulse, followed by a wash with normal saline to allow the broken stones to flow out of the body.

U100 laser lithotripsy was performed using the U100Plus laser lithotripter (Germany). The optical fiber of the laser was inserted into the bile duct through the choledochoscope. The laser capacity was set to 160mj and aligned with the center of the stone. After the stone was broken up, there was a rinse with saline to clear small stones, or they were taken out with a blue net. After the stones were removed, a drainage tube was inserted into the fistula and the puncture point was treated.

Operation Indexes: The operation time, intraoperative bleeding, postoperative pain

Table-I. Comparison of patient characteristics between the two groups [n (%),$\overline{X}$±S].

Group	*n*	*Gender (male/ Female)*	*Age (year)*	*Stone location(n)*					
				Left intrahepatic bile duct	*Right intrahepatic bile duct*	*Common bile duct*	*Left hepatolithiasis with common bile duct*	*Right hepatolithiasis with common bile duct*	*Intrahepatic bile duct*
Group-I	43	22/21	59.35±7.20	10	13	7	6	4	3
Group-II	54	29/25	58.87±6.69	15	14	6	7	7	5
χ^2/t	-	0.062	0.338				1.278		
P	-	0.803	0.736				0.937		

duration and hospital stay were recorded. Biliary bleeding and residual stones in the two groups were counted. The criteria for judging biliary bleeding were the presence of bloody fluid, detected by choledochoscopy, and the outflow of bloody fluid from the drainage tube.[9] The criteria for residual stones were ultrasound and/or CT examination seven days after the operation.[10] To assess liver function fasting venous blood samples were collected from 4l patients before the operation and seven days after the operation, basic patient information was recorded. Total bilirubin (TBIL), alanine aminotransferase (ALT) and albumin (ALB) levels were detected by enzyme-linked immunosorbent assay.

Statistical Analysis: SPSS 22.0 was used for data processing, [n (%)] was used to represent the counting data for χ^2 test;($\overline{X}\pm S$) was used to represent measurement data for t-test;(P<0.05) was considered statistically significant.

RESULTS

A total of 97 patients met the inclusion criteria of this retrospective study, including 51 males and 46 females. Their age ranged from 46 to 71 years, with an average of 59.08±6.89 years. Patients that were treated with pneumatic ballistic lithotripsy combined with PTCSL comprised Group-I, and 54 patients that were treated with U100 laser lithotripsy combined with PTCSL comprised Group-II.

There was no significant difference in the basic clinical data and in the operation time and intraoperative bleeding between the two groups (Table-I, P>0.05). The postoperative pain duration and hospital stay of patients in Group-II were shorter than those in Group-I (Table-II, P<0.05). Patients in Group-II had lower biliary bleeding rate (3.70% vs. 16.27%, P<0.05) and lower stone residue rate (1.85% vs. 11.63%, P<0.05) than patients in Group-I (Table-III). Before the operation, there was no significant difference in TBIL, ALT or ALB concentrations between the two groups (P>0.05). At 7 days post operation, both groups showed lower TBIL, ALT and ALB concentrations than what was observed before the operation. However, patients in Group-II had significantly higher levels of TBIL, ALT and ALB compared to Group-I patients (Table-IV, P<0.05).

DISCUSSION

Our study demonstrated that U100 laser and pneumatic trajectory combined with percutaneous transhepatic cholangiolithotomy is associated with shorter duration of pain and hospital stay in patients with intra-and extrahepatic bile duct

Table-II: Comparison of surgical indicators between the two groups ($\overline{X}$±S).

Group(n)	*Operation time (min)*	*Intraoperative blood loss(ml)*	*Duration of postoperative pain(d)*	*Hospital stays(d)*
Group-I (n=43)	160.09±20.04	179.93±18.35	4.28±1.12	10.74±2.05
Group-II (n=54)	162.48±21.40	182.42±16.90	2.30±0.72	7.17±1.79
t	0.338	0.562	10.082	9.176
P	0.736	0.576	<0.001	<0.001

Table-III: Comparison of biliary bleeding and residual stones in the two groups [n (%)].

Group	*n*	*Biliary bleeding*	*Stone residue*
Group-I	43	7(16.27)	5(11.63)
Group-II	54	2(3.70)	1(1.85)
x^2	-	4.497	3.943
P		0.034	0.047

stones. The rate of bile duct bleeding and stone residue in this group of patients was lower, which is similar to results by Lamanna A et al.[11] Chunlin Y et al. explored the safety and effectiveness of ureteroscopic holmium laser lithotripsy (UHLL) and ureteroscopic pneumatic lithotripsy (UPL) in the treatment of impacted ureteral calculi (IUC). They showed that UHLL and UPL were safe and effective, but UHLL has the advantages of shorter operation time and high stone-free ratio.[12] The mechanism of U100 laser lithotripsy combined with PTCSL uses a dual frequency and dual pulse Nd doped yttrium aluminum garnet laser, which can emit infrared light (wavelength 1064nm) and green light (wavelength 532nm). During lithotripsy, the stones absorb 20% green light to form uniform plasma, and the plasma has the ability to absorb 80% infrared light This promotes the conversion of laser energy into a mechanical flushing wave and disintegrates stones from the center.[13] For example: Garg s et al. compared the efficacy, safety and complications of laser (Ho: YAG) and pneumatic ballistic internal lithotripsy in the treatment of ureteral calculi and showed that the stone clearance rate of laser lithotripsy was higher, it was safe and was not associated with complications.[14] The driving force of the mechanical shock wave on the stones is lower than that used in pneumatic ballistic lithotripsy, which can reduce the damage to biliary tract, reduce postoperative pain and the biliary bleeding rate.

During lithotripsy, the stones can be pushed, which can damage the biliary wall, possibly causing severe postoperative pain and increasing the risk of biliary bleeding.[15] In terms of stone removal, the ui000 light of U100 laser lithotripsy can be bent arbitrarily to enter the bile duct which can break and remove the more difficult stones, reducing incidences of any residual stones. In comparison, the pneumatic ballistic lithotripsy rod cannot be bent, which may cause the stones to shift and drift back, making it difficult to remove hidden or small stones, increasing the possibility of stone residue.[16]

When patients with intra-and extrahepatic bile duct stones are treated using surgery, the surgical trauma may cause damage to the patient's liver and reduce their liver function.[17] Therefore, in recent years, the protection of liver function is considered when designing and selecting the surgical procedure used for intra-and extrahepatic bile duct stone removal. In this study, TBIL, ALT and ALB concentrations within the two groups were significantly lower after the surgery. However, patients in Group-II, showed higher levels of TBIL, ALT and ALB than those in Group-I, post-operation. Muglia et al. compared and analyzed the effects of pneumatic ballistic lithotripsy and U100 laser lithotripsy on patients' liver function during PTCSL.[18] They found than patients treated with U100 laser lithotripsy had less postoperative liver function damage, consistent with the results of this study. It is suggested that U100 laser lithotripsy combined with PTCSL can reduce the negative impact on liver function when treating intra-and extrahepatic bile duct stones. The absorption coefficients of infrared light and green laser emitted

Table-IV: Comparison of liver function indexes between the two groups before operation and seven days after operation ($\overline{X}$±S).

	TBil(μmol/L)		*t*	*P*	*ALT(U/L)*		*t*	*P*	*ALB(g/L)*		*t*	*P*
Group (n)	*Preop-erative*	*7d after opera-tion*			*Preop-erative*	*7d after opera-tion*			*Preop-erative*	*7d after opera-tion*		
Group-I (n=43)	28.05± 3.48	15.28± 2.76	72.717	< 0.001	71.14± 4.49	42.30± 4.07	262.109	< 0.001	36.30± 3.66	28.30± 3.36	80.133	< 0.001
Group-II (n=54)	28.54± 3.61	19.33± 2.84	58.534	< 0.001	72.50± 5.39	53.48± 4.84	142.497	< 0.001	36.57± 4.22	32.68± 3.85	24.986	< 0.001
t	0.676	7.066	-	-	1.354	12.342	-	-	0.339	5.882	-	-

by U100 laser lithotripsy do not cause a thermal effect during lithotripsy, and human tissues cannot absorb these two lasers, which eliminates the damage caused by the mechanical shock wave on the bile duct and liver, thereby effectively reducing the adverse impact on liver function.[19] On the other hand, the process of pneumatic ballistic lithotripsy effectively pushes the projectile using compressed gas through lithotripsy probe rod, which can cause significant mechanical damage to the function of the biliary tract and liver.

Limitations:. The sample size was relatively small with only 97 patients who qualified for this study within our hospital. Additionally, patients were only monitored for seven days post-operation, which may make the conclusions one-sided and limited.

CONCLUSION

U100 laser lithotripsy combined with PTCSL is more effective in the treatment of intra-and extrahepatic bile duct stones as compared to pneumatic ballistic combined with PTCSL. It is associated with lower postoperative pain, reduced incidence of biliary bleeding and stone residue, and significantly lesser negative impact on liver function.

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Authors' Contributions:

ZY: Conceived and designed the study.
ZY & BS: Collected the data and performed the analysis.
ZY: Was involved in the writing of the manuscript and is responsible for the integrity of the study.
All authors have read and approved the final manuscript.

U100 激光与气压弹道联合经皮肝穿刺胆道镜取石术治疗肝内外胆管结石的效果比较研究及其对肝功能的影响

Zhongliang Yin[1], Bin Shen[2]

摘要

目的：比较 U100 激光与气压弹道联合经皮经肝胆道镜碎石术（PTCSL）治疗肝内外胆管结石的疗效及对肝功能的影响。
方法：选取 2020 年 5 月至 2021 年 5 月我院收治的 97 例肝内外胆管结石患者病历进行回顾性分析。其中 43 例采用气压弹道碎石联合 PTCSL 治疗（I 组），54 例采用 U100 激光碎石联合 PTCSL 治疗（II 组）。比较分析两组治疗效果及对肝功能的影响。
结果：两组手术时间及术中出血量无显著差异（P>0.05）。II 组患者术后疼痛时限和住院时间均短于 I 组（P<0.05）。II 组胆道出血率（3.70%）低于 I 组（16.27%，P<0.05），结石残留率（1.85%）亦低于 I 组（11.63%，P<0.05）。II 组患者总胆红素（TBIL）、丙氨酸氨基转移酶（ALT）和白蛋白（ALB）水平均优于 I 组（P<0.05）。
结论：与气压弹道相比，U100 激光碎石联合 PTCSL 治疗肝内外胆管结石具有术后疼痛轻、住院时间短、胆道出血及结石残留少、对肝功能损伤更小的优势。

关键词：U100 激光碎石术；经皮经肝胆道镜碎石术；肝内外胆管结石；手术；肝功能。

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引言

肝内外胆管结石的高残余结石率、高复发率及高再次手术率仍是胆道外科面临的棘手难题。肝内胆管走行迂曲、管径狭窄且结构复杂，多数肝内外胆管结石呈簇状散在分布，可引发肝胆管狭窄。这些结石还会阻塞胆管，极易导致复发性胆管炎，进而引发发热、腹痛等症状。

此外，若胆道梗阻未及时解除，可能导致大量细菌在胆道内积聚，造成胆道压力持续升高，从而促使感染性物质在胆道内扩散。细菌及毒素可侵入肝窦和动脉，引发全身性感染及更严重的并发症，例如可能危及患者生命的梗阻性化脓性胆管炎和肝脓肿。

对于肝内外胆管结石的传统保守治疗，通常采用抗炎药物和保肝疗法。然而这些方法疗效有限，往往最终仍需通过手术治疗肝内外胆管结石。经皮经肝胆道镜碎石术（PTCSL）作为常见外科手术，能有效清除结石、解除梗阻并促进引流通畅。

目前治疗肝内外胆管结石有多种碎石方法。气压弹道碎石术最为常见，能有效粉碎结石，但存在结石残留问题，且在肉芽组织情况下效率较低。U100 激光碎石技术将激光能量转化为冲击波，可从结石中心实现"崩解"，产生的推进力较小，从而减少对胆管和肝组织的损伤。近年来，我院采用 U100 激光碎石联合经皮肝穿刺胆道镜取石术治疗肝内外胆管结石患者。本研究主要目的是比较 U100 激光与气压弹道联合经皮肝穿刺胆道镜碎石术治疗肝内外胆管结石的疗效及其对肝功能的影响。

方法

本研究回顾性分析了 2020 年 5 月至 2021 年 5 月期间我院收治的 97 例（男性 51 例，女性 46 例）肝内外胆管结石患者的临床资料。其中 43 例采用气压弹道碎石联合经皮经肝胆道镜取石术（PTCSL）治疗的患者归为第一组，54 例采用 U100 激光碎石联合 PTCSL 治疗的患者归为第 II 组。

纳入标准：符合基于超声、CT 等影像学检查结果的肝内外胆管结石诊断标准；肝内胆管扩张>4mm；无既往腹壁切开减张术或胆道手术史；知晓研究并签署知情同意书配合治疗。

排除标准：严重基础疾病、器官功能障碍及恶性肿瘤；经皮经肝胆道镜取石术禁忌症；病历资料不完整。本研究经我院医学伦理协会批准（批准号：JXFY-L20210313，日期：2021 年 3 月 10 日）。

麻醉后，根据术前检查确定经皮经肝穿刺路径。穿刺点位于剑突下右缘腹壁或右第 8~10 肋间。在超声实时监测下完成经皮经肝穿刺。穿刺针进入靶区胆管后，拔出内芯并抽取胆汁。确认穿刺成功后，将导丝注入穿刺针管，并沿导丝方向用 8F 筋膜扩张器扩张瘘管。

在确认无出血后，将匹配的鞘管套件套入 16F 或 18F 扩张器，输送至靶区肝内胆管。撤出扩张器并留置鞘管，使鞘管一端位于肝内胆管，另一端留置体外，从而在肝内胆管与体表之间建立瘘管通道。通过该通道将胆道镜置入靶区胆管，用生理盐水冲洗使细小结石随液体流出体外，或用取石蓝网进行清除。

采用瑞士 EMS SA CH21260 NYON 公司生产的气压弹道碎石机进行气压弹道碎石术。气压设定为 2×100kPa，通过连续脉冲击碎结石后，用生理盐水冲洗使碎石排出体外。

采用德国 U100Plus 激光碎石机实施 U100 激光碎石术。激光光纤经胆道镜插入胆管，激光能量设定为 160 毫焦，对准结石中心进行碎石。结石粉碎后，采用生理盐水冲洗清除细小碎石，或用蓝色取石网篮取出。结石清除后，于瘘管内留置引流管并对穿刺点进行处理。

肝内外胆管结石的治疗

表 1. 两组患者特征比较[n\%), X±S]。

Table1: Comparison of patient characteristics between the two groups [n (%), $\bar{X}\pm S$]

Group	n	Gender (male/female)	Age (year)	Stone location(n)					
				Left intrahepatic bile duct	Right intrahepatic bile duct	Common bile duct	Left hepatolithiasis with common bile duct	Right hepatolithiasis with common bile duct	Intrahepatic bile duct
Group-I	43	22/21	59.33±7.21	10	13	5	6	4	5
Group-II	54	29/25	58.67±6.89	15	14	6	7	7	5
χ^2/t	-	0.062	0.535				1.329		
P	-	>0.05	0.736				0.857		

手术指标：记录手术时间、术中出血量、术后疼痛持续时间和住院时间。两组患者的胆道出血和残余结石情况均被记录。判断胆道出血的标准为胆道镜检发现血性液体，以及引流管中有血性液体流出。残余结石的判定标准为术后 7 天进行超声和/或 CT 检查。为评估肝功能，术前及术后 7 天从 41 例患者空腹静脉采血，记录患者基本信息。采用酶联免疫吸附法检测总胆红素（TBIL）、丙氨酸氨基转移酶（ALT）和白蛋白（ALB）水平。

统计分析：采用 SPSS 22.0 软件进行数据处理，计数资料以[n（%）]表示并采用 X^2 检验；计量资料以（X±S）表示并采用 t 检验；P<0.05 视为差异具有统计学意义。

结果

本研究共纳入 97 例符合回顾性研究标准的患者，其中男性 51 例，女性 46 例。患者年龄范围为 46 至 71 岁，平均年龄 59.08±6.89 岁。采用气压弹道碎石术联合经皮肾镜取石术（PTCSL）治疗的患者归为 I 组（54 例），采用 U100 激光碎石术联合 PTCSL 治疗的患者归为 II 组。

两组患者在基础临床资料、手术时间及术中出血量方面均无显著差异（表-I，P>0.05）。II 组患者的术后疼痛时限和住院时间均短于 I 组（表-II，P<0.05）。与 I 组患者相比，II 组患者具有更低的胆道出血率（3.70% vs. 16.27%，P<0.05）和结石残留率（1.85% vs. 11.63%，P<0.05）（表-III）。术前两组患者的总胆红素（TBIL）、谷丙转氨酶（ALT）和白蛋白（ALB）浓度均无显著差异（P>0.05）。术后 7 天时，两组患者的 TBIL、ALT 和 ALB 浓度均较术前降低，但 II 组患者的 TBIL、ALT 和 ALB 水平显著高于 I 组患者（表-IV，P<0.05）。

表 II：两组手术指标对比（X±S）。

Table-II: Comparison of surgical indicators between the two groups ($\bar{X}\pm S$)

Group(n)	Operation time (min)	Intraoperative blood loss(ml)	Duration of postoperative pain(d)	Hospital stay(d)
Group-I (n=43)	160.09±25.04	179.95±18.35	4.28±1.12	10.74±2.05
Group-II (n=54)	162.46±21.40	182.42±16.50	2.50±0.72	7.17±1.79
t	0.938	0.562	10.082	9.176
P	0.746	0.576	<0.001	<0.001

表-III：两组胆道出血与残余结石情况对比[n(%)]。

Table-III: Comparisons of biliary bleeding and residual stones in the two groups [n (%)]

Group	n	Biliary bleeding	Stone residue
Group-I	43	7(16.27)	5(11.63)
Group-II	54	2(3.70)	1(1.85)
χ^2	-	4.497	3.943
P		0.034	0.047

讨论

我们的研究表明，U100 激光和气压弹道联合经皮经肝胆道取石术，可缩短肝内外胆管结石患者的疼痛持续时间和住院时间。该组患者的胆道出血率和结石残留率较低，这与 Lamanna A 等人 11 的研究结果相似。Chunlin Y 等人探讨了输尿管镜钬激光碎石术（UHLL）与输尿管镜气压弹道碎石术（UPL）治疗嵌顿性输尿管结石（IUC）的安全性和有效性。研究表明两种术式均安全有效，但 UHLL 具有手术时间短、结石清除率高的优势。U100 激光碎石联合经皮经肝胆道镜取石术（PTCSL）采用双频双脉冲掺钕钇铝石榴石激光。可发射红外光（波长 1064nm）与绿光（波长 532nm）。碎石过程中，结石吸收 20%绿光形成均匀等离子体，该等离子体具有吸收 80%红外光的特性，促使激光能量转化为机械冲洗波并从结石中心实现碎石。例如 Garg S 等人比较了激光（Ho:YAG）与气压弹道腔内碎石术治疗输尿管结石的疗效、安全性及并发症，结果显示激光碎石术的结石清除率更高，安全性良好且未增加并发症风险。该机械冲击波对结石的作用力低于气压弹道碎石术，可减轻胆道损伤、降低术后疼痛及胆道出血率。

在碎石过程中，结石可能被推动，这会损伤胆管壁，可能导致严重的术后疼痛并增加胆道出血的风险。在取石方面，U100 激光碎石机的 ui000 光线可任意弯曲进入胆管，能击碎并取出较难处理的结石，降低残石发生率。相比之下，气压弹道碎石杆无法弯曲，可能导致结石游走性回漂，使隐藏的小结石难以取出，从而增加结石残留的可能性。

当采用手术治疗肝内外胆管结石患者时，手术创伤可能导致患者肝脏损伤并降低肝功能。因此近年来，在设计和选择用于清除肝内外胆管结石的手术方案时，会考虑对肝功能的保护作用。本研究中，两组患者术后 TBIL（总胆红素）、ALT（谷丙转氨酶）和 ALB（白蛋白）浓度均显著降低。但 II 组患者术后 TBIL、ALT 和 ALB 水平高于 I 组。Muglia 等学者对比分析了气动弹道碎石术与 U100 激光碎石术在经皮经肝胆道镜取石术(PTCSL)中对患者肝功能的影响。他们发现接受 U100 激光碎石术治疗的患者术后肝功能损伤更小，这与本研究结果一致。这表明 U100 激光碎石术联合 PTCSL 治疗肝内外胆管结石时，能减轻对肝功能的负面影响。U100 激光碎石机发出的红外光和绿色激光的吸收系数在碎石过程中不会产生热效应，人体组织无法吸收这两种激光，从而消除了机械冲击波对胆管和肝脏造成的损伤，有效减少了肝功能受到的不良影响。另一方面，气动弹道碎石术的过程通过碎石探杆利用压缩气体有效推动弹丸，这可能对胆道和肝脏功能造成显著的机械损伤。

表 IV：两组患者术前与术后 7 天肝功能指标比较（X±S）。

Table-IV: Comparison of liver function indexes between the two groups before operation and seven days after operation ($\overline{X}\pm S$).

	TBil(μmol/L)		t	P	ALT(U/L)		t	P	ALB(g/L)		t	P
Group (n)	Preop-erative	7d after opera-tion			Preop-erative	7d after opera-tion			Preop-erative	7d after opera-tion		
Group-I (n=43)	28.05± 3.48	15.28± 2.76	72.717	< 0.001	71.14± 4.49	42.30± 4.07	262.109	< 0.001	36.30± 3.66	28.30± 3.36	80.133	< 0.001
Group-II (n=54)	28.54± 3.61	19.33± 2.84	58.534	< 0.001	72.50± 5.39	53.48± 4.84	142.497	< 0.001	36.57± 4.22	32.68± 3.85	24.986	< 0.001
t	0.676	7.066	-	-	1.354	12.342	-	-	0.339	5.882	-	-

局限性：样本量相对较小，本院仅有 97 名患者符合本研究条件。此外，患者术后仅接受为期七天的监测，这可能使得研究结论存在片面性和局限性。

结论

U100 激光碎石术联合经皮经肝胆道镜取石术(PTCSL)治疗肝内外胆管结石的疗效优于气压弹道碎石联合 PTCSL。该治疗方案具有术后疼痛轻、胆道出血及结石残留发生率低、对肝功能负面影响显著较小等优势。

两种不同碎石方法在经皮经肝胆管穿刺碎石取石术的效果比较

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【摘要】　目的　研究 U100 激光碎石与气压弹道碎石在经皮经肝胆管穿刺碎石取石术中的效果。**方法**　随机选取 2017 年 4 月至 2019 年 3 月本院普外二科收治的 121 例肝内外胆管结石的患者，分成两组：试验组，75 例，采用超声引导下经皮经肝胆管穿刺硬质胆道镜取石 +U100 激光碎石术；对照组，46 例，采用超声引导下经皮经肝胆管穿刺硬质胆道镜取石 + 气压弹道碎石术。比较两组手术时间、术中出血、残石率、术后疼痛、术后第 1 天肝功能。**结果**　试验组平均手术时间明显短于对照组，差异有统计学意义（$P < 0.05$）；试验组术中胆道出血情况少于对照组，差异有统计学意义（$P < 0.05$）；试验组术后残石率少于对照组，差异有统计学意义（$P < 0.05$）；试验组术后疼痛程度较对照组为轻，差异有统计学意义（$P < 0.05$）；两组术后第 1 天 ALP、GGT、ALT 和 AST 差异有统计学意义（均 $P > 0.05$）。结论　U100 激光碎石在经皮经肝胆管穿刺硬质胆道镜碎石取石术中具有取石效率更好、术后残石率发生更小、术后疼痛更小等优点，对肝脏损伤可能更小，值得临床推广应用。

【关键词】　U100；气压弹道；肝胆管结石；胆道镜
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Comparison on effects of two different methods of percutaneous transhepatic bile duct puncture lithotomy

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【Abstract】　Objective　To compare the effects of U100 laser lithotripsy and pneumatic ballistic lithotripsy in percutaneous transhepatic bile duct exploration. **Methods**　A total of 121 patients with intra- and extra-hepatic bile duct stones admitted to the Second Department of General Surgery of our hospital from April, 2017 to March, 2019 were selected and divided into two groups: an experimental group (n=75), treated by ultrasound-guided percutaneous transhepatic bile duct puncture and rigid choledochoscopy for stone removal and by U100 laser lithotripsy; and a control group (n=46), treated by ultrasound-guided percutaneous transhepatic bile duct puncture and rigid choledochoscopy for stone removal and by pneumatic ballistic lithotripsy. The operation time, intraoperative bleeding, residual stone rate, postoperative pain, and liver function on day 1 after the operation were compared between the two groups. **Results**　The average operation time, intraoperative hemobilia, postoperative residual stone rate, and postoperative pain degree were better in the experimental group than in the control group,

with statistical differences (all $P < 0.05$). There were no statistical differences in the levels of ALP, GGT, ALT, and AST the first day after the operation between these two groups (all $P > 0.05$). **Conclusion** U100 laser lithotripsy has better stone removal efficiency, lower postoperative residual stone rate, and less postoperative pain and liver damage in percutaneous transhepatic bile duct puncture and rigid choledochoscopy, so it is worthy of clinical application.

【Key words】 U100; Pneumatic ballistic lithotripsy; Bile duct stones; Rigid choledochoscopy

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肝内外胆管结石的手术方式多种多样，而在超声引导下的经皮经肝胆管镜取石术（percutaneous transhepatic cholangioscopic lithotripsy，PTCSL）已被国内外肝胆外科医生认为创伤最小、取石效率较高的手术方式[1-2]。目前，国内肝内外胆管结石手术碎石方法主要有用 U100 激光碎石、气压弹道碎石、液电碎石、钬激光等[3-6]。我科自 2017 年开展超声引导下经皮经肝胆管穿刺一期硬质胆道镜取石 +U100 激光碎石或弹道碎石术以来，取得不错效果。现比较 U100 激光碎石与气压胆道碎石在经皮肝胆管穿刺碎石取石术中的效果。

1　资料与方法

1.1　病例资料　随机选取 2017 年 4 月至 2019 年 3 月本院普外二科收治的 121 例肝内外胆管结石患者，男 54 例，女 67 例，年龄（54.31 ± 12.56）岁。术前采用 256 排螺旋 CT 检查诊断：肝内外胆管结石。所有操作均为同一组人员。将所有 121 例患者分成两组；试验组：采用术中超声引导下经皮肝胆管穿刺硬质胆道镜取石 +U100 激光碎石术，75 例，男 34 例，女 41 例，年龄（53.51 ± 13.22）岁，左肝内胆管结石 11 例，右肝内胆管结石 13 例，胆总管结石 4 例，左肝胆管结石合并胆总管结石 19 例，右肝胆管结石合并胆总管结石 17 例，肝内胆管结石 8 例，肝内外胆管结石 3 例；对照组：采用术中超声引导下经皮肝胆管穿刺硬质胆道镜取石 + 弹道碎石术，46 例，男 20 例，女 26 例，年龄（54.63 ± 11.98）岁，左肝内胆管结石 9 例，右肝内胆管结石 7 例，胆总管结石 2 例，左肝胆管结石合并胆总管结石 13 例，右肝胆管结石合并胆总管结石 10 例，肝内胆管结石例 4，肝内外胆管结石例 1 例。两组年龄、性别、结石位置、术前肝功能差异无统计学意义（均 $P > 0.05$），具有可比性。

1.2　病例纳入标准　⑴无肝胆管手术史的患者；⑵结石胆管相应肝段叶不萎缩；⑶肝内胆管扩张 > 4 mm；⑷门脉高压表现，Child A、B 级；⑸凝血功能正常，无腹水。

1.3　主要设备及参数

1.3.1　Qiaotech 硬质胆道镜　硬质镜管，内窥镜镜管外径（mm）≤ Φ4.65 mm；内窥镜工作长度（mm）≤ 260 mm；器械通道直径（mm）≥ Φ2 mm；视向角：10°，视场角：60°。

1.3.2　德国奥林巴斯纤维胆道镜　视野角≥ 125°（在空气中），≥ 83°（在水中），镜深 3 ~ 50 mm，弯曲角度：上≥ 180°，下≥ 130°，先端硬性部径≤ 4.8 mm，软性插入管部径≤ 4.9 mm，钳道内径≥ 2.2 mm，有效长度≥ 350 mm，全长≥ 650 mm。

1.3.3　U100 激光碎石　双波长，532 nm 和 1 064 nm；脉冲能量 120 mJ 和 160 mJ；频率：1、3、5、10、15、20 Hz；脉冲宽度：1.18 ~ 1.20 μs；脉冲峰值功率：≥ 133 kW；光纤尺寸：560 μm（外径）× 3.5 m（长）；光纤弯曲半径：最小弯曲半径小于 0.5 cm。

1.3.4　HAWK 气压弹道碎石　电压和频率：220 V，50 Hz；控制器工作压力：0.15 ~ 0.40 MPa；工作频率：单次，1 Hz、5 Hz、12 Hz；探针规格：Φ2.0 × 400.0、Φ0.8 × 600.0、Φ1.0 × 600.0、Φ1.6 × 600.0。

1.4　手术过程　⑴术前 CT 明确诊断后，术前超声定位结石和穿刺路径，明确手术方案；⑵术中超声定位按术前设计路径穿刺目标胆管；⑶微创扩管套件将穿刺瘘道扩管至 14 ~ 16F，置入相同型号保护鞘管；⑷硬质胆道镜顺保护鞘管进入胆道，较小结石采用冲水吸出、取石网篮、取石钳取出；⑸较大结石，试验组采用 U100 激光碎石成较小结石后采用第 4 步，对照组采用气压弹道碎石较小结石后采用第 4 步；⑹术中超声示 3 ~ 4 级胆管内的结石，改用纤维胆道镜，部分难以取出，试验组则可用 U100 进入纤维胆道镜进一步碎石，对照组气压弹道碎石杆为不可弯曲材料，则只能用网篮掏出；⑺术毕，瘘道置入相同型号引流管引流；⑻术后 1 周复查 CT 有无残石。

1.5　观察指标说明　⑴手术时间：自超声定位开始至置管引流结束。取石结束标准：胆道镜下探查 + 术中超声未见结石；⑵胆道出血：以术中胆道镜下可见血性液体及置管引流出血性液体为标准；⑶残石率：术后 1 周复查 CT 有无残石；⑷疼痛评分：采用视觉模拟评分法（Visual Analogue Scale/Score，VAS）。患者床头设有评分标尺，根据疼痛程度评分。

1.6　统计学方法　采用 SPSS 21.0 进行统计学分析，计量资料行 t 检验，计数资料行 χ^2 检验，$P < 0.05$ 差异有统计学意义。

2　结果

试验组手术时间（147.58 ± 76.27）min，对照组（189.63 ± 95.62）min，差异有统计学意义（t=2.669，P=0.008 7）；情况，试验组术中出血 6 例，无出血 69 例，对照组术中出血 13 例，无出血 33 例，试验组术中胆道出血情况少于对照组，差异有统计学意义（χ^2=8.842，P=0.002 9）；试验组残石 8 例，取净 67 例，对照组残石 25 例，取净 21 例，试验组术后残石率少于对照组，差异有统计学意义（χ^2=19.15，$P < 0.0001$）；试验组术后疼痛程度较对照组轻，差异有统计学意义（$P < 0.05$），见表 1；两组术后第 1

表 2　两组患者术后第 1 天生化指标比较（$\bar{x} \pm s$，U/L）

组别	n	ALP	GGT	ALT	AST
试验组	75	156.90 ± 101.45	95.28 ± 67.63	97.68 ± 49.20	102.36 ± 58.38
对照组	46	187.88 ± 143.15	121.54 ± 98.02	89.45 ± 37.62	98.74 ± 47.81
t 值		1.391 0	1.742 0	0.972 9	0.353 9
P 值		0.166 9	0.084 0	0.332 6	0.724 1

天 ALP、GGT、ALT 和 AST 差异无统计学意义（均 $P > 0.05$），见表 2。

表 1　两组患者术后疼痛程度比较

组别	n	1 ~ 3 分	4 ~ 6 分	7 ~ 10 分
试验组	75	56	17	2
对照组	46	22	16	8

注：χ^2=12.2，P=0.002 2

3　讨论

PTCSL 已被认为治疗肝内外胆管结石最佳的手术方式之一。尽管如此，提高手术效率、减少术后残石率、减少术中术后并发症等仍是此类疾病治疗值得关注的焦点。而 U100 激光碎石和气压弹道碎石为目前国内外常用的肝内外胆管结石的碎石手段。

U100 激光碎石是双频双脉冲掺钕钇铝石榴石激光器，能发出波长为 1 064 nm 的红外光和 532 nm 的绿光。在碎石过程中，占激光总能量的 20% 绿光被结石吸收，并在结石表面形成均匀的等离子体，等离子体充分吸收约占激光总能量的 80% 红外光的能量，使激光能量瞬间转化为机械冲击波，能准确高效地从结石中央“崩解”结石，对结石产生的推动力极小。由于人体组织不吸收绿光，不产生等离子体，红光对人体组织无效，不会造成正常人体组织的损伤[7-8]。而气压弹道碎石作用为机械性[4]，不可避免地造成胆道管壁不同程度损伤，是导致胆道出血发生率较高的主要原因。如果操作不慎，甚至可能胆道穿孔。本组研究显示，虽两组均未出现胆道穿孔，但气压弹道碎石组发生胆道出血的发生率较多，而术后复查肝功能气压弹道碎石组肝功能升高较多可能也与术中胆道损伤有一定关系。本组研究患者术后疼痛气压弹道组较 U100 激光碎石组高，可能与气压弹道碎石的机械性损伤有一定关系。

本研究显示，由于胆管内充满胆汁，胆道镜进入需要冲水才能看清胆管内结石，而这样造成结石容易漂移，U100 激光碎石能在较短的时间内将结石高效粉碎，对结石的推动力较小，而且碎石后的结石颗粒较细，相应地结石回漂率发生低，细的结石容易排出，取石效率较高，残石率发生率低，同时由于 U100 光线为可任意弯曲材料，可用于纤维胆道镜进入 3 ~ 4 级胆管碎石，可将结石取净。而气压弹道碎石应用压缩气体推动子弹体撞击碎石探杆而产生碎石效应，对结石的推动力较大，容易造成结石移位，结石回漂率发生较高；由于碎石后结石颗粒仍较粗，取出仍存在一定困难，取石效率较低且气压弹道碎石杆为不可弯曲材料，只能用于硬质胆道镜，无法用于纤维胆道镜取出 3 ~ 4 级胆管内的结石碎石，残石率也较高。本研究中，U100 激光碎石组取石效率明显高于气压弹道组，同时术后 1 周复查 CT 显示，前者的残石率较后者的发生率更低。

综上所述，U100 激光碎石设备在 PTCSL 手术中具有碎石效率较高、碎石更安全、残石率更少、肝脏损伤更少、术后疼痛更少、应用更为广泛等优点，推荐用于 PTCSL 及肝内外胆管结石手术中。

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When cholecystostomy tube and transpapillary stents for recurrent cholecystitis fail due to large gallstones: rescue with laser lithotripsy via cholecystoduodenal fistula

Jennifer T. Higa, MD,[1] Shayan S. Irani, MD[2]

Surgical candidates with acute cholecystitis and symptomatic cholelithiasis have conventionally been managed with cholecystectomy. Alternative interventions for nonoperative candidates include percutaneous gallbladder drainage or endoscopic decompression through ERCP and cystic duct stents.[1,2] Percutaneous drains have inherent limitations and drain-related issues: pain, bleeding, obstruction, leaking, and dislodgement. Furthermore, they may fail to achieve definitive decompression, especially in cases of large-volume cholelithiasis. ERCP with cystic duct stent placement can provide effective gallbladder decompression as well; however, neither modality addresses the burden of stone disease. An evolving role exists for EUS-guided gallbladder drainage (EUS-GBD) using lumen-apposing metal stents (LAMSs) for definitive treatment of cholecystitis and to facilitate endotherapy of the stone burden.[3-5]

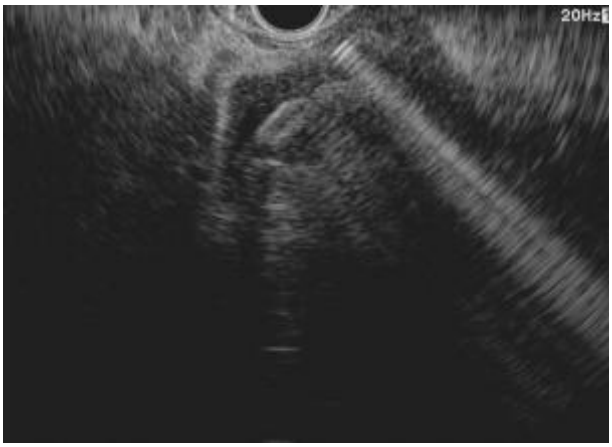


Figure 1. EUS image of a large volume of cholelithiasis occluding the gallbladder lumen.

CASE PRESENTATION AND ENDOSCOPIC METHODS

A 74-year-old woman with cholelithiasis causing recurrent cholecystitis and hepatic abscesses refractory to cystic duct stent placement and percutaneous gallbladder drainage presented for consideration of EUS-GBD. She had significant medical comorbidities that precluded surgical candidacy for elective cholecystectomy. After percutaneous drain placement by interventional radiology, she had unremitting drain-related pain and multiple bouts of drain dislodgement. She subsequently underwent ERCP for endoscopic transpapillary gallbladder drainage, including biliary sphincterotomy and placement of a 7F $\times$ 15-cm plastic double-pigtail stent. However, despite indwelling percutaneous and transcystic duct stent placement, she experienced recurrent bouts of cholecystitis, which prompted referral for EUS-GBD.

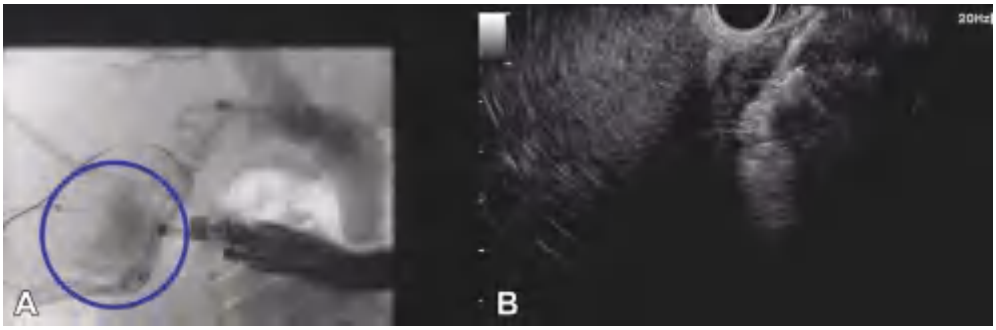


Figure 2. (A) Fluoroscopic (circled) and (B) EUS images of a difficult deployment of lumen-apposing metal stent to create the cholecystoduodenostomy in light of the substantial stone burden that compressed the gallbladder flange.

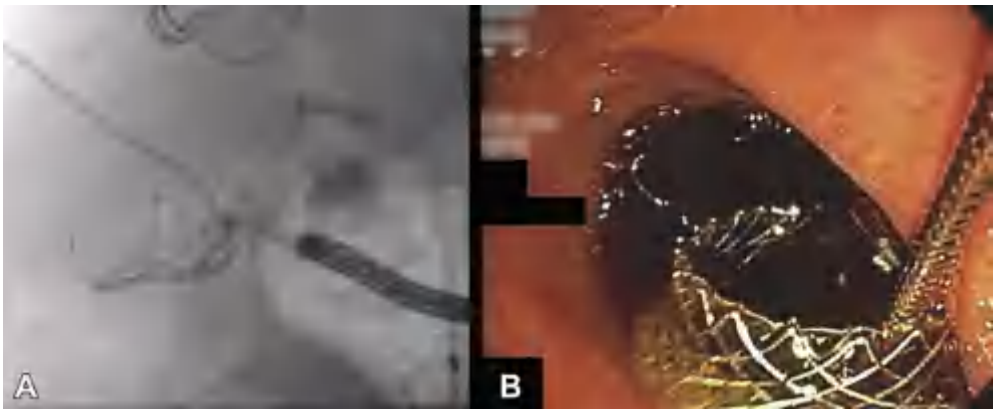


Figure 3. (A) Fluoroscopic and (B) endoscopic images of successful 15-mm × 10-mm cautery-enhanced lumen-apposing metal stent deployment.

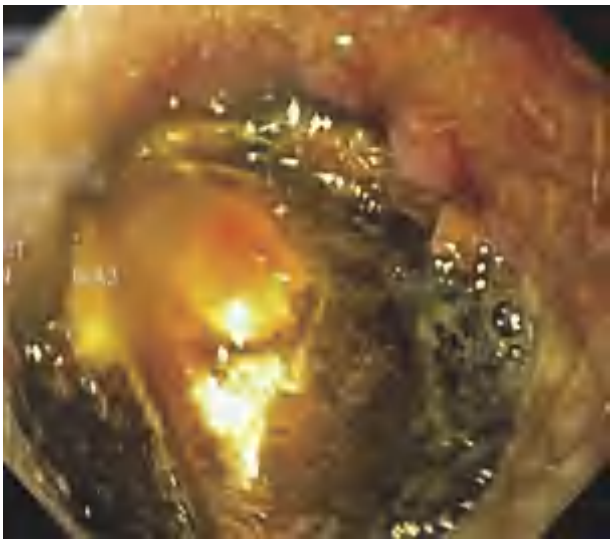


Figure 4. Endoscopic view of the occluding stone within the body of the gallbladder.



Figure 5. Successful fragmentation of the stone by using laser lithotripsy.

Examination with EUS confirmed a large occluding stone within the body of the gallbladder measuring 6 cm in size with a very narrow area of lumen available for stent deployment (Fig. 1; and Video 1, available online at www.VideoGIE.org). An EUS-guided, cholecystoduodenal fistula was created using a 15-mm cautery-enhanced LAMS for gallbladder decompression, which was challenging owing to the entire gallbladder lumen being filled with stones (Fig. 2A and B; Fig. 3A and B). The stone could not be fractured with electrohydraulic lithotripsy owing to its density and size (Fig. 4). The stone was subsequently obliterated over 2 endoscopic treatment sessions by using laser lithotripsy (Figs. 5 and 6). The gallbladder was successfully emptied of all stone debris (Figs. 7 and 8), permitting removal of the percutaneous drain and transpapillary stents. The transmural LAMS was left in place indefinitely. In >2-year follow-up, the patient remained without recurrent cholecystitis.

Despite complete occlusion of the gallbladder lumen by large symptomatic cholelithiasis, a LAMS can be carefully deployed. Cholecystoscopy and gallstone laser lithotripsy are feasible when electrohydraulic lithotripsy fails, and they offer a safe and efficacious treatment option for patients who fail conventional therapy for cholecystitis.

DISCLOSURE

All authors disclosed no financial relationships.

Abbreviations: GBD, gallbladder drainage; LAMS, lumen-apposing metal stent.



Figure 6. After stone fragmentation, the previously placed drains (percutaneous interventional radiology drain and the transpapillary pigtail stent) were visible within the gallbladder lumen.

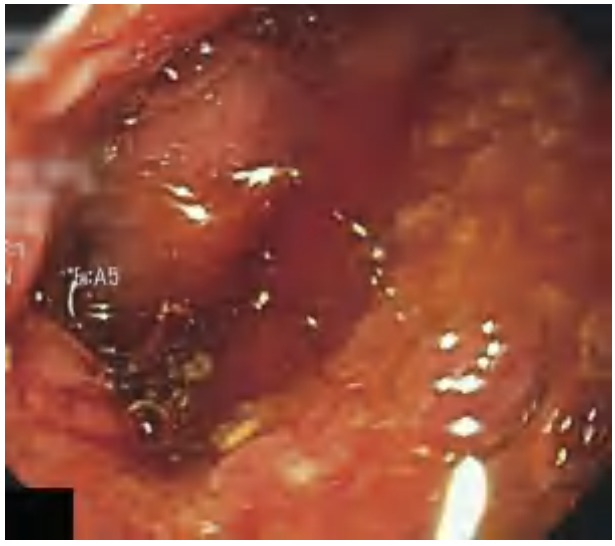


Figure 7. Cholecystoscopy was performed after drain removal to confirm clearance of the gallbladder lumen.

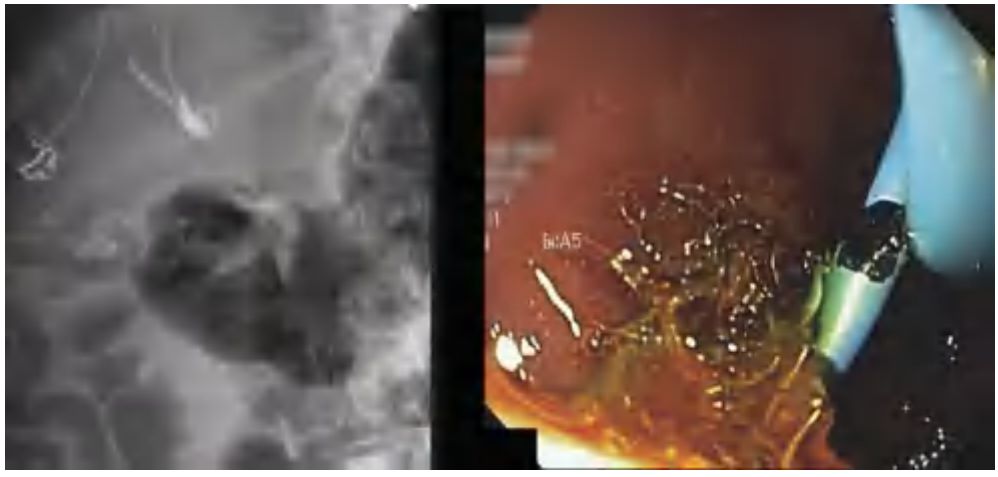


Figure 8. The transduodenal lumen-apposing metal stent plus 7F × 3-cm double-pigtail stents were left indefinitely without any recurrent cholecystitis in >3 years of follow-up.

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当胆囊造瘘管和经乳头支架用于因胆结石过大导致复发性胆囊炎治疗失败：采用经胆囊十二指肠瘘行激光碎石术

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对于患有急性胆囊炎和症状性胆石症的手术患者，传统治疗方案是实施胆囊切除术。对于不适合手术的患者，可选择经皮胆囊引流或通过 ERCP（经皮胆道成形术）和胆囊管支架进行内镜减压等替代疗法。[1,2] 穿刺引流管存在固有局限性，可能引发疼痛、出血、梗阻、漏液及移位等问题。此外，对于胆石体积较大的患者，此类引流管往往难以实现彻底减压。 ERCP

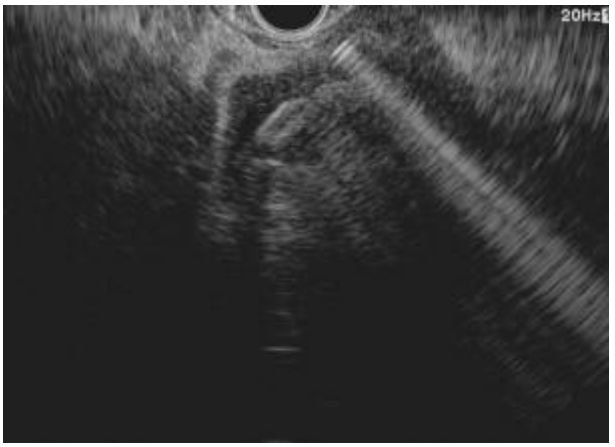


图1. 胆囊结石阻塞胆囊腔的 EUS 影像。

囊性导管支架置入术同样能有效缓解胆囊压力，但两种方法都无法解决结石问题。目前，采用腔内金属支架（LAMSs）的 EUS 引导胆囊引流术（EUS - GBD）正发挥着重要作用，既能作为胆囊炎的根治手段，又能辅助完成结石的内镜治疗。[3-5]

病例介绍及内镜方法

一位74岁女性患者因胆石症引发反复发作的胆囊炎和肝脓肿，对囊状导管支架置入术及经皮胆囊引流治疗无效，遂前来考虑接受 EUS - GBD 手术。患者存在多种严重基础疾病，无法进行择期胆囊切除术。经介入放射学经皮引流术后，患者持续出现引流管相关疼痛，并多次发生引流管移位。随后她接受了内镜经乳头胆囊引流术（ERCP），包括胆总括约肌切开术及置入7F×15厘米塑料双猪尾支架。然而，尽管已置入经皮和经胆囊的留置支架，患者仍反复发作胆囊炎，最终促使医生转诊其接受 EUS - GBD 手术。

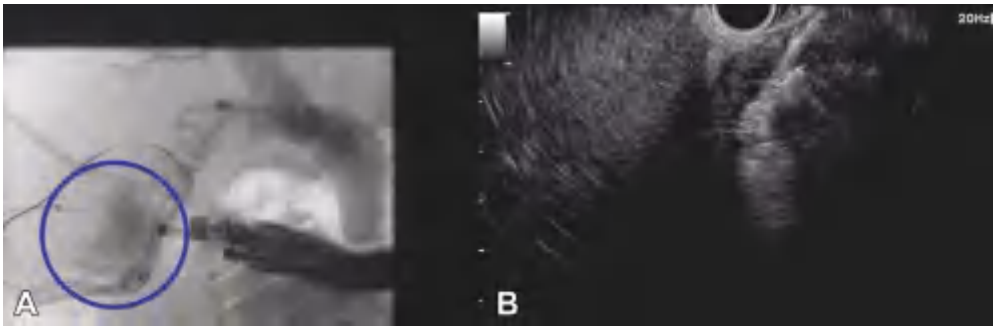


图2. (A) 显示荧光透视（圆圈标记）与(B) EUS 成像，展示了在胆囊瓣受结石压迫的情况下，置入腔内金属支架形成胆囊十二指肠吻合术的困难操作过程。

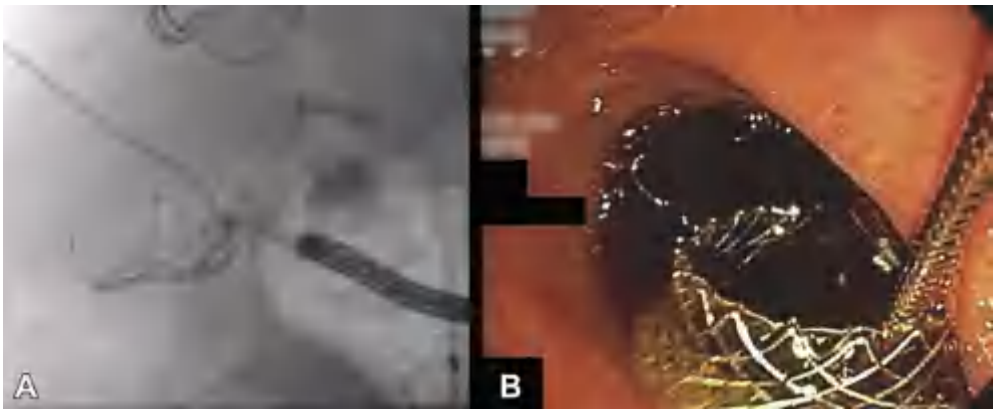


图3. (A) 火花内镜与(B) 内窥镜拍摄的15毫米×10毫米电凝增强型腔内金属支架成功植入术实况。

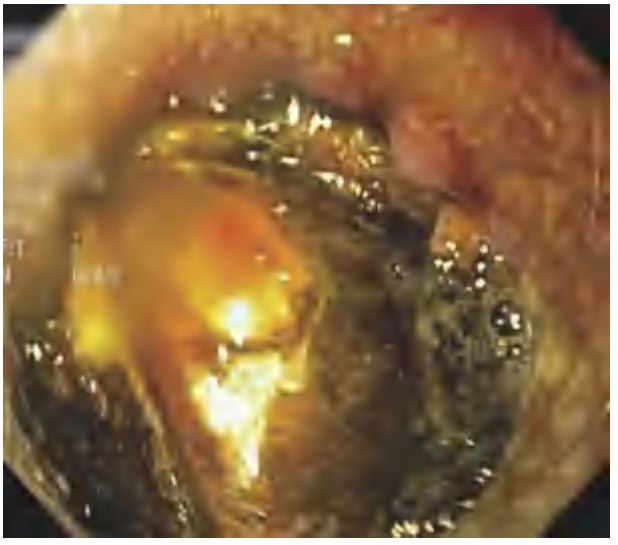


图4. 胆囊体内的闭塞结石内窥镜影像。



图5. 激光碎石术成功碎石的案例。

EUS 检查显示胆囊主体内存在一颗直径6厘米的大型闭塞结石，导致支架置入区域极其狭窄（图1； 视频1，详见 www. VideoGIE.org 在线）。为进行胆囊减压，医生采用15毫米电凝增强型LAMS（腔内取石系统）尝试建立 EUS 引导的胆总管十二指肠瘘，但由于整个胆囊腔内布满结石，操作难度极大（图2 A、B； 图3 A、B）。由于结石体积过大且密度极高，电液碎石术未能成功碎石（图4）。随后通过两次内镜治疗，采用激光碎石术彻底清除结石（图5 和 6）。胆囊内所有碎石残留物被成功排空（图7 和 8），从而移除了经皮引流管和经乳头支架。经壁LAMS留置时间未作限制。

在两年以上的随访中，患者未再出现胆囊炎复发。

即便胆囊腔完全被大块症状性胆石完全阻塞，仍可谨慎实施经内镜逆行胰胆管成形术（LAMS）。当电液碎石术失败时，可采用胆囊镜联合激光碎石术，为传统治疗胆囊炎无效的患者提供安全有效的治疗方案。

披露

所有作者均未披露任何财务关系。

缩略语： GBD，胆囊引流；LAMS，腔内金属支架。



图6. 石块碎裂后，先前置入的引流管（经皮介入放射学引流管和经乳头状尾部支架）在胆囊腔内清晰可见。



图7. 在移除引流管后进行胆囊镜检查，以确认胆囊腔已完全排空。

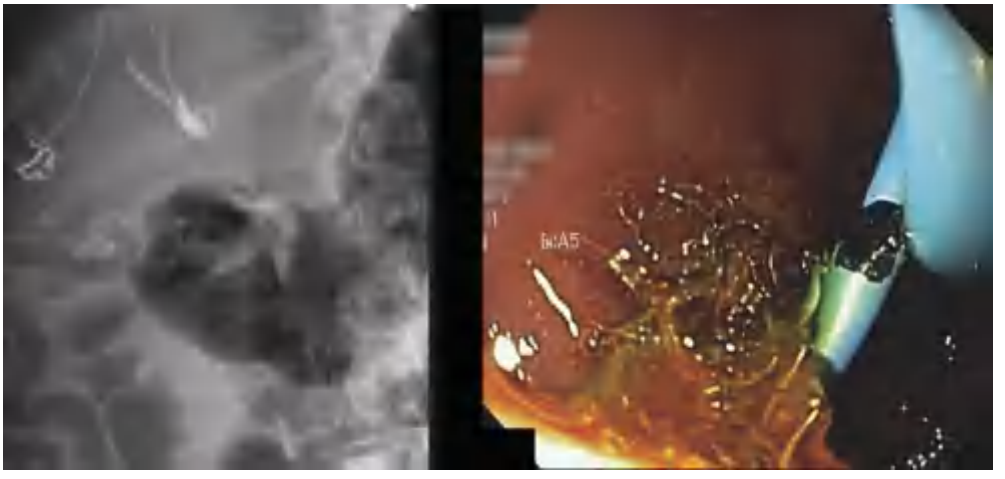


图8. 在超过3年的随访中，经十二指肠腔内置金属支架联合7F×3厘米双猪尾支架的治疗方案，未出现任何复发性胆囊炎。

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Efficacy and safety of endoscopic laser lithotripsy and lithotomy through the lumen-apposing metal stent for giant gallbladder stones

Wei Wang, MD,[1,*] Bowei Liu, MD,[2,*] Ke Qi, MD,[1] Xingang Shi, MD,[1] Zhendong Jin, MD,[1] Zhaoshen Li, MD[1]

Background and Aims: EUS-guided gallbladder drainage has been increasingly applied for acute cholecystitis in high-risk surgical patients. In cases of EUS-guided gallbladder drainage with lumen-apposing metal stents (LAMSs), endoscopic retrieval of gallstones becomes feasible. However, retrieval of giant gallstones is still difficult because of the limited space in the saddle section of the LAMS. In this study, we aimed to evaluate the efficacy and safety of endoscopic laser lithotripsy and lithotomy through LAMSs for the removal of giant gallstones.

Methods: Five consecutive patients with recurrent cholecystitis due to giant gallstones were enrolled. We proceeded with EUS-guided LAMS implantation. Endoscopic laser lithotripsy and lithotomy then was performed through the LAMSs, and the stents were removed after all stones were extracted. The patients were followed up at scheduled times.

Results: EUS-guided LAMS implantation was successfully performed, and target gallstones were completely removed in all 5 patients. There was no severe bleeding, perforation, or stent migration during the operation. No recurrence of gallstones was found at late follow-up.

Conclusions: Endoscopic laser lithotripsy and lithotomy through LAMSs could be a safe and effective approach for removal of giant gallstones. (VideoGIE 2020;5:318-23.)

Cholecystectomy is the main treatment method for gallstones but is not always suitable for all patients. Some serious adverse events and secondary problems after cholecystectomy have attracted increasing concern among both doctors and patients.[1-4] Thus, some new endoscopic gallbladder-sparing surgeries have been tentatively applied in clinical cases.[5,6] Of these natural orifice transluminal endoscopic surgery techniques, EUS-guided gallbladder drainage has been increasingly applied for acute cholecystitis in high-risk surgical patients.[7-9] In case of EUS-guided gallbladder drainage with lumen-apposing metal stents (LAMSs), endoscopic retrieval of gallstones through LAMSs becomes feasible, especially for small stones.[10] The LAMS provides both a passage of drainage and a bridge that allows the endoscope into the gallbladder. However, larger stones cannot be extracted directly because of the limited space in the saddle section of the LAMS. Endoscopic laser lithotripsy and lithotomy (ELLL) may be a good method and has been performed successfully in our practice.[11] In this study, we aimed to evaluate the efficacy and safety of the new approach.

PATIENTS AND METHODS

Patients

Five consecutive patients in Changhai Hospital were enrolled in this study between February 2016 and October 2017. The inclusion criteria were as follows: (1) symptomatic gallstones were diagnosed by ultrasound, CT, or magnetic resonance imaging; (2) the maximum diameter of the gallstone was greater than 1.5 cm; (3) the gallbladder contraction function was fine; and (4) the patients rejected surgery and desired preservation of the gallbladder. The exclusion criteria were (1) atrophy of the gallbladder and/or thickening of the gallbladder wall; (2) coagulopathy; (3) ascites; and (4) poor general condition and intolerance of endoscopic treatment. All patients provided informed consent before the procedure.

EUS-guided LAMS implantation

Patients were placed in a horizontal position while under single-lumen intubated anesthesia. All patients received prophylactic antibiotic treatment before the procedure. EUS-guided interventional procedures were

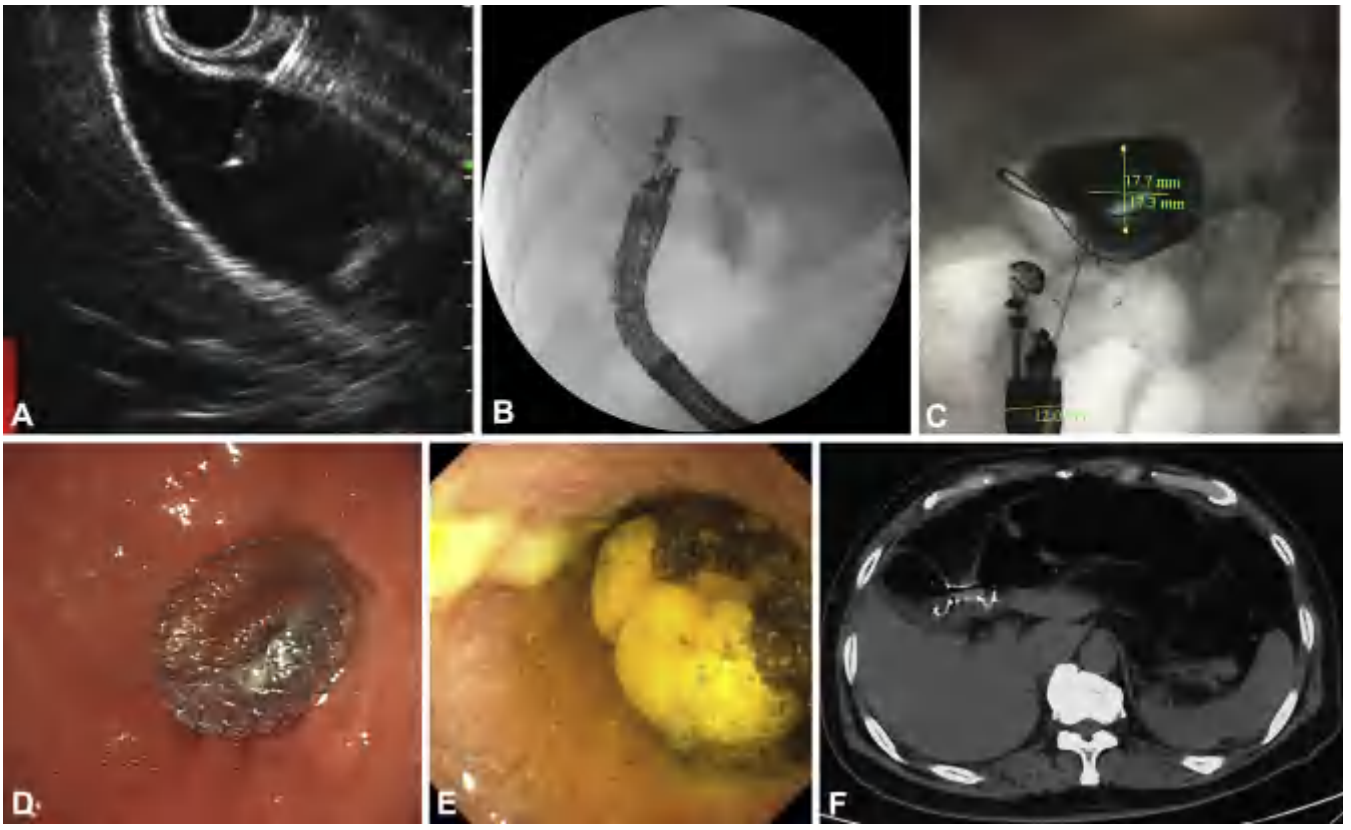


Figure 1. EUS-guided lumen-apposing metal stent implantation. A, EUS-guided puncture and irrigation of the gallbladder. B, A guidewire was advanced into the gallbladder through the needle. C, Imaging showed the gallstone. D, Successful deployment of the stent under EUS and fluoroscopic guidance. E, Gastroscopy showing the gallstone through the stent. F, CT image showing the stent in good position.

performed using a linear-array echoendoscope (GIF-UCT260; Olympus Medical, Tokyo, Japan) under fluoroscopic guidance. The optimum puncture site was chosen as per the distance between the gallbladder and digestive tract and operability of the endoscope d either the antrum of the stomach or the bulb of the duodenum. EUS-guided transmural puncture was performed with a 19-gauge needle (EchoTip Access Needle; Cook Medical, Bloomington, Ind, USA) under color Doppler guidance. After the needle was inserted into the gallbladder, sterile normal saline solution was used for gallbladder aspiration and lavage to avoid bile leakage into the peritoneal cavity if necessary. Next, a 0.035-inch guidewire (Jagwire; Boston Scientific, Natick, Mass, USA) was advanced into the gallbladder through the needle. The guidewire was coiled into 2 to 3 circles in the gallbladder to ensure stability. The needle then was removed, and a cystotome (CST-10; Cook Medical) was applied to establish a passage into the gallbladder. Afterward, the stent delivery system was inserted over the guidewire and advanced into the gallbladder. Deployment of the stent proceeded under EUS and fluoroscopic guidance until the distal and proximal flanges were both expanded and in good position (Fig. 1).

ELLL through the LAMS

U-100 plus frequency-doubled double-pulse laser (FREDDY; World of Medicine, Berlin, Germany) was used to break down large stones. After a gastroscope with a 2.8-mm work channel (GIF-H-260; Olympus Medical) was advanced into the gallbladder, the laser fiber passed through the channel and contacted the stones immersed in water. Laser lithotripsy proceeded in work mode 120 mJ and 5/10 Hz until all stone fragments were smaller than 1 cm. Various devices were selected to remove the fragments according to the stone shape and size. Larger pieces were extracted by basket or trielcon, and smaller pieces were extracted by rat-tooth forceps. Washing and suction was effective for sand grains and stones that had fallen into the cystic duct. All visible pieces were extracted, and no retained stones were found by antegrade cholangiography (Fig. 2). The LAMS then was removed, and gastroscopy and histopathologic examinations for potential mucosal lesions proceeded. Finally, the artificial fistula was handled properly according to actual conditions (Fig. 3).

Main outcome measurements

The main outcome parameters include technique success rate, clinical success rate, and adverse events.



Figure 2. Endoscopic laser lithotripsy and lithotomy through the lumen-apposing metal stents. A-C, The giant gallstones were broken into fragments by laser. D, Minor hemorrhage occurred during laser lithotripsy. E-G, The fragments were extracted by baskets, disposable bags, and rat-tooth forceps, respectively. H, I, Gastroscopy and biopsy were performed for potential mucosal lesions.

Technique success is defined as the implantation of the LAMS. Clinical success is defined as complete removal of gallstones. Adverse events include bleeding, peritonitis, perforation, failed stent deployment, and stent migration. Procedure-related parameters include puncture sites, operation time of stent implantation, interval time between ELLL and stent implantation, operation time of ELLL, and healing time of fistula.

Follow-up

Regular US and CT examination was performed at 3, 6, and 12 months after surgery in the first year and every 6 months in the following years. Gastroscopy and MRCP were performed if necessary.

RESULTS

Five patients (1 male and 4 female) were enrolled in the study. A total of 6 large stones were found. The size of gallstones ranged from 12.5 $\times$ 16.7 mm to 23.8 $\times$ 28.8 mm. EUS-guided LAMS implantation was successfully performed via a transgastric approach (n Z 2) and transduodenal approach (n Z 3). The mean operation time of stent implantation was 33 minutes, ranging from 25 to 42 minutes. One patient had 5 days of postoperative fever and upper abdominal pain because of localized peritonitis. For the 5 patients, the interval between ELLL and stent implantation was 28, 14, 2, 2, and 7 days, respectively. ELLL was successfully performed in all 5 patients through the LAMSs. The



Figure 3. Healing condition of the artificial fistulas after stent removal. A, B, The fistula closed 3 days after stent removal in case 2. C-E, The fistula had not closed spontaneously 3 days after stent removal, and endoclips were used to promote closure in case 3. F, The fistula nearly closed 11 days after stent removal in case 3. G-I, The fistula was closed with endoclips immediately after stent removal and nearly closed 10 days later in case 4.

mean time of ELLL is 2.5 hours, ranging from 0.5 to 5 hours. There was no pneumoperitoneum, subcutaneous emphysema, or stent migration in any of the 5 cases, except a minor hemorrhage that occurred in 1 case during laser lithotripsy. No stone pieces fell into the common bile duct, as confirmed by antegrade cholangiography. ERCP proceeded in 1 case for retrieval of stone fragments retained in the neck of the gallbladder. All LAMSs were removed immediately after complete retrieval of gallstones. The artificial fistula was completely self-closed in the first 2 patients, and endoclips were used to promote the closure of fistulas in the last 3 cases. The mean healing time of the fistula was 6.6 days, ranging from 2 to 11 days. No recurrence of gallstones was found after a mean follow-up of 27.8 months (range 24-36 months) (Table 1).

DISCUSSION

In recent years, endoscopic transgastric and transrectal gallbladder-preserving cholecystolithotomy have been tentatively applied in the clinic.[12] The gallbladder incision should be closed with endoclips after stone removal in this type of surgery. Residual endoclips in the abdominal cavity will influence not only the gallbladder contraction function but also subsequent US and magnetic resonance examinations. Moreover, they may lead to recurrence of gallstones. With the rapid development of endoscopic instruments and techniques, EUS-guided interventional procedures have been applied more extensively.[13] As a typical example of EUS-guided natural orifice transluminal endoscopic surgery, EUS-guided gallbladder drainage with

TABLE 1. Clinical and technical characteristics

	Case 1	Case 2	Case 3	Case 4	Case 5
Sex	Female	Male	Female	Female	Female
Age, y	65	60	49	45	33
Acute cholecystitis	Yes	No	No	No	No
Size of gallbladder, mm	69.2 × 24.5	52.2 × 34.4	39.3 × 23.5	49.4 × 16.3	56.0 × 24.0
Number of gallstones	1	1	1	2	1
Size of gallstones, mm	26.2 × 19.0	23.8 × 28.8	24.5 × 11.4	18.6 × 12.6 23.6 × 18.3	16.7 × 12.5
Puncture sites	Duodenal bulb	Gastric antrum	Gastric antrum	Duodenal bulb	Duodenal bulb
Technique success	Yes	Yes	Yes	Yes	Yes
Time of stents implantation, min	30	42	33	25	35
Peritonitis	No	No	No	No	Yes
Interval time between ELLL and stent implantation, days	28	14	2	2	7
Clinical success	Yes	Yes	Yes	Yes	Yes
Time of ELLL, hours	5	4	1.5	1.5	0.5
Hemorrhage	No	Yes	No	No	No
Subcutaneous emphysema	No	No	No	No	No
Pneumoperitoneum	No	No	No	No	No
Stent immigration	No	No	No	No	No
Combined ERCP	No	No	No	Yes	No
Gastroscopic biopsy in gallbladder	No	Yes	No	No	No
Fistulas handling method	Putting aside	Putting aside	Putting aside + endoclips	Endoclips	Endoclips
Healing time of fistula, days	2	3	11	10	7
Recurrence of gallstones	No	No	No	No	No
Duration of follow-up, months	36	28	27	24	24

ELLL, Endoscopic laser lithotripsy and lithotomy.

LAMSs has showed merit, such as safety, effectivity, and less injury to the gallbladder.[13,14] The LAMS has bilateral anchor flanges and a saddle section and is fully covered. Theoretically, a LAMS allows adhesion between 2 organs via bilateral anchor flanges, as is done with a surgical anastomosis. In addition, the fully covered metal stent could prevent side leakage. All of these advantages make LAMSs an ideal device for endoscopic treatment of gallbladder diseases.

The diameter of the saddle section of LAMSs is approximately 1.5 cm. Stones measuring less than 1 cm can be removed easily through the LAMS, but larger stones should be broken into smaller fragments to facilitate retrieval. ELLL may be an effective method for giant stones, as established in our previous report.[11] To further validate the effectivity and safety, we prospectively treated 5 consecutive patients. Although the sample size is small, the results could provide some good suggestions.

First, the body of the gallbladder may be the optimal puncture site, although the neck of the gallbladder is more advised because it is less mobile as compared with the body of the gallbladder. However, the narrow space will make the deployment of the stent challenging and create difficulties in the treatment of residual stones in the gallbladder neck.[7,15] In the fourth case, the stone fragments retained in the neck of the gallbladder could not be removed because of the blockage caused by the anchor flanges. After repeated failure, the residual stones were removed with the method of endoscopic transpapillary retrograde flush and suction (Video 1, available online at www.VideoGIE.org).

Second, the optimal timing for endoscopic laser lithotripsy and lithotomy should be no less than 2 weeks after LAMS implantation. To ensure safety, the interval between laser lithotripsy and stent implantation in the first case was 4 weeks, which was enough for the fistula tract to mature. All subsequent procedures were safe and successful. The fistula closed completely 2 days after stent removal. On the basis of the first case, the interval was compressed to 2 weeks for the second case, and the fistula closed completely 3 days after stent removal. As a minimally invasive procedure, we expected this method to be an effective

and safe procedure as compared with laparoscopic cholecystectomy and to be successfully completed within 1 week. Thus, we compressed the whole operation time of the last 3 cases. The interval between laser lithotripsy and stent implantation of the last 3 cases was 2, 2, and 7 days, respectively. Although no adverse events occurred during ELLL, the fistulas did not heal quickly after stent removal. Endoclips were used to promote the closure of fistulas in all of the last 3 cases. The healing time of the fistulas was 11, 10, and 7 days. This suggests that the healing time of the defects depends on the maturity of the fistulas, and 2 weeks may be an optimal time.

Third, the stone fragments should be within 1 cm in diameter to allow extraction through the stent. However, pieces should not be too small because this may increase rather than decrease the difficulty of retrieval. Overly small pieces could not be grasped by the baskets or forceps, and retrieval may be more difficult if some fall into the cystic duct or behind the stent. Moreover, some overly small pieces will most likely fall into the common bile duct during the operation, but fortunately this did not happen in any of the 5 cases.

Fourth, what is considered success for this novel approach to the treatment of gallstones? Success will be measured not merely by no evidence of residual stones in the gallbladder and no pieces falling into the cystic duct or common bile duct, but also by no evidence of precancerous or neoplastic lesions found in the gallbladder wall, which is a potential risk for patients. It is essential that gastroscopic and histopathologic examinations proceed after complete removal of stones. If necessary, endoscopic mucosal resection or endoscopic submucosal dissection should be performed d after all, the LAMSs supply the passage and chance for repeat operations.

Fifth, it is crucial to prevent the recurrence of gallstones after the operation. Although the causes are varied, it is confirmed that ursodeoxycholic acid may play a role in preventing the relapse of lithiasis after gallbladder-protecting lithotomy. The patients were all administrated ursodeoxycholic acid except keeping regular meals, especially breakfast. All patients were followed up every 6 months after the operation, and no recurrence occurred.

In conclusion, we show that ELLL is safe and feasible for gallstones through LAMSs, especially for giant gallstones. This could be an effective alternative treatment for patients who are not suitable for open surgery. However, further studies are needed to evaluate the long-term results and effectiveness.

DISCLOSURE

All authors disclosed no financial relationships.

Abbreviations: ELLL, endoscopic laser lithotripsy and lithotomy; LAMSs, lumen-apposing metal stents.

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内窥镜激光碎石术的疗效与安全性
经腔内金属支架碎石术治疗巨型胆囊结石

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背景与目的：在高风险手术患者急性胆囊炎治疗中， EUS 引导胆囊引流术的应用日益广泛。对于采用腔内金属支架（LAMSs）的 EUS 引导胆囊引流术，内镜取石术已成为可行方案。然而，由于LAMSs鞍区空间有限，巨结石的取出仍存在困难。本研究旨在评估通过LAMSs实施内镜激光碎石术及碎石术治疗巨结石的疗效与安全性。

研究方法：本研究纳入5例因巨大胆结石导致复发性胆囊炎的连续患者。采用 EUS 引导下经内镜激光碎石术（LAMS）进行支架植入，随后通过LAMS实施内镜激光碎石术和碎石术，待所有结石清除后取出支架。患者按计划时间接受随访。

结果： EUS 引导下LAMS植入术顺利完成，5例患者均成功清除目标胆结石。术中未发生严重出血、穿孔或支架移位，随访未见结石复发。

结论：经内镜激光碎石术结合LAMSs进行碎石术，是治疗巨型胆结石安全有效的有效方法。（VideoGIE2020：5：318-23.）

胆囊切除术是治疗胆结石的主要方法，但并非所有患者都适合接受该手术。近年来，术后出现的严重并发症和继发性问题引发医生和患者日益关注。[1-4] 此背景下，新型内镜保胆手术技术已开始在临床中试用。[5 6] 在自然腔道内镜手术技术中，经 EUS 引导的胆囊引流术已广泛应用于高风险手术患者的急性胆囊炎治疗。[7-9] 当采用经 EUS 引导的金属腔内支架（LAMS）进行胆囊引流时，通过LAMS内镜取石成为可能，尤其适用于小结石。[4 11] 本研究旨在评价新方法的有效性和安全性。

患者和方法

患者

2016年2月至2017年10月期间，上海长海医院连续收治了五例符合研究条件的患者。入选标准包括：(1)经超声、CT或磁共振成像确诊为症状性胆结石；(2)结石最大直径超过1.5厘米；(3)胆囊收缩功能良好；(4)患者拒绝手术并希望保留胆囊。排除标准为：(1)胆囊萎缩或胆囊壁增厚；(2)凝血功能异常；(3)腹水；(4)患者整体状况较差或无法耐受内镜治疗。所有患者均在术前签署了知情同意书。

EUS 引导LAMS植入术

患者在单腔插管麻醉下保持水平位。所有患者术前均接受预防性抗生素治疗。使用线阵超声内镜进行

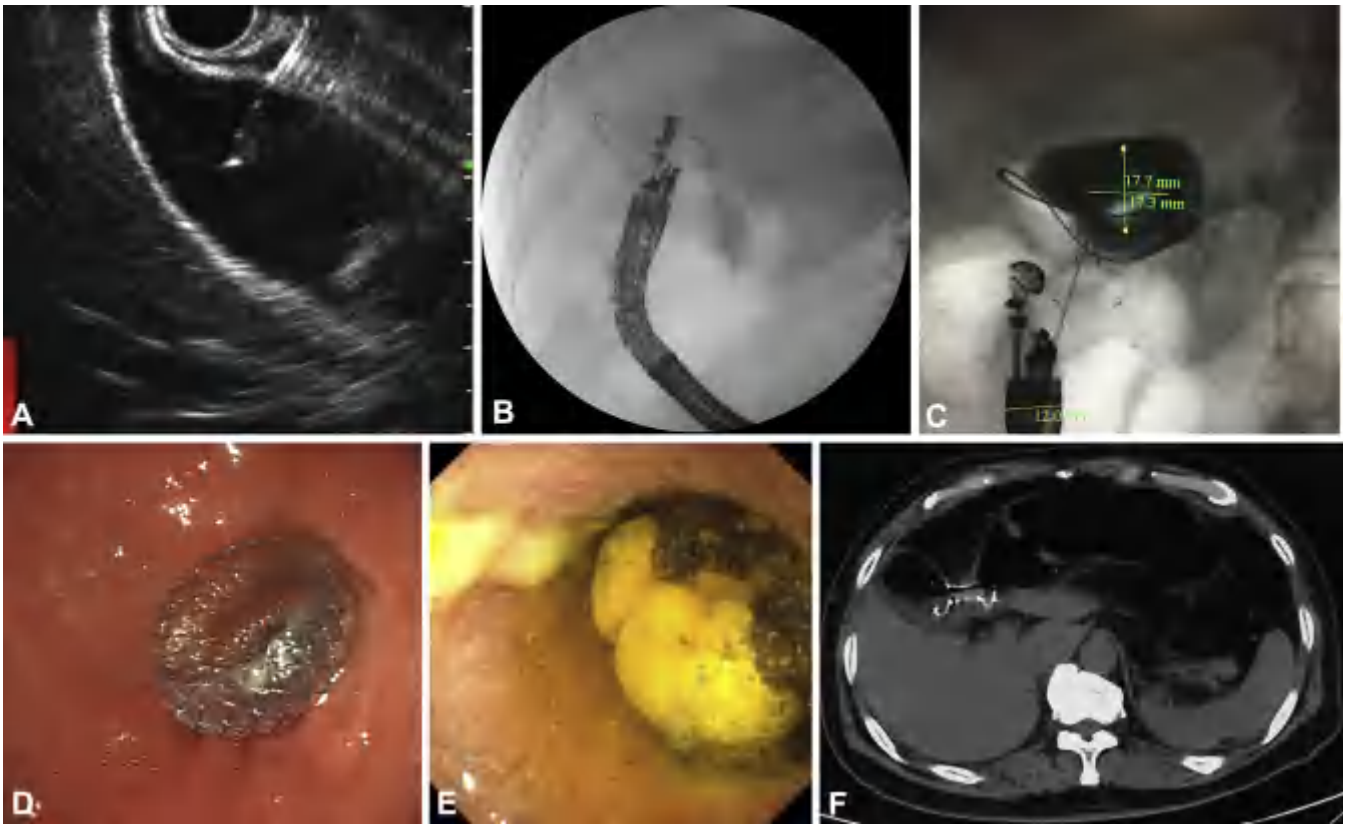


图1. EUS 引导下腔内金属支架植入术。A， EUS 引导下胆囊穿刺与灌洗。B，导丝经针道推进至胆囊。C，影像显示胆结石。D， EUS 与透视引导下支架成功置入。E，胃镜显示经支架的胆结石。F，CT影像显示支架位置良好。

eus引导下的介入操作（GIFUCT260；奥林巴斯医疗，东京，日本）完成操作。根据胆囊与消化道的距离及内镜操作性，选择最佳穿刺部位——胃窦或十二指肠球部。采用彩色多普勒引导下，使用19号针头（EchoTip Access Needle；库克医疗，布卢明顿，印第安纳州，美国）进行 EUS 引导的经壁穿刺。将针头插入胆囊后，使用无菌生理盐水进行胆囊抽吸和灌洗，必要时可防止胆汁泄漏至腹腔。随后，将0.035英寸导丝（Jagwire；波士顿科学，纳蒂克，马萨诸塞州，美国）经针头推进至胆囊内。将导丝在胆囊内盘绕2-3圈以确保稳定性。移除针头后，使用胆囊切开器（CST-10；库克医疗）建立胆囊通道。最后，将支架输送系统沿导丝推进至胆囊内。在 EUS 和透视引导下展开支架，直至远端和近端凸缘均扩张到位（图1）。

ELLL 通过 LAMS

使用U-100 Plus倍双频双脉冲激光（Freddy；德国柏林世界医学公司）进行碎石治疗。将配备2.8毫米工作通道的胃镜（GIF-H-260；奥林巴斯医疗）推进胆囊后，将激光光纤穿过通道接触浸泡在水中的结石。采用120毫焦、5/10赫兹的工作模式进行激光碎石，直至所有结石碎屑均小于1厘米。根据结石形态和大小选择不同器械进行碎石：较大碎屑用篮式钳或三锥钳取出，较小碎屑则用鼠齿钳处理。对于落入胆囊管的砂粒结石，采用冲洗和负压吸引法有效清除。通过逆行性胆道造影（图2）确认所有可见碎屑已完全取出，未发现残留结石。随后取出LAMS装置，进行胃镜检查及黏膜病变组织病理学检测。最后根据实际情况妥善处理人工瘘管（图3）。

主要结局指标

主要结局指标包括技术成功率、临床成功率及不良事件发生率。



图2. 通过腔内金属支架进行内镜激光碎石术与碎石术。A-C图：激光碎裂巨型胆结石形成碎石。D图：碎石过程中出现轻微出血。E-G图：碎石碎块分别通过碎石篮、一次性碎石袋和鼠齿钳取出。H、I图：对潜在黏膜病变进行胃镜检查并取活检。

技术成功定义为LAMS（胆道内支架系统）的植入。临床成功定义为完全清除胆结石。不良事件包括出血、腹膜炎、穿孔、支架植入失败及支架移位。手术相关参数包括穿刺部位、支架植入手术时间、 ELLL 与支架植入间隔时间、 ELLL 手术时间及瘘管愈合时间。

后续

术后第一年分别在3、6、12个月进行常规X光和CT检查，之后每年检查一次。必要时进行胃镜检查和MR-CP检查。

结果

本研究共纳入5例患者（1男4女），共发现6枚大型胆结石，结石大小范围为12.5×16.7毫米至23.8×28.8毫米。经 EUS 引导的LAMS支架植入术通过经胃途径（2例）和经十二指肠途径（3例）成功实施。支架植入术平均耗时33分钟，具体时间为25-42分钟不等。其中1例患者因局部腹膜炎出现术后5天发热伴上腹痛症状。5例患者的 ELLL 检查与支架植入间隔时间分别为28天、14天、2天、2天和7天。所有5例患者均通过LAMS支架成功完成 ELLL 检查。



图3.支架移除后人工瘘管的愈合情况。A、B：病例2中瘘管在支架移除3天后自行闭合。C-E：病例3中瘘管在支架移除3天后未自行闭合，需使用内钉促进闭合。F：病例3中瘘管在支架移除11天后接近闭合。G-I：病例4中瘘管在支架移除后立即使用内钉闭合，10天后接近闭合。

ELLL 的平均手术时间为2.5小时，范围在0.5至5小时之间。除1例患者在激光碎石术中出现轻微出血外，其余5例均未发生气腹、皮下气肿或支架移位。经逆行胆道造影证实，结石碎片均未进入胆总管。1例患者采用经皮胆道取石术（ERCP）取出残留于胆囊颈部的结石碎片。所有取石术后立即移除了腔内取石器（LAMS）。前2例患者人工瘘管完全自闭，后3例患者使用内钉促进瘘管闭合。瘘管平均愈合时间为6.6天，范围在2至11天之间。平均随访27.8个月（24-36个月）后，未发现胆结石复发（表1）。

讨论

近年来，内镜经胃及经直肠保胆取石术在临床中已开始尝试应用。[12] 该手术中取出胆结石后，胆囊切口需用内镜夹闭合。腹腔内残留的内镜夹不仅会影响胆囊收缩功能，还可能干扰后续超声和磁共振检查，甚至导致胆石复发。随着内镜器械与技术的快速发展， EUS 引导介入手术已得到更广泛应用。[13] 作为 EUS 引导自然腔道内镜手术的典型代表， **内镜超声引导下应用lams行胆囊**

表1.临床和技术特征

	案例 1	案例 2	案例 3	案例 4	案例5
性别	女性的	男性	女性的	女性的	女性的
年龄，y	65	60	49	45	33
急性胆囊炎	是	不	不	不	不
胆囊大小，mm	69.2 × 24.5	52.2 × 34.4	39.3 × 23.5	49.4 × 16.3	56.0 × 24.0
胆结石数量	1	1	1	2	1
胆结石大小，mm	26.2 × 19.0	23.8 × 28.8	24.5 × 11.4	18.6 × 12.6 23.6 × 18.3	16.7 × 12.5
穿刺部位	十二指肠球部	胃窦	胃窦	十二指肠球部	十二指肠球部
技术成功	是	是	是	是	是
支架植入时间，min	30	42	33	25	35
腹膜炎	不	不	不	不	是
ELLL 和支架植入之间的间隔时间，天	28	14	2	2	7
临床成功	是	是	是	是	是
ELLL 时间，小时	5	4	1.5	1.5	0.5
出血	不	是	不	不	不
皮下气肿	不	不	不	不	不
腹膜气肿	不	不	不	不	不
支架移位	不	不	不	不	不
组合 ERCP	不	不	不	是	不
胆囊胃镜活检	不	是	不	不	不
瘘管处理方法	暂不处理	暂不处理	暂不添加内嵌片段	内夹	内夹
瘘管愈合时间（天）	2	3	11	10	7
胆结石复发	不	不	不	不	不
随访持续时间，月	36	28	27	24	24

ELLL 内窥镜激光碎石术和碎石术。

引流术在安全性、有效性及对胆囊损伤较小等方面展现出显著优势。[13,14] 该系统采用双侧锚定法兰和鞍形结构设计，并配备全覆膜支架。从理论上讲，LAMS通过双侧锚定法兰实现器官间粘连，其原理与外科吻合术类似。此外，全覆膜金属支架还能有效防止侧漏问题。这些优势使得LAMS系统成为内镜治疗胆囊疾病的理想选择。

LAMS（经皮取石系统）的鞍座部分直径约为1.5厘米。对于直径小于1厘米的结石，可通过LAMS轻松取出；而较大结石则需先碎成小块以便取出。如我们先前报告所述，ELLL（碎石系统）可能是处理巨型结石的有效方法。[11] 为进一步验证其疗效与安全性，我们前瞻性治疗了5例连续患者。虽然样本量较小，但结果仍能提供有价值的参考依据。

首先，胆囊体可能是最佳穿刺部位，但由于胆囊颈部与胆囊体相比活动度较小，因此更建议穿刺胆囊颈部。然而狭窄的空间结构使得支架置入难度增加，同时给治疗残留结石带来挑战。[7,15] 在第四例病例中，锚定凸缘造成的阻塞导致结石碎块滞留于胆囊颈部无法清除。经过多次尝试失败后，最终采用经乳头逆行冲洗吸引法成功取出残留结石（视频1，可在线查看于www.VideoGIE.org）。

其次，内窥镜激光碎石术与碎石术的最佳实施时机应至少在LAMS支架植入术后两周。为确保手术安全，首例病例中激光碎石术与支架植入术之间间隔4周，这足以让瘘管通道充分成熟。后续所有手术均安全顺利，瘘管在支架取出后2天完全闭合。基于首例经验，第二例病例将间隔缩短至2周，瘘管在支架取出后3天即完全闭合。与腹腔镜胆囊切除术相比，腹腔镜胆囊切除术是一种安

全、有效的微创手术，且能在1周内顺利完成。因此，我们成功缩短了最后3例病例的手术总时长。最后3例病例中，激光碎石术与支架植入术的间隔时间分别为2天、2天和7天。虽然在 ELLL 过程中未出现不良事件，但支架取出后瘘管愈合速度较慢。所有最后3例病例均采用内钉促进瘘管闭合，其愈合时间分别为11天、10天和7天。这表明瘘管愈合时间取决于其成熟度，两周可能是最佳治疗周期。

第三，结石碎块的直径应控制在1厘米以内，以便通过支架顺利取出。但切忌碎块过小，否则反而会增加取出难度。过小的碎块可能被捞网或镊子夹不住，若部分碎块掉入胆囊管或支架后方，取出时会更加困难。此外，手术过程中极小的碎块很可能卡在胆总管中，但幸运的是，在这5例病例中均未发生这种情况。

第四，这种新型胆结石治疗方法的成功标准是什么？成功不仅需要证明胆囊内无残留结石、无碎片进入胆囊管或总胆管，更需确认胆囊壁未发现癌前病变或肿瘤性病灶——这正是患者面临的重要风险。必须在完全清除结石后进行胃镜和组织病理学检查。必要时应实施内镜黏膜切除术或内镜黏膜下剥离术，毕竟LAMSs为后续手术提供了通道和机会。

第五，术后预防胆结石复发至关重要。尽管病因复杂多样，但研究证实熊去氧胆酸可能对预防胆囊保护性碎石术后结石复发具有积极作用。除保持规律饮食（尤其是早餐）外，所有患者均接受熊去氧胆酸治疗。术后每6个月随访一次，未出现复发病例。

综上所述，我们证实经皮经胆管碎石术（LAMSs）联合 ELLL 技术治疗胆结石安全可行，尤其适用于巨结石患者。该疗法可作为不适合开放手术患者的替代治疗方案。但需进一步研究以评估其长期疗效。

披露

所有作者均未披露任何财务关系。

缩写：ELLL，内镜激光碎石术和碎石术；LAMSs，腔内金属支架。

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· 胆石症 ·

CT 引导下经皮肝穿刺胆道镜联合双频激光碎石取石治疗复发性肝内胆管结石患者疗效及安全性分析*

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【摘要】 **目的** 探讨在 CT 引导下经皮肝穿刺胆道镜联合双频激光碎石取石治疗复发性肝内胆管结石患者的疗效和安全性。**方法** 2017 年 9 月～2020 年 2 月我院收治的 60 例复发性肝内胆管结石患者,其中 31 例(A 组)接受 CT 引导下经皮肝穿刺胆道镜取石术(PTCSL)联合双频激光碎石取石治疗,另 29 例(B 组)接受开腹手术治疗。采用化学发光免疫分析仪检测血清皮质醇(COR)和肾上腺素(EP)水平。**结果** A 组手术时间、肛门排气时间、首次排便时间和术后住院时间分别为(89.7±10.1)min、(30.3±3.6)h、(2.3±0.3)d 和(6.9±1.1)d,显著短于 B 组【分别为(101.9±12.2)min、(34.7±4.1)h、(2.7±0.4)d 和(11.8±1.6)d,$P<0.05$】,术中出血量为(40.2±8.8)ml,显著少于 B 组[(97.4±10.6)ml,$P<0.05$];在术后 7 d,A 组血白细胞计数、中性粒细胞百分比、血清 COR 和 EP 水平分别为(9.7±1.0)×10^9/L、(67.8±5.9)%、(310.1±30.7)mmol/L 和(210.7±22.8)pg/mL,显著低于 B 组【分别为(11.8±1.3)×10^9/L、(76.4±7.1)%、(385.5±34.4)mmol/L 和(247.3±23.1),$P<0.05$】;A 组血清 ALT、AST、ALP 和 TBIL 水平分别为(39.7±3.7)U/L、(39.9±4.1)U/L、(80.1±8.5)和(19.4±1.8)μmol/L,显著低于 B 组【分别为(45.6±5.1)U/L、(45.5±5.1)U/L、(85.9±6.8)和(23.0±3.4),$P<0.05$】;A 组术后并发症发生率为 9.7%,显著低于 B 组的 41.4%($P<0.05$);A 组结石残余率为 6.5%(2/31),显著低于 B 组的 31.0%(9/29,$P<0.05$)。**结论** 与传统开腹手术相比,采取在 CT 引导下经皮肝穿刺胆道镜联合双频激光碎石取石治疗复发性肝内胆管结石患者可减轻手术损伤,加快术后胃肠功能的恢复,可能与诱发的氧化应激和炎性反应较轻有关,同时其手术并发症和结石残留率也低。

【关键词】 肝内胆管结石;经皮肝穿刺胆道镜取石术;双频激光碎石;疗效

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Efficacy and safety of CT-guided percutaneous transhepatic choledochoscopy and dual-frequency laser lithotripsy combination in the treatment of patients with recurrent hepatolithiasis

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【**Abstract**】 **Objective** The aim of this clinical observation was to investigate the efficacy and safety of CT-guided percutaneous transhepatic choledochoscopic lithoteipsy (PTCSL) and dual-frequency laser lithotripsy (DFLL) combination in the treatment of patients with recurrent hepatolithiasis. **Methods** A total of 60 patients with recurrent hepatolithiasis were admitted to our hospital between September 2017 and February 2020, and 31 patients in group A received CT-guided PTCSL and DFLL and 29 patients in group B underwent open choledochofiberscope and DFLL. Serum cortisol (COR) and epinephrine (EP) were detected. **Results** The operation time, exhaust time, first defecation time and postoperative hospitalization stay in group A were (89.7±10.1)min, (30.3±3.6)h, (2.3±0.3)d and (6.9±1.1)d, all significantly shorter than [(101.9±12.2)min, (34.7±4.1)h, (2.7±0.4)d and (11.8±1.6)d, respectively, $P<0.05$], while blood loss was (40.2±8.8)ml, much less than [(97.4±10.6)ml, $P<0.05$] in group B; at the end of seven days after operation, the white blood cell counts, neutrophil percentage, serum COR and EP levels were (9.7±1.0)×10^9/L, (67.8±5.9)%, (310.1±30.7)mmol/L and (210.7±22.8)pg/mL, significantly lower than [(11.8±1.3)×10^9/L, (76.4±7.1)%, (385.5±34.4)mmol/L and (247.3±23.1), respectively, $P<0.05$] in group B; serum ALT, AST, ALP and bilirubin level were (39.7±3.7)U/L, (39.9±4.1)U/L, (80.1±8.5) and (19.4±1.8)μmol/L, significantly lower than [(45.6±5.1)U/L, (45.5±5.1)U/L, (85.9±6.8) and (23.0±3.4), respectively, $P<0.05$] in group B; the incidence of postoperative complications was 9.7%, significantly lower than 41.4% ($P<0.05$) and the stone residual rate was 6.5%, significantly lower than 31.0% in

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group B($P<0.05$). **Conclusion** CT-guided (PTCSL) and DFLL combination could reduce surgical damage, accelerate postoperative recovery of gastrointestinal functions with low stone residual rate, which might be related to less oxidative stress and inflammatory reaction.

【Key words】 Hepatolithiasis; Percutaneous transhepatic cholangioscopic lithotomy; Dual-frequency laser lithotripsy; Efficacy

肝内胆管结石是我国常见病、多发病,复发率高,需反复多次手术治疗,是我国良性胆道疾病死亡的重要原因[1,2]。目前,肝脏部分切除术是公认的治疗该病的首选方法。然而,临床上常见术后结石复发或高龄患者不能耐受等情况[3]。经皮肝穿刺胆道镜取石术(percutaneous transhepatic choledochoscopic lithoteipsy,PTCSL)属于微创手术,经皮经肝穿刺建立肝内胆管与外界之间的通道,通过胆道镜检查、碎石、取石,可经窦道反复多次取石并能纠正胆道狭窄[4,5]。在施行 PTCSL 手术过程中,术者多联合使用液电碎石和钬激光碎石来解决结石坚硬或嵌顿等问题[6]。双频激光可通过将光能量瞬间转化为强大的机械冲击波碎石,能在短时间内准确高效地击碎结石[7]。本研究针对复发性肝内胆管结石患者,通过与传统开腹手术进行对比,在 CT 引导下采取 PTCSL 联合双频激光碎石治疗肝内胆管结石患者,观察了临床疗效和安全性,旨在为临床处理这类患者提供经验参考。

1 资料与方法

1.1 一般资料 2017 年 9 月~2020 年 2 月我院收治的复发性肝内胆管结石患者 60 例,男 35 例,女 25 例;年龄 42~74 岁,平均年龄为(60.2±5.7)岁。经腹部 B 超或者 CT 检查诊断为肝内胆管结石复发。结石位于左侧肝内 17 例,右侧 19 例,双侧 24 例,有胆囊切除术史 24 例,胆肠吻合术 6 例,开腹右半肝切除术 4 例,开腹左半肝切除术 2 例,开腹左外叶肝切除术 9 例,胆总管探查术 15 例。无合并胆管出血或癌变,肝内胆管扩张>5 mm,结石所在肝叶无萎缩、无腹水。排除标准:弥漫性胆管狭窄、合并严重的心脑血管疾病、伴有急性梗阻性化脓性胆道感染、合并免疫功能缺陷或血液系统疾病、意识障碍或精神异常、妊娠或哺乳期妇女。患者及其家属签署知情同意书,本研究经我院医学伦理学委员会审核。

1.2 手术方法 将患者分为两组,在 A 组 31 例患者,采用 CT 引导下 PTCSL 联合双频激光碎石取石治疗。在 CT 引导下,根据肝内扩张胆管的位置,确定穿刺层面,避开动静脉,选择穿刺点、穿刺路径、进针角度和深度,于体表作好标记。将穿刺针刺入扩张的胆管后待胆汁流出,注入造影剂,置入 8 F 导管引流。在穿刺肝胆管引流 2 周后,扩张窦道。全身麻醉,经猪尾管注入造影剂,植入引导丝,在 C 臂机下观察引导丝进入肝内胆管后,退出猪尾管,用 Cook Urological Incorporated 肾造瘘扩张器套件顺导丝扩张通道,置入 20 F 外鞘管,形成胆道镜进出通道。使用日本 Olympus 纤维胆道镜软镜,经 20 F 外鞘管进入肝内胆管,用取石网套取出较小的结石。对超过 0.5 cm 的结石,则以双频激光碎石机碎石后取出,对细小碎片和泥沙样结石,用吸引器抽出。在取完结石后,常规探查肝内外胆管,确定镜下无结石后退出胆道镜,留置 T 管。术后来院,行 B 超检查,观察有无结石残留。当发现有残石或仍有胆管狭窄时,再次行胆道镜下联合双频激光碎石取石;在 B 组 29 例患者,采取开腹手术治疗,全身麻醉,松解腹腔粘连,切开胆总管进入肝内,使用 Olympus 纤维胆道镜联合双频激光碎石机碎石,用 COOK 网篮取石。术后,常规留置胆道引流管。

1.3 检测指标 使用日本希森美康医用电子有限公司生产的 XT-2000I 全自动血液细胞分析仪测定白细胞计数(white blood cell count,WBC)和中性粒细胞计数(neutrophil,NEUT);使用德国西门子公司生产的 ADVIA Centaur XP 全自动化学发光免疫分析仪检测血清皮质醇(cortisol,COR)和肾上腺素(epinephrine,EP)水平。

1.4 统计学方法 应用 SPSS 20.0 软件进行数据处理与分析,计量资料以 $\bar{x}\pm s$ 表示,组间比较采用独立样本 t 检验;计数数据采用 x^2 检验,$P<0.05$ 为差异具有统计学意义。

2 结果

2.1 两组围术期指标比较 A 组手术时间、肛门排气时间、首次排便时间和术后住院时间显著短于 B 组,术中出血量显著少于 B 组($P<0.05$,表 1)。

2.2 两组血清应激反应指标比较 在术后 7 d,A 组血 WBC、N、血清 COR 和 EP 水平显著低于 B 组($P<0.05$,表 2)。

表 1　两组围术期指标($\bar{x}\pm s$)比较

例数	手术时间(min)	术中出血(mL)	术后排气(h)	首次排便(d)	住院日(d)
A 组 31	89.7±10.1①	40.2±8.8①	30.3±3.6①	2.3±0.3①	6.9±1.1①
B 组 29	101.9±12.2	97.4±10.6	34.7±4.1	2.7±0.4	11.8±1.6

与 B 组比,①P<0.05

表 2　两组血清应激反应指标($\bar{x}\pm s$)比较

	例数	WBC($\times10^9$/L)	NEUT(%)	COR(mmol/L)	EP(pg/mL)
A 组术前	31	6.6±0.7	54.7±6.0	175.6±18.3	112.7±12.0
术后	31	9.7±1.0①	67.8±5.9①	310.1±30.7①	210.7±22.8①
B 组术前	29	6.5±0.8	55.9±6.1	173.8±19.1	115.1±13.3
术后	29	11.8±1.3	76.4±7.1	385.5±34.4	247.3±23.1

与 B 组比,①P<0.05

2.3 两组肝功能指标比较　在术后 7 d,A 组血清 ALT、AST、ALP 和 TBIL 水平显著低于 B 组(P<0.05,表 3)。

2.4 两组结石残余和复发情况比较　A 组结石残余率为 6.5%(2/31),显著低于 B 组的 31.0%(9/29,P<0.05);A 组结石复发率为 16.1%(5/31),与 B 组的 24.1%(7/29)比,差异无统计学意义(P>0.05)。

2.5 两组术后并发症发生率比较　A 组术后并发症发生率显著低于 B 组(P<0.05,表 4)。

表 3　两组肝功能指标($\bar{x}\pm s$)比较

	例数	ALT(U/L)	AST(U/L)	ALP(g/dL)	TBIL(μmol/L)
A 组术前	31	76.3±4.7	61.6±5.7	93.6±7.7	27.3±3.6
术后	31	39.7±3.7①	39.9±4.1①	80.1±8.5①	19.4±1.8①
B 组术前	29	75.1±5.3	60.3±6.6	94.1±8.8	26.9±4.1
术后	29	45.6±5.1	45.5±5.1	88.9±6.8	23.0±3.4

与 B 组比,①P<0.05

表 4　两组术后并发症发生率(%)比较

	例数	切口感染	切口疝	胆道感染	胆漏	腹腔脓肿	肠梗阻	小计
A 组	31	1	1	0	1	0	0	3(9.7)①
B 组	29	4	1	2	2	1	2	12(41.4)

与 B 组比,①P<0.05

3　讨论

肝内胆管结石发病率高,易合并胆管炎、胆道狭窄甚至引起胆道肿瘤,溶石排石效果往往疗效差,易反复发作[8,9]。目前,治疗的原则为取尽结石,清除病灶,解除狭窄,通畅引流,减少复发[10]。

传统开腹肝叶切除术是临床上公认治疗肝内胆管结石最有效的方法之一,取石可直接消除病灶,但由于手术造成较大的创口,肝脏解剖结构复杂,术后感染等并发症发生率高[11-13]。近年来,PTCSL 治疗肝内胆管结石逐渐在临床上被使用,CT 引导下 PTCSL 联合双频激光碎石不需开腹手术,仅需约 1 cm 左右的穿刺孔,创伤小,术后恢复快,可留置引流管,窦道形成后可反复进行结石清除[14,15]。高龄且基础疾病较多,一般情况差不能耐受开腹手术的患者或不愿意接受开腹手术的患者在 CT 引导 PTCSL 联合双频激光碎石取石是治疗肝内胆管结石的适宜方法[16]。

本研究 A 组术中出血量少于 B 组,经皮肝穿刺只造成 0.6 cm 左右的穿刺口,相对于传统的开腹手术,其造成的伤口较小,术中保护鞘管,建立窦道,术后置入引流管支撑,不会造成大量的出血,术中出血量少。此外,本研究显示 A 组患者手术时间、术后排气时间、首次排便时间、术后住院时间均显著短于 B 组。根据胆管弯度的大小进行 PTCSL 手术操作,缩短了手术时间。传统开腹手术剥离胆囊与周围粘连组织,可造成一定的损伤,腹腔长时间暴露可能会导

致肠胃组织水肿的发生,延长了术后恢复时间。PTCSL 手术经皮肝穿刺对腹腔扰动较少,且穿刺术后患者即可饮食,不影响肠胃功能,有利于患者术后的恢复。研究表明[17,18],手术刺激促进交感-肾上腺髓质轴 EP 分泌,引起外周血 COR 水平升高。同时,手术造成的组织损伤会引起 WBC 计数升高。本研究 A 组术后 WBC 计数、中性粒细胞百分比、血清 COR 和 EP 水平均显著低于 B 组,提示 PTCSL 手术对患者应激反应较小,进一步说明 CT 引导 PTCSL 联合双频激光碎石治疗肝内胆管结石患者机体所受创伤和刺激较小,有利于患者术后恢复。相关研究表明[19],PTCSL 手术更有利于患者术后肝功能的恢复。本研究 A 组术后肝功能指标显著低于 B 组。在 PTCSL 治疗过程中不需要阻断血管,可有效避开血管,精确穿刺,最大限度地保护肝脏,同时应用经皮经肝穿刺术后恢复能力好,有利于肝胆生理功能的恢复。

本研究术后两组均出现切口感染、切口疝、胆漏等并发症,但 B 组术后并发症发生率为 41.4%,显著高于 A 组的 9.7%。CT 引导 PTCSL 联合双频激光碎石治疗肝内胆管结石患者手术切口较小、出血少、手术损伤小,整个手术过程中患者痛苦较轻,伤口易愈合,有利于降低术后并发症的发生。一般来说,直径 1.5 cm 以上的结石或质地坚硬者往往碎石取石困难。本研究 A 组有 8 例患者在第一次碎石取石时未能取净,经窦道第二次或第三次取石才获得成功。PTCSL 手术治疗的缺点是需要分次取石,取石周期较长[20]。本研究 A 组结石残留率显著低于 B 组。CT 引导 PTCSL 联合双频激光碎石治疗通过多次、反复取石,使得结石取净率大大提高。本研究两组术后结石复发率比较无显著性差异,但本研究随访时间较短,且纳入病例数较少,后续将进一步扩大样本量,延长随访时间,分析两种手术方法治疗患者结石复发率的差异。

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CT 引导下经皮肝穿刺胆道镜联合双频激光碎石取石治疗复发性肝内胆管结石对应激反应及肝功能的影响

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[摘　要] 目的：观察 CT 引导下经皮肝穿刺胆道镜联合双频激光碎石取石治疗复发性肝内胆管结石对应激反应及肝功能的影响。方法：研究对象共 106 例，均为在湖北科技学院附属浠水医院接受治疗的复发性肝内胆管结石患者，选取时间为 2020 年 2 月—2023 年 2 月。随机分入对照组和观察组，每组 53 例。对照组实施开腹胆道镜联合双频激光碎石取石术，观察组实施 CT 引导下经皮肝穿刺胆道镜联合双频激光碎石取石术。比较两组治疗效果。结果：两组当中，观察组的出血量更少，手术时间、排气时间、排便时间、术后住院时间更短（$P < 0.05$）。对 ALT、AST、ALP、TBIL 进行统计分析，治疗前两组对比（$P > 0.05$）；两组治疗前与治疗后对比，治疗后更低（$P < 0.05$）；治疗后两组对比，观察组更低（$P < 0.05$）。对 WBC、NEUT、CRP、COR、EP 进行统计分析，治疗前两组对比（$P > 0.05$）；两组治疗前与治疗后对比，治疗后更高（$P < 0.05$）；治疗后两组对比，观察组更低（$P < 0.05$）。两组当中，观察组的并发症总发生率更低（$P < 0.05$）。结论：CT 引导下经皮肝穿刺胆道镜联合双频激光碎石取石治疗复发性肝内胆管结石可以减轻应激反应，提高肝功能，降低并发症发生率，促进术后康复。

[关键词] CT 引导；经皮肝穿刺；胆道镜；双频激光碎石取石；复发性；肝内胆管结石；应激反应；肝功能

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肝内胆管结石是发生在左、右肝管 Y 型分叉上方的结石，在我国的发病率较高。肝内胆管结石的含菌量高，在发病早期症状不明显，因此容易引发局部感染、胆管狭窄等症状。保守治疗无法快速缓解肝内胆管结石患者的症状，因此临床多给予手术治疗。过去肝脏部分切除术是临床治疗肝内胆管结石的首选术式，而近几年随着胆道镜和激光碎石技术的完善，肝内胆管结石也开始可以使用不切除肝脏的方法来治疗 [1]。常规胆道镜使用时经腹腔入路，通过肝外胆管置入胆道，清除结石，但这一术式仍具有较大的创伤性 [2]。经皮肝穿刺手法可以通过单一的通道置入胆道镜及碎石工具，完成手术操作，进一步减小了肝内胆管结石的手术创伤 [3]。本研究中观察 CT 引导下经皮肝穿刺胆道镜联合双频激光碎石取石治疗复发性肝内胆管结石对应激反应及肝功能的影响。

1　资料与方法

1.1　一般资料

研究对象共 106 例，均为在湖北科技学院附属浠水医院接受治疗的复发性肝内胆管结石患者，选取时间为 2020 年 2 月—2023 年 2 月。纳入标准：（1）采用临床影像学技术确诊肝内胆管结石。（2）有治疗史，治疗后病情复发。（3）有手术适应证且耐受手术。（4）意识清晰。（5）同意参与研究。排除标准：（1）存在心、脑、肺、肾严重疾病。（2）存在急性胆道梗阻或感染。（3）存在血液或免疫疾病。（4）存在肿瘤。（5）存在精神疾病。随机分入对照组和观察组，每组 53 例。对照组中男 28 例、女 25 例；年龄最小的 24 岁、最大的 67 岁，平均（57.63 ± 6.79）岁；结石直径最小的 5 mm、最大的 10 mm，平均（7.12 ± 2.12）mm。观察组中男 29 例、女 24 例；年龄最小的 25 岁、最大的 68 岁，平均（57.77 ± 6.49)岁；结石直径最小的 5 mm、最大的 10 mm，平均（7.09 ± 2.33) mm。两组以上资料对比（$P > 0.05$）。

1.2　方法

对照组实施开腹胆道镜联合双频激光碎石取石术：在右侧肋缘下做斜切口，解剖胆囊三角，将胆总管剪开一个 1 cm 长的切口，置入胆道镜。使用取石网篮将较小的结石取出。对于较大的结石，经胆道镜置入双频激光碎石光纤，击碎结石，使用网篮取出击碎的结石，对泥沙样结石使用吸引器抽出。检查结石是否取净，撤出胆道镜，缝合切口，留置 T 管。观察组实施 CT 引导下经皮肝穿刺胆道镜联合双频激光碎石取石术：通过 CT 确定结石的位置，选择避开血管、穿刺路径短的部位作为穿刺点，规划好穿刺的角度、深度，并做好体表标记。

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使用穿刺针穿刺到达胆管，看到流出胆汁后确认穿刺成功，引流 1 ~ 2 周。引流后拔除引流管，经窦道置入导丝，沿着导丝置入扩张器，扩张窦道。撤回扩张器，置入胆道镜，使用取石网篮将较小的结石取出。对于较大的结石，经胆道镜置入双频激光碎石光纤，击碎结石，使用网篮取出击碎的结石，对泥沙样结石使用吸引器抽出。使用 CT 检查结石是否取净，撤出胆道镜，留置 T 管。术后 1 周复诊，若残留结石，则再次实施手术。

1.3　观察指标

记录两组的出血量、手术时间、排气时间、排便时间、术后住院时间。治疗前和治疗后分别检测肝功能指标，包括丙氨酸氨基转移酶（ALT）、天门冬氨酸氨基转移酶（AST）、碱性磷酸酶（ALP）、总胆红素（TBIL）。检测时抽取空腹肘静脉血，离心后取血清完成检测，AST、ALP 使用比色法检测，ALT、TBIL 使用分光光度法检测。治疗前和治疗后分别检测应激反应指标，包括白细胞计数（WBC）、中性粒细胞计数（NEUT）、C 反应蛋白（CRP）、皮质醇（COR）、肾上腺素（EP）。检测时抽取空腹肘静脉血，一部分使用全自动血细胞分析仪检测 WBC、NEUT，一部分离心后取血清，使用免疫比浊法检测 CRP，使用化学发光法检测 COR、EP。

1.4　统计学分析

用 SPSS 25.0 统计学软件进行数据分析，计量资料用均数 ± 标准差（$\bar{x} \pm s$）表示，采用 t 检验，计数资料用百分比（%）表示，采用 χ^2 检验。$P < 0.05$ 为差异有统计学意义。

2　结果

2.1　术后康复指标

两组当中，观察组的出血量更少，手术时间、排气时间、排便时间、术后住院时间更短（$P < 0.05$）。详见表 1。

2.2　治疗前后的肝功能指标

对 ALT、AST、ALP、TBIL 进行统计分析，治疗前两组对比（$P > 0.05$）；两组治疗前与治疗后对比，治疗后更低（$P < 0.05$）；治疗后两组对比，观察组更低（$P < 0.05$）。详见表 2。

2.3　治疗前后的应激反应指标

对 WBC、NEUT、CRP、COR、EP 进行统计分析，治疗前两组对比（$P > 0.05$）；两组治疗前与治疗后对比，治疗后更高（$P < 0.05$）；治疗后两组对比，观察组更低（$P < 0.05$）。详见表 3。

2.4　术后并发症

两组当中，观察组的并发症总发生率更低（$P < 0.05$）。详见表 4。

表 1　术后康复指标（$\bar{x} \pm s$）

组别	出血量（mL）	手术时间（min）	排便时间（h）	排气时间（h）	术后住院时间（d）
对照组（n=53）	102.35±9.94	102.21±12.27	34.77±4.02	2.73±0.41	12.04±1.79
观察组（n=53）	37.69±7.21	90.24±9.21	30.17±3.14	2.29±0.29	7.03±1.27
t 值	38.335	5.680	6.565	6.378	16.618
P 值	＜ 0.001	＜ 0.001	＜ 0.001	＜ 0.001	＜ 0.001

表 2　治疗前后的肝功能指标（$\bar{x} \pm s$）

组别	ALT（U/L）		t 值	P 值	AST（U/L）		t 值	P 值	ALP（g/dL）		t 值	P 值	TBIL（μmol/L）		t 值	P 值
	治疗前	治疗后			治疗前	治疗后			治疗前	治疗后			治疗前	治疗后		
对照组（n=53）	76.25±4.52	45.20±5.05	33.353	＜ 0.001	61.04±5.64	45.49±5.21	14.744	＜ 0.001	93.96±7.82	89.03±7.05	3.409	＜ 0.001	27.25±3.70	23.03±3.44	6.081	＜ 0.001
观察组（n=53）	76.38±4.41	39.35±3.62	47.250	＜ 0.001	61.31±6.77	40.43±6.12	16.656	＜ 0.001	93.87±7.92	80.11±8.10	8.843	＜ 0.001	27.19±3.61	19.29±1.86	14.162	＜ 0.001
t 值	0.150	6.854			0.223	4.583			0.059	6.047			0.084	6.962		
P 值	0.881	＜ 0.001			0.824	＜ 0.001			0.953	＜ 0.001			0.933	＜ 0.001		

表 3　治疗前后的应激反应指标（$\bar{x} \pm s$）

组别	WBC（×10⁹/L）		t 值	P 值	NEUT（%）		t 值	P 值	CRP（mg/L）		t 值	P 值	COR（mmol/L）		t 值	P 值	EP（pg/mL）		t 值	P 值
	治疗前	治疗后			治疗前	治疗后			治疗前	治疗后			治疗前	治疗后			治疗前	治疗后		
对照组（n=53）	6.62±0.70	11.79±1.35	24.751	＜ 0.001	55.12±6.05	76.35±6.25	17.768	＜ 0.001	2.07±0.75	9.04±2.17	22.101	＜ 0.001	174.72±18.61	386.76±22.15	53.359	＜ 0.001	123.34±11.72	243.43±18.56	39.829	＜ 0.001
观察组（n=53）	6.65±0.72	9.67±1.01	17.725	＜ 0.001	55.24±6.11	66.89±5.27	10.511	＜ 0.001	2.08±0.61	7.52±2.04	18.600	＜ 0.001	175.03±19.24	307.25±20.21	34.496	＜ 0.001	124.01±12.52	209.65±16.92	29.621	＜ 0.001
t 值	0.217	9.154			0.102	8.424			0.075	3.715			0.084	19.305			0.284	9.792		
P 值	0.828	＜ 0.001			0.919	＜ 0.001			0.940	＜ 0.001			0.933	＜ 0.001			0.777	＜ 0.001		

表 4 术后并发症 [例（%）]

组别	切口感染	切口疝	胆道感染	胆漏	肠梗阻	胆道出血	反流性胆管炎	并发症
对照组（n=53）	4（7.55）	1（1.89）	2（3.77）	2（3.77）	2（3.77）	1（1.89）	2（3.77）	14（26.42）
观察组（n=53）	1（1.89）	1（1.89）	0（0.00）	1（1.89）	0（0.00）	1（1.89）	1（1.89）	5（9.43）
χ^2 值	1.889	0.000	2.039	0.343	2.039	0.000	0.343	5.194
P 值	0.169	1.000	0.153	0.558	0.153	1.000	0.558	0.023

3　讨论

肝内胆管结石可导致胆汁排泄不畅，引发胆道感染，使患者表现出寒战、疼痛、黄疸、高热等症状，导致肝功能降低 [4]。手术是目前临床治疗肝内胆管结石的主要方法。肝内胆管结石的病情复杂，术后容易残留结石，虽然随着手术技术和影像技术的进步，残石率明显下降，但临床仍有很多治疗后复发的患者 [5]。本研究中选取的就是复发的肝内胆管结石患者。近几年，胆道镜技术在临床上得到应用，肝内胆管结石的治疗创伤性随之减小。术中通过切开腹壁、胆总管，可以将胆道镜插入，将结石击碎和取出，解除患者的临床症状。但这种术式存在切口大、出血量多等局限性。CT 引导下经皮肝穿刺胆道镜手术可以在 CT 的辅助下准确知晓肝脏、胆管、结石的解剖关系，准确计算出取石的最佳路径，之后通过引流制作窦道，方便手术操作的实施，减少手术误伤血管、胆管的可能性，进而以较小的创伤达到治疗目的 [6]。部分学者认为，术前的引流可导致住院费用和感染风险的增加，但良好的预防措施可以控制感染，而且患者术后的住院时间短，能在一定程度上弥补术前住院时间长的缺点 [7]。

本研究中，治疗后观察组的 ALT、AST、ALP、TBIL 低于对照组（$P < 0.05$）。这是因为两种手术均取得了一定的疗效，改善了肝功能，但观察组的手术方法不容易残留结石，虽然这种方法也会在手术过程中对肝脏造成损伤，但因为手术时间短、损伤较小，术后肝功能恢复较快。反观开腹手术，虽然胆道镜的使用可以减少切除肝脏的创伤，但手术时间长，长时间复杂的手术操作难免会损伤肝组织，再加上为了取石需要多次扩张胆管，因此术后肝功能的恢复较观察组差。手术创伤的严重程度也可以通过应激指标反映出来，应激反应强烈的患者往往更容易发生并发症，术后康复速度也会受到影响。本研究中，治疗后两组的 WBC、NEUT、CRP、COR、EP 均较治疗前升高（$P < 0.05$）。这说明手术给两组患者的机体均造成了一定的创伤，患者体内炎症反应增强。但在治疗后，观察组的 WBC、NEUT、CRP、COR、EP 比对照组低（$P < 0.05$）。说明观察组的治疗方案引起的应激反应更小。

综上所述，CT 引导下经皮肝穿刺胆道镜联合双频激光碎石取石治疗复发性肝内胆管结石可以减轻应激反应，提高肝功能，降低并发症发生率，促进术后康复。

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论 著

SpyGlass DS 系统联合激光碎石法与常规分次治疗胆总管大结石的效果和安全性的对比分析

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摘要：目的 比较SpyGlass DS系统激光碎石治疗术与内镜逆行胰胆管造影术（ERCP）下常规分次治疗胆总管大结石的安全性和有效性。**方法** 选取2021年11月—2023年10月该院行ERCP，术中提示胆总管大结石的患者（ > 2 cm）38例，分为实验组（n = 18）和对照组（n = 20），实验组使用SpyGlass DS系统联合激光碎石治疗，对照组使用分次治疗（第1次放入胆管支架，3个月后再次行常规ERCP下胆总管结石取出术）。比较两组患者术后结石清除成功率和ERCP术后并发症发生率；手术3个月后随访，并复查磁共振胆胰管成像（MRCP），以明确是否有胆总管残余结石。**结果** 实验组手术时间长于对照组，差异有统计学意义（P < 0.05）。两组患者取石成功率和近期并发症发生率比较，差异均无统计学意义（P > 0.05），实验组远期并发症发生率低于对照组，但差异无统计学意义（P = 0.090）。**结论** 由SpyGlass DS引导的激光碎石术治疗胆总管大结石的疗效确切，安全性高，术后结石复发率低。

关键词： 胆总管大结石；内镜逆行胰胆管造影术（ERCP）；SpyGlass DS；碎石术；术后并发症；结石复发率
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Comparative analysis of the efficacy and safety of SpyGlass DS system combined with laser lithotripsy and conventional fractional treatment of large calculus of common bile duct

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Abstract: Objective To compare the safety and efficacy of SpyGlass DS system laser lithotripsy and conventional fractional treatment under endoscopic retrograde cholangiopancreatography (ERCP) in treatment of large calculus of common bile duct. **Method** 38 patients with large calculus of common bile duct (> 2 cm) during ERCP from November 2021 to October 2023 were selected and divided into experimental group (n = 18) and control group (n = 20). The experimental group was treated with SpyGlass DS system combined with laser lithotripsy. The patients in the control group were treated with split treatment (the first biliary stent was placed, and the calculus of common bile duct were removed under conventional ERCP again 3 months later). The success rate of stone clearance and the incidence of complications after ERCP were compared between the two groups. Magnetic resonance cholangiopancreatography (MRCP) was performed 3 months after surgery to determine whether there were residual calculus of common bile duct. **Results** The surgical time of the experimental group was longer than

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that of the control group, and the difference was statistically significant ($P < 0.05$). There was no significant difference in the stone clearance rate and the incidence of short-term complications between the two groups ($P > 0.05$). The incidence of long-term complications in the experimental group was lower than that in the control group, but the difference was not statistically significant ($P = 0.090$). **Conclusion** SpyGlass DS guided laser lithotripsy is effective and safe for the treatment of large calculus of common bile duct, with a low recurrence rate.

Keywords: large calculus of common bile duct; endoscopic retrograde cholangiopancreatography (ERCP); SpyGlass DS; lithotripsy; postoperative complications; stone recurrence rate

目前，胆总管结石的治疗方法较多，首选内镜逆行胰胆管造影术（endoscopic retrograde cholangiopancreatography，ERCP）。虽然ERCP可以通过括约肌切开术、机械网篮碎石术和球囊取出术，解决大多数常规大小的胆总管结石，而胆总管大结石（直径＞2 cm）被称为困难结石，有时无法顺利取出[1-4]。因此，对于无法一次性取出的困难胆总管结石，常先放置胆总管塑料支架，大部分结石在此期间可以被磨碎，择期（一般3个月后）再次行胆总管结石取出，并行机械网篮碎石术和球囊取出术，可以一次性取出全部结石。但仍有小部分困难结石在放置胆总管支架后，择期仍无法取出，需要更多侵入性的取石技术[5-6]，如：经腹腔镜胆总管切开取石等。近年来，胆道镜（SpyGlass DS系统）被广泛应用于临床。有研究[7-9]报道，在SpyGlass引导下治疗胆总管大结石，效果良好。胆道镜直视下行激光碎石，使得胆总管困难结石有了一次性取尽的可能[10-11]。本文通过对比两种方式治疗的安全性和疗效，以确定SpyGlass DS引导的激光碎石术治疗胆总管大结石的效果，是否与常规分次取胆总管大结石相当。现报道如下：

1　资料与方法

1.1　一般资料

回顾性分析2021年11月—2023年10月本院38例行ERCP的患者的临床资料，分为实验组（$n = 18$）和对照组（$n = 20$），实验组使用SpyGlass引导的激光碎石术，对照组使用分次取石治疗。实验组中，男7例，女11例；年龄30～83岁，平均（57.12±14.86）岁；对照组中，男12例，女8例；年龄34～83岁，平均（62.24±16.47）岁。两组患者基线资料比较，差异无统计学意义（$P > 0.05$），具有可比性。见表1。

表1　两组患者一般资料比较

Table 1　Comparison of general data between the two groups

组别	性别/例		年龄/岁	结石大小/cm
	男	女		
实验组（$n = 18$）	7	11	57.12± 14.86	2.24±0.21
对照组（$n = 20$）	12	8	62.24±16.47	2.16±0.20
t/χ^2值	1.67†		0.16	0.89
P值	0.193		0.184	0.417

注：†为χ^2值。

纳入标准：年龄＞18岁；超声、CT和/或磁共振成像等影像学检查提示胆总管结石者；最大结石直径≥2 cm；患者和家属同意参与本研究，并签署知情同意书。排除标准：活动性急性胰腺炎者；脓毒性休克者；有肝内胆管结石；有胰、胆、壶腹部恶性疾病者；既往行括约肌切开术；凝血功能异常（部分凝血活酶时间大于对照组的2倍）者；血小板偏低（$< 50 \times 10^9/\mu L$）；奥迪括约肌功能障碍；原发性硬化性胆管炎；胆总管囊肿；怀孕者；有胃大部切除术史（毕Ⅱ式或Roux-en-Y重建手术史）；无法给予知情同意者。

1.2　方法

1.2.1　器械　十二指肠镜（生产厂家：Olympus，型号：TJF-260V），ERCP相关附件（包括：乳头括约肌切开刀、取石球囊、扩张球囊、导丝和鼻胆引流管等）、胆管塑料支架、胆道全覆膜金属支架和高频电刀等（生产厂家：南微医学科技股份有限公司）；SpyGlass内镜直视系统（生产厂家：波士顿科学公司），双频激光仪（型号：U-100 Plus），相关附件（包括：SpyBite活检钳和SpyScope成像导管）[10]。

1.2.2　术前准备　术前禁食禁饮12 h。操作过程中

患者均吸氧，行心电监护和经皮动脉血氧饱和度监测，所有患者术前肛门塞入吲哚美辛栓预防感染。

1.2.3 ERCP 操作 患者取左侧卧位，术者操作十二指肠镜到达十二指肠乳头，并常规行胆胰管插管，根据术中情况，行内镜十二指肠乳头括约肌切开术及内镜下球囊扩张术，插管成功后行ERCP，留置导丝。

1.2.4 对照组 行分次取石治疗。ERCP后，观察胆总管结石位置、大小和数量，尝试使用网篮取石，针对较大结石（＞2 cm），利用网篮碎石，若结石仍较大，无法取出，根据胆管长度和结石位置，放置胆管塑料支架，抽出导丝，结束操作。3个月后，再次行ERCP，重复术前准备步骤，ERCP后再次观察结石情况，并尝试采用网篮或取石球囊进行取石。将较大结石用网篮碎石后，分次取出，取石结束后，再次行胆管造影，以确保胆管内无残留结石，最后放置鼻胆引流管。术后常规禁食禁饮和胃肠减压，并给予质子泵抑制剂（proton pump inhibitor，PPI）抑酸、黏膜保护剂护胃、生长抑素抑制胰酶分泌和补液等治疗，观察患者有无腹痛、发热、恶心呕吐和呕血黑便等不适，于术后4、8和24 h复查血常规、血淀粉酶和尿淀粉酶，术后24 h复查肝功能和肾功能等指标。酌情使用抗生素治疗。如果两次尝试均未能取净结石，则建议行手术治疗。

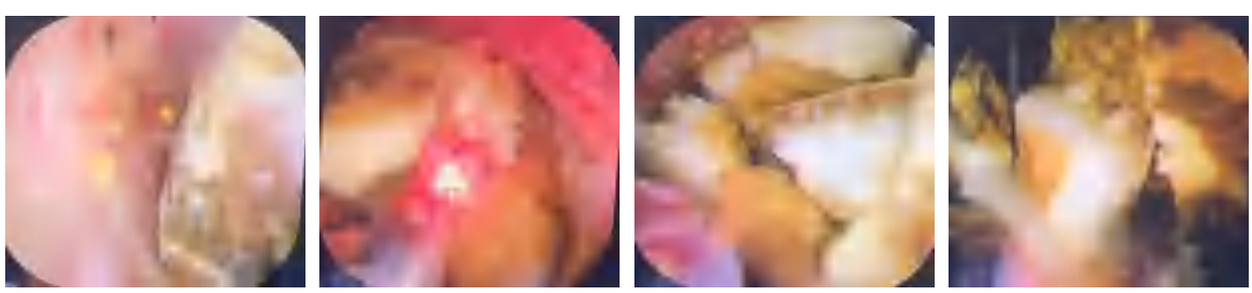
1.2.5 实验组 采用SpyGlass DS系统激光碎石治疗。通过十二指肠镜的工作孔道，将SpyGlass DS系统传送导管连同光纤摄像头置入，并小心谨慎操作，将其送至胆管内进行直视下观察，此时，需观察结石的大小和性状，大致确定碎石操作的位置后，拔除导丝，送入激光光纤，于直视下，将光纤末端对准大结石，采用U-100 Plus双频激光仪进行碎石[9]（图1），直至结石完全碎裂。碎石后根据患者情况，必要时行胆管支架置入。观察胆道无出血后，退镜。术后常规禁食禁饮和胃肠减压，给予PPI抑酸、黏膜保护剂保护胃黏膜、生长抑素抑制胰酶分泌和补液等治疗，观察患者有无腹痛、腹胀和发热等不适，于术后4、8和24 h复查血常规、血淀粉酶和尿淀粉酶，术后24 h复查肝功能和肾功能等指标。酌情使用抗生素治疗。

1.3 观察指标

1.3.1 取石成功率 包括：手术时间和取石情况。实验组统计一次性取石成功率，由于对照组为分次取石，故统计第2次取石成功率。

1.3.2 近期并发症发生率 密切关注患者术后的腹部体征和生命体征等情况，于术后4、8和24 h，检测患者血尿淀粉酶、血常规和肝肾功能等指标。若出现明显腹痛伴随超出正常水平3倍的淀粉酶升高，需及时完善CT检查，结合症状和影像学结果，即可诊断为术后胰腺炎（postoperative pancreatitis，PEP）。若淀粉酶升高程度未达到正常范围的3倍，即可诊断为高淀粉酶血症。术后患者均给予胃肠减压，观察胃管引流情况，若出现咖啡色血或者鲜红色血，甚至出现黑便，考虑为术后出血。如患者腹部持续疼痛，伴有腹肌紧张，甚至出现腹膜刺激征，需及时完善CT或X线检查，提示膈下游离气体，则考虑为穿孔。若患者术后发热，体温超过38.5℃，伴有血象、碱性磷酸酶和谷氨酰转移酶升高，考虑为胆管炎。

1.3.3 远期并发症发生率 术后随访3个月，通过



A B C D

A：SpyGlass胆道镜示胆总管大结石；B：将光纤放置于大结石表面；C：SpyGlass DS引导的激光碎石术；D：碎石成功。

图1 SpyGlass DS引导的激光碎石术

Fig.1 Laser lithotripsy guided by SpyGlass DS

腹部 B 超、CT 或磁共振胆胰管成像（magnetic resonance cholangiopancreatography，MRCP）等检查，以了解结石复发情况。

1.4　统计学方法

采用 SPSS 20.0 软件对数据进行分析，计量资料以均数 ± 标准差（$\bar{x} \pm s$）表示，组间比较用独立样本 t 检验，组内比较用配对样本 t 检验；计数资料以例或百分率（%）表示，比较采用 χ^2 检验或 Fisher 确切概率法。$P < 0.05$ 为差异有统计学意义。

2　结果

2.1　两组患者手术情况比较

实验组手术时间为（31.80 ± 3.03）min，较对照组的（23.40 ± 4.37）min 明显延长，差异有统计学意义（$P < 0.05$）。实验组均一次性取石成功，取石成功率为 100.00%，对照组有 3 例第 2 次 ERCP 取石未成功，取石成功率为 85.00%，两组患者比较，差异无统计学意义（$P = 0.090$）。见表 2。

2.2　两组患者近期并发症发生率比较

实验组与对照组高淀粉酶血症、PEP、出血和胆道感染等近期并发症发生率比较，差异均无统计学意义（$P > 0.05$）。见表 3。

2.3　两组患者远期并发症发生率比较

实验组术后 3 个月随访，均无结石复发，结石复发率为 0.00%；对照组第 2 次 ERCP 取石后 3 个月随访，有 3 例患者影像学检查提示仍有胆管结石，结石复发率为 15.00%，但两组患者比较，差异无统计学意义（$P = 0.090$）。

表 2　两组患者手术情况比较

Table 2　Comparison of operation status between the two groups

组别	手术时间/min	取石成功率 例(%)
实验组（$n = 18$）	31.80±3.03	18(100.00)
对照组（$n = 20$）	23.40±4.37	17(85.00)
t/χ^2 值	6.70	2.93†
P 值	0.000	0.090

注：†为 χ^2 值。

表 3　两组患者近期并发症发生率比较　例(%)

Table 3　Comparison of recent complication rates between the two groups　n (%)

组别	高淀粉酶血症	PEP	出血	胆道感染
实验组（$n = 18$）	5(27.78)	1(5.56)	1(5.56)	0(0.00)
对照组（$n = 20$）	7(35.00)	2(10.0)	0(0.00)	1(5.00)
χ^2 值	0.23	0.26		
P 值	0.632	0.612	0.285†	0.335†

注：†为 Fisher 确切概率法。

3　讨论

困难胆总管结石[12]是根据其直径（> 2 cm）、形状、数量、位置（肝内或胆囊管），或解剖因素（胆总管扭曲、远端结石、结石嵌顿、胆总管远端较短或胆总管远端急性成角 < 135°）而定义。传统的 ERCP[13-16]包括：内镜十二指肠括约肌切开术、机械碎石术和内镜下乳头大球囊扩张术[17-20]，大多数情况下取石都是成功的，但第 1 次使用机械碎石术和腹腔镜下胆管切开取石术，胆道结石的清除率只有 65.00% ~ 70.00%。对于无法一次性取出的困难胆总管结石，可以先放置胆总管塑料支架，择期（一般 3 个月后）再行胆总管结石取出，大部分结石在此期间可以被磨碎，在进行机械网篮碎石术和球囊取出术后，可以一次性取出全部结石，在 SpyGlass 广泛引入之前，此方法被大多数医院所采用。近年来，胆道镜系统（SpyGlass DS）被广泛应用于临床，大量研究[21-23]报道了 SpyGlass 引导下胆管内取石治疗胆总管结石的优点，包括：手术视野十分清晰，直视下手术更加安全；可以更清楚地明确结石大小和位置，及其与胆总管的关系，做到准确碎石；碎石结束后，可以再次仔细观察胆管，避免结石残留等，由于其安全性好，甚至被应用于妊娠合并胆总管结石的治疗中[24-26]。目前，关于分次取石与 SpyGlass DS 系统引导下碎石术的直接比较的报道，较为罕见。本研究旨在确定 SpyGlass DS 系统引导研究激光碎石术治疗胆总管大结石的效果，是否与常规分次取石法相当。

临床关于分次治疗胆管困难结石与其他取石方法

的对比研究较少，最近的一项回顾性研究[27]纳入 85 例接受胆道塑料支架置入治疗难治性结石的患者，在第 2 次行 ERCP 时，整体结石完全清除率仍然很低（64.71%，55/85），依旧有约 28.00% 的患者需要机械碎石。有学者[28]认为，支架置入后结石尺寸的减小，可能会降低后续 ERCP 中对机械碎石的需求，但代价是需要重复的手术导致成本增加。本研究中，考虑到分次取石的情况，第 1 次 ERCP 主要目的为放置胆管支架，多数未进行取石操作，无法比较取石成功率，且放置胆管支架的操作时间较短，与取石或碎石等操作相比，PEP 或感染等并发症发生率明显较低，故将 2 次取石后，各项数据与 SpyGlass DS 引导的激光碎石术做对比更有意义。本研究证实，SpyGlass DS 系统引导下的取石成功率与分次取石相当，且两种术式的近期并发症发生率无差异，虽然 Spyglass DS 引导下远期并发症（结石复发率）发生率低于常规分次取石，但差异无统计学意义（$P = 0.090$）。

SpyGlass DS 直接可视化系统（SpyGlass DS）与第一代模型比较，其为数字版胆道镜，提高了图像分辨率，并纳入了专用的冲洗和吸引口，还有更能弯曲的尖端。这些改进可能有助于结石清除率的提高。如果所有患者均使用 Spyglass DS 引导下的激光碎石术，首次手术的结石清除率可能更高。有研究[29]评估了 2016 年 1 月—2023 年 8 月期间美国食品和药品监督管理局制造商和用户设施设备体验数据库中报道的 SpyGlass DS 系统不良事件，1 743 份报告中，62 份（3.56%）发现了与患者相关的不良事件，其中，33 份使用 SpyGlass DS，29 份使用 SpyGlass DS Ⅱ，最常见的不良事件是出血，其次是穿孔、感染、败血症和胰腺炎。另有研究[30]表明，SpyGlass DS 系统引导的激光碎石术，可能会增加感染或持续性菌血症的风险，最常见的 Spyglass 相关并发症是胆管炎，发生率高达 14.00%。由于本次研究对接受激光碎石的患者均进行了抗生素预防，没有发生胆管炎。

综上所述，SpyGlass DS 引导下激光碎石术，结石清除率高，效果较好，术后近期和远期并发症与常规分次取石相当。但本研究仍存在一定的局限性，没有纳入更多、更复杂和更困难的结石患者，且样本量较小，可能存在偏倚，将来需要更多的研究数据来支持以上观点。

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·论著·

经皮经肝十二指肠乳头肌扩张顺行排石术联合双频双脉冲激光碎石治疗大直径胆总管结石

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【摘要】 目的　本研究旨在评估经皮经肝十二指肠乳头肌扩张顺行排石术联合输尿管软镜引导双频双脉冲 ND:YAG 激光碎石术（PTPBD-FREDDY）治疗巨大（直径>1.5 cm）胆总管结石的安全性和有效性。**方法**　回顾性分析 2017 年 12 月至 2021 年 10 月在山东大学第二医院和山东颐养健康集团新汶中心医院收治的 26 例大直径困难胆总管结石患者，其中 4 例患者无法耐受外科手术或内镜治疗、6 例患者内镜治疗失败，另外 16 例患者拒绝接受再次手术治疗。所有患者均接受了 PTPBD-FREDDY 治疗，首先在输尿管镜监视下应用 FREDDY 激光将结石粉碎，然后应用球囊将结石推送入十二指肠内。主要研究终点为技术成功率。次要研究终点包括结石复发率以及相关并发症。**结果**　26 例患者均成功完成手术，技术成功率为 100%。胆总管结石直径平均碎石断石和手术时间显著高于混合结石和胆固醇结石（$P<0.01$）。术后主要并发症包括轻度发热 3 例、腹痛 3 例、恶心 2 例和胰腺炎 1 例，1 例患者出现胆管出血，经保守治疗后好转。未观察到胰瘘、胆血征或胆管穿孔等严重并发症。术后随访 2 年，未观察到结石复发的病例。**结论**　PTPBD-FREDDY 技术对于巨大胆总管结石患者来说是一种安全、有效的治疗方法。它为无法耐受手术、内镜治疗失败的巨大胆总管结石患者提供了一种新的治疗手段，具有良好的前景。

【关键词】 胆总管结石；　放射学，介入性；　输尿管镜；　激光

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Percutaneous transhepatic papillary balloon dilation combined with dual-frequency double-pulse laser lithotripsy for large-diameter common bile duct stones

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【Abstract】 Objective　To evaluate the safety and efficacy of percutaneous transhepatic papillary balloon dilation (PTPBD) combined with flexible ureteroscopy-guided dual-frequency double-pulse ND:YAG (FREDDY) laser lithotripsy (PTPBD-FREDDY) for the treatment of giant (>1.5 cm diameter) common bile duct stones. **Methods**　A retrospective analysis was conducted on 26 patients with large-diameter difficult choledocholithiasis admitted to two medical centers from

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December 2017 to October 2021. Among these patients, four could not tolerate surgery or endoscopic treatment, six experienced failure of endoscopic treatment, and 16 refused to undergo endoscopic or surgical treatment. All patients underwent the PTPBD-FREDDY procedure. The FREDDY laser lithotripsy was performed under ureteroscopic guidance, followed by a balloon to push the stones into the duodenum. The primary endpoint was the technical success rate, and the secondary endpoints included the rate of stone recurrence and related complications. **Results** All 26 patients successfully completed the operation, achieving a technical success rate of 100%. The average lithotripsy frequency and operation time for bilirubin stones were significantly higher than those of mixed stones and cholesterol stones ($P<0.01$). The main postoperative complications included mild fever ($n=3$), abdominal pain ($n=3$), nausea ($n=2$) and vomiting ($n=1$). One patient experienced biliary tract bleeding, which improved after conservative treatment. No serious complications such as pancreatitis, sepsis, or biliary perforation were observed. After 2 years of follow-up, no cases of stone recurrence were observed. **Conclusions** PTPBD-FREDDY is a safe and effective treatment for patients with giant common bile duct stones. It provides a new therapeutic option for patients with giant choledocholithiasis who can not tolerate surgery or have failed endoscopic treatment, demonstrating promising prospects.

[Key words] Choledocholithiasis; Radiology, interventional; Ureteroscopes; Lasers

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胆石症是一种常见的消化系统疾病，胆总管结石(common bile duct stones，CBDS)发病率占胆石症患者的10%–15%，大多胆总管结石为继发性胆管结石，常合并胆囊结石[1]。但有症患者多无临床症状，大多数为查体时发现，部分患者会出现反复发作的胆绞痛、黄疸或发热等症状[2]。目前，内镜逆行胰胆管造影(endoscopic retrograde cholangiopancreatography，ERCP)联合乳头括约肌切开术是胆总管结石的主要治疗手段[3]，但是对于巨大胆总管结石(直径>1.5 cm)，ERCP治疗可能会面临困境[4]。2008年以来，经皮经肝十二指肠乳头肌扩张预行碎石术(percutaneous transhepatic papillary balloon dilation，PTPBD)在国内逐渐应用于胆总管结石的治疗并显示出良好的前景[5-6]。激光碎石技术已在泌尿系统结石治疗中成功应用，近年来也逐渐应用于肝内胆管和胆总管困难结石的治疗。双脉双频冲ND:YAG激光(frequency-doubled dual pulse ND:YAG laser lithotripsy，FREDDY)是一种冷激光，其在经皮经肝十二指肠乳头肌扩张预行碎石术中的应用鲜有报道。本研究旨在评估PTPBD联合FREDDY激光在治疗大直径困难胆总管结石(直径>1.5 cm)方面的安全性和有效性。

对象与方法

一、对象

1. 患者：本研究为单臂回顾性研究。分析2017年12月至2021年10月在山东大学第二医院和山东颐养健康集团新汶中心医院收治的26例胆总管结石患者，患者年龄为43–83(66±12)岁，其中男性12例，女性14例。最大结石的直径为18.9–25.1(21.8±2.4)mm。9例患者合并胆囊结石。所有患者均未做过胆囊手术。26例患者中，4例患者由于心肺功能不全、麻醉禁忌证、上消化道狭窄等原因不适合手术；6例患者曾尝试行ERCP失败，而另外16例患者拒绝ERCP或手术治疗。研究经医院伦理委员会批准(批文号：LCLL-2019-008)，患者知情同意。

2. 纳入标准：(1)通过腹部超声及增强计算机断层扫描(CT)或磁共振胰胆管成像(MRCP)以及内镜超声(EUS)确诊的胆总管结石患者(图1)；



图1 胆总管结石1例患者的术前影像资料 患者女性，80岁，间歇黄疸，伴上腹痛，腹部增强CT平扫显示胆总管巨大结石(白箭)

(2)胆总管结石直径>15 mm;(3)患者年龄 18–90 岁;(4)卡氏评分不低于 70 分;(5)不耐受或拒绝 ERCP 或外科手术。

3. 排除标准:(1)合并多发肝内胆管结石;(2)严重凝血功能障碍(凝血酶原时间>17 s 和/或血小板计数<60×10⁹/L);(3)恶病质或预期寿命不足 3 个月;(4)严重的心功能衰竭(根据纽约心脏病协会心功能分级标准:Ⅳ级);严重的通气功能障碍(第 1 秒用力呼气容积小于正常预计值的 35%);(5)处于妊娠或哺乳期的女性。

二、方法

1. PTPBD 操作流程:术前根据 CT 值判断结石的性质,CT 值≤40 HU 为胆固醇结石,CT 值>40 HU 为胆色素类结石,混合性结石表现为结石边缘呈环状高密度,中心为低密度的充盈缺损[9]。手术采用静脉麻醉(右美托咪啶)联合局部麻醉(利多卡因)。患者取仰卧位,在 DSA 引导下,于右侧腋中线第 8–9 肋间隙穿刺肝内胆管,穿刺成功后,先置入 8 Fr 鞘进行预扩张,行胆管造影,明确结石位置、大小(图 2A),之后置入 12 Fr 鞘(Olympus,日本),应用推动脉导管配合 150 cm 超滑导丝通过十二指肠乳头,进入十二指肠内,应用 10 mm×40 mm 球囊扩张乳头肌(图 2B)。通过 12 Fr 鞘将 9.8 Fr 输尿管软镜(Olympus,日本)置入胆管内,观察结石形态、位置,将 U100plus 激光纤维(W.O.M, Germain)通过输尿管镜的操作通道进入胆总管内,使其与胆总管结石密切接触,使用 120 mJ 或 160 mJ 单脉冲和 5 Hz 或 10 Hz 频率进行碎石(图 2C)。在激光碎石过程中,持续注入生理盐水以获得清晰的视野,同时提供激光碎石所需的液体环境。直视下发射激光粉碎结石,结石粉碎后,应用球囊将结石推送进入十二指肠内(图 2D)。然后进行镜检和胆管造影,确保所有结石均被清除(图 2E)。术后放置 10.2 Fr 外引流管(图 2F),1 周后重复胆管造影,如未发现残余结石,则移除导管;如有残留结石,则重复 PTPBD。对于合并有急性胆系感染的患者,先行胆管外引流,待 5–7 d,感染纠正后再行排石术。

2. 随访:所有病例自手术当天开始随访,随访至 2023 年 10 月。随访内容包括体格检查、实验室检查和影像学评估(图 3)。观察技术成功率、临床成功率及并发症情况。如胆总管结石完全清除则认为技术成功;无论患者有无残余结石,只要患者症状消失,则认为临床成功。并发症的详细信息按照介入放射学学会(SIR)标准,参见文献[10]。

三、统计学处理

所有数据使用 SPSS 统计 24.0(IBM,美国)进行分析。分类变量以数字和百分比表示。连续变量的正态分布通过 Kolmogorov-Smirnov 检验进行评估。对于正态分布的连续数据,采用 $\bar{x} \pm s$ 表示;对

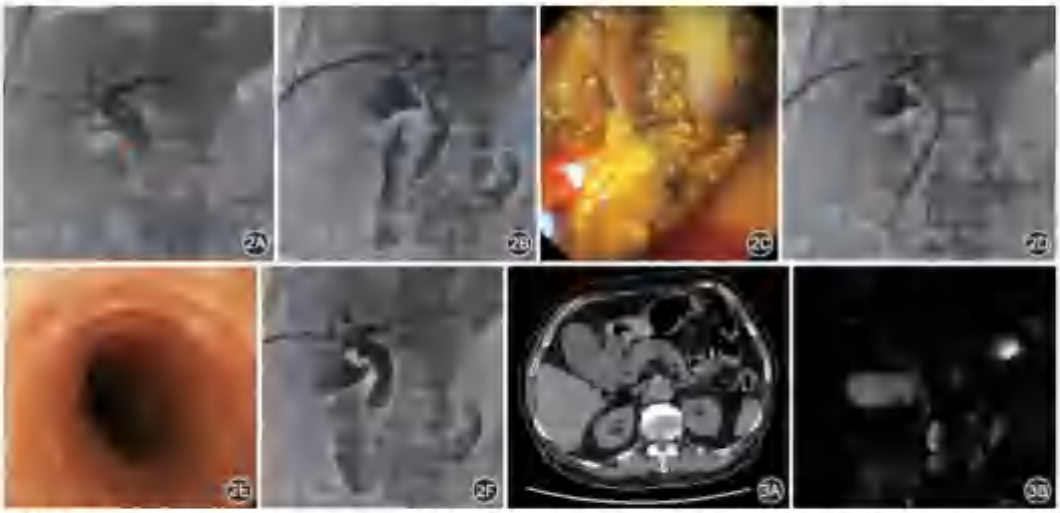


图 2　胆总管结石患者接受手术操作流程　经皮穿刺肝内胆管建立工作通道,胆管造影显示胆总管下大结石(2A,红箭),应用 10 mm×40 mm 球囊扩张十二指肠乳头肌(2B),经输尿管软镜于工作通道送入激光光纤,直视下应用激光粉碎结石(2C),然后应用球囊将结石推送入十二指肠内(2D),镜下查看胆总管内结石清失(2E),置双周径 10.2 Fr 外引流管,造影见胆总管内充盈缺损消失(2F)　图 3　与图 2 同一患者术后随访资料　术后 6 个月复查腹部 CT(仰卧位平扫)(3A),MRCP(3B)显示胆总管结石消失,未见复发

于非正态分布的数据用 $M(Q_1, Q_3)$ 表示。使用配对 t 检验比较术前、术后 1 周和 1 个月的检验数据，$P<0.05$ 为差异有统计学意义。

结　果

一、患者一般资料

26 例患者中，心肺功能不全 2 例，上消化道狭窄 1 例，麻醉禁忌证 1 例。既往病史中，ERCP 失败 6 例，不耐受 ERCP 或外科手术 4 例，拒绝 ERCP 或者外科手术 16 例。患者结石数量，1 个 12 例，≥2 个 14 例。结石类型为胆固醇结石 5 例，混合结石 2 例，胆色素结石 19 例。

二、术后结果

26 例患者均成功完成手术，技术成功率为 100%。最常用的激光碎石模式是 120 mJ 单脉冲和 5 Hz，占比为 69.2%（18/26）。所有类型结石的平均手术时间依次为胆固醇结石（65±9）min，混合型结石（82±4）min，胆红素结石（105±14）min（$t=3.9$，$P<0.05$）。不同类型结石的平均碎石频率依次为胆固醇结石 776（673–848）次，混合型结石 956（924–989）次，胆红素结石 1 550（1 008–3 325）次。患者丙氨酸转氨酶、总胆红素和白细胞计数在手术后逐渐恢复正常。术前和术后血清淀粉酶和血红蛋白水平差异无统计学意义（均 $P>0.05$）（表 1）。

表 1　患者术前术后实验室指标

指标	术前	术后 2 周	t 值	P 值
丙氨酸转氨酶（U/L）	101±51	35±8	13.66	<0.001
总胆红素（μmol/L）	65±19	22±5	12.71	<0.001
淀粉酶（U/L）	75±25	67±18	1.31	0.203
白细胞计数（×10⁹/L）	10.9±3.0	6.2±1.3	8.34	<0.001
血红蛋白（g/L）	122±7	122±6	−0.43	0.667

三、并发症及随访

主要并发症为轻度发热 11.5%（3/26），腹痛 11.5%（3/26），恶心 7.7%（2/26）和呕吐 3.8%（1/26）。未见胆汁性腹膜炎、胆管或十二指肠穿孔以及与手术相关的围手术期死亡。3 例患者在手术后 3 天淀粉酶水平升高，经生长抑素治疗后淀粉酶水平恢复正常。1 例患者术后胆管引流管引流出血性液体，应用止血药物治疗后出血停止。术后 2 年随访，未发现慢性胆管炎和结石复发病例。

讨　论

胆总管结石可引发梗阻性黄疸、胰腺炎、急性梗阻性化脓性胆管炎等严重并发症，特别对于合并心肺等基础疾病的高龄患者风险更大。尽管 ERCP 联合乳头肌切开术是目前胆总管结石的首选治疗方法，但在 10%–15% 的患者中，这一方法可能无法完全清除胆管结石，往往需要联合其他治疗方式[1]。

1986 年，Lux 等[2]就首次成功使用钬激光在人体内进行内镜逆行激光碎石术。随着激光技术的不断发展，激光碎石术已成为难治性胆总管结石的治疗选择之一。但目前已发表的研究中，涉及胆总管结石激光碎石的报道都是应用消化内镜引导，并且有些情况下内镜引导实施该手术十分困难。Verma 等[3]报道了 1 例 91 岁的巨大胆总管结石患者，多次接受 ERCP 治疗均未成功，包括 ERCP 联合钬激光碎石等。最终，介入放射学家经皮向胆管内置入 14 Fr 鞘，应用输尿管软镜直视下钬激光碎石成功。

PTPBD 是近年来新兴的微创治疗技术，尤其对于高龄、合并严重基础疾病等无法手术或内镜治疗失败的胆总管结石患者，PTPBD 具有一定的优势，其疗效及安全性已被大量研究证实[4]。作为一种冷激光，FREDDY 激光波长远低于人体软组织吸收产生热量的波长，所以不会造成结石周围的软组织热损伤[5]。目前临床上双频双脉冲激光主要用于传统外科手术、腹腔镜手术、内镜操作及 ERCP 等常规手段难以取出的胆管结石，而其在 PTPBD 中的应用鲜有报道。本研究在此基础上进一步探索，将 PTPBD 与 FREDDY 相结合，用于处理大直径困难胆总管结石，结果显示此种方法技术可缩短手术时间，提高结石清除率。

结石直径是影响手术成功率的一个主要因素，大直径胆总管结石是胆石症微创治疗的难点之一，直径超过 1.5 cm 的胆总管结石往往需要联合其他碎石手段[6]。Liu 等[7]开展了多中心前瞻性队列研究，对比 ERCP 与 PTPBD 治疗胆总管结石的效果，结果发现对于直径>15 mm 的结石，应用 ERCP 治疗的结石清除率为 90%，术后胰腺炎的发生率为 2%，胆管出血及十二指肠穿孔的发生率为 1%。本研究应用 FREDDY 激光碎石，结石清除率可达 100%，表现出显著的优势。近年来，乳头大球囊扩张术在 ERCP 治疗胆总管大结石中的应用逐渐增多，但大

球囊扩张能可能在一定程度上对十二指肠乳头括约肌的结构和功能造成损伤；同时由于大直径球囊对乳头的作用强烈，可能造成乳头水肿诱发胰腺炎[15]。汪静等[11]回顾性分析46例采用乳头大球囊扩张术治疗的大直径胆总管结石，术后胰腺炎发生率为15.2%，出血发生率为13%。本研究结果显示，PTPBD-FREDDY 治疗大直径胆总管结石胆管出血的发生率较低，而且未出现围手术期死亡、胰腺炎、肠道或胆管穿孔等严重并发症，可能原因为 FREDDY 激光的碎石效率较高，结石粉碎后体积变小，应用小直径球囊就能够将碎石推送入十二指肠内，从而减少了大球囊扩张可能造成的组织损伤。

总结操作的技术要点如下：(1)建立工作通道时需逐级扩张，先置 8 Fr 鞘，应用导丝配合导管通过十二指肠乳头肌，进入肠道内，之后置换送入周径 12 Fr，长度 35 cm 长鞘，远端位于肝总管内。(2)应用球囊扩张十二指肠乳头肌时，应逐渐增加压力，充分扩张。(3)置入输尿管软镜时要轻柔，避免镜头损伤。(4)激光碎石操作过程中，注意保持激光光纤在工作视野内，避免尖端划伤周围组织。

本研究结果表明在传统治疗难以实施或失败的情况下，PTPBD-FREDDY 激光碎石术可以作为一种安全有效的替代治疗方法，不仅技术成功率高，术后并发症也非常轻微，具有良好的前景。

利益冲突 所有作者声明无利益冲突

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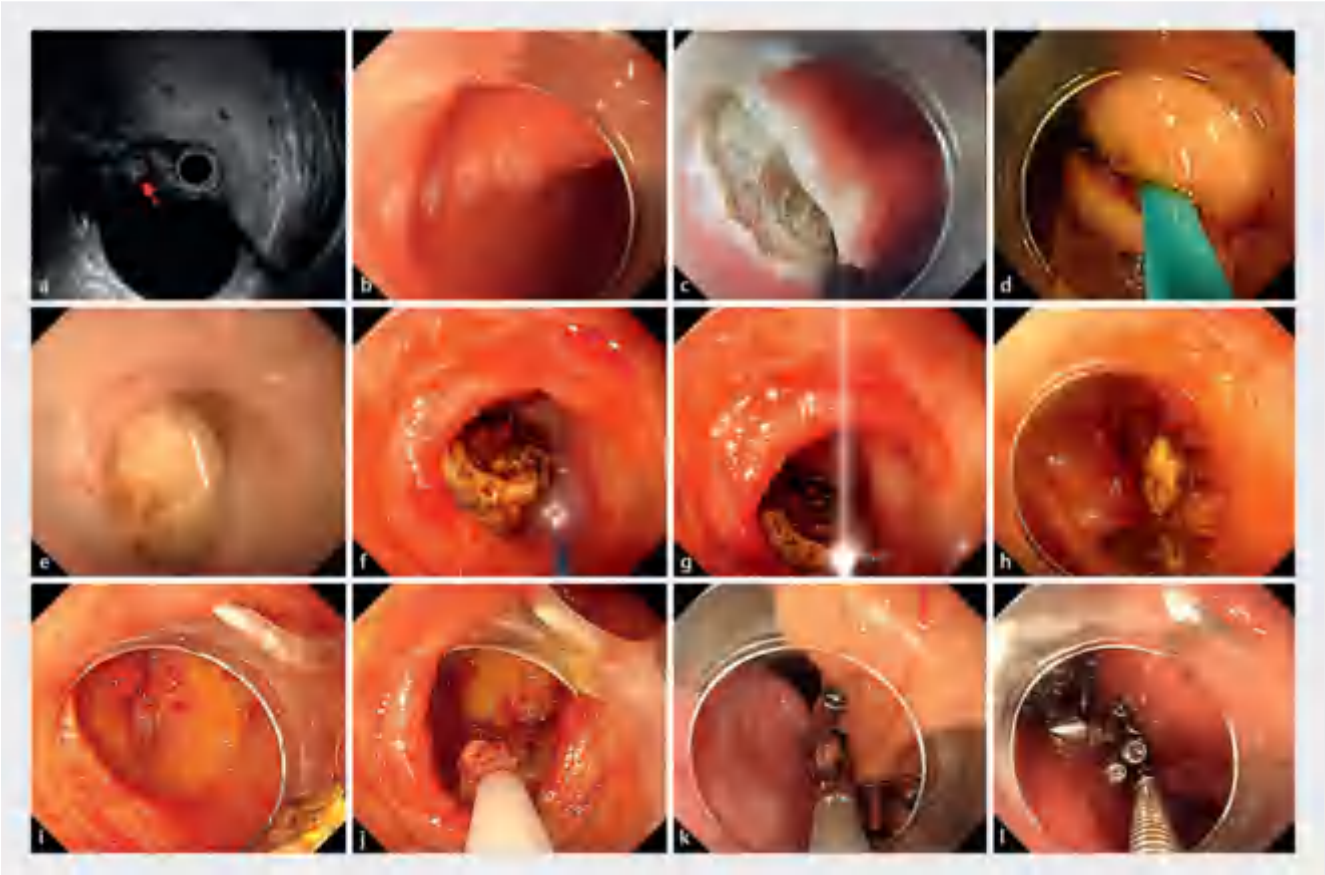
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A novel "NOTES" technique for treating incarcerated stones in the gallbladder neck

OPEN ACCESS

Incarceration of stones in the gallbladder neck often causes acute inflammation and, in severe cases, even pyogenic gangrene. Medical treatment is often ineffective, and guidelines recommend laparoscopic cholecystectomy (LC) as the preferred treatment within 24 to 72 hours of onset [1, 2]. However, this procedure carries a relatively high risk of adverse events, including bile duct injury, postoperative bile leakage, common bile duct stones, and other serious problems [3]. In nonsurgical patients, endoscopic options such as endoscopic ultrasound (EUS)-guided drainage with metal stents have improved the treatments that could be offered [4, 5]. In this report, we first present a novel endoscopic solution, derived from NOTES, to address stone obstruction of the gallbladder neck.

A 59-year-old woman presented with right epigastric pain for 1 month, which had worsened over the past 2 days. Abdominal ultrasonography, hepatobiliary scintigraphy and EUS revealed an incarcerated stone of approximately 13 × 12 mm in the gallbladder neck as the underlying cause. The patient declined LC and requested preservation of her gallbladder. To address the issue, we performed endoscopic laser lithotripsy and lithotomy through a transgastric mini-incision of the cholecystic fundus (▶ Fig. 1, ▶ Video 1). During the procedure, the anterior wall of the gastric antrum was perforated with a sterile colonoscope (PCF-Q260JI, 3.2-mm channel diameter; Olympus, Tokyo, Japan). Subsequently, the gallbladder fundus was located and a 3- to 4-mm incision was made using a flush knife (Fuji, Tokyo, Japan). Incision occlusion was achieved with a lithotomy



▶ Fig. 1 Endoscopic laser lithotripsy and lithotomy through transgastric mini-incision of the cholecystic fundus for treatment of an incarcerated stone in the gallbladder neck of a 59-year-old woman. a EUS showed an incarcerated stone in the gallbladder neck. b, c Active perforation of the anterior wall of the gastric antrum. d Making a 3- to 4-mm incision of the cholecystic fundus and exchanging the suppurative bile with normal saline after incision occlusion with a lithotomy balloon. e An incarcerated stone was found embedded in the entrance to the gallbladder neck. f, g, h Laser lithotripsy and lithotomy. i, j Gallbladder lavage and biopsies of superficial protuberant red lesion. k Closure of the gallbladder incision with clips. l Closure of the gastric wall.

VIDEO



▶ Video 1 Endoscopic laser lithotripsy and lithotomy through a transgastric mini-incision of the cholecystic fundus for treatment of an incarcerated stone in the gallbladder neck of a 59-year-old woman.

balloon (Micro-Tech, Nanjing, China) to prevent bile leakage, followed by thorough exchanges of suppurative bile with normal saline. After adequate gallbladder lavage, the incision was widened to 12 to 14 mm. Upon entering the gallbladder cavity, congestion and edema of the gallbladder wall were observed, along with an incarcerated stone embedded in the entrance to the gallbladder neck. Laser lithotripsy (U100plus lithotripter-Laser, W.O.M. WORLD OF MEDICINE AG, Berlin, Germany) was performed using a laser fiber (560 µm × 3.5 m, SiliconFlex 300Rplus, Berlin, Germany) to fragment the stones, which were subsequently extracted using an extraction bag (Alton, Shanghai, China). The gallbladder cavity was flushed and biopsies of a 5-mm superficial, protuberant, red lesion were taken. Finally, the gallbladder incision was closed, the abdominal cavity was flushed, and the gastric wall was closed. The patient had an uneventful postoperative course and was discharged 3 days after the endoscopic surgery. Pathology of the gallbladder wall indicated inflammation of the cells. During the 15-month follow-up, the patient's symptoms completely resolved, and no obvious stones were detected in her gallbladder by ultrasonography at her 1-month and 6-month follow-up visits. Thus, endoscopic laser lithotripsy and lithotomy through a transgastric mini-incision of the cholecystic fundus might offer a feasible approach for management of incarcerated stones in the gallbladder neck, especially solitary stones.

Conflict of Interest

The authors declare that they have no conflict of interest.

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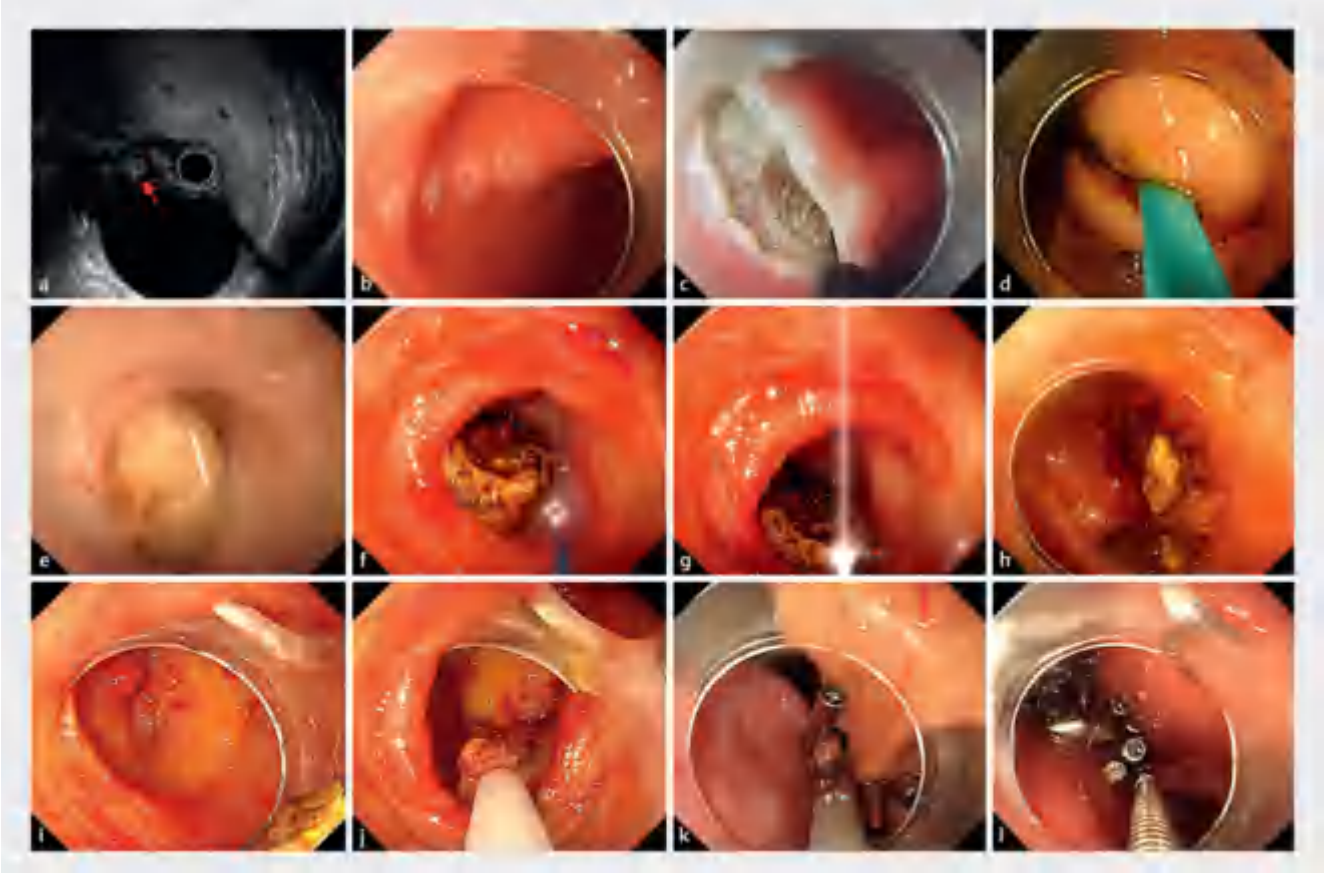
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一种治疗胆囊颈结石的新型“NOTES”技术

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胆囊颈结石发生嵌顿时常引发急性炎症，严重时甚至可能发展为化脓性坏疽。目前医学治疗效果显著，指南推荐在发病后24至72小时内采用腹腔镜胆囊切除术（LC）作为首选治疗方案[1,2]。但该手术存在较高风险，可能引发胆管损伤、术后胆漏、胆总管结石等严重并发症[3]。对于非手术患者，内镜下治疗方案（如超声内镜（EUS）引导下金属支架引流术）可改善可提供的治疗选择[4,5]。本报告首次提出一种源自NOTES的新型内镜解决方案，用于治疗胆囊颈结石梗阻。

患者，女，59岁，右上腹疼痛1个月，近2天加重，腹部超声检查、肝胆显像及超声内镜检查显示胆囊颈结石约13×12mm，为潜在病因，患者拒绝肝切除术（LC）并要求保留其胆囊。为解决该问题，我们通过经胃小切口胆囊底内镜激光碎石术(▶图1，视频1）实施手术。术中使用无菌结肠镜（型号PCF-Q260JI，3.2毫米通道直径；日本东京奥林巴斯公司）穿刺胃窦前壁进行穿刺。随后定位胆囊底部，采用冲孔刀（日本东京富士公司）制作3-4毫米切口，通过使用一种经皮肾镜取石球囊（产自



▶图1通过经胃小切口胆囊底内镜激光碎石术及取石术治疗59岁女性胆囊颈梗阻结石。a腹式超声显示胆囊颈存在梗阻结石。b、c胃窦前壁活动性穿孔。d切开胆囊底3-4毫米切口，用取石球囊封闭切口后注入生理盐水置换脓性胆汁。e发现梗阻结石嵌于胆囊颈入口处。f、g、h激光碎石及取石术。i、j胆囊灌洗及浅表隆起红色病灶活检。k胆囊切口缝合闭合。l胃壁缝合闭合。

磁带录像



▶ 视频1通过胆囊底经胃小切口进行内窥镜激光碎石术和碎石术治疗59岁女性胆囊颈部嵌顿结石。

中国南京的微技术公司）实现了切口封堵，以防止胆汁泄漏。随后通过胸腔引流将脓性胆汁与生理盐水进行彻底置换。充分胆囊灌洗后，将切口扩大至12-14毫米。进入胆囊腔后，可见胆囊壁充血水肿，并发现嵌顿结石位于胆囊颈入口处。采用激光碎石仪(U100 plus激光碎石机-Laser，德国柏林W.O. M.世界医学股份公司）配合激光光纤（560μm×3.5米，SiliconFlex 300Rplus，德国柏林）碎裂结石，随后使用取石袋（上海奥顿公司）取出结石。冲洗胆囊腔后，取样活检一处5毫米的浅表隆起红色病灶。最终缝合胆囊切口，冲洗腹腔气体后关闭气管切口。患者术后恢复顺利，于内镜手术后3天出院。胆囊病理检查显示细胞炎症。在15个月的随访期间，患者症状完全消失，且在1个月和6个月的随访中，超声检查未发现其胆囊内有明显结石。因此，通过经胃小切口胆囊底内镜激光碎石术联合取石术，可能为治疗胆囊颈部嵌顿结石（尤其是孤立性结石）提供可行方案。

违背公众利益的行为

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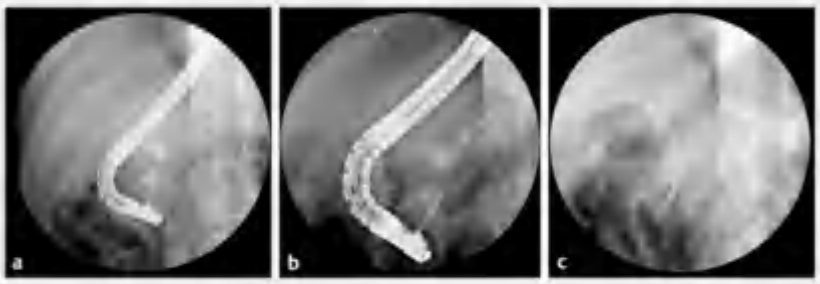
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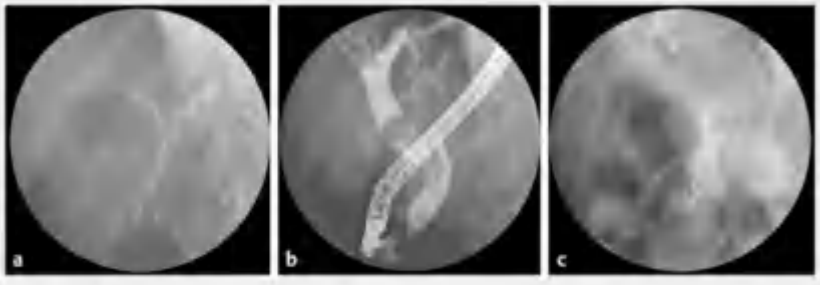
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Removal of lollipop-shaped stent-stone complex using direct-vision laser lithotripsy

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▶ Fig. 1 Initial ERCP findings (3 y prior). a Cholangiography showed a smooth, symmetrical stricture in the pancreatic segment of the common bile duct with upstream dilation. b Pancreatography revealed a slender, smooth stricture in the pancreatic head region of the main pancreatic duct, with mild dilation in the body and tail. c Plastic stents were placed in both the bile and pancreatic ducts.



▶ Fig. 2 Emergency ERCP findings (1 mo prior). a Biliary and pancreatic plastic stents were seen in situ, with cast-like pancreatic duct stones along the pancreatic stent. b Cholangiography revealed a round filling defect encasing the stent, forming a lollipop-shaped stent-stone complex. c A second biliary stent was placed alongside the original.



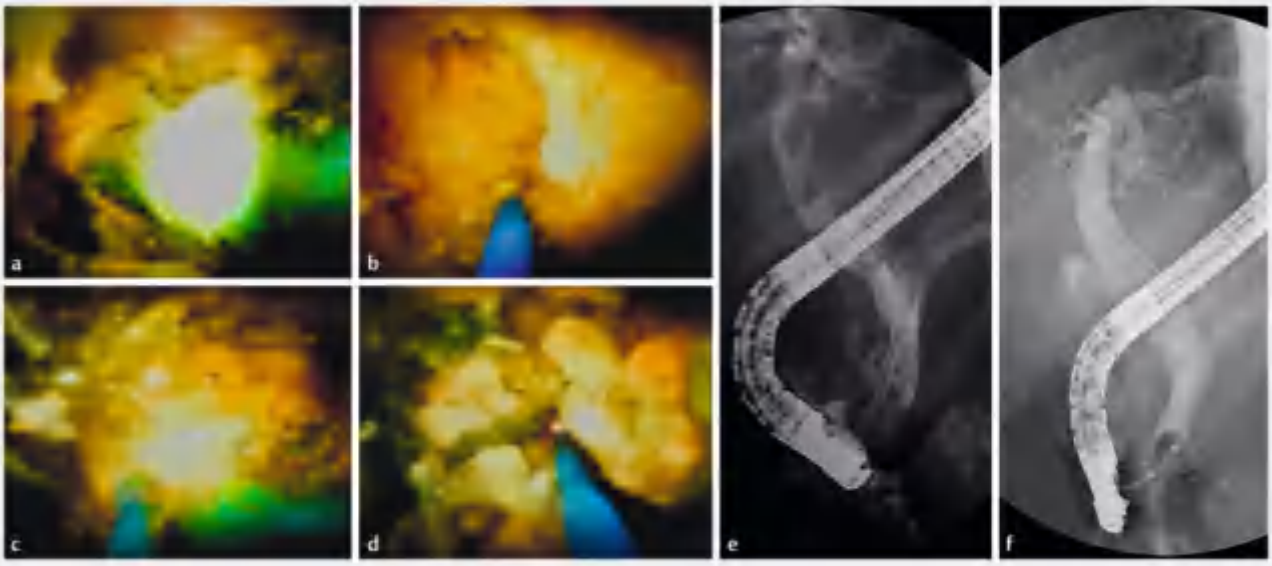
▶ Video 1 Removal of lollipop-shaped stent-stone complex using direct-vision laser lithotripsy.

Long-term retention of biliary plastic stents (PS) can lead to a rare complication: the formation of a lollipop-shaped stent-stone complex (LSSC) [1], where stones encase the proximal end of the stent, making endoscopic removal technically difficult. We report a case of successful LSSC removal using peroral cholangioscopy (POCS)-guided frequency-doubled dual pulse Nd:YAG (FREDDY) laser lithotripsy.

A 72-year-old man, previously diagnosed with IgG4-related sclerosing cholangitis, underwent biliary and pancreatic PS placement three years prior to alleviate obstructive jaundice (▶ Fig. 1), followed by corticosteroid therapy. He was lost to follow-up. One month before admission, he presented with jaundice and fever. Emergency ERCP showed resolution of the biliary stricture but revealed a retained LSSC in the common bile duct (CBD). Removal attempts using standard tools failed, fracturing the stent at the duodenal lumen. A supplementary PS was placed to ensure drainage (▶ Fig. 2). Following stabilization, repeat ERCP was performed using POCS-guided laser lithotripsy. The PS was fully encased in yellow stones, forming an LSSC. FREDDY laser lithotripsy (U-100 Plus; World of Medicine, Berlin, Germany) was applied at the stent-stone interface under direct visualization to fragment the stones and gradually release the stent. The stent was successfully removed, and residual stones were cleared (▶ Fig. 3, ▶ Video 1). The patient recovered well and was discharged three days later.

LSSC formation is associated with long-term stent retention (≥301 days) and CBD dilation [2]. The potential for LSSC formation should be considered in patients with long-term PS indwelling and dilated CBD. Endoscopic LSSC removal is technically challenging: standard endoscopic tools may fail, and forcible extraction risks ductal injury and perforation. Extracorporeal shock wave lithotripsy is technically complex [3], while surgical intervention is traumatic. FREDDY laser lithotripsy is safer than Ho:YAG laser and electrohydraulic lithotripsy [4,5]. POCS-guided FREDDY laser lithotripsy offers a safe, minimally invasive, and effective approach for LSSC management.

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▶ Fig. 3 POCS-guided laser lithotripsy for LSSC removal. a POCS visualized a blue plastic stent encased in yellow stones, forming an LSSC. b, c A laser fiber was applied to the stent-stone interface and large stone. d Lithotripsy successfully fragmented the stone. e Cholangiography confirmed LSSC resolution and stone fragmentation. f Both stent and stone fragments were removed; balloon-occluded cholangiography showed no residual filling defects.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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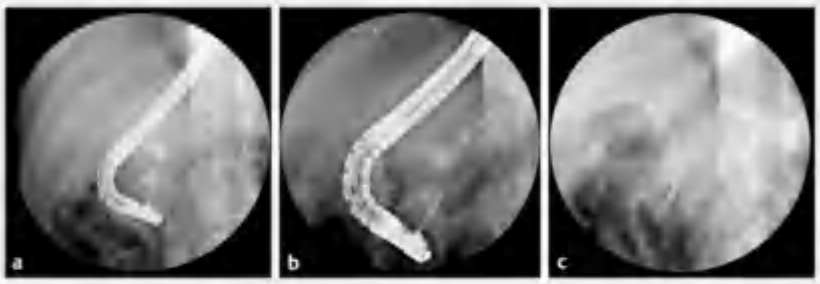
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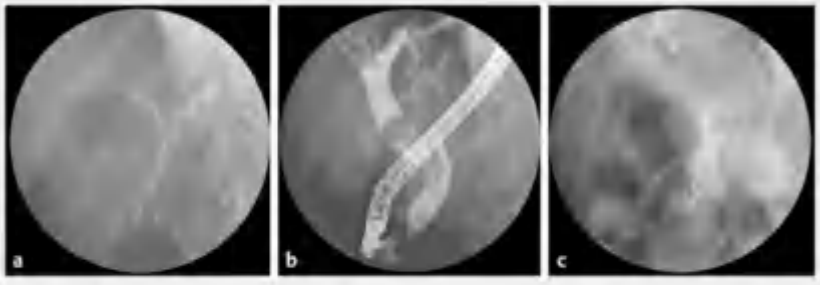
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直视下激光碎石术清除棒棒糖形支架结石复合体

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▶图1初始ERCP检查结果（3年前）。a胆管造影显示，共同胆管胰段存在光滑对称狭窄，上游段扩张。b胰腺造影显示，主胰管胰头段狭窄管腔细长光滑，胰体和胰尾段轻度扩张。c在胆管和胰管中均置入了塑料支架。



▶图2紧急ERCP检查结果（1个月前）。a胆道与胰腺塑料支架原位可见，胰腺支架周围可见铸型胰管结石。b胆道造影显示支架周围存在圆形充盈缺损，形成棒棒糖状支架结石复合体。c在原有支架旁放置了第二根胆道支架。

胆道塑料支架（PS）长期留置可能导致罕见并发症——棒棒糖样支架结石复合体（LSSC）[1]。这种结石包裹支架近端的情况，使得内镜取石技术难以实施。本文报道一例采用经口胆道镜（POCS）引导下，采用频率加倍双脉冲Nd：YAG（Freddy）激光碎石术成功清除LSSC的病例。

一名72岁男性患者，此前确诊为IgG4相关硬化性胆管炎，在3年前接受了胆道和胰腺PS置入术，以缓解梗阻性黄疸（▶图1），确诊后开始接受皮质类固醇治疗，但患者随后失访。入院前一个月，患者因黄疸和发热就诊。急诊ERCP显示胆道狭窄已缓解，但发现胆总管（CBD）内存在残留胆总管结石（LS-SC）。使用标准器械尝试取出失败，导致十二指肠腔内支架断裂。为确保引流效果，追加置入辅助性PS（▶图2）。病情稳定后，采用经内镜超声引导的激光碎石术（POCS-GLE）进行二次ERCP检查。PS被黄色石块完全包裹，形成一个LSSC 。

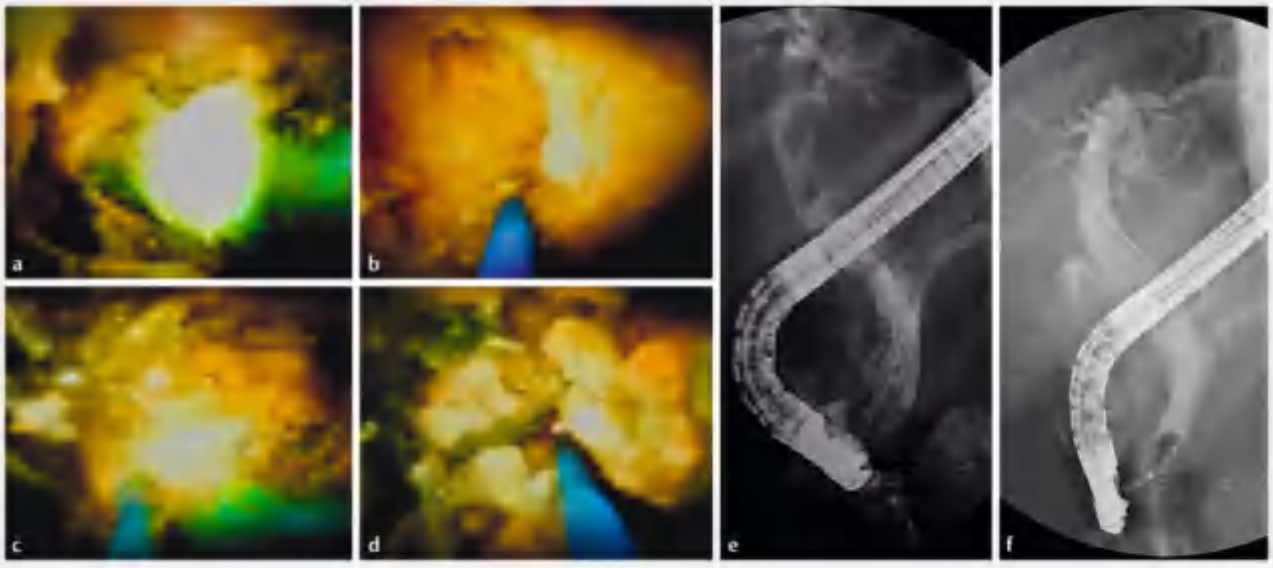


▶视频1：采用直视激光碎石术移除棒棒糖形支架结石复合体

在直接可视化下，对支架-结石界面进行FREDDY激光碎石（U-100Plus；World of Medicine，Berlin，Germany）以碎石并逐渐释放支架。支架被成功取出，残留结石被清除（▶图3， 视频1）。患者恢复良好，3天后出院。

LSSC的形成与支架长期留置（≥301天）及胆总管扩张相关[2]。对于长期留置PS支架且胆总管扩张的患者，需考虑LSSC形成的潜在风险。内镜下LSSC切除技术难度较高：标准内镜器械可能失效，强行取出可能导致胆管损伤或穿孔。体外冲击波碎石术技术复杂[3]，而外科手术创伤较大。Freddy激光碎石术比Ho：YAG激光和电液碎石术更安全[4,5]。POCS引导下的Freddy激光碎石术为LSSC管理提供了安全、微创且有效的解决方案。

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▶图3 POCS引导激光碎石术清除LSSC。a POCS显示蓝色塑料支架包裹黄色结石，形成LSSC。b、c在支架与结石的接触面及大结石处使用激光光纤进行碎石治疗。d碎石术成功粉碎结石。e胆道造影显示结石完全溶解且碎石效果良好。f术后支架与碎石均被取出，球囊阻断胆道造影未见残留充盈缺损。

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胆道镜下双频双脉冲激光碎石治疗胆道术后残余结石的疗效及安全性分析

陈馨　方艳燕　杜苏明　杜俊杰　姚君霞　黄振南　潘凡

［摘要］ **目的**　探讨胆道镜下双频双脉冲激光碎石治疗胆道术后结石残余的疗效及安全性。**方法**　2014 年 8 月～2022 年 12 月收治的胆道术后残余结石病人 112 例，按照治疗方式分为两组：观察组 63 例，采用胆道镜下双频双脉冲激光碎石治疗；对照组 49 例，采用胆道镜下常规网篮取石治疗。比较两组病人结石取尽情况、并发症情况、围手术期相关指标、手术情况等相关指标。**结果**　观察组和对照组结石取净率分别为 95.2% 和 73.5%，平均取石次数分别为 2 次和 3 次，平均手术时间分别为 22.8 分钟和 24.1 分钟，两组比较差异有统计学意义（$P<0.05$）。观察组术后谷氨酰转肽酶水平低于对照组（63 U/L vs. 109.0 U/L，95% CI：-63～-9，$P<0.05$），且观察组术后谷氨酰转肽酶降低程度大于对照组（-40.8 U/L vs. -28.0 U/L，95% CI：-23.5～-0.8，$P<0.05$），差异有统计学意义。观察组和对照组并发症发生率分别为 1.6% 和 14.2%，两组比较差异有统计学意义（$P<0.05$）。**结论**　胆道镜下双频双脉冲激光碎石治疗胆道术后残余结石具有高效、安全、便捷等优势。

［关键词］ 双频双脉冲激光；　胆道镜；　胆道术后残余结石；　碎石术

Efficacy and safety analysis ofcholedochoscopic dual-frequency dual-pulse laser lithotripsy in the treatment of postoperative biliary residual stones

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［**Abstract**］ **Objective**　To investigate the efficacy and safety of choledochoscopic dual-frequency dual-pulse (DFDP) laser lithotripsy for the treatment of postoperative biliary tract stone remnants. **Methods**　A total of 112 patients with residual stones after biliary tract surgery admitted from August 2014 to December 2022 were divided into two groups according to treatment modalities. The observation group ($n=63$) received choledochoscopic DFDP laser lithotripsy, while the control group ($n=49$) underwent conventional basket extraction. We compared stone clearance rates, complications, perioperative indicators, and surgical outcomes between the two groups. **Results**　The stone extraction rate of the observation group was significantly higher than that of the control group (95.2% vs. 73.5%, $P<0.05$), and the difference was statistically significant. Compared with the control group, the observation group had fewer average stone removals (two times vs three times, $P<0.05$) and shorter average operation time (22.8 min vs. 24.1 min, $P<0.05$). The postoperative gamma-glutamyl transferase (GGT) level of the observation group was lower than that of the control group (63 U/L vs. 109.0 U/L, 95% CI: -63～-9, $P<0.05$), and the degree of postoperative GGT reduction in the observation group was greater than that in the control group (-40.8 U/L vs. -28.0 U/L, 95% CI: -23.5～-0.8, $P<0.05$), the differences were both statistically significant. The observation group demonstrated a statistically significant reduction in complication rate compared to control group (1.6% vs. 14.2%, $P<0.05$). **Conclusion**　DFDP laser lithotripsy under choledochoscopy for the treatment of residual stones after biliary surgery has the advantages of high efficiency, safety and convenience.

［**Key words**］ dual-frequency dual-pulse laser;　choledochoscopy;　postoperative biliary residual stones;　lithotripsy

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肝内外胆管结石具有高结石残留率、高术后复发率、高二次手术率的临床特征[1]。手术是肝胆管结石最有效的治疗方法[2]，取尽结石是该病治疗的核心[3]。部分结石直径过大、质地过硬、铸型、出现嵌顿等，一期手术无法取尽致使结石残留。二次手术难度大、创伤大。双频双脉冲(DFDP)激光理论上可在实现结石高效分解的同时规避胆道软组织热损伤风险，是理想的碎石设备，近年来被运用于胆道结石的碎石治疗[4]。我们自 2014 年 8 月起开展胆道镜下常规网篮取石治疗，于 2016 年 1 月开展胆道镜下 DFDP 激光碎石治疗。本研究回顾性分析相关病例资料，对比两种治疗方式的临床疗效及并发症情况。

对象与方法

一、对象

2014 年 8 月～2022 年 12 月期间收治胆道术后残余结石病人 112 例。按照治疗方式分为两组：对照组 49 例，行胆道镜下常规网篮取石治疗；观察组 63 例，行胆道镜下 DFDP 激光碎石治疗。为预留术后胆道镜操作空间，病人留置 18FT 管，术后组织包绕 T 管形成窦道直径约 0.8 cm，因此将直径≥0.8 cm，无法直接通过窦道的结石纳入难治性结石；同时将影像学提示高密度(CT 值范围为 100～200 HU)的质硬结石或影像学提示阳性但胆道镜下呈铸型、嵌顿、堆砌，不具备网篮直接套取条件的结石纳入为难治性结石。本研究经医院伦理委员会批准，且病人均已知情同意。

纳入标准：(1)胆道探查术后留置 T 管时长开腹手术≥6 周，腹腔镜手术≥8 周；部分高龄、严重糖尿病、营养不良、腹腔积液或长期服用激素的病人，窦道形成缓慢，可酌情延长至手术后≥12 周；(2)影像学检查(MRCP、彩超、CT、经 T 管胆道造影等)明确诊断胆道内存在残余结石；(3)结石直径≥0.8 cm、结石质地坚硬或铸型、嵌顿、堆砌等难治性残余结石；(4)临床资料完整。排除标准：存在严重循环、呼吸、血液、精神系统疾病，无法耐受胆道镜治疗；治疗过程中因其他疾病中断治疗或无法行多次胆道镜治疗；窦道、胆管狭窄或 T 管意外脱落，胆道镜无法进入；术后失访或拒绝接受影像学复查。两组病人基线资料比较，差异无统计学意义($P>0.05$)。见表 1。

二、方法

1. 设备：U100plus 激光碎石机，Olympus 胆道镜，胆道镜摄像系统，取石网篮等。

2. 手术方法：两组病人术前均签署知情同意书，手术均由同一人完成。病人取平卧位，予吸氧，静脉滴注氟比洛芬酯镇痛。拔除原有 18F 型号 T 管，利多卡因表面麻醉。胆道镜循窦道缓慢进入，边进镜边生理盐水冲洗，结合影像学资料定位结石，镜下直视残余结石。(1)对照组：行胆道镜下常规网篮取石治疗。取石网篮或取石钳抓取结石；如遇结石较大或嵌顿，则采用取石网篮捣碎联合取石钳钳夹方式使结石碎裂后成小块，再联合高压冲洗及网篮套取等方式拖拽取出结石。(2)观察组：行胆道镜下 DFDP 激光碎石治疗。

表 1　两组术前基线资料比较

基线资料	对照组(49 例)	观察组(63 例)	$t/\chi^2/Z$	P
性别(例,%)			$\chi^2=-1.162$	0.245
男	21(42.9)	34(54)		
女	28(57.1)	29(46)		
年龄(岁)	62.38±13.68	60.22±11.24	$t=0.893$	0.374
身体质量指数(kg/m²)	21.62±2.68	21.26±2.28	$t=0.782$	0.438
白细胞计数(×10⁹/L)	6.24±1.46	6.41±1.53	$t=-0.581$	0.562
血小板计数(×10⁹/L)	214.38±59.45	206.65±59.69	$t=0.681$	0.497
凝血酶原时间(s)	11.89±0.84	11.71±0.48	$t=1.383$	0.185
总胆红素(μmol/L)	9.2(4.2,55.2)	7.5(3.4,57.9)	$Z=-0.349$	0.727
直接胆红素(μmol/L)	5.2(2.6,32.3)	4.8(2.2,39.3)	$Z=-0.739$	0.472
丙氨酸氨基转移酶(ALT,U/L)	32.0(9.0,196.0)	21.3(10.5,204.4)	$Z=-1.645$	0.100
门冬氨酸氨基转移酶(AST,U/L)	29.0(16.0,204.0)	22.4(12.2,143.5)	$Z=-1.927$	0.054
谷氨酰转肽酶(U/L)	81.0(28.0,605.0)	55.0(20.0,823.1)	$Z=-1.372$	0.170
碱性磷酸酶(U/L)	111(67,453)	106(59,641)	$Z=-0.487$	0.626
结石长径大小(cm)	1.36±0.23	1.42±0.26	$t=1.242$	0.221
结石分布位置(例,%)			$\chi^2=0.651$	0.885
肝左叶	11(22.5)	15(23.8)		
肝右叶	15(30.6)	16(25.4)		
肝左、右叶	15(30.6)	23(36.5)		
肝总管	8(16.3)	9(14.3)		

万方数据

针对质地较硬、嵌顿或巨大结石，在生理盐水冲洗的同时，设置 DFDP 激光碎石仪参数（能量单相 120 mJ，频率为 10 Hz），循镜置入激光光纤，头端抵住结石中央激发激光，每次激发时间 2～3 s，可连续多次激发，配合生理盐水间断冲洗及震荡，直至结石分解成细小若干块，用取石网篮逐一取出，或自行排出。

3. 结石取净标准：（1）胆道镜检查未见结石残留；（2）影像学检查：胆道造影、CT、MRCP、彩超检查未见结石残留征象。达到取尽标准后可拔除 T 管。如未取尽，则重置 18F 引流管，间隔 1 周后再次行胆道镜探查至取尽结石。

4. 观察指标：（1）结石取尽情况：结石取尽率、结石一次取尽率；（2）围手术期实验室指标：包括术前术后炎症指标、肝功能指标。（3）手术相关情况：包括平均取石次数、平均手术时间、平均住院时间。（4）并发症：包括胆道感染、胆道穿孔、胆漏、胆道出血、窦道损伤、腹痛腹泻等。

5. 随访：采用电话或门诊方式随访，随访时间 24 个月。通过胆道造影、彩超、CT、MRCP 等检查明确最终结石取尽情况及残留或复发情况。

三、统计学方法

采用 SPSS 25.0 软件分析数据。符合正态分布计量资料用均数 ± 标准差（$\bar{x} \pm s$）表示，两组间比较采用 t 检验；不符合正态分布的计量资料用 M（P25，P75）表示，两组间比较则采用 Mann－Whitney U 检验。计数资料用例（%）表示，两组间比较采用 χ^2 检验。$P < 0.05$ 为差异有统计学意义。

结　果

1. 两组手术情况见表 2。观察组结石取净率高于对照组，差异有统计学意义（$P < 0.05$）。两组结石一次取净率差异无统计学意义（$P > 0.05$）。观察组平均取石次数少于对照组，术后 γ-谷氨酰胺转移酶（GGT）水平低于对照组，平均手术时间短于对照组，差异有统计学意义（$P < 0.05$）。两组术后白细胞计数、血小板计数、凝血酶原时间、总胆红素、直接胆红素、ALT、AST、碱性磷酸酶等比较，差异均无统计学意义（$P > 0.05$）。两组平均住院时间相比差异无统计学意义（$P > 0.05$）。

2. 两组并发症发生情况见表 3。观察组病人并发症发生率显著低于对照组，两组比较差异有统计学意义（$P < 0.05$）。

3. 两组术前术后实验室指标变化情况见表 4。结果表明，观察组术前术后 GGT 水平下降程度大于对照组，差异有统计学意义（$P < 0.05$）。其他指标变化值比较，差异无统计学意义（$P > 0.05$）。

4. 两组术后随访情况：112 例病人均完成全程随访，随访时间 24 个月。对照组中 13 例病人结石未取尽，其中 3 例行二次手术取石，且因胆道狭窄术后 24 个月结石再发。观察组病人随访期内未出现结石复发。

讨　论

经 T 管窦道胆道镜技术通过可视化操作实现多靶次、微创化取石，有效降低二次手术率[5]。但对于因体型过大、铸型嵌顿或合并胆道狭窄，弯曲、畸形成等胆道解剖变异导致的难治性结石，单纯依靠常规网篮取石存在技术局限性。DFDP 激光碎石系统可同步激发波长为 532 nm、1 064 nm 的绿激光和近红外激光，前者在结石表面形成均匀分布的等离子体，后者为等离子体赋能，增强冲击波效应，从而震碎结石[6]。该双波长激光对人体软组织无热损伤效应，理论上具有极高的临床应用安全性。

本研究结果显示，观察组结石取净率高于对照组，

表 2　两组手术情况比较

组别	例数	结石取净[例（%）]		结石一次取净[例（%）]		平均取石次数（次）	平均手术时间（min/次）	平均住院时间（天/次）
		是	否	是	否			
对照组	49	36（73.5）	13（26.5）	17（34.7）	32（65.3）	3.0（1.0，5.0）	24.1 ± 3.1	2.0（1.5，2.5）
观察组	63	60（95.2）	3（4.8）	25（39.7）	38（60.3）	2.0（1.0，2.0）	22.8 ± 2.3	1.5（1.0，2.0）
$t/\chi^2/Z$		$\chi^2 = 8.963$		$\chi^2 = 0.293$		$Z = -2.395$	$t = -2.450$	$Z = -1.755$
P		0.003		0.695		0.017	0.016	0.079

注：平均手术时间指每位病人行 1 次胆道镜治疗的平均时间；平均住院时间指每位病人 1 次住院的平均时长。

表 3　两组并发症情况[例（%）]

组别	例数	胆漏	胆管炎	窦道损伤	胆道出血	腹痛泻	胆瘘	总计
对照组	49	2（4.1）	3（6.1）	1（2.0）	0	0	1（2.0）	7（14.2）
观察组	63	1（1.6）	0	0	0	0	0	1（1.6）
$t/\chi^2/Z$								$\chi^2 = 6.701$
P								0.020

万方数据

表 4 两组术前术后实验室指标变化情况

组别		例数	白细胞计数($\times10^9$/L)	血小板计数($\times10^9$/L)	凝血酶原时间(s)	总胆红素(μmol/L)	直接胆红素(μmol/L)
对照组	术前	49	6.24±1.46	214.38±59.45	11.89±0.84	9.2(4.2,55.2)	5.2(2.6,32.3)
	术后	49	6.76±1.53	197.06±50.30	11.66±0.42	12.6(8.7,87.1)	7.2(5.3,17.6)
	变化值	49	0.39(0.02,0.81)	−12(−19,0)	0.1(−0.1,0.3)	−0.7(−1.6,0.6)	0.4(−0.8,1.1)
观察组	术前	63	6.41±1.53	206.65±59.69	11.71±0.48	7.5(3.4,57.5)	4.8(2.2,39.3)
	术后	63	6.66±1.77	205.46±50.22	11.85±0.67	12.2(7.5,46.4)	6.9(5.0,8.9)
	变化值	63	0.30(−0.37,0.86)	−12(−16,4)	0.1(−0.3,0.3)	−0.7(−2.2,0)	−0.3(−0.9,1.2)

组别		例数	ALT(U/L)	AST(U/L)	GGT(U/L)	碱性磷酸酶(U/L)
对照组	术前	49	32.0(9.0,106.0)	29.0(16.0,204.0)	81.0(28.0,605.0)	111.0(67.0,455.0)
	术后	49	42.0(31.5,72.0)	41.0(28.0,49.0)	109.0(51.5,176.0)	104.0(82.5,142.5)
	变化值	49	−7.0(−12.0,1.5)	−4.0(−10.0,6.0)	−28.0(−46.0,−15.0)	−45.0(−61.5,−30.0)
观察组	术前	63	21.3(10.5,204.4)	22.4(12.2,143.5)	55.0(20.0,823.1)	106.0(59.0,641.0)
	术后	63	38.4(24.3,68.2)	32.3(23.9,50.4)	63.0(41.7,118.0)*	97.3(78.4,153.0)
	变化值	63	−3.1(−9.4,3.4)	1.6(−4.8,5.9)	−40.8(−75.2,−19.1)*	−44.0(−63.5,−26.4)

注：*与对照组相比，*P<0.05

观察组平均取石次数、平均手术时间均显著减少，说明 DFDP 激光碎石技术能够有效提高复杂残余结石的清除效率。观察组术后 GGT 水平明显降低，且降低幅度大于对照组，说明该技术能够更大程度缓解甚至解除胆道梗阻，减少胆汁瘀滞，为后期肝功能的恢复创造有利条件。但两组结石一次取尽率比较差异无统计学意义，一方面与残余结石散在分布的特征有关；另一方面，碎石后结石成渣需通过 T 管引流系统逐步排出，此过程一定程度上延长了治疗时间。

观察组并发症发生率低于对照组，仅有 1 例病人出现轻微腹痛症状，考虑与操作时冲洗液流速过快致使胆道内压力骤升有关，休息后症状自行缓解。对照组中取石网篮搅碎、切割或暴力拖拽结石等操作，易造成胆道损伤、窦道撕裂等并发症，甚至存在网篮钢丝断裂的可能，故其并发症发生率相对较高。DFDP 激光将结石击碎后取出，通过“化整为零”的策略从根本上减少了暴力操作。

远期随访结果显示，对照组中 13 例病人未取净结石，7 例行二次手术取石，其中 3 例因胆道狭窄在随访 12 个月内出现结石复发，观察组病人随访期内未出现结石复发。该 3 名病人均行二次手术，并未全程贯彻胆道镜下常规网篮取石治疗，存在二次手术改变胆道内环境及解剖结构的可能，故其预后情况未与观察组进行进一步比较。

该技术与常规网篮取石比较，可有效解决网篮操作空间不足、无法处理巨大嵌顿结石的短板。现有研究报道液电碎石的成功率略低于激光碎石，且因其冲击波扩散效应，并发症发生率较激光碎石高[7]。钦激光的并发症发生率约为 1.96 %～4.62 %，且以胆道热损伤为主[8]。DFDP 激光在碎石效率及安全性方面具有优势，目前被认为是优于钦激光的碎石手段[7]。

受单中心条件限制，本研究未设置液电碎石、钦激光碎石等对照亚组，未进行各碎石设备的横向比较。本研究样本量较小，可能影响统计效力，有待后续扩大样本或进行多中心亚组比较。

综上所述，胆道镜下双频双脉冲激光碎石技术通过精准能量传递实现结石高效分解，显著提高胆道残余结石的取尽率，缩短治疗周期，同时其不损伤软组织的特性有效降低了并发症风险。未来可通过多中心随机对照试验进一步验证其长期疗效。

利益冲突说明 作者之间无利益冲突

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万方数据

·短篇论著·

经口胆胰管镜下能量碎石治疗胆总管巨大结石的临床研究

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【提要】 比较经口胆胰管镜下激光和液电两种能量碎石治疗胆总管巨大结石的临床疗效及安全性。回顾性病例对照研究纳入吉林市人民医院消化内镜中心 2022 年 1 月至 2025 年 2 月因胆总管巨大结石行内镜逆行胰胆管造影术（endoscopic retrograde cholangiopancreatography，ERCP）联合经口胆胰管镜下能量碎石的患者，根据能量碎石的方式不同，分为激光组和液电组。主要观察指标为技术成功率、手术时间、短期并发症发生率，次要观察指标为治疗前后临床资料及术后处理。研究纳入 69 例患者，其中激光组 40 例，液电组 29 例，两组间基线资料比较差异无统计学意义（$P>0.05$）。技术成功率方面，激光组及液电组均为 100.0%，差异无统计学意义（$P=1.000$）。液电组 ERCP 操作时间［53.00（43.00，70.00）min 比 68.00（50.00，80.50）min，$Z=2.073$，$P=0.038$］和能量碎石时间［23.00（17.00，39.00）min 比 35.00（27.75，40.75）min，$Z=2.262$，$P=0.024$］短于激光组。短期并发症中，液电组术中及术后出血发生率高于激光组［17.2%（5/29）比 0.0%（0/40），$P=0.011$］；术后胰腺炎、胆管炎、穿孔发生率两组间差异均无统计学意义（$P>0.05$）。术后胆道引流激光组 37 例，液电组 26 例。经口胆胰管镜下能量碎石治疗胆总管巨大结石中，液电碎石与激光碎石成功率相当，液电碎石操作时间较激光碎石少，但安全性低于激光碎石，临床可根据病例选择具体的碎石方式。

【关键词】 胰胆管造影术，内窥镜逆行； 经口胆胰管镜； 胆总管巨大结石； 激光碎石； 液电碎石

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Clinical study on peroral cholangioscopy-guided lithotripsy for large common bile duct stones

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【Summary】 To compare the clinical efficacy and safety of laser lithotripsy and electrohydraulic lithotripsy (EHL) under peroral cholangioscopy for large common bile duct (CBD) stones, a retrospective case-control study was conducted on large CBD stones patients who underwent endoscopic retrograde cholangiopancreatography (ERCP) combined with peroral cholangioscopy-guided lithotripsy at Digestive Endoscopy Center of Jilin People's Hospital from January 2022 to February 2025. Patients were divided into the laser group and the EHL group based on the lithotripsy method used. Primary outcomes included technical success rate, procedure time, and incidence of short-term complications. Secondary outcomes included clinical data before and after treatment, and postoperative management. A total of 69 patients were included. The laser group comprised 40 patients and the EHL group 29 patients. There were no statistically significant differences in baseline characteristics between the two groups ($P>0.05$). Both the laser group and

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the EHL group achieved technical success rate of 100.0%, with no statistically significant difference (P=1.000). The ERCP procedure time [53.00 (43.00, 70.00) min VS 68.00 (50.00, 80.50) min, Z=2.073, P=0.038] and energy lithotripsy time [23.00 (17.00, 39.00) min VS 35.00 (27.75, 40.75) min, Z=2.262, P=0.024] were significantly shorter in the EHL group than those in the laser group. For short-term complications, the incidence of intraoperative and postoperative hemorrhage in the EHL group was higher than that in the laser group [17.2% (5/29) VS 0.0% (0/40), P=0.011]. No statistically significant differences were observed between the two groups in the incidences of postoperative pancreatitis, cholangitis, or perforation (P>0.05). Postoperative biliary drainage was performed in 37 cases in the laser group and 26 cases in the EHL group. In the treatment of giant CBD stones via energy lithotripsy under peroral cholangioscopy, the technical success rate of electrohydraulic and laser lithotripsy are comparable. EHL is associated with shorter procedural durations but a less favorable safety compared with laser lithotripsy. Therefore, the choice of lithotripsy modality should be tailored to the clinical characteristics.

[Key words] Cholangiopancreatography, endoscopic retrograde; Peroral cholangioscopy; Large common bile duct stones; Laser lithotripsy; Electrohydraulic lithotripsy

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内镜逆行胰胆管造影术(endoscopic retrograde cholangiopancreatography, ERCP)是胆总管结石治疗的基础,通常在内镜乳头括约肌切开术后,用球囊或网篮取出胆管结石,被认为是实现胆管结石清除的"标准"技术。对于被定义为"困难胆管结石",包括胆总管巨大结石,欧洲指南建议根据胆管的解剖结构、结石的形状和大小以及个人偏好等选择替代或辅助技术来实现结石清除[1]。上述技术包括机械碎石术、体外冲击波碎石术以及经口胆镜管镜辅助碎石术等。随着消化内镜领域科学技术的创新,经口胆肠管镜问世,目前有两种经口胆肠管镜辅助碎石技术:液电碎石(electrohydraulic lithotripsy, EHL)和激光碎石。每种方法应用的安全性及有效性都各具优势,目前还没有研究将激光碎石术与液电碎石术进行比较。回顾性研究显示两种方法有相似的成功率[2-3],但仍需临床进一步验证。本研究回顾性分析吉林市人民医院消化内镜中心行ERCP联合经口胆肠管镜下能量碎石治疗的胆总管巨大结石患者临床资料,旨在评估液电碎石与激光碎石的临床疗效及安全性。

一、资料与方法

1. 研究对象:纳入吉林市人民医院消化内镜中心2022年1月至2025年2月因胆总管巨大结石行ERCP联合经口胆肠管镜下能量碎石的患者临床资料进行回顾性病例对照研究。纳入标准:(1)术前通过CT或MRCP检查明确诊断结石长径>1.5 cm的巨大胆总管结石;(2)有外科手术禁忌证;(3)符合ERCP适应证;(4)知情同意,自愿接受经口胆肠管镜下能量碎石治疗;(5)无影响凝血功能的疾病及用药史。排除标准:(1)已知明确胆道系统恶性肿瘤;(2)不能耐受ERCP操作或不能配合,易造成失访者;(3)有严重心肺功能不全、肝肾功能障碍、凝血功能障碍、精神疾病等患者;(4)患有上消化道梗阻病变,十二指肠镜无法插入;(5)研究者认为不宜参加本临床研究者。

研究分为两个组:ERCP联合经口胆胰管镜下液电碎石组(液电组)和ERCP联合经口胆胰管镜下激光碎石组(激光组),所有患者手术在经口胆胰管镜操作大于200例的经验丰富的同一医疗组完成。本研究已取得吉林市人民医院伦理委员会批准,伦理批件号:LS-2023-0004。

2. 使用器械:十二指肠镜(日本奥林巴斯,TJF260V),eyeMAX胆胰成像系统(中国南微医学,CDS22007),超声内镜(日本富士,SU-9000),液电碎石机(中国西安远鸿,IME-1000),激光碎石机(德国WOM,U100PULS),乳头切开刀(日本奥林巴斯,KD-V211M-0725),导丝(中国南微医学,MTN-RM-89/45-A),鼻胆引流管(美国库克,EABD-7-LIGUORY-C),取石网篮(日本奥林巴斯,FG-V422PR),胆胰管内引流管(美国库克)。

3. 治疗方法:患者取左侧卧位,在全身麻醉下完成ERCP联合经口胆胰管镜下能量碎石。具体操作流程如下:十二指肠镜插达十二指肠降段,拉直镜身进行大乳头常规插管;确认进入胆总管后根据病情选择合适的器械对乳头进行切开、扩张;沿导丝进入胆胰成像系统的光纤导管至胆管内,直视下寻找胆总管巨大结石的位置,将导丝撤出,在胆胰成像系统的光纤导管下将管道内置入液电电极导丝或激光光纤,对准结石表面进行能量碎石(液电碎石使用"OOD脉冲"模式,能量0.40 J;激光碎石参数设置单脉冲150 mJ,频率5 Hz),碎石后进行网篮或球囊取石,特殊部位的结石选择直视下子母网篮取石。碎石、取石过程可反复进行;在直视下观察是否有残留结石、胆道损伤、出血等,尽可能将结石一次性取净;导丝引导下置入塑料支架或鼻胆管进行引流;若十二指肠乳头有出血,应用冰去甲肾上腺素生理盐水冲洗或金属夹夹闭,确认无活动性出血后退镜。

4. 术后处理:患者术后24 h下禁食、抗炎、补液及抑酸等处理,密切监测患者生命体征、临床症状及血常规、血清淀粉酶等指标,必要时进行CT等其他影像学检查。

5. 观察指标:收集两组患者的基本资料,如年龄、性别、原发病情况、CT或MRCP或EUS评估的结石大小及个数,同时统计两组能量碎石技术的技术成功率、手术时间和短期并发症发生情况。主要观察指标:技术成功率、手术时间、短期并发症发生率,次要观察指标:治疗前后临床资料及术后处理。技术成功是指结石通过胆胰成像系统直视能量碎石并完全取出;临床成功是指患者术后腹痛、发热较术前完全缓解,黄疸指标较术前下降50%以上。

操作短期并发症定义:(1)出血,包括ERCP术中早期出

血及术后迟发性出血，本中早期出血主要观察能量碎石过程中由胆管壁损伤造成的出血或十二指肠乳头处因能量碎石器械所造成的出血；(2)ERCP后胰腺炎(post-ERCP pancreatitis，PEP)：操作后新出现的持续性上腹疼痛等胰腺炎相关的临床症状持续超过24 h，同时伴有血清淀粉酶超过正常上限的3倍；(3)ERCP后高淀粉酶血症(post-ERCP hyperamylasemia，PEH)：ERCP术后无新发胰腺炎相关临床症状，仅表现为血清淀粉酶升高；(4)术后穿孔：本研究主要观察因能量碎石时液电电极导丝或激光光纤所造成的乳头处或胆管壁的穿孔。

6.统计学分析：采用R语言(4.4.1版本)对数据进行处理与分析，对于连续型变量，如符合正态分布，采用$\bar{x}\pm s$进行统计描述，组间比较采用独立样本t检验。不符合正态分布则采用$M(Q_1,Q_3)$进行描述，组间比较采用独立样本秩和检验；对于计数资料：采用例数(%)进行描述，组间比较采用卡方检验，不满足卡方检验时使用Fisher精确概率法。双侧$P<0.05$为差异有统计学意义。

二、结果

1.入选病例情况：共回顾性分析77例患者，激光组41例，排除1例，液电组36例，排除7例，最终纳入激光组40例，其中男26例，女14例，年龄为(70.75±12.39)岁；液电组29例，其中男13例，女16例，年龄为(67.41±13.28)岁。两组患者性别、年龄、基础疾病、结石情况等基线资料比较差异无统计学意义($P>0.05$)，如表1所示。

2.手术结果：激光组40例患者及液电组29例患者均达到技术成功，技术成功率均为100.0%，差异无统计学意义($P>0.05$)。液电组ERCP操作时间短于激光组，能量碎石时间短于激光组，差异有统计学意义($P<0.05$)，见表2所示。

3.术后短期并发症比较：液电组总体并发症12例(41.4%)，激光组总体并发症7例(17.5%)，液电组并发症发生率高于激光组，差异有统计学意义($\chi^2=4.804$，$P=0.028$)。在并发症分类中，液电组出血发生率高于激光组，差异有统计学意义($P<0.05$)；其余并发症组间差异无统计学意义($P>0.05$)，见表2。液电组5例出血患者中，有4例为液电电极导丝碎石时划伤胆管壁所引起的术中出血(3例患者通过完整取石后出血自行停止，1例患者取石后仍有少量出血，于胆管内留置金属覆膜支架压迫后止血)，另1例为十二指肠乳头切开后迟发性出血，再次行ERCP于十二指肠乳头上方应用金属夹夹闭进行止血，同时予补液、止血对症治疗后出血停止。两组患者出现PEP及胆管炎患者均经保守治疗后短期内好转。激光组消化道穿孔为十二指肠乳头切开后所致，通过保守治疗后好转，与能量碎石过程无直接关系。

4.治疗后处理：术后胆管引流共4例，其中激光组1例，液电组3例；术后留置胆道塑料支架59例，其中激光组34例，液电组25例，两组术后生化指标较术前明显下降，且均达到100.0%临床成功率。

讨论 对于胆总管巨大结石，ERCP具有风险大、操作难度高等限制，机械碎石可以达到治疗的效果，但术中会出现机械碎石阻塞困难，网篮断裂等情况。随着内镜技术的不断进步，设备研发的不断更新换代，能量碎石通过"间接"放射的方式对胆总管巨大结石进行碎石治疗。但结石残留率高，且因无法直视，安全性低。经口胆胰管镜的问世，可以从"间接"放射转向"直接"内镜下能量碎石的可视化[4]。Buxbaum等[5]的一项随机对照试验将60例结石患者随机分为两组，一组为经口胆胰管镜辅助激光碎石(42例)，另一组为常规治疗(18例)，后者包括球囊、网篮取出、机械碎石和乳突扩张。结果显示在接受经口胆胰管镜检查的患者中结石清除成功率为93%，而仅使用常规治疗的患者成功率为67%($P=0.009$)。本研究纳入的69例患者均一次性通过经口胆胰管镜直视的能量碎石达到结石完全取出的效果，也证实了经口胆胰管镜直视碎石的过程更加精准、有效，同时能缩短操作时间以及提高治疗成功率。

目前有两种经口胆胰管镜辅助能量碎石技术，液电碎石和激光碎石。液电碎石系统通过双腔探头和电荷发生器

表1 胆总管巨大结石患者激光组与液电组间基线资料比较

组别	例数	年龄(岁，$\bar{x}\pm s$)	性别(例，男/女)	高血压[例(%)]	糖尿病[例(%)]	冠心病[例(%)]	胆道相关手术史[例(%)]	结石长径[mm，$M(Q_1,Q_3)$]	结石个数[例(%)]				
									1	2	3	4	5
激光组	40	70.75±12.39	26/14	14(35.0)	5(12.5)	6(15.0)	18(45.0)	18.30(15.90,20.33)	36(90.0)	2(5.0)	2(5.0)	0(0.0)	0(0.0)
液电组	29	67.41±13.28	13/16	11(37.9)	2(6.9)	3(10.3)	12(41.4)	17.60(15.70,19.30)	23(79.3)	1(3.4)	3(10.3)	1(3.4)	1(3.4)
统计量		$t=1.059$	$\chi^2=2.784$	$\chi^2=0.063$			$\chi^2=0.090$	$Z=0.360$					
P值		0.294	0.095	0.803	0.690[a]	0.724[a]	0.765	0.719			0.440[a]		

注：[a]采用Fisher精确概率法

表2 胆总管巨大结石患者激光组与液电组的操作情况及并发症比较

组别	例数	技术成功[例(%)]	ERCP操作时间[min，$M(Q_1,Q_3)$]	能量碎石时间[min，$M(Q_1,Q_3)$]	并发症[例(%)]				
					出血	术后胰腺炎	胆管炎	术后穿孔	术后穿孔
激光组	40	40(100.0)	68.00(50.00,80.50)	35.00(27.75,40.75)	0(0.0)	5(12.5)	0(0.0)	1(2.5)	1(2.5)
液电组	29	29(100.0)	53.00(43.00,70.00)	23.00(17.00,39.00)	5(17.2)	6(20.7)	1(3.4)	0(0.0)	0(0.0)
统计量			$Z=2.073$	$Z=2.262$					
P值		1.000[a]	0.038	0.024	0.011[a]	0.507[a]	0.420[a]	1.000[a]	1.000[a]

注：ERCP指内镜逆行胰胆管造影术；[a]采用Fisher精确概率法

工作，在探头尖端的电极间传输电荷产生火花，使周围流体膨胀，最终产生振荡压力冲击波，使石头碎裂[9]。而激光碎石系统的工作原理是将高功率密度的激光聚焦在结石表面，集中的高功率产生由离子和自由电子气体聚合组成的等离子体，该等离子体产生振荡波并诱导石头表面破裂[10]。经口胆肠管镜下两种能量碎石的方式均应用于胆总管巨大结石治疗中，均显示有较高的临床疗效且安全性良好[11-12]。但目前还没有在ERCP联合经口胆肠管镜下治疗胆总管巨大结石研究中将激光碎石术与液电碎石术进行比较。本研究进行了两种治疗方式的回顾性分析，结果表明，激光组和液电组基线资料比较差异无统计学意义；技术成功率方面，激光组及液电组均为100.0%，且临床疗效相似，但液电组ERCP操作时间低于激光组，液电组能量碎石时间低于激光组。因能量碎石的原理不同，液电组结石暴破力较强于激光组，原因主要为液电电极导丝可不用对准结石正中心，只要接近结石旁侧，有液体介质既可以放电碎石；而激光光纤必须对准结石中心，在液体介质下才可以聚焦碎石。若术中因胆管走行迂曲或结石位置不理想，激光碎石的操作难度就会增加，所以会延长手术时间。在术后短期并发症中，液电组容易发生出血，主要是因为液电电极导丝先端质地较硬，易划伤胆管壁，且在液电碎石过程中会产生气体，与碎石和液体混合后导致视野模糊，影响观察，易损伤胆管壁；而激光碎石基本不会出现上述情况。对于两组出现胰腺炎、穿孔以及胆管炎的病例，主要也是因为操作不当所引起，如操作过程中经口胆旋管镜在十二指肠乳头处压迫胰管开口诱发胰腺炎；碎石过程中若灌洗时间过长、吸引步，易诱发胆管炎；而穿孔是指为十二指肠乳头切开所致的胰腺穿孔，而非因经口胆肠管镜下能量碎石所致，上述并发症均在内科保守治疗后好转。笔者认为液电碎石更加快捷、碎石效果理想，而激光碎石更为安全。

为了避免相关不良事件的发生，笔者认为液电碎石过程中应注意在直视内镜下，电极导丝指向结石，并从胆管镜尖端向前移动至少5 mm，位于距结石1–2 mm的位置。当达到一个正确而稳定的位置，并且清晰地看到石头时，液电碎石系统就会被脚踏板激活。盐水溶液冲洗对于提供冲击波传播介质，使导管和结石可视化并冲洗碎片至关重要。曾有研究表明在经口胆肠管镜先端应用透明帽，再联合能量碎石，可以将先端保护在透明帽中，从而减少对胆管壁的损伤[13]。在应用经口胆肠管镜能量碎石过程中一定要保证胆道压力切勿过高，灌洗和负压吸引同时进行，以防出现胆管炎、肝脓肿等不良事件。

综上，本研究通过回顾性分析评价经口胆肠管镜下激光或液电两种能量碎石方式用于胆总管巨大结石治疗的临床疗效及并发症，显示液电碎石比激光碎石效果强，可以缩短手术操作时间，但激光碎石较液电碎石具有相对较高的安全性。但本研究为回顾性研究，且样本量较小，仍需要开展大样本、多中心、随机分组的前瞻性研究，探究激光或液电两种能量碎石方式用于胆总管巨大结石治疗，甚至其他困难胆管结石的临床疗效及安全性。

利益冲突　所有患者声明不存在利益冲突

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泌尿篇精选

ELSEVIER

A Retrospective Study of Minipercutaneous Laser Lithotripsy for Treatment of Allograft Kidney Lithiasis Obstruction

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ABSTRACT

Objective. To evaluate the safety and effectiveness of invasive percutaneous laser lithotripsy to manage allograft kidney lithiasis obstruction.

Methods. We treated 11 patients with kidney allograft lithiasis with minimally invasive percutaneous nephrolithotomy (mPCNL).

Results. All patients treated by mPCNL showed no residual stones thereafter. All subjects recovered successfully without major complications with improved renal function and reduced serum creatinine values.

Conclusion. mPCNL was safe and effective to treat kidney allograft lithiasis obstruction. We suggest that it may be considered to be a first-line option for this condition.

KIDNEY ALLOGRAFT lithiasis obstruction is an infrequent, difficult-to-manage complication of renal transplantation. Its incidence has been reported to be 0.23% to 0.97% of all renal transplant patients.[1,2] Between 2005 and 2012, 11 patients with kidney allograft lithiasis obstruction were treated in our hospital. Herein, we retrospectively analyzed these cases, discussing the application of minipercutaneous laser lithotripsy to treat this condition.

MATERIALS AND METHODS

Patients

Between January 2005 and December 2012, 11 patients including 7 men and 4 women of age range 34 to 63 years (mean-45) were admitted to our hospital at 14 to 67 months (mean-37) after renal transplantation. Upon admission, 3 patients displayed acute oliguria/anuria with discomfort at the transplant site, but without fever or acute hypertension. Three patients showed gross hematuria with discomfort at the transplant site. One patient had fever and a urinary tract infection. The other 4 patients had no symptoms but were detected to have renal transplant insufficiency on examinations with subsequent ultrasonography suggesting allograft lithiasis and hydronephrosis (Fig 1). Urinary ultrasonography in all patients revealed transplant lithiasis at the renal pelvis and upper ureter. The stones ranged from 0.9 to 2.4 cm in diameter. No ureteral dilation or stones were detected in the distal ureters of the transplanted kidneys; arterial and venous blood flows in all cases were normal.

Six patients underwent kidneys, ureter, and bladder radiography (KUB) and intravenous pyelograms (IVP). All shape images of the transplants were normal. KUB revealed radioopaque stones in 4 patients. The other 2 patients had radiolucent stones discovered on computed tomography (CT). IVP revealed the latter 2 patients to display dilation and swelling of the renal pelvis and proximal ureter of the transplanted kidney. Five patients underwent CT (unenhanced, contrast-enhanced, and 3-dimensional reconstruction) of the allograft kidney, ureter, and bladder. CT scans indicated that all of these patients had transplant lithiasis with renal pelvic obstruction.

All patients were checked for blood biochemical indicators of renal insufficiency including creatinine, uric acid, calcium, parathyroid hormone (Table 1). The mean serum creatinine concentration was 197 μmol/L (range: 158e352, normal: 53e155); mean uric acid concentration was 278 μmol/L (range: 181e506, normal: 178e416); mean calcium concentration was 2.2 mmol/L (range: 1.8e2.9, normal: 2e2.5); mean parathyroid hormone concentration was 27.5 pg/mL (range: 12.3e45.8, normal: 11e62); mean hemoglobin concentration was 118 g/L (range: 98e143, normal: 110e120).

Treatment

All patients underwent percutaneous laser lithotripsy in the supine position under combined spinal-epidural anesthesia. The stones were accessed via a middle calyx approach with ultrasound guidance. A puncture needle (Cook Medical, Bloomington, Ind, USA) was inserted percutaneously into the collecting system of the

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Table 1. Serum Creatinine Levels Before and After Lithotripsy

Before lithotripsy (mmol/L)	3 d after lithotripsy (mmol/L)	1 mo after lithotripsy (mmol/L)
178	76	68
158	106	77
352	224	168
164	119	86
220	121	101
201	126	99
195	118	91
181	129	110
174	121	90
181	134	93
166	109	84

Differences were statistically significant between the preoperative and postoperative levels at both time points (both $P < .05$).

transplanted kidney. The needle was withdrawn and urine effusion was confirmed, indicating correct entry into the collecting system. A Zebra guide wire (Cook Medical) was advanced through the sheath and an 8/18-French dilator/sheath set (Cook Medical) placed along the guide wire. The stones were then disintegrated using a U100 laser (W.O.M., Germany).

One double-J stent and 1 nephrostomy tube were placed in each patient. Patients with preoperative urinary tract infections were prescribed empirical antibiotic therapy (Sulperazon, 6 g/d, Pfizer, New York, NY, USA) for 3 days. If the urine effusion was purulent after puncture, a nephrostomy tube was placed and the patient underwent a subsequent (second-stage) percutaneous laser lithotripsy 1 week after the first operation.

Statistical Analysis

Data were analyzed using t tests (SPSS 13.0, SPSS, Chicago, Ill, USA). A P value of less than .05 was considered to be statistically significant.

RESULTS

All patients recovered successfully without major complications. In the 1 patient who had a preoperative urinary infection, urine culture suggested Escherichia coli infection. One week after the first operation, the drainage became clear and the patient underwent a second percutaneous laser lithotripsy.

After lithotripsy, KUB failed to detect residual stones in any patient (Fig 2). One day after lithotripsy, the patients passed 3000 to 5000 mL of urine. The nephrostomy tube (if placed) and urethral catheter were removed at 24 to 48 hours and 48 to 72 hours after the procedure, respectively. Moreover, 48 hours after operation, the mean hemoglobin concentration was reduced by 5.9 g/L (range: 3.0e12.0; $P > .05$) compared with the preoperative level.

After lithotripsy, all patients showed improved renal function and reduced serum creatinine. At 3 days after lithotripsy (Fig 2), the mean creatinine level was reduced to 126 mmol/L (range: 76e204). One month after lithotripsy, the double-J stent was removed in all patients. The serum creatinine level further decreased to 97 mmol/L (range: 68e168). Spectral analysis showed that the stones removed from 5 patients were composed of calcium oxalate; those from 3 patients, uric acid; from 2 patients, mixtures of calcium oxalate and uric acid; and from the remaining patient, ammonium magnesium phosphate. The patients were followed for 14 to 62 months (mean: 39), during which no stone recurrences were discovered by ultrasonography. Six months after lithotripsy, the mean serum creatinine level was 94 mmol/L (range: 62 to 157).



Fig 1. Radiograph prior to lithotripsy showing ureteral obstruction and hydronephrosis of the transplanted kidney.

DISCUSSION

With improved renal transplantation techniques and because of anatomical changes in the transplanted kidney and ureter, transplant lithiasis occurs infrequently. The mechanisms of renal transplant lithiasis are unclear. They have been suggested to be related to metabolic abnormalities, urinary obstruction, and urinary infection. Stones identified within 6 weeks after transplantation are usually native to the donor kidney.[3e6] Stones are typically composed of oxalate and urates.

Because the allografted kidney and associated ureter are denervated, the patient experiences no obvious pain from the lithiasis (eg, renal colic).[1] Consequently, it is usually identified during examinations for other complications such as fever, infection, hematuria, and renal dysfunction. The patients in our study followed this pattern, primarily presenting with hematuria, infection, or renal pelvic obstruction, although some did experience discomfort at the transplant site as well. For patients with renal transplant lithiasis who experience no obvious renal obstruction or



Fig 2. Kidney-ureter-bladder radiograph taken 3 days after lithotripsy, showing no residual stones.

dysfunction, renal biopsy may be required to differentiate lithiasis from transplant rejection.

Persistent transplant lithiasis and renal obstruction may lead to damage and even loss of the transplant function. Therefore, treatment should be considered immediately upon diagnosis. However, open surgical treatments can be difficult for several reasons. First, the transplanted kidney and ureter may be severely adherent to adjacent tissues, which renders surgery difficult and increases the risk of operative injuries. Second, potential postoperative complications, such as infection, urinary extravasation, urinary fistula, are difficult to overcome and may lead to transplant dysfunction. Moreover, the operation involves significant cost, patient pain, and a slow recovery. Therefore, open surgical treatments are not well accepted as the treatment of choice.

Several studies have reported successful treatment of renal transplant lithiasis with extracorporeal shock wave lithotripsy (ESWL).[4,6,7] However, because the renal transplant is inside the pelvic cavity, it is difficult to locate the stones for this procedure and the shock wave is blocked by the pelvis. Consequently, steinstrasse formation is a frequent complication of this treatment, which further aggravates the injuries to the transplanted kidney. Given these disadvantages, we suggest that ESWL for renal transplant lithiasis requires strict patient selection. Subjects with successful ureteral drainage and no urinary tract obstruction may undergo ESWL under strict clinical monitoring. One study has suggested ureteroscopic nephrolithotomy[8] as an alternative treatment. However, in our experience, the site of ureteral-bladder anastomosis is usually located at the bladder apex, making urethral intubation and endoscopy entry difficult. Recently, He et al[9] performed ureteroscopic nephrolithotomy in 8 patients with transplant ureteral lithiasis, with only 3 successful outcomes. Two patients developed high fevers after the procedures and 1, a postoperative infection that was controlled by percutaneous nephrostomy.

Percutaneous nephroscopic lithotomy for renal transplantation was first introduced in 1982.[10] Because of its advantages of rapid obstruction relief and easy control of infection, it has become the first choice in many hospitals for large stones (>1.5 cm) or after failed ESWL.[11e14] In our study, all patients experienced clear improvement in renal function after the procedure. One patient with a preoperative creatinine of 352 ㎜ol/L decreased to 157 ㎜ol/L after the procedure.

Earlier studies typically used standard percutaneous nephrolithotomy procedures, which require a portal dilation of 26 to 32 French. Recently, several studies in China[9,15] have explored minipercutaneous nephrolithotomy for transplant lithiasis, using a portal dilation of 14 to 18 French. A smaller portal may reduce potential injuries to the interlobar arteries of the transplanted kidney thus preventing massive intraoperative hemorrhage. The modest decrease in mean hemoglobin level and biochemical evidence of stable renal function during follow-up suggests the safety of the treatment presented herein.

Considering that the renal transplant is located in the iliac fossa, a percutaneous calyceal fornix puncture is a simple procedure with a short procedure time. With increasing application of minipercutaneous procedures and improved lithotripsy techniques, the risk of transplant injury is expected to steadily decrease. Our experience from these cases suggested that percutaneous laser lithotripsy provided a high stone resolution rate and a fast recovery with only limited impact on transplant function. We suggest that, under current technical conditions, minipercutaneous laser lithotripsy may be a preferred treatment for kidney allograft lithiasis obstruction.

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经皮微创激光碎石术治疗同种异体移植肾结石梗阻的回顾性研究

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摘要

目的：评估侵入性经皮激光碎石术治疗同种异体移植肾结石梗阻的安全性与有效性。
方法：采用微创经皮肾镜取石术（mPCNL）治疗 11 例同种异体移植肾结石患者。
结果：所有接受 mPCNL 治疗的患者术后均未出现残余结石。受试者均成功康复，无重大并发症，肾功能改善且血清肌酐值下降。
结论：mPCNL 是治疗同种异体移植肾结石梗阻安全有效的方法，建议将其作为该病症的一线治疗方案。

肾脏同种异体移植物结石性梗阻是肾移植术后一种罕见且难以处理的并发症。据文献报道，其发病率约占所有肾移植患者的 0.23%至 0.97%。1,2 在 2005 年至 2012 年间，我院共收治了 11 例肾脏同种异体移植物结石梗阻患者。本文通过回顾性分析这些病例，探讨微型经皮激光碎石术在该病症治疗中的应用。

材料与方法

患者

2005 年 1 月至 2012 年 12 月期间，我院收治了 11 例肾移植术后 14 至 67 个月（平均 37 个月）的患者，包括 7 名男性和 4 名女性，年龄范围 34 至 63 岁（平均 45 岁）。入院时，3 名患者出现急性少尿/无尿伴移植部位不适，但无发热或急性高血压症状。3 名患者表现为肉眼血尿伴移植部位不适。1 名患者出现发热和尿路感染。其余 4 名患者虽无症状，但检查发现移植肾功能不全，后续超声检查提示移植肾结石和肾积水（图 1）。所有患者的泌尿系统超声均显示移植肾肾盂及上段输尿管存在结石，结石直径 0.9 至 2.4 厘米。移植肾远端输尿管未检出输尿管扩张或结石；所有病例的动静脉血流参数均正常。

六名患者接受了肾脏、输尿管及膀胱 X 线摄影（KUB）和静脉肾盂造影（IVP）。所有移植器官的形态影像均显示正常。KUB 检查发现 4 名患者存在不透 X 线的结石，另 2 名患者经计算机体层摄影（CT）检出透 X 线结石。IVP 显示后 2 名患者的移植肾肾盂及近端输尿管存在扩张与肿胀现象。五名患者接受了同种异体移植肾、输尿管及膀胱的 CT 检查（包括平扫、增强扫描及三维重建）。CT 扫描证实这些患者均存在移植肾结石伴肾盂梗阻。

所有患者均接受了肾功能不全相关血液生化指标检测，包括肌酐、尿酸、钙和甲状旁腺激素（表 1）。血清肌酐平均浓度为 197 mmol/L（范围：158-352，正常值：53-155）；尿酸平均浓度为 278 mmol/L（范围：181-506，正常值：178-416）；钙平均浓度为 2.2 mmol/L（范围：1.8-2.9，正常值：2-2.5）；甲状旁腺激素平均浓度为 27.5 pg/mL（范围：12.3-45.8，正常值：11-62）；血红蛋白平均浓度为 118 g/L（范围：98-143，正常值：110-120）。

治疗

所有患者均在腰硬联合麻醉下取仰卧位接受经皮激光碎石术。通过超声引导下的肾中盏入路定位结石。将穿刺针（美国印第安纳州布卢明顿市库克医疗公司）经皮插入移植肾的收集系统。穿刺针撤出后确认尿液积聚，表明已正确进入集合系统。随后沿鞘管置入斑马导丝（库克医疗），并沿导丝放置 8/18 法式扩张器/鞘管组（库克医疗）。继而使用 U100 激光碎石机（德国 W.O.M.公司）对结石进行粉碎处理。

表 1.碎石术前后血清肌酐水平

Before lithotripsy (μmol/L)	3 d after lithotripsy (μmol/L)	1 mo after lithotripsy (μmol/L)
178	76	68
158	106	77
352	224	168
164	119	86
220	121	101
201	126	99
195	118	91
181	129	110
174	121	90
181	134	93
166	109	84

术前与术后两个时间点的水平差异均具有统计学意义（均为 P < 0.05）。

每位患者均置入一根双 J 管和一根肾造瘘管。术前存在尿路感染的患者需接受为期 3 天的经验性抗生素治疗（舒普深，6 克/日，辉瑞制药，美国纽约州纽约市）。若穿刺后发现尿液积脓，则留置肾造瘘管，患者需在首次手术后 1 周接受二期经皮激光碎石术。

统计分析

数据采用 t 检验进行分析（SPSS 13.0 版，美国伊利诺伊州芝加哥市 SPSS 公司）。P 值小于 0.05 被视为具有统计学显著性。

结果

所有患者均成功康复，未出现重大并发症。术前存在泌尿系统感染的 1 例患者中，尿培养显示大肠杆菌感染。首次手术一周后，引流液转清，患者接受了第二次经皮激光碎石术。

碎石术后，KUB 检查未在任何患者体内检测到残留结石（图 2）。术后一天，患者排尿量达 3000 至 5000 毫升。肾造瘘管（如放置）与导尿管分别在术后 24 至 48 小时和 48 至 72 小时拔除。此外，术后 48 小时的平均血红蛋白浓度较术前水平下降 5.9 克/升（范围：3.0-12.0；P>0.05）。

碎石术后，所有患者肾功能均有所改善，血清肌酐水平下降。术后 3 天（图 2），平均肌酐值降至 126 mmol/L（范围：76e204）。术后一个月，所有患者的双 J 管均被拔除。血清肌酐水平进一步降至 97 mmol/L（范围：68e168）。光谱分析显示，5 例患者取出的结石成分为草酸钙；3 例为尿酸结石；2 例为草酸钙与尿酸混合结石；剩余 1 例为磷酸铵镁结石。患者随访 14 至 62 个月（平均 39 个月），期间超声检查未发现结石复发。碎石术后 6 个月，平均血清肌酐值为 94 mmol/L（范围：62 至 157）。



图 1. 碎石术前 X 光片显示移植肾输尿管梗阻及肾积水。

讨论

随着肾移植技术的进步以及移植肾和输尿管解剖结构的变化，移植肾结石的发生率较低。移植肾结石的形成机制尚不明确，目前认为可能与代谢异常、尿路梗阻和尿路感染有关。移植术后 6 周内发现的结石通常来源于供体肾脏。结石成分主要为草酸盐和尿酸盐。

由于移植肾及相连的输尿管处于去神经状态，患者不会因结石病（如肾绞痛）感受到明显疼痛。因此，这种情况通常是在检查其他并发症时被发现，例如发热、感染、血尿和肾功能障碍。我们研究中的患者也符合这一规律，主要表现为血尿、感染或肾盂梗阻，不过也有部分患者在移植部位出现了不适感。对于没有明显肾梗阻或功能障碍的肾移植结石患者，可能需要肾活检来区分结石和移植排斥反应。



图 2. 碎石术后 3 天拍摄的肾脏-输尿管-膀胱平片，显示无残留结石。

移植肾结石持续存在及尿路梗阻可能导致移植肾功能损害甚至丧失。因此一经确诊就应立即考虑治疗。然而开放性手术治疗存在诸多困难：首先，移植肾与输尿管可能严重粘连于

周围组织，导致手术难度增加及操作损伤风险升高；其次，术后感染、尿外渗、尿瘘等并发症难以克服，可能引发移植肾功能障碍。此外该术式还存在费用高昂、患者疼痛明显及恢复缓慢等问题。因此开放性手术并非理想的治疗选择。

多项研究报告显示，采用体外冲击波碎石术(ESWL)成功治疗了肾移植术后结石病例。然而，由于移植肾位于盆腔内，该手术存在结石定位困难且冲击波易受骨盆阻挡的问题。因此，碎石堆积形成是该治疗常见的并发症，会进一步加重移植肾损伤。鉴于这些弊端，我们认为肾移植结石的 ESWL 治疗需要严格筛选病例。对于输尿管引流通畅且无尿路梗阻的患者，可在严密临床监测下实施 ESWL。有研究建议采用输尿管镜肾结石取石术作为替代治疗方案。但根据我们的经验，输尿管-膀胱吻合口通常位于膀胱顶端，这导致尿道插管和内镜进入操作困难。近期 He 等学者为 8 例移植输尿管结石患者实施输尿管镜肾实质切开取石术，仅 3 例成功。其中 2 例术后出现高热，1 例发生术后感染，最终通过经皮肾造瘘术得以控制。

经皮肾镜取石术用于肾移植患者最早于 1982 年提出。由于该技术具有快速解除梗阻和易于控制感染的优势，现已成为许多医院治疗大结石（>1.5 厘米）或体外冲击波碎石术失败后的首选方案。在我们的研究中，所有患者术后肾功能均获得明显改善。其中一名术前肌酐达 352 毫摩尔/升的患者，术后降至 157 毫摩尔/升。

早期研究通常采用标准经皮肾实质切开取石术，该术式需建立 26 至 32 法制的通道扩张。近期中国学者发表研究探索了采用 14 至 18 法制通道的微型经皮肾镜取石术治疗移植肾结石。较小尺寸的通道可降低移植肾叶间动脉损伤风险，从而避免术中大出血。随访期间平均血红蛋白水平的适度下降及肾功能稳定的生化证据，均表明本治疗方案的安全性。

鉴于肾移植位于髂窝，经皮肾盏穹窿穿刺术操作简便且耗时短。随着微创经皮手术应用的日益普及和碎石技术的进步，移植肾损伤风险预计将持续降低。本组病例经验表明，经皮激光碎石术具有结石清除率高、恢复快的特点，且对移植肾功能影响有限。我们认为在当前技术条件下，微创经皮激光碎石术或可成为肾同种异体移植物结石梗阻的首选治疗方案。

输尿管镜 U100 激光碎石术和气压弹道碎石术治疗输尿管上段结石的疗效比较

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摘要:目的 比较输尿管镜下 U100 激光碎石术和气压弹道碎石术治疗输尿管上段结石的疗效及安全性。**方法** 选取 2013 年 12月-2018 年 9 月柳州市人民医院收治的输尿管上段结石患者 100 例作为研究对象,按照随机数字表法分为观察组和对照组,各 50例。对照组行输尿管镜下气压弹道碎石术,观察组行输尿管镜下 U100 激光碎石术,比较两组手术时间、单次碎石成功率、结石彻底清除率、手术并发症发生率,并分析单次碎石失败原因。**结果** 观察组单次碎石成功率及结石清除率为 90.00%、86.00%,高于对照组的 68.00%、60.00%($P<0.05$);观察组手术时间为(35.84±5.34)min,短于对照组的(55.08±9.78)min($P<0.05$);观察组并发症发生率为 12.00%,低于对照组的 30.00%($P<0.05$);两组碎石失败的主要原因是碎石过程中结石上移至肾脏,术中未能找到结石所致。**结论** 输尿管镜下 U100 激光碎石具有手术时间短、高效、安全及并发症少等优点,是治疗输尿管上段结石的有效手段。

关键词:输尿管镜;U100 激光碎石术;气压弹道碎石术;输尿管上段结石

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Comparison of the Efficacy of Ureteroscopic U100 Laser Lithotripsy and Pneumatic Lithotripsy in the Treatment of Upper Ureteral Calculi

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Abstract:Objective To compare the efficacy and safety of ureteroscopic U100 laser lithotripsy and pneumatic lithotripsy in the treatment of upper ureteral calculi.**Methods** A total of 100 patients with upper ureteral calculi admitted to the People's Hospital of Liuzhou from December 2013 to September 2018 were selected as the research objects and divided into observation group and control group according to the random number table method, with 50 cases in each group. The control group was treated with ureteroscopic pneumatic ballistic lithotripsy, and the observation group was treated with ureteroscopic U100 laser lithotripsy. The operation time, single lithotripsy success rate, stone clearance rate and incidence of surgical complications were compared between the two groups, and the causes of single lithotripsy failure were analyzed.**Results** The success rate of single lithotripsy and stone clearance rate in the observation group were 90.00% and 86.00%, which were higher than 68.00% and 60.00% in the control group (P<0.05). The operation time of the observation group was (35.84±5.34) min, which was shorter than (55.08±9.78) min of the control group ($P<0.05$). The incidence of complications in the observation group was 12.00%, which was lower than 30.00% in the control group ($P<0.05$). The main reason for the failure of crushed stone in the two groups was that the stones moved up to the kidney during the lithotripsy, and the stones were not found during the operation.**Conclusion** The ureteroscopic U100 laser lithotripsy has the advantages of short operation time, high efficiency, safety and few complications, which is an effective method for the treatment of upper ureteral calculi.

Key words: Ureteroscopy;U100 laser lithotripsy;Pneumatic ballistic lithotripsy;Upper ureteral calculi

输尿管上段结石(upper ureteral calculi)是泌尿外科常见疾病,肾结石排出过程受阻而嵌顿滞留于输尿管上段是其主要病因,临床主要表现为运动后血尿、肾绞痛,伴或不伴恶心、呕吐甚至发热等全身症状,部分患者可并发肾功能损害。输尿管上段结石因其独特的空间位置结构等因素, 现代微创治疗有多种选择方式,主要包括体外冲击波碎石术、经尿道输尿管镜碎石术、微通道经皮肾镜碎石取石术和腹腔镜下输尿管切开取石术等,每种方法均有利有弊[1]。近年来,U100Plus 双频双脉冲激光碎石术因其高效碎石且对人体组织损伤小的优点已广泛应用于临床[2,3]。本研究旨在比较输尿管镜下 U100 激光碎石术与气压弹道碎石术治疗输尿管上段结石的疗效及

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安全性，现报道如下。

1 资料与方法

1.1 一般资料 选取 2013 年 12 月–2018 年 9 月柳州市人民医院收治的输尿管上段结石患者 100 例作为研究对象。纳入标准：①术前经泌尿系 B 超及 KUB+IVP 和/或泌尿系 CT 平扫确诊；②单侧单发且同侧未合并肾结石；③结石最大径<2 cm。排除标准：①严重的凝血功能障碍，如血友病、长期使用抗凝药物等；②严重心肺功能障碍不能耐受麻醉或手术者；③妊娠期或严重畸形无法摆截石位者；④患肾重度积水、ECT 提示肾功能近乎丧失者；⑤尿路狭窄或输尿管畸形导致输尿管镜进镜失败，或输尿管镜到达结石部位但尚未开始碎石结石即冲入肾内而改行其它治疗方式者。采用随机数字表法将研究对象分为观察组和对照组，每组 50 例。观察组中男 31 例，女 19 例；年龄 25~68 岁，平均年龄（43.92±9.82）岁；结石位置：左侧 30 例，右侧 20 例；结石最大径 0.6~1.8 cm，平均结石最大径（1.34±0.26）cm。对照组中男 35 例，女 15 例；年龄 19~75 岁，平均年龄（44.65±10.26）岁；左侧 28 例，右侧 22 例；结石最大径 0.7~1.6 cm，平均结石最大径（1.26±0.31）cm。两组性别、年龄、结石位置、结石最大径比较，差异无统计学意义（P>0.05），可对比。本研究已通过医院伦理委员会审查，研究对象术前均已知情同意并自愿签署知情同意书。

1.2 方法

1.2.1 观察组 予以输尿管镜下 U100 激光碎石术：采用硬膜外麻醉或全身麻醉，截石位，W0LF（F8/9.8）输尿管硬镜在摄像系统直视下经尿道进入膀胱，寻到患侧输尿管开口后插入斑马导丝作引导，输尿管镜通过壁间段后即减小灌注液压力以避免结石上移，缓缓进境达结石部位。经工作通道置入激光光纤（直径 0.42 mm），激光脉冲能量设置 120~150 mJ，频率调整为 3~5 Hz，间断适量冲水保持视野清晰，直视下将光纤顶端抵住结石中央，采用连续脉冲间断发射法，将大块结石击碎成小块，再逐个粉碎至 3 mm 以下的碎石屑。必要时使用套石篮，防止手术过程中结石漂移。当结石表面完全被息肉包裹时，可将光纤直接插入结石处进行“盲打”，待结石被击碎，输尿管腔道开放后再进一步碎石。

1.2.2 对照组 予以输尿管镜下气压弹道碎石术：麻醉、手术体位及操作步骤同观察组一致。窥见结石后置入 0.8~1.2 mm 碎石杆，气压弹道碎石机设置为 1.5~2.5 个大气压，将结石轻轻抵于输尿管内壁，应用空气压缩泵，连续脉冲式击碎结石。

两组患者术后均常规留置 F5 双 J 管 1 根，导尿管留置 1~3 d 拔除。所有患者术后 4 周返院复查泌尿系 CT 平扫，决定拔除双 J 管或者进一步治疗。

1.3 观察指标 比较两组治疗情况[手术时间、单次碎石成功率（术中输尿管镜能到达结石部位并完成碎石即为碎石成功）及结石彻底清除率（手术后 4 周随访并复查 CT 平扫显示无泌尿系结石或结石直径 3 mm 以下作为结石彻底清除的判定标准[4]，术后残留结石直径≥4 mm 认为是有临床意义的残留结石，结石直径≥5 mm 的患者需进一步结合 ESWL 治疗[5]）]、并发症发生情况（指碎石过程输尿管穿孔、撕脱或断裂及术后出现发热、肾绞痛）及单次碎石失败原因。

1.4 统计学方法 以 Excel 建立数据库，利用 SPSS 24.0 统计学软件进行数据分析。计量资料以（$\bar{x}\pm s$）表示，采用 t 检验；计数资料以[n(%)]表示，采用 χ^2 检验。以 P<0.05 表示差异有统计学意义。

2 结果

2.1 两组治疗情况比较 观察组单次碎石成功率及结石清除率高于对照组，而手术时间短于对照组（P<0.05），见表 1。

2.2 两组并发症发生情况比较 观察组并发症发生率低于对照组（P<0.05），见表 2。

表 1 两组治疗情况比较[$\bar{x}\pm s$, n(%)]

组别	n	手术时间（min）	单次碎石成功率	结石彻底清除率
对照组	50	55.08±9.78	34（68.00）	30（60.00）
观察组	50	35.84±5.34	45（90.00）	43（86.00）
统计值		t=12.215	χ^2=4.574	χ^2=7.844
P		0.000	0.032	0.015

表 2 两组并发症发生情况比较[n(%)]

组别	n	输尿管穿孔	发热	肾绞痛	发生率
对照组	50	2(4.00)	7(14.00)	6(12.00)	15(30.00)
观察组	50	1(2.00)	3(6.00)	2(4.00)	6(12.00)*

注:* 与对照组比较,χ^2==4.882,P=0.027

2.3 两组单次碎石失败原因比较 观察组碎石过程中有 7 例患者出现结石上移至肾盂或肾盏，其中 3 例通过改变体位后输尿管镜在肾盂找到结石并通过激光一次碎石成功;另 4 例滑落入肾盏的结石未能找到；碎石过程输尿管穿孔改后腹腔镜切开取石 1 例。对照组碎石过程中有 15 例结石上移,其中 1 例通过改变体位在肾盂找到结石并碎石成功;另 14 例未能找到而导致手术失败;2 例穿孔改腹腔镜切开取石 1 例、开放手术 1 例。两组输尿管穿孔多发生于结石表面被大量息肉包裹者。

3 讨论

输尿管上段结石需外科干预者多以微创治疗为主,及时清除结石并解除输尿管梗阻是其治疗的关键。传统开放手术因出血较多、创伤性大、术后恢复慢、感染发生率高等弊端已逐渐被微创手术所取代[6,7]。而手术精准高效、创伤小、术后恢复快等优点促使输尿管镜激光碎石术成为该疾病的主要治疗方式,也是目前主要的研究方向[8]。然而,在输尿管镜碎石术治疗输尿管上段结石方面,激光碎石与气压弹道碎石何种方式效果更优尚无明确定论。

临床上激光碎石机主要分为钬激光和 U100 激光 2 类,其中 U100 激光碎石机能发出 2 种波长的光，一种为波长 532 nm 的绿光，另一种为波长 1064 nm 的红外光,因此又称为双频双脉冲激光机,而绿光为可见光,约占激光能量的 20%,其被输尿管结石表面吸收后形成等离子体;红外光为不可见光,约占激光能量的 80%,结石表面的等离子体在足够均匀的条件下,即可充分吸收红外光的能量,并在瞬间转化为机械冲击波。由于 U100 激光碎石机的冲击波峰值功率极高,因此可在极短时间内精准高效地崩解结石。同时,它包含的绿光和红外光的波长并不在人体组织吸收的范围内,而且作用于软组织的时间很短，因此 U100 激光不会使软组织产生热效应[9],属于一种“冷激光”,不会损伤泌尿道正常的管壁。有动物实验证明[10],当激光频率调整为 10 Hz,能量设置 120 mJ,持续发射 1500 个激光脉冲作用于动物膀胱黏膜，只造成接触部位的膀胱黏膜轻度充血、水肿,电子显微镜下未见膀胱肌层的损伤及穿孔。由于绿光在镜头表面无法形成等离子体,所以对镜头的损耗也较小[11]。U100 激光的作用原理充分保障了碎石过程的安全性，通过输尿管镜直视下碎石精准度高,不易发生管腔穿孔[12]。本研究中观察组并发症发生率低于对照组(P<0.05),进一步验证了 U100 激光的安全性。但 U100 激光碎石术也存在一定不足，即无法同时处理结石合并的息肉及输尿管狭窄,且对于硬度较高的胱氨酸结石,因绿光无法在结石表面形成等离子体，故 U100 激光对胱氨酸结石碎石效果差[13,14]。

气压弹道碎石自 90 年代初开始应用于临床,其原理是通过压缩空气驱动密闭盒中的弹丸驱动金属杆做机械运动,导致结石被击碎[15]。气压弹道碎石具有操作简单、无石率较高、价格低廉等优点,但手术过程中结石上移至肾脏的风险相对较高[16]。另外,在处理输尿管结石时，频繁的使用气压弹道对固定在局部黏膜上的同一块结石进行碎石，可促使该结石进一步嵌入输尿管黏膜从而影响结石的排出。而 U100 激光碎石机采用双频和双脉冲激光使碎石能量成倍数增加,效率更高,疗效更显著,结石碎片更小[17],加上激光光纤柔软纤细,而且在碎石过程中产生的冲击对结石的推动力很小[18]。本研究结果显示,观察组单次碎石成功率及结石清除率高于对照组,而手术时间短于对照组(P<0.05),与既往研究报道基本一致[19]。碎石失败的主要原因是碎石过程中结石上移至肾脏,术中未能找到结石所致,观察组结石上移发生率低于对照组，也证实 U100 激光碎石术的高效性。此外,观察组中结石上移后仍能成功碎石占比高于对照组。分析认为,碎石过程中,当结石上移入肾盂、肾盏隐约可见时,碎石杆往往无法触及,而激光光纤却可以到达,并根据光纤与结石之间产生的摩擦感和碎石声响来判定是否接触、击碎结石[20]。鉴于本研究纳入样本量少,且受到随访时间短等因素的制约，所得结论还有待大样本研究进

一步验证。

U100 激光碎石虽有许多优势，但操作过程仍需要注意以下几点：①光纤到位率要高，光纤与结石的距离应≤3 mm，碎石效果较好[9]；②虽然波长为 532 nm 的绿光在镜头表面无法形成等离子体，不会对镜头造成直接损害，但瞬间崩裂的碎石片仍可能损伤镜头，故碎石时光纤应伸出足够的距离；③由于纤细的光纤有可能损伤肾盂及输尿管黏膜，在盲目碎石的情况下仍需谨慎；④U100 激光的绿光对眼睛有一定的刺激，可佩戴滤光片眼罩保护眼睛；⑤碎石过程若结石漂移入肾，尤其是肾积水不显著者，可进镜至肾盂，反复适量冲水、放水并配合变换体位，结石有可能再次出现在视野内而被激光光纤成功击碎[21]。

综上所述，输尿管镜下 U100 激光碎石术具有手术时间短、高效、并发症少及结石清除率高等优点，是治疗输尿管上段结石的有效手段。

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自拟滋阴补肾根石汤联合绿激光镜下U-100激光碎石术治疗复杂膀胱结石的疗效观察

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【摘要】 **目的** 探究自拟滋阴补肾根石汤联合绿激光镜下U-100激光碎石术治疗复杂膀胱结石的疗效。**方法** 选取2017年3月至2019年3月本院收治的复杂膀胱结石患者78例，随机数表法分为两组，各39例。两组患者均行绿激光镜下U-100激光碎石术治疗，对照组接受常规术前准备和术后康复护理，观察组在对照组基础上加服自拟滋阴补肾根石汤，比较两组患者治疗前后最大尿流率（Qmax）、残余尿量（RUV）水平，术后住院时间、术后并发症发生情况及临床治疗效果。**结果** 治疗前，两组患者Qmax、RUV水平比较，差异均无统计学意义（均$P>0.05$）；治疗后，观察组Qmax为

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(18.17±2.64) ml/s，大于对照组(15.73±3.21) ml/s，RUV 为(17.64±4.65) ml，低于对照组(28.43±5.28) ml，差异均有统计学意义(均 $P<0.05$)；观察组术后住院时间为(7.26±1.38) d，明显短于对照组(9.56±1.12) d，差异有统计学意义($P<0.05$)；治疗后，两组患者均出现一定的并发症，其中观察组尿瘘、血尿、结石复发率分别为 5.13%、7.69%、5.13%，均低于对照组 20.51%、25.64%、23.08%，差异均有统计学意义(均 $P<0.05$)；两组患者结石残留率比较，差异无统计学意义($P>0.05$)；观察组治疗总有效率为 89.74%(35/39)，高于对照组 71.79%(28/39)，差异有统计学意义($P<0.05$)。**结论**　自拟滋阴补肾提石汤联合绿激光镜下 U-100 激光碎石术治疗复杂膀胱结石方面疗效确切，能有效改善患者的临床症状，减少住院时间，降低术后并发症发生率和结石复发率，是治疗复杂膀胱结石较为安全、有效的方法。

【关键词】　膀胱结石；　绿激光镜下 U-100 激光碎石术；　滋阴补肾；　提石汤

Self-made Ziyin Bushen Genshi decoction combined with green laser endoscopic U-100 laser lithotripsy in treatment of complicated bladder stones

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【Abstract】　**Objective**　To explore the curative effect of self-made Ziyin Bushen Genshi decoction combined with green laser endoscopic U-100 laser lithotripsy in treatment of complicated bladder stones. **Methods**　A total of 78 patients with complicated bladder stones who were admitted into and treated at our hospital between March, 2017 and March, 2019 were selected and divided into an observation group and a control group by the random number table method, with 39 cases in each group. All the subjects were treated with green laser endoscopic U-100 laser lithotripsy. The control group were given routine preoperative preparation and postoperative rehabilitation nursing, while the observation group were treated with self-made Ziyin Bushen Genshi decoction on the basis of the treatment of the control group. The maximum urinary flow rates (Qmax), residual urine volume (RUV), postoperative hospital stay, postoperative complications and clinical treatment effects were compared between the 2 groups. **Results**　There were no statistical differences in Qmax and RUV between the two groups before the treatment (both $P>0.05$). After the treatment, the Qmax was higher and the RUV was lower in the observation group than in the control group [(18.17±2.64) ml/s vs. (15.73±3.21) ml/s and (17.64±4.65) ml vs. (28.43±5.28) ml; both $P<0.05$]. The postoperative hospital stay of the observation group was shorter than that of the control group [(7.26±1.38) d vs. (9.56±1.12) d, $P<0.05$]. After treatment, there were complications in both group, and the incidences of urinary fistula and hematuria and the stone recurrence rate were lower in the observation group than in the control group (5.13% vs. 20.51%, 7.69% vs. 25.64%, and 5.13% vs. 23.08%; all $P<0.05$). There was no statistical difference in the stone residual rate between the 2 groups ($P>0.05$). The treatment response rate in the observation group was higher than that in the control group (89.74% vs. 71.79%; $P<0.05$). **Conclusions**　Self-made Ziyin Bushen Genshi decoction combined with green laser endoscopic U-100 laser lithotripsy is effective in treatment of complicated bladder stones. It can effectively relieve the patients' clinical symptoms, shorten their hospital stay, and reduce the incidence of postoperative complications as well as stone recurrence rate. It is a safe and effective method treating complicated bladder stones.

【Key words】　Bladder stones; Green laser endoscopic U-100 laser lithotripsy; Ziyin Bushen Genshi decoction

膀胱结石是一种以排尿受阻中断疼痛放射至远端尿道及阴茎头部、伴有排尿困难、血尿、膀胱刺激症状为典型症状的常见泌尿外科疾病，多继发于下尿路梗阻、尿路感染、良性前列腺增生、膀胱异物、尿道狭窄或神经源性膀胱等疾病，在老年男性人群中发病率较高[1-2]。手术治疗是目前膀胱结石的临床主要治疗手段，随着微创碎石技术的不断发展，经尿道激光碎石术逐渐应用于膀胱结石的治疗中[3]，该方法显著有效地实现了避免开放手术，但仍存在手术时间长、膀胱及尿道损伤风险大的缺点[4]。中医药在治疗膀胱结石方面具有独特优势，已有研究发现，中药辅助手术治疗在前列腺增生合并膀胱结石的治疗中具有显著的临床疗效，可明显改善患者临床症状，降低术后并发症的发生率[5]。为丰富中医药防治膀胱结石的经验方法，本研究采用自动进退外套鞘与透明合绿激光镜下 U-100 激光碎石术治疗复杂膀胱结石，取得良好效果，现报道如下。

1　资料与方法

1.1　一般资料　选取 2017 年 3 月至 2019 年 3 月本院收治的复杂膀胱结石患者 78 例，随机数表法分为两组，各 39 例。对照组年龄范围为 55～78 岁，年龄(65.58±8.43)岁；多发膀胱结石 23 例，单发膀胱结石 16 例；合并前列腺增生 20 例，

膀胱异物10例，神经源性膀胱9例。观察组年龄范围为55～75岁，年龄(63.27±7.86)岁；多发膀胱结石25例，单发膀胱结石14例；合并前列腺增生22例，膀胱异物9例，神经源性膀胱8例。纳入标准：(1)患者经肾功能、B超及尿常规检查确诊为复杂膀胱结石；(2)患者均为男性，年龄≥50岁；(3)单发结石最大径≥3 cm，多发结石最大径≥2 cm；(4)近期未服用过影响检查指标的药物；(5)本研究经医院伦理委员会批准，患者及家属知情同意，自愿签字。排除标准：(1)存在手术禁忌证患者；(2)存在严重血液性病或遗传病患者；(3)存在急性肿瘤患者；(4)存在严重认知功能障碍，难以配合治疗患者。两组患者基线资料比较，差异均无统计学意义(均$P>0.05$)，具有可比性。

1.2 方法 所有患者均接受绿激光镜下E-100激光碎石术治疗，术前行降压降糖，纠正电解质紊乱，改善酸碱平衡，抗感染等对症治疗；患者取截石位，采用腰硬外麻醉，26F绿激光镜经尿道置入膀胱，观察膀胱内结石的大小及位置，经绿激光镜循光通道置入E-100激光光纤(激光能量为双频120～160 W，频率为10～15 Hz)，抵于结石表面；启动激光，直接粉碎结石，或采用"转孔搬心法"逐个粉碎结石，保证碎石均可通过绿激光镜内鞘；采用Elik泵进行冲洗，将碎石完全冲出。对照组术后给予常规护理，进行补液维持水电解质平衡，同时口服抗生素预防感染。观察组在术后2 d开始服用自拟温阳补肾根石汤。该汤剂配方为：金钱草30 g，川木通、车前子各15 g，枸杞子、生地黄、黄芪、牛膝、菟丝子、威灵仙、何首乌、鸡金炒各20 g。药材切片或颗粒后置于容器中，加入1 500 ml白酒，浸过药方，保存期间经常摇动，浸泡30 d后，过滤去渣即成。患者口服2次，5～10 ml/次，连续服用2周。

1.3 观察指标 (1)记录治疗前后两组患者的最大尿流率(Qmax)和残余尿量(RUV)，比较两组患者的术后住院时间。(2)术后并发症：观察两组患者术后并发症的发生情况，包括泌尿系感染、血尿、结石残留和结石复发等。(3)治疗效果：参考《中药新药临床研究指导原则(试行)》制定临床疗效评价标准[7]。其中，临床症状基本消失，尿常规检查结果为阴性，B超结果显示无结石残留或存在少量结石残留为显效；临床症状部分改善，尿常规检查有少量红细胞，B超结果显示有结石残留为有效；临床症状未改善，B超结果显示结石数量及位置无明显变化为无效。总有效率=(显效+有效)/总例数×100%。

1.4 统计学处理 采用SPSS20.0统计软件对数据进行分析，计量资料以($\bar{x}\pm s$)表示，行t检验；计数资料以n(%)表示，行χ^2检验；以$P<0.05$为差异有统计学意义。

2 结果

2.1 两组患者治疗前后Qmax、RUV水平及术后住院时间比较 治疗前，两组患者Qmax、RUV水平比较，差异均无统计学意义(均$P>0.05$)；治疗后，两组患者Qmax明显上升，RUV水平明显下降，且观察组Qmax大于对照组，RUV低于对照组，差异均有统计学意义(均$P<0.05$)；观察组术后住院时间明显短于对照组，差异有统计学意义($P<0.05$)；见表1。

2.2 两组患者治疗前后血糖及蛋白尿指标比较 治疗后，两组患者均出现一定的并发症，其中观察组泌尿系感染和结石复发率均低于对照组，差异均有统计学意义(均$P<0.05$)；两组患者结石残留率比较，差异无统计学意义($P>0.05$)；见表2。

表2 两组患者治疗前后血糖及蛋白尿指标比较[n(%)]

组别	n	泌尿系感染	血尿	结石残留	结石复发
观察组	39	2(5.13)	3(7.69)	1(2.56)	2(5.13)
对照组	39	8(20.51)	10(25.64)	3(7.69)	9(23.08)
χ^2值		4.129	4.525	1.054	5.166
P值		0.042	0.035	0.305	0.023

2.3 两组患者临床治疗效果比较 观察组治疗总有效率为89.74%(35/39)，高于对照组71.79%(28/39)，差异有统计学意义($P<0.05$)，见表3。

表3 两组患者临床治疗效果比较[n(%)]

组别	n	显效	有效	无效	总有效
观察组	39	21(53.85)	14(35.90)	4(10.26)	35(89.74)
对照组	39	10(25.64)	18(46.15)	11(28.21)	28(71.79)

注：与对照组比较，$\chi^2=5.268$，$P=0.022$

3 讨论

根据膀胱结石的临床症状，中医将膀胱结石归为石淋、砂淋、血淋等范畴，认为膀胱结石为脾胃亏虚，湿热浊邪，脉瘀成石，蕴结膀胱而致，与脾肝气机升降、三焦气化密切相关[8]。外科手术治疗虽能有效清除膀胱内结石，但由于一些微小结石在膀内难以排出，操作器械需反复进出膀胱，增加了尿道损伤的风险。中医学强调辨证论治，施治个体化治疗，在治疗膀胱结石方面具有明显优势[9]。刘建霞等[10]在膀胱结石患者的治疗中应用自拟排石方辅助治疗，发现患

表1 两组患者治疗前后Qmax、RUV水平及术后住院时间比较($\bar{x}\pm s$)

组别	n	Qmax(ml/s)		RUV(ml)		术后住院时间(d)
		治疗前	治疗后	治疗前	治疗后	
观察组	39	8.17±1.97	18.17±2.64	125.78±21.65	13.64±4.63	7.20±1.38
对照组	39	8.26±2.16	15.73±3.21	128.45±20.87	28.43±5.28	9.56±1.12
t值		0.192	3.666	0.557	9.577	8.082
P值		0.848	<0.001	0.579	<0.001	<0.001

者的膀胱结石复发率降低，下尿路症状也得到明显改善，进一步表明中西医联合疗法治疗膀胱结石疗效确切。

本研究在绿激光镜下 U-100 激光碎石术的基础上配合自拟滋阴补肾根石汤口服治疗，活方中，金钱草性甘，有利湿退黄，利尿通淋，消肿解毒之效。现代药理学认为金钱草的主要成分为黄酮类，对泌尿系结石有抑制作用，可通过调节尿液 pH，扩张输尿管等方式抑制结石生长，促进结石排出[10]。海金沙为植物海金沙的干燥成熟孢子，性寒，有清热利湿、通淋止痛之效，可抑制泌尿系组织中草酸钙结晶的形成[11]；生地黄、黄芪可清热凉血、补气固表；牛膝、车前子、墨旱莲可益肾通经、利尿通淋，滋补肝肾；威灵仙、何首乌有通经祛湿、补益精血之功效，诸药合用，共奏利湿通淋、清热消积、补肾益气之效[12]。研究结果显示，治疗后，观察组 Q_{max} 大于对照组，RUV 水平和术后住院时间明显低于或短于对照组，且观察组的治疗总有效率为 89.74%，高于对照组 71.79%，提示滋阴补肾根石汤联合绿激光镜下 U-100 激光碎石术可有效改善复杂膀胱结石患者的临床症状，进一步提高治疗有效率，缩短住院时间。观察组患者于术前即开始服用滋阴补肾根石汤，一方面可溶出排石；另一方面可滋阴补肾，活血益气，通过加强患者的抵抗力，提高其手术耐受力，加快术后恢复[13]。对比两组患者并发症发生情况可知，观察组尿痿、血尿发生率和结石复发率均低于对照组，两组患者的结石残留率无明显差异，提示滋阴补肾根石汤服合绿激光镜下 U-100 激光碎石术可有效降低复杂膀胱结石患者术后并发症发生率和结石复发率。绿激光镜下 U-100 激光碎石术主要通过 U-100 激光瞬间产生的高能量使结石破裂，在碎石期间，若术及时冲洗碎石屑，可能会影响对手术视野，进而对输尿管造成误伤[14]。本研究中，观察组在对照组基础上加服滋阴补肾根石汤，一方面可利尿排石，抑制结石的形成；另一方面，可提高手术碎石的效果，减少术中冲洗及器械操作时间，降低膀胱及尿道黏膜的损伤，进而降低术后并发症的发生率[15]。

综上所述，自拟滋阴补肾根石汤联合绿激光镜下 U-100 激光碎石术在治疗复杂膀胱结石方面疗效确切，能有效改善患者的临床症状，减少住院时间，降低术后并发症的发生率和结石复发率，是治疗复杂膀胱结石较为安全、有效的方法。

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·论著·

双频双脉冲激光碎石治疗输尿管结石的效果

黄旭元 薄隽杰 陈斌 李东 冷静 戴胜国 王益鑫

【摘要】 **目的** 探讨新型双频双脉冲激光治疗输尿管结石疗效。 **方法** 总结 150 例输尿管镜下双频双脉冲激光碎石经验。男 94 例，女 56 例；平均年龄 42 岁。结石位于输尿管上段 48 例，中段 35 例，下段 64 例。合并另一侧多枚结石者 3 例。 **结果** 150 例患者一次碎石成功 136 例（90.6%），1 周结石排净 131 例（96.3%）。上段碎石失败 9 例中，二期行 ESWL 治疗 5 例；输尿管成角扭曲改开放手术 2 例，碎石中发生输尿管穿孔 2 例。中下段失败 5 例，其中碎石不完全 1 例，尿酸性结石未能粉碎 1 例，输尿管镜操作失败改开放手术 3 例。患者术后均出现轻重不等的肉眼血尿。无发热，脓肾病例。平均手术时间 32 min，平均激光工作时间 3.3 min。术后平均住院 2.5 d。 **结论** 双频双脉冲激光是一种功能单一、操作简单、安全、对软组织损伤小，碎石高效的激光。可作为输尿管结石不宜行 ESWL 治疗或 ESWL 治疗失败后的一种选择方法。

【关键词】 尿结石； 激光

Frequency-doubled-double-pulse laser lithotripsy of ureteral calculi *HUANG Xu-yuan, BO Jun-jie, CHEN Bin, et al. Department of Urology, Renji Hospital, Shanghai Second Medical University, Shanghai* 200001, China

【**Abstract**】 **Objective** To study and evaluate frequency-doubled-double-pulse laser (FREDDY) lithotripsy of ureteral calculi. **Methods** The experience of 150 cases of ureteral calculi treated with FREDDY from April to December in 2001 was summarized. 94 are male patients and 56 female with an average age of 42. There were 48 cases of upper, 35 middle and 64 lower ureteral stone. **Results** Of 150 cases, 136 (90.6%) were successful on the first lithotripsy. Of which in 131 cases (96.8%) the stone fragment completely expelled in one week. The procedure failed in 9 cases of upper ureteral calculi. Among them, 5 cases was due to up drift of calculi or incomplete lithotripsy and was then shifted to ESWL therapy. 2 was due to angular twist of the ureter and changed to open operation, and another 2 was due to perforation of ureter during the procedure. Of the 5 failed cases with middle and lower ureteral calculi, 1 was due to incomplete lithotripsy, nonfragmentation in 1 case and failure of ureteroscopy in 3 (changed to open operation). Different degree of hematuria was seen in every case after operation. High fever or pyonephrosis after operation has not been observed. The average operation time was 32 minutes, and the average time for laser working was 3.3 minutes. The average hospitalization after operation was 2.5 days. **Conclusions** FREDDY is a kind of laser with the characteristics of single function, simple operation, safe, less damage to the soft tissue and high efficiency of lithotripsy. The procedure is indicated if ESWL failed or not indicated.

【**Key words**】 Urinary calculi; Lasers

腔镜下激光碎石是一种继液电碎石，超声碎石和气压弹道碎石后更为高效安全的方法[1-4]。2001 年 4 月起，我院试用德国 WOM 公司双频双脉冲激光（Frequency-doubled-double pulse Nd: YAG laser, FREDDY）治疗输尿管结石 150 例，效果良好，现报告如下。

材料与方法

一、临床资料

本组 150 例。男 94 例，女 56 例。年龄 16～82 岁，平均 42 岁。左侧 79 例，右侧 67 例，双侧 4 例，共 154 侧。结石位于输尿管，

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下段 64 例。合并另一侧多枚结石者 3 例。术前有 ESWL 史者 35 例。结石直径 0.8～1.8 cm，平均 1.0 cm。

二、方法

硬膜外麻醉，截石位，直视下插入输尿管镜，沿输尿管向上，找到结石后，插入激光光纤，激光脉冲能量 120 mJ，脉冲频率 5Hz。冲水保持视野清晰，直视下将激光光纤顶端触及结石轻抵住，采用连续脉冲间断发射法粉碎结石。

碎石时光纤对准结石中央，先将大块结石碎成小块，再碎成粉末。多枚结石者，自上而下依次碎石。合并有息肉者，轻者可避开息肉直接碎石，结石表面完全被息肉包裹时，先用输尿管镜轻轻推挤结石，蹭去息肉，使光纤接触到结石表面后再碎石。碎石后留置工作导丝，改换膀胱镜下插入双 J 管。术后 1 周复查 KUB，结石排净即可拔管。下段结石不常规放置双 J 管，女性患者、结石较小、粉碎彻底、操作时间短者，可单纯留置输尿管导管，1～2 d 后拔除。

结　果

本组 150 例中，一次碎石成功 136 例(90.6%)，其中输尿管上段结石 48 例中，一次碎石成功 39 例(81.2%)。中下段 99 例及多发结石 3 例一次成功碎石 97 例(95.1%)。上段碎石失败 9 例中，结石上移和碎石不完全、结石过大 5 例，二期行 ESWL 治疗。输尿管成角扭曲，输尿管镜不能上插至结石处发现结石而改开放手术 2 例。术中输尿管穿孔 2 例。中下段失败 5 例，其中碎石不完全 1 例，尿酸性结石未能粉碎 1 例，输尿管镜操作失败改开放手术 3 例。碎石成功 136 例中 1 周结石排净 131 例(96.3%)。136 例碎石患者术后均出现轻重不等的肉眼血尿，109 例(80%)1～3 d 血尿消失，27 例(20%)结石排净，拔除双 J 管后血尿消失。无发热、脓肾病例。输尿管镜下碎石操作穿孔 2 例，即行开放手术 1 例，1 例保守治疗，二期手术取石。136 例单次碎石成功患者平均手术时间 32 min，平均激光工作时间 3.3 min。平均术后住院 2.5 d(1～5 d)。

讨　论

一、碎石原理和特点

FREDDY 双频双脉冲激光是一种新型钕-YAG 激光。由 1064 μm 的红外光和 532 μm 的绿光两种不同波长的光依各自的频率组成。作用机理是，激光经光纤将激光束能量打到结石表面，绿光部分被结石表面吸收，在结石表面形成等离子体，等离子体再吸收不可见红外光后崩裂，产生的冲击波粉碎结石。属一种机械能性碎石作用。具有碎石效率高，对组织损伤小，安全简单的特点[5]。

FREDDY 适用于泌尿系结石，胆道结石和唾液腺结石。碎石效能是普通激光的 6 倍。而且对各类性质的泌尿系结石几乎都有效。Zorcher 等[5] 对 61 例结石患者行体外 FREDDY 激光碎石实验，碎石有效率达 100%。本组仅 1 例棕色光滑的尿酸性结石不能被有效击碎，改用套石篮套出。

二、碎石方法和注意点

FREDDY 激光作用于结石后，产生“爆炸”性碎石作用，脉冲可有效地将结石粉碎成小块 。我们体会，碎石时先将光纤对准结石中央，从大块开始粉碎。当结石嵌顿，几乎充满输尿管腔时，如果将光纤对准结石的边缘碎石，瞬间崩裂的碎石片可能造成输尿管损伤穿孔。

采用连续脉冲间断发射法碎石，频率不宜太快，脉冲发射时间不宜太长。激光作用于结石表面会形成一阵“气雾”，影响视野，稍微等待或加大冲洗水的压力可消散气雾。视野不清，盲目连续发射脉冲，易造成输尿管损伤。

大结石粉碎后，输尿管腔显现，为避免结石回漂上移。可降低冲洗压力，也可关闭进水开关，打开出水开关，让积水自然下流以清晰视野。

处理多枚结石时，若下面结石较大，可作初步粉碎，镜子越过下部结石，追踪到最上面结石，自上往下碎石，避免上部结石回漂入肾盂。

高位结石的上移回漂或碎石不完全仍是上段结石处理时一大难题。对于第 3 腰椎以上水平的结石，宜采用快速中央碎石法，为防止高位结石回漂，光纤抵住结石后，降低冲水压力，采用快速连续脉冲，将结石粉碎成小块。FREDDY 激光的结石清除率 115 mg/min，每 mg 结石粉碎仅需 17.6 个脉冲[5]。

碎石后常规留置双 J 管。1 周后复查 KUB，结石排净即可拔管。女性患者可单纯留置输尿管导管，1～2 d 后拔除。碎石术后出现的肉眼血尿，尤其是合并息肉增生者，抗炎止血处理，多饮水后 1～3 d，血尿可消失，部分病例在结石排净，拔除双 J 管后血尿才能停止。

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三、对软组织作用与息肉处理

动物实验发现，将 FREDDY 激光光纤直接对准兔膀胱黏膜采用 90 mJ，连续 2 000 个脉冲冲击，仅引起轻度充血性黏膜水肿，光镜下也仅发现轻到中度的黏膜下出血及上皮层点状凝固坏死，无肌层损伤和穿孔[5]。因此术中软组织照射不会造成输尿管管壁穿孔损伤。但此特点不能使息肉得到同时处理。当结石合并有息肉时，息肉增生轻者可避开息肉直接碎石。当结石表面完全被息肉包裹时，可先用输尿管镜轻轻推挤结石，蹭去息肉，使光纤能直接接触到结石表面，再行碎石。结石嵌顿时间长或 ESWL 碎石术后结石不能下排的病例，几乎都有不同程度的息肉增生，可不作特殊处理。结石排净后，息肉会自然消退。

四、激光操作防护

绿色波的闪烁和不可见的红外光对人视力有一定损害作用，尤其在光纤没有触及结石空发射或触及软组织发射时，光波对眼睛有较强的刺激作用。操作者需佩戴特制的滤波防护镜。尽量采用视频装置下手术，避免直视下操作。

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·手术学研究·

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双频双脉冲 U-100Nd:YAG 激光碎石治疗泌尿系结石(附 101 例报告)

许晓文,徐耀庭,黄汝强,谢敏

[摘要] 目的 探讨双频双脉冲 U-100 掺钕钇铝石榴石(Nd:YAG)激光粉碎泌尿系结石的疗效及安全性。 方法 应用双频双脉冲 U-100Nd:YAG 激光经输尿管镜和尿道膀胱镜治疗泌尿系结石 101 例,其中输尿管结石 83 例,膀胱结石 15 例,后尿道结石 3 例。 结果 输尿管结石碎石成功率为 91.6%(76/83),膀胱结石碎石成功率为 80.0%(12/15),尿道结石碎石成功率为 100%(3/3)。平均手术时间33 min,平均激光工作时间(5.5±2.8)min。输尿管结石碎石后平均15(7~28)d 排净结石。 结论 双频双脉冲 U-100 Nd:YAG 激光能迅速、高效地粉碎泌尿系结石,对正常泌尿系器官无损伤。

[关键词] 钕; 激光; 碎石术; 泌尿系结石

[中图分类号] R692.4; R693.4; R694.4 [文献标识码] A

Treatment of Urinary Calculi with the Frequency-Doubled Double-Pulse U-100 Neodymium of YAG Laser (A Report of 101 cases)

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Abstract: Objective To evaluate the effect and safety of the frequency-doubled double-pulse U-100 neodymium of YAG (Nd:YAG) laser lithotripsy of calculi in the urinary tract. **Methods** 101 cases of urinary calculi treated by the frequency-doubled double-Pulse U-100 Nd of YAG laser under ureteroscope and cystoscope were reviewed retrospectively, included 83 cases with ureterolith, 15 with cystolith and 3 with posterior urethral calculus. **Results** The successful rate of lithotripsy was 91.6%(76/83) in ureterolith, 80%(12/15) in cystolith, and 100%(3/3) in posterior urethral calculus. The mean time of operation was 33 minutes and the laser worked 5.5±2.8 minutes in average. The stonefreeing time was 7~28 days and the average time was 15 days. **Conclusions** The frequency-doubled double-pulse U-100 Nd of YAG laser can shatter stones quickly and efficiently with no damage to the normal urinary organ.

Key words: neodymium; laser; lithotripsy; urinary calculi

自 2002 年 1 月~2003 年 5 月,我院采用德国 WOM 公司生产的双频双脉冲 U-100 掺钕钇铝石榴石(Nd:YAG)激光碎石机,经输尿管镜和尿道膀胱镜治疗泌尿系结石 101 例,疗效满意,报道如下。

1 临床资料

1.1 一般资料

本组 101 例,男 61 例,女 40 例,平均年龄 43(20~74)岁。输尿管结石 83 例,其中上段结石 48 例,中段结石 14 例,下段结石 21 例;79 例结石单发,4 例多发(包括 2 例双侧输尿管结石);结石横径 5~15 mm,纵径 6~20 mm;合并输尿管息肉 6 例,3 例曾行体外冲击波碎石(ESWL)。膀胱结石 15 例,其中 13 例伴有前列腺增生症,单发结石 10 例,多发结石 5 例,结石直径平均 21.2(10~40)mm。尿道结石 3 例,均为后尿道结石,结石直径平均 18.5(12~21)mm。

1.2 治疗方法

1.2.1 输尿管结石的治疗 采用 $F_{8/9.8}$Wolf 输尿管半硬镜和德国 WOM 公司生产的双频双脉冲 U-100Nd:YAG 激光碎石机。在连续硬膜外麻醉下,取膀胱截石位。经输尿管镜向患侧输尿管插入输尿

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管导管，用手控间断水压扩张法冲开膀胱壁段，并在输尿管导管引导下，用直入法或侧入法将输尿管镜推进输尿管内，缓缓上行到达结石部位后，从输尿管镜工作通道插入激光光纤接触结石，以每秒 5 个激光脉冲频率进行碎石。6 例合并输尿管息肉者，2 例用鳄鱼嘴式输尿管异物钳钳取息肉后再碎石；4 例直接将光纤伸入息肉至结石处进行盲目碎石，再通过输尿管镜的上下摆动，去除息肉组织。术后常规留置双 J 管 1～3 周。

1.2.2 膀胱结石的治疗 通过膀胱镜操作通道置入激光光纤直抵结石，以每秒 5～10 个激光脉冲频率进行碎石。其中 9 例伴前列腺增生症者，碎石后同期行经尿道前列腺汽化电切术(TUVRP)，术后用 Ellik 抽吸泵将结石碎片及前列腺组织一起吸出。术后留置导尿管 2～7 d。

1.2.3 尿道结石的治疗 经尿道膀胱镜操作通道置入激光光纤至结石处将结石粉碎；碎石片推入膀胱后用 Ellik 抽吸泵吸出；未完全击碎的结石在膀胱内继续粉碎。术后留置导尿管 2～3 d。

2 结 果

本组 101 例均未发生输尿管、膀胱、尿道穿孔和损伤等并发症。91 例结石一次性粉碎成功，总碎石成功率为 90.1%。其中，输尿管结石碎石成功率为 91.6%(76/83)，膀胱结石为80.0%(12/15)，尿道结石为100%(3/3)。输尿管结石经平均发射132(30～800)个激光脉冲后被粉碎；膀胱结石平均发射激光脉冲530(100～2 000)个；尿道结石平均发射激光脉冲420(50～1 000)个。激光平均工作时间为(5.5±2.8)min。平均手术时间33(15～60)min。碎石后结石排净时间：输尿管结石平均15(7～28)d；膀胱结石和尿道结石平均1.5(1～3)d。术后患者平均住院时间5(3～7)d。碎石失败的7例输尿管结石病人中，4例为肾盂输尿管交界处结石，碎石中结石随水流漂入肾盂而改行 ESWL 治疗；2例因输尿管上段迂曲合并狭窄，输尿管镜无法通过而改行开放手术；1例因结石坚硬，结石仅被部分击碎而改行 ESWL 治疗。碎石未成功的3例膀胱结石均因结石体积大，质地坚硬而未能击碎，其中2例改行大力碎石钳机械碎石，1例改行开放手术。

3 讨 论

80 年代以来，随着 ESWL 和内窥镜腔内碎石方线下降[1]。内窥镜技术的飞速发展和腔内碎石器的日臻完善，尤其是先进激光碎石机的问世，使内窥镜腔内碎石技术有成为治疗泌尿系结石的首选方法的趋势。双频双脉冲 U-100 Nd：YAG 激光碎石系统是德国 WOM 公司于 2000 年上市的一种先进腔内碎石装置，能发出波长为 1 064 nm 的红外光和 532 nm 的绿光，故称为双频激光机。在碎石过程中，绿光先被结石吸收形成等离子体，等离子体再充分吸收红外光的能量，产生机械冲击波使结石粉碎。由于所产生的冲击波峰值功率极高，在很短的时间内就能准确高效地将结石击碎，所以对结石产生的推动力极小[2]。这样大大减少了上段输尿管结石在碎石过程中上移进入肾盂的可能。人体正常组织由于不吸收这两种波长的激光，因此不会造成正常泌尿道管壁的损伤[3]。鉴于以上优点，有时在看不清结石的情况下，还可以直接将光纤伸到结石处进行盲视下碎石，根据感觉到的结石异物感以及听到的特殊碎石声来判定是否接触或击碎结石。本组有 4 例输尿管结石因结石被息肉包裹无法看到，采用盲视下碎石方法，3 例结石被成功粉碎。也正因为无损伤这一优点，本组 101 例结石患者无一例发生输尿管、膀胱、尿道的穿孔和损伤。

应用双频双脉冲 U-100 Nd：YAG 激光对不同部位的泌尿系结石进行碎石时，笔者所采用的方案、手法以及激光的脉冲频率也有所不同。在对上段输尿管结石进行激光碎石时，为防止结石上移进入肾盂，采取了以下防治措施：①激光脉冲频率设定在每秒 5 个，可减少因频率提高而增加的推动结石的机会，从而减少了结石上移进入肾盂的可能。②最大限度地调低灌注液的流速及压力，采用间断手控水压法，以能看清结石为度。③进镜后，采用头高脚低位，减少结石随水流漂入肾盂的可能。④对已经向上移位或位置较高的结石，使用异物钳先将结石下拉，然后再进行碎石。⑤对于上段输尿管迂曲影响进镜者，让助手用手在患侧脊肋角用力上顶，使患侧肾脏上移、迂曲输尿管拉直以利进镜，或试用调大灌注液压力以及调整输尿管导管角度等方法设法通过。本组有 4 例患者术前 IVU 显示输尿管上段迂曲，输尿管镜下发现输尿管近端几乎成一盲端，随即采用手助以及用输尿管导管调整角度等方法，使输尿管镜顺利进入，直达结石部位完成碎石。

膀胱结石由于体积较大，表面光滑坚硬，往往会

的困难。尤其是以胱氨酸成份为主的结石更难被击碎。本组通过对 15 例膀胱结石进行激光碎石的临床实践,认为以下经验值得借鉴:①将激光脉冲频率调高至每秒 10 个,且应始终将激光光纤对准结石的同一部位反复击打,在这个过程中一定要有耐心。当结石表面出现一裂缝或突破口时,结石就比较容易被粉碎了。②对于直径> 40 mm 的膀胱结石,主张以开放手术为宜,否则在碎石或碎石后容易引起膀胱粘膜的广泛性水肿,或因碎石粘附于粘膜上造成结石残留,甚至引发膀胱出血[4]。

对于尿道结石的碎石,笔者主张采用在原位对准结石的同一部位反复击打的方法;当然,也可将结石部分击碎后推入膀胱按膀胱结石进行碎石。

本组通过对101例泌尿系结石进行激光碎石的临床观察结果显示,双频双脉冲 U-100 Nd:YAG 激光腔内碎石术具有快速、安全、微创以及碎石成功率和结石排净率高、患者康复快等优点,因此是目前治疗泌尿系结石的理想方法。不足的是,这种激光碎石系统不能同时处理结石合并的息肉。但是,根据笔者的经验,结石合并的息肉往往质脆易碎,通常经过输尿管镜的上下摆动,大部分息肉可脱落。即便是碎石后息肉有部分残留,也不至于影响碎石的排出。

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经皮肾穿微造瘘输尿管镜气压弹道 /U100 激光碎石治疗复杂性肾结石

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摘要：目的 探讨复杂性肾结石微创的治疗方法。方法 采用经皮肾穿微造瘘输尿管镜气压弹道 / U100 激光碎石治疗复杂性肾结石 47 例。结果 47 例经皮肾穿微造瘘手术顺利完成,40 例结石被击碎取尽,5 例结合体外冲击波碎石排净,2 例有少量残留结石,结石清除率为 95.7%,均无严重并发症。结论 经皮肾穿微造瘘输尿管镜气压弹道 / U100 激光碎石治疗复杂性肾结石术具有创伤小、安全、恢复快、痛苦少的优点,是治疗复杂性肾结石的良好方法之一。认为 U100 激光碎石术比气压弹道碎石术更具有优越性。

关键词： 肾结石;输尿管镜;经皮肾穿微造瘘(PCN) ;气压弹道 / U100 激光碎石术
中图分类号： R692.4 文献标识码： B

Percutaneous reno-ureteroscopy pneumatic lithotripsy and Frequency-doubled-doubled-pulse laser lithotripsy in the treatment of complicated renal stone

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Abstract: Objective: To study and evaluate the minimally invasive therapy for complicated renal stone. **Methods:** 47 patients with complicate renal stone were treated by percutaneous reno-ureteroscopy pneumatic lithotripsy and frequency-doubled-doubled-pulse laser lithotripsy. **Results:** Percutaneous renal stone fistulization in the 47 cases were successful. Renal stone was fragmented and taken cleanly in 40 cases, completely excreted by method of operation combined with ESWL in 5 cases, and a less stones being survived in 2 cases, the total stone clearance rate was 95.7%. There was no severe postoperative complication. **Conclusions:** Percutaneous reno-ureteroscopy pneumatic lithotripsy and frequency-doubled-doubled-pulse laser lithotripsy for complicated renal stone have the adventages of high effectiveness, safety and rapid recovery, less suffering. Both are good procedures in treatment of complicated renal stone. But we think that the frequency-doubled-doubled-pulse laser lithotripsy method is much better than that of the pneumatic lithotripsy.

Key words: Kidney calculi; ureteroscope; PCN; pneumatic lithotripsy and frequency-doubled-doubled-pulse laser lithotripsy
CLC number: R692.4 **Document code:** B

2001年 5 月 ~2004 年 4 月,我院采用经皮肾穿微造瘘输尿管镜气压弹道术(2003 年以前) /U100 激光碎石术(2003 年以后),效果满意。现报告如下：

1 资料与方法

本组 47 例。男 26 例,女 21 例;年龄 25~63 岁,平均 45 岁。左肾结石 25 例,右肾结石 22 例;多发性结石 23 例,铸形结石 17 例。7 例有肾脏开放性手术史,9 例有 ESWL 史,21 例血肌酐、尿素氮升高,16 例结石伴尿路感染。

有尿路感染者术前抗炎治疗至控制感染。采用硬膜外麻醉,先截石位逆行插置输尿管导管,然后改

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俯卧位。患侧上腹部下垫高 15~20 cm,向输尿管导管注入生理盐水使肾盂充盈扩张后,再在 B 超引导下穿刺。12 肋缘下腋后线至骶棘肌外侧缘之间区域在 B 超引导下用 18 F 穿刺针向肾结石穿刺,引出尿液后放入斑马导丝, 用筋膜扩张器沿斑马导丝从 8 F 扩张至 16 F、14 F 和 16 F 筋膜扩张器带有相应的 Peel- away 薄鞘,退出筋膜扩张器后,留下 Peel- away 薄鞘,沿鞘进德国 Wolf8.0/9.8Fr 输尿管镜,在电视监视下插入肾内用气压弹道碎石机(2003 年以前有 18 例) /U100 激光(2003 年以后有 29 例) 将结石击碎取出。U100 激光碎石可将大部分结石击碎成粉末状,沿 Peel- away 鞘插入吸引管吸出(吸引管接 12 号橡胶管尿管) 。如肾铸形结石或肾多发性结石一次不能全部取尽,或取石时出血以致视野不清,则可分次碎石取石,或配合体外冲击波碎石(ESWL) 治疗。碎石后,拔出输尿管导管,顺行插入 D- J 管做支架和内引流, 放置肾造瘘管接袋, 并用丝线缝合固定。肾造瘘管一般 3~5 d 后拔除,D- J 管一般 4 周后拔除(若有残留结石,则行 ESWL 或再次行肾造瘘输尿管镜气压弹道 /U100 激光碎石术, 待结石取尽或排净后再拔除, 拔管时间一般不超过 3 个月。如合并肾盂输尿管连接部(UPJ) 处狭窄,D- J 管可留置 8 周。

2　结果

47 例中 1 次碎石成功 30 例,2 次碎石成功 8 例,3 次碎石成功 2 例,5 例结合体外冲击波碎石排净,2 例有少量残留结石,结石清除率 95.7%,均无严重并发症发生。

3　讨论

1976 年 Fernstron 和 Johannson 首次应用肾镜通过经皮穿刺扩张的肾造瘘通道进行肾盂结石取石,并成为一种取代开放性手术的新方法[1]。但由于肾通道较粗,容易引起术中术后出血,术后漏尿,肾周血肿及术后肾皮质疤痕大,且操作繁琐,曾一度不为泌尿外科医师接受。近年来, 由于腔内泌尿外科的迅速发展, 技术不断提高, 其并发症相应减少。微创 PCN,使损伤及出血这两个重要的并发症明显降低,用输尿管镜气压弹道 /U100 激光碎石术, 因输尿管镜较小,操作灵活,可达到肾盂及大部分肾盏碎石取石。上可从肾盏顺行插入输尿管上段处理输尿管上段结石,微造瘘创伤小,对不能耐受开放性手术的患者也能接受,同时,对于一次不能取净的结石,可重复取石。

成功地建立适当的肾造瘘通道是经皮肾穿碎石术的关键。B 超引导下选择达到结石最短距离的穿刺路径,选用 12 肋缘下腋后线至骶棘肌外侧缘之间区域, 对于多发性结石应选择用各部位结石均能兼顾的穿刺路径。要从肾盏穿刺到肾盂, 而不要直接穿刺肾盂,以免损伤肾脏动静脉,同时避免放置造瘘管后尿漏外渗。采用气压弹道碎石时, 尽量将结石击碎,以便从肾造瘘管取出。U100 激光碎石可将大部分结石击碎成粉末状, 可沿 Peel- away 鞘插入吸引管吸出。无法一次性取尽的结石, 或输尿管镜无法到达结石部位,或因出血而视野不清,则可分次碎石取石[2],也可结合 ESWL 治疗。

气压弹道碎石原理是压缩气体后使气体产生高速往返的撞击运动而达到碎石,撞针往返幅度为 2、3mm,不产生热量,对周围组织不造成严重损伤。但由于肾造瘘的通道较小,结石必须击碎成小块,输尿管镜进出取石的次数较多, 潜在损伤肾内黏膜的危险增加。而德国 WOM 公司生产的双频双脉冲 U100 Nd:YAG 激光碎石机发出的激光是一种新型钕 - YAG 激光, 由 1 064 μ m 的红外光和 532 μ m 的绿光两种不同波长的光依各自的频率组成。其作用机制是经光纤将激光束能量打到结石表面, 绿光部分被结石表面吸收,在结石表面形成等离子体,等离子体再吸收不可见红外光后崩裂, 产生的冲击波粉碎结石,具有碎石效率高,对组织损伤小、安全、简单的优点[3]。人体正常组织由于不吸引这两种波长的激光, 因此不会造成正常泌尿系管壁的损伤[4]。FREDDY 适用于泌尿系结石、胆道结石和唾液腺结石。对各类性质泌尿系结石几乎都有效。Zorcher[3]等对 61 例结石患者行体外 FREDDY 激光碎石实验,碎石有效率达 100%。U100 激光将结石粉碎成小块甚至粉末状, 可插入吸管将粉末状的碎石吸出或让其自行排出,大大减少输尿管镜进出肾造瘘通道的次数,降低损伤的可能;同时减少手术时间。所以我们认为 U100 激光碎石比气压弹道碎石具有更大的优越性。

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张,扩张至 16 F,并推入 16 F Peel-away 塑料薄鞘建立皮肾通道。输尿管镜经通道进入肾集合系统,在灌洗泵的冲洗下,找到肾盂,进入输尿管,找到结石,给予气压弹道碎石,应用灌注泵的水压及结石下方输尿管导管水压将结石冲洗出或用取石钳直接钳夹出结石碎片,术后常规留置 5 F 双 J 管 4 周,并留置 16 F 肾造瘘管 5~7 d,术后 2、3 d 行腹平片检查了解结石及双 J 管位置情况。

2　结果

32 例患者均获穿刺成功,并顺利找到结石行气压弹道碎石取石,手术时间 30~120 min,平均时间 60 min,术中出血量平均约 30 ml。术后复查腹平片显示 32 例患者均一次全部取尽结石,成功率 100%。术后 5 例患者出现肾造瘘管周漏尿,给予保持导尿管通畅及调整肾瘘管位置后,2、3 d 消失。6 例患者术后出现发热,体温在 38℃左右,给予抗生素治疗后,3 d 左右恢复正常。32 例患者术后均有不同程度血尿,给予止血、卧床休息,1~3 d 血尿消失,术后平均住院时间 7 d。

3　讨论

随着腔内技术的发展,对于输尿管上段结石,传统的开放手术已难为患者所接受。而对于病程小于 1 个月的患者,首选仍为原位体外冲击波碎石(ESWL);若病史较长且已并发同侧肾盂积液、感染甚至脓肾形成,此时周围常有息肉形成[1],行 ESWL 则存在结石难以击碎及排石困难等缺点。而采用 URL 治疗,因上段输尿管移动性大,输尿管折曲而使输尿管镜意外刺穿输尿管,引起穿孔、出血、撕裂、断裂及剥脱等严重并发症[2]。另外可能因输尿管镜无法达到结石部位或结石被冲上肾盂又需结合 ESWL 治疗,成功率为 22%~60%[3]。后腹腔镜输尿管切开取石术(RLU)虽然成功率较高,但其创伤较大,术后住院时间较长,而且需要全麻,术后还有伤口漏尿等并发症[4]。常规 PCN 由于肾通道较粗,容易引起术中、术后肾出血、术后漏尿、肾周血肿以及肾皮质瘢痕大等不足,而且操作繁琐[5]。作者采用 mini-PCNL 治疗输尿管上段结石,均一次取尽结石,成功率 100%,无输尿管穿孔、狭窄、术后大出血等,具有创伤小、恢复快、操作安全可靠、结石一次取尽等优点。

通过对本组患者的治疗,作者的体会是:①对于合并有同侧肾结石患者,行 URL 或 RLU 常无法同时处理肾结石,而采用 mini-PCNL 可在输尿管镜下一并处理,提高取石率;②对于输尿管上、中、下段多发性结石,可先应用 URL 治疗输尿管中、下段结石,且尽可能行 URL 取石,然后再应用 mini-PCNL 处理输尿管上段结石。作者应用该技术治疗 2 例患者,均一次成功,摆脱了开放手术需多处切口才能完成的尴尬局面;③为提高成功率,术前充分了解结石的部位、大小及肾积水情况,行肾穿刺时,应穿入肾脏的中、上盏,且术中结合 C 臂 X 光机,了解穿刺点与肾盂、输尿管的位置,以便镜下迅速找到肾盂、输尿管,同时应将 Peel-away 薄鞘推入肾盂、输尿管内,以防结石在水压冲洗下进入肾盏,引起结石残余。

微创经皮肾穿刺取石术是近几年开发治疗输尿管上段结石的新方法[6],通过对本组病例的观察,笔者认为 mini-PCNL 是治疗输尿管上段结石的有效方法,尤其适合于合并脓肾或合并有同侧输尿管中、下段结石的患者。

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·论著·

双频双脉冲激光碎石术与电子弹道碎石术治疗肾输尿管结石的比较

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摘要：目的 比较经输尿管镜电子弹道碎石术与双频激光碎石术治疗肾结石和输尿管结石的疗效和安全性。**方法** 总结应用输尿管镜技术治疗 107 例输尿管结石和肾结石患者的临床资料，其中电子弹道碎石术(EKL)54 例,双频激光碎石术(U100L)53 例。**结果** 双频激光碎石术单次手术碎石率为 90.6%,高于电子弹道碎石术的 75.9%, $P<0.01$;双频激光碎石术平均结石排净时间为 19 d,明显少于电子弹道碎石术的 35 d, $P<0.01$;双频激光碎石组无明显并发症发生,电子弹道碎石组发生输尿管穿孔损伤 3 例。**结论** 双频激光碎石术是治疗肾输尿管结石的一种安全、有效的方法。

关键词： 肾结石和输尿管结石;内窥镜术;碎石术
中图分类号： R693.4 **文献标识码：** A

Comparative study of electronic lithotripsy and frequency-doubled double pulse ND: AG laser lithotripsy for pelvic and ureteral stone

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Abstract: Objective: To compare the efficacy and safety of endoscopic electronic lithotripsy (EKL) and endoscopic frequency-doubled double pulse laser lithoripsy (U100L) for pelvic and ureteral stones. **Methods:** From Jan. 2002 to Jun. 2003, 107 consecutive patients underwent endoscopic lithotripsy either with the Germany electronic lithotripter (54 cases) or with the Germany frequency-doubled double pulse laser lithotripter (53 cases) for the treatment of pelvic and ureteral stones. **Results:** The single session overall successful rate of stone fragmentation of U100L was higher than that of EKL (90.6% vs .75.9%, $P<0.01\%$), The average stonefree time was shorter for U100L (19 days vs. 35 days, $P<0.01$), No major complication has been observed in U100L whereas 3 perforations were encountered in EKL. **Conclusions:** U100L is effective and safe treatment for pelvic and ureteral stones.

Key words: pelvicstone and ureteralstone; endoscopy; lithotripsy
CLC number: R693.4 **Document code:** A

自 2002 年 1 月～2003 年 6 月,我们分别应用德国产电子弹道碎石术 (WAZL Elektronik lithotripsy, EKL) 和德国产双频双脉冲掺钕钇铝石榴石激光碎石术 (Frequency-Doubled Double Pulse ND:YAG Laser ,U100L) 治疗肾输尿管结石 107 例,并对两种碎石技术的疗效、安全性、方便快捷性进行比较,报告如下。

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1　材料和方法

1.1　临床资料

1.1.1　EKL 组　54 例。男 29 例,女 25 例;年龄 20~75 岁,平均 42 岁。应用 WALZ EL27-EKLCompact 电子弹道碎石机碎石。

1.1.2　U100L 组　53 例。男 41 例,女 12 例;年龄 12~78 岁,平均 49 岁。应用 W.O.M.U100 Laser(FREDDY)双频双脉冲激光碎石机治疗。

1.2　方法

体位:截石位(占 68.0%)或侧卧位(32.0%),麻醉:96.4%采用连续硬膜外麻醉联合腰麻下碎石,3.6%采用气管内插管全麻下碎石。

附表　U100L 组与 EKL 组结石碎石情况

	U100L	EKL
输尿管结石位置病例数(例)	36	36
平均手术时间(min)	18	35
碎石成功率(%)	91.42	83.33
术后残石 ESWL(例)	3	6
平均住院时间(d)	3.6	6.2
术后需输血(例)	1	3
肾结石(PCN)病例数(例)	18	17
平均手术时间(min)	30	70
碎石成功率(%)	84.62	58.82
术后残石 ESWL(例)	2	7
平均住院时间(d)	5.8	10.0
术后需输血(例)	2	6
总计	U100L	EKL
平均手术时间(min)	25(10～50)	45(30～90)
术后住院天数(d)	3.2(2～7)	5.8(3～11)
结石排净时间(d)	19(7～26)	35(11～54)
平均碎石时间(min)	5	13
平均结石排空率(%)	90.60	75.90

EKL 组:将 9.8F 硬性输尿管镜置入患侧输尿管或经皮肾通道进入肾集合系统,发现结石后从输尿管镜操作腔置入直径 0.8~2.0 mm WALZ Elektronik Lithotron (EL27-EKL) 电子弹道碎石机 EKL 弹针探头(A2 535～A2 538 型),末端通过手柄 A2534 连接于电磁振动微处理器主机 EL27-EKL。碎石时,弹针探头远端直抵结石,脉冲频率设置为 50~60 Hz,撞击能量为 70 mJ,以单击或连击模式将结石粉碎。U100L 组:采用 9.8F 硬性输尿管镜置入患侧输尿管或微经皮肾通道进入肾集合系统[1]。发现结石后,石英玻璃光导纤维自操作腔直抵结石。设置能量/频率为 0.12J/1~10 Hz。两组碎石效果见附表。术中发现 49 例输尿管结石患者合并结石处或远端息肉。

1.3　统计学方法

以上二组间数据结果的比较应用 t 检验。

2　结果

EKL 组结石一次粉碎率为 75.9%(41/54),23 例结石周围或远端伴有肉芽组织息肉形成[2]。本组病例手术中有 10 例较大的结石碎块被冲入或残留于肾盂或肾盏内,另外 3 例输尿管下段结石则停留在原来位置。这 13 例结石第 1 次手术未被完全击碎者,结石大部分具有较高的密度或直径 >10 mm,伴有局部输尿管息肉包裹,未完全粉碎的结石难以自行排出,或再次手术或放置双 J 管后行体外冲击波碎石(ESWL),均碎石成功。9 例由于术中损伤肾盂或输尿管黏膜,出血较多,术后予以输血,量约 200～800 ml 不等。术后并发症:其中 3 例术中出现不同程度穿孔损伤,术后出现损伤处输尿管瘢痕狭窄,其中 1 例术后出现感染并导致瘢痕纤维化,后行输尿管镜球囊扩张术治疗成功;2 例通过留置 2 根双 J 管(或 1 根双 J 管和 1 根输尿管导管)保守治疗成功。

U100L 组结石一次粉碎率达 90.6%(48/53),明显高于 EKL 组(P<0.01),本组病例术中有 3 例较大的结石碎块被冲入或残留于肾盂或肾盏内,术中均通过输尿管软镜在空间小、位置偏、取石难度大的肾盏内成功碎石。2 例肾盂肾盏多发和 1 例输尿管结石因结石数目较多且较坚硬,与周围黏膜组织紧密接触粘连、嵌顿、肉芽组织包裹、碎石困难,出血较多,术中仅输注 200 ml 鲜血。5 例输尿管或肾结石结石在手术之后残留于原位,未完全粉碎的结石于术后 1 周行体外冲击波碎石术(ESWL),均获得碎石成功,术后 5～7 d 结石排空率 90.60%。U100L 组无输尿管狭窄或损伤,术后 24 h 发热 3 例,血常规炎症参数不升高,无病理性尿液改变。无例外延长住院时间,无中转开放手术,无致命性并发症发生[3]。

EKL 组平均手术时间、术后住院天数和结石排净时间分别为 45 min(30～90 min)、5.8 d(3～11 d)和 35.0 d(11～54 d);U100L 组分别为 25min(10～50min)、3.2 d(2～7 d)和 19.0 d(7～26 d)。综上所述,U100L 组各项指标均低于 EKL 组(P<0.001)。

3　讨论

EKL 和 U100L 相对于开放手术更为快速、有

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效、安全。EKL 过程中无电流产生,释放热量极少,由于弹针探头的最大冲击幅度只有 2 mm,故由水肿和出血所致的黏膜损伤较轻微并呈一过性。同样,双频激光是发射两种波长脉冲方式,采用的是一种非灼热性的工作方法,在红色光(λ =635 nm)的引导下,绿光(λ =532 nm,占激光总能量的 20%)在结石表面形成等离子区,然后红外光(λ =1064 nm,占激光总能量的 80%)被结石全部吸收,同时产生了最高的峰值功率,使激光能量瞬间转化为冲击波,产生崩解效果,碎石时间短。使用的输出功率仅为 1.2 瓦,组织穿透深度 0 mm/2 000 pulses,对周围组织不产生热效应,故在直视下碎石,一般不会发生输尿管穿孔损伤的危险。

U100L 双频激光是以脉冲形式发射,脉冲宽度仅为 1.2μs,发射时间极短,而获得的脉冲峰值功率却是极高的,达到 100 kW,可粉碎各种成分和密度的结石,而不至于对输尿管黏膜造成严重损伤且整个碎石过程时间短,效率高。U100L 双频激光采用极易弯曲的石英光纤,具有极好的柔韧性,弯曲直径可达 10mm,因此可以很好地和输尿管软镜相配合,完成难度较大的取石术[4]。在 U100L 双频激光碎石时应注意采取以下措施预防或处理结石移位:中心碎石法,避免石片对黏膜的损伤影响手术野;中等频率,功率设定在 <0.12J/1,3,510 Hz 范围内,因为功率越大结石越易移位[5];低压灌洗,积水自流保持视野清晰,尽量减慢碎石过程中冲洗液的流速;术中可使用"三爪"钳或套石篮先将结石固定,再行碎石;结石一旦移位至肾盂或肾盏,可用输尿管软镜寻找结石,再行碎石;多枚结石由上往下碎石,避免上部结石回漂入肾盂;高位结石可以采用快速中央碎石法。本组 3 例结石移位者中 3 例均通过输尿管软镜成功碎石。但在 EKL 组中,因无法应用输尿管软镜,10 例碎石过程中结石移位至肾盏或肾盂者第一次手术碎石均失败,只得二次手术或行 ESWL 术。EKL 组一次结石粉碎率明显低于 U100L 组,而平均手术时间和术后结石排净时间却显著长于 U100L 组。

EKL 组因电子弹针探头偏粗,近乎占据输尿管硬镜整个操作腔隙,从而影响冲洗液体的灌入,使得手术操作范围模糊,给碎石造成困难,同时增加损伤输尿管黏膜的机率。而 U100L 组 26 例合并息肉者,因 U100L 双频激光的石英光纤直径仅为 0.73 mm,激光探头细小,在输尿管镜中可联合使用等多个工作器械,U100L 在保持术野方面优于 EKL。U100L 还具有极大的弯曲程度[6],可通过输尿管软镜,我们对术中 3 例者进行输尿管软镜成功碎石,效果满意。在应用 U100L 双频激光碎石时,针对成份偏硬结石,应从结石边缘开始[7],即光导纤维顶端应抵住结石的侧面,通过碎石在边缘表面产生一个腔隙,然后反复移动光纤顶端,瞬间产生冲击波"崩解效果"可将腔隙扩大,达到完全粉碎结果。对于术中反复冲击结石无效时,应考虑结石表面可能覆盖有黏液层,可在结石边缘以较低能量冲击,使其高速旋转,借周围组织或水流的剪切力剥除黏液层,之后就可轻而易举碎石了。对于 EKL 碎石,一般是从结石中心开始,整个结石有可能被碎成几大块,整体作用力不均匀,其中大部分需要再次粉碎,但有可能会被水流冲出视野或冲至肾盂,这将花费更多的时间寻找甚至找不到结石,此外部分结石可随冲击波嵌顿于输尿管黏膜下,进一步取石困难。反复试插导丝或碎石时弹针造成输尿管黏膜水肿、出血,继而撕裂、穿孔,其中 1 例是导丝所致,2 例是视野模糊情况下电子弹道碎石误伤所致。一旦穿孔发生,手术应立即停止,根据穿孔的位置、大小决定是否立即开放修补。如穿孔不严重,无感染、无明显尿外渗可采取保守治疗,即留置双 J 管,术后复查 KUB 以确定双 J 管的位置,定期随访,必要时再次手术,行输尿管镜球囊扩张术,也可达到满意效果。双 J 管有引流和支撑输尿管的作用,而且小的结石可顺着双 J 管下滑[8]。U100L 组结石排净时间明显短于 EKL 组,可能与下列因素有关:U100L 组结石粉碎程度比 EKL 组高,大多数结石经双频激光"等离子效应"碎石后成为均匀的细小颗粒状,直径 <1.5 mm(呈粉末状);而电子弹道轰击碎石后碎石块虽 <2.5 mm,但普遍比双频激光碎石后的碎石块大。双频激光碎石时可将嵌入输尿管黏膜内的结石块游离出来,而气压弹道碎石则无法游离此类结石,相反,对于固定在局部输尿管黏膜上的同一块结石进行反复的电子弹道碎石,可使该结石碎片嵌入局部输尿管黏膜而影响结石的排出。双频激光碎石设备具有稳定性极好、非灼热性、功能单一、操作简单(不需经常调节激光能量和脉冲频率)等功能[9],而电子弹道碎石设备却无此功能。双频激光碎石时间短、损伤小,对软组织有最大程度的保护作用,输尿管黏膜出血、充血、水肿的程度极轻,术后并发症少,有利于术后排石。本组结果显示,U100L 双频激光碎石术较 EKL 电子弹道碎石更为有效、安全和快捷。

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优于腹腔镜下保守性手术。

对于无生育要求的输卵管妊娠，我们主张采用输卵管切除术 如果有生育要求，但粘连不严重的未破裂型输卵管妊婚选择造口术或输卵管切开取胚胎术 输卵管妊娠流产且妊娠物已排出至伞端，则选用妊娠产物排出术[7]。

3.2.3 手术技巧 腹腔内积血多时先用大口径吸管将大部分游离血吸出，对不需保留输卵管或破口大，出血多且输卵管无法保留者，采用自制滑结套圈套扎切除法，整个手术均在机械方法下完成，术中原则上不使用电刀、电凝。行造口术或取胚术时，注意勿反复钳夹及挤压，并常规于病灶上方输卵管管腔局部注射 MTX 5～10 mg 作预防。输卵管妊娠流产且妊娠物已排出至伞端，轻轻挤压伞端上方的输卵管，尽可能完整取出妊娠物。Shamini 等[8]研究认为用垃圾袋收集可减少滋养细胞在腹腔镜内的再次种植。

术中使用生理盐水 500～1 500 ml 反复冲洗腹、盆腔至冲洗液清亮，术后不放置引流管，对破裂型和流产型及小部分未破裂型输卵管妊娠，我们取呈 15°的低骨盆倾斜体位，以彻底冲洗盆腔。

3.2.4 MTX 使用 有作者[1]推荐异位妊娠保守性手术后 24 h 内预防性地单次 MTX（mg/kg）给药，可以大大减少此并发症的发生，缩短随访时间。我们仅在腹腔镜没有发现的异位病灶术后预防性给以 MTX 肌注，随访至今未再出现 PEP。

总之，通过术式的正确选择、操作技巧的改进，以及药物性预防和医生警惕性提高，是可以有效避免 PEP 的发生。

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（乐 园 编辑）

输尿管镜 U100 激光与体外冲击波碎石术应用于输尿管上段结石患者临床治疗中的效果观察

【摘　要】 **目的**　分析输尿管上段结石患者经输尿管镜 U100 激光与体外冲击波碎石术治疗的临床效果。**方法**　回顾性分析我院 2014 年 3 月至 2015 年 11 月期间收治的 70 例输尿管上段结石患者的临床资料，按照入院顺序将所有患者分为两组，即：观察组（35 例）与对照组（35 例）。对照组 35 例输尿管上段结石患者给予体外冲击波碎石术治疗，观察组 35 例输尿管上段结石患者给予输尿管镜 U100 激光治疗。对比两组临床疗效。**结果**　观察组 35 例输尿管上段结石患者的手术时间、住院时间、碎石成功率、术后结石排净率、并发症发生率明显优于对照组 35 例输尿管上段结石患者，差异有统计学意义（P＜0.05）。**结论**　输尿管上段结石患者经输尿管镜 U100 激光治疗的临床效果十分显著，值得在临床上推广运用。

【关键词】 输尿管上段结石；　体外冲击波碎石术；　输尿管镜 U100 激光；　效果

输尿管上段结石，实质上就是泌尿外科经常发生的一种疾病[1]。现阶段，临床上对于输尿管上段结石患者的治疗，主要采取开放手术、腹腔镜输尿管切开取石、输尿管镜激光碎石以及体外冲击波碎石等方法[2]。本文主要通过收集我院 2014 年 3 月至 2015 年 11 月期间收治的 70 例输尿管上段结石患者的临床资料，探讨输尿管上段结石患者经输尿管镜 U100 激光与体外冲击波碎石术治疗的临床效果，现报道如下。

资料与方法

1．一般资料

回顾性分析我院 2014 年 3 月至 2015 年 11 月期间收治的 70 例输尿管上段结石患者的临床资料，所有患者手术治疗均经 CT、B 超确诊为。输尿管上段结石。按照入院顺序将所有患者分为两组，即：观察组（35 例）与对照组（35 例）。观察组 35 例输尿管上段结石患者与对照组 35 例输尿管上段结石患者的一般资料（病程、结石位置、结石直径、年龄、性别等）无显著差异，无统计学意义（P＞0.05），详见表 1。

表 1　观察组患者与对照组患者一般资料对比分析

组别	例数	性别		病程（年）	平均年龄（岁）	结石位置		结石直径（cm）
		男	女			左侧	右侧	
观察组	35	21	14	2.8±1.5	45.7±2.6	19	16	1.46±0.71
对照组	35	19	16	3.2±1.1	43.6±3.1	17	18	1.52±0.53

2．方法

2.1 对照组

对照组 35 例输尿管上段结石患者给予体外冲击波碎石术，即：选取南鲸 ESWL108G 型碎石机进行体外冲击波碎石操作，碎石过程中运用彩超进行定位跟踪。冲击次数控制在 2000 次以上，3000 次以下，平均冲击次数控制在 2200 次，同时将电压控制在 8kV-13kV。

2.2 观察组

观察组 35 例输尿管上段结石患者给予输尿管镜 U100 激光碎石，即：给予连续全身麻醉，取低截石位，直视下将 WOLF F9 硬质输尿管镜经尿道插入，再将输尿管导丝插入患侧输尿管口，沿着导丝的方向入镜，给予灌注泵冲水，保证输尿管处于充盈的状态，持续入境至结石位置之后，暂停冲水操作，转变为人工注水方式，将 U100 激光光纤沿着输尿管镜插入操作通道，将其功率设定为双频 120W；出现合并息肉状况的输尿管上段结石患者，首先应当尝试导丝引导输尿管镜通过息肉之后才能够开展碎石操作。手术之后对 F6 双“J”管予以放置，放置时间为 28d-3 个月。

3．观察指标

对比观察组患者与对照组患者的手术时间、住院时间、碎石成功率、术后结石排净率、并发症发生率。

4．疗效判定

治疗成功：KUB 联合 B 超检查显示结石全部排除。治疗失败：KUB 联合 B 超检查显示结石未碎。

5．统计学方法

选取 SPSS19.0 软件处理数据，计数资料经 x2 检验，计量资料经 t 检验，计量资料经（$\bar{x}\pm s$）表示，P＜0.05 时表示差异有统计学意义。

结　果

1．观察组与对照组各项手术指标对比

如表 1 所示，观察组手术时间显著短于对照组，差异有统计学意义（P＜0.05）；观察组的住院时间显著短于对照组，差异有统计学意义（P＜0.05）；观察组碎石成功率显著高于对照组，差异有统计学意义（P＜0.05）；观察组术后结石排净率显著高于对照组，差异有统计学意义（P＜0.05）。

表 1　观察组与对照组各项手术指标对比分析（$\bar{x}\pm s$）

组别	例数	手术时间（min）	住院时间（d）	碎石成功率[%(n/n)]	结石排净率[%(n/n)]
观察组	35	28.54±2.59	4.9±1.5	97.1（34/35）	94.3（33/35）
对照组	35	40.29±2.53	6.8±3.2	77.1(27/35)	74.3（26/35）
t/x² 值		14.5134	2.4043	4.5902	3.8829
P 值		0.0000	0.0212	0.0322	0.0488

2．观察组与对照组并发症发生率对比

如表 2 所示，观察组 35 例输尿管上段结石患者并发症发生率显著低于对照组 35 例输尿管上段结石患者，差异有统计学意义（P＜0.05）。

表 2　观察组与对照组并发症发生率对比分析（n，%）

组别	例数	严重出血	尿外渗	高热	黏膜撕脱	输尿管穿孔	总发生率
观察组	35	1（2.8）	0（0）	0（0）	0（0）	2（5.8）	3（8.6）
对照组	35	3（8.6）	1（2.8）	5（14.2）	1（2.8）	1（2.8）	11（31.4）
X²				4.3750			
P 值				0.0365			

结　论

输尿管上段结石是一种泌尿外科疾病，结石直径不超过 1cm 且无梗阻状况的时候，可给予 ESWL 治疗；若是复杂性结石，应当给予手术治疗[3]。输尿管上段结石由于与肾盂开口之间的距离比较近，因此在碎石时极易因水流冲击被推回肾脏中，严重影响手术治疗。选用输尿管镜能够清楚的观察结石所处位置，停止灌注泵操作，选取头高手地位，转变为手工注水，能够有效将结石冲出[4]。

输尿管镜 U100 激光碎石术应用于输尿管上段结石治疗中，首先需要在输尿管口置入输尿管镜，这是 U100 激光碎石术的一个重要步骤；同时，应当充分重视患者的体位，给予膀胱截石位，尽量使双下肢处于下垂状态，将尿道外口与输尿管口置于同一条直线中，这样有利于进镜[5]。

本研究中，观察组 35 例输尿管上段结石患者的手术时间、住院时间均优于对照组 35 例输尿管上段结石患者，差异有统计学意义（P＜0.05）；同时，观察组的碎石成功率、结石排净率及并发症发生率分别为 97.1%、94.3%、8.6%，对照组依次为 77.1%、74.3%、31.4%；差异有统计学意义（P＜0.05）。与金森军[6]的研究结果类似。

综上所述，输尿管上段结石患者经输尿管镜 U100 激光治疗的临床效果十分显著，明显优于体外冲击波碎石术治疗，能够在很大程度上缩短手术时间、住院时间，有利于降低并发症发生率，提高排石率，值得在临床上推广运用。

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U100 双频激光和气压弹道碎石治疗输尿管结石的疗效比较

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[摘要]　**目的**：探讨 U100 双频激光治疗输尿管结石的优越性。**方法**：对经 U100 双频激光和气压弹道两种碎石方法治疗输尿管结石的疗效进行比较。**结果**：术后 2～4 周，U100 双频激光碎石（双频激光组）结石排净率 93.8%（167/178），气压弹道碎石（气压弹道组）为 85.0%（267/314）；双频激光组结石回漂到肾盂发生率 3.4%（6/178），气压弹道组为 6.7%（21/314）；双频激光组并发症相对较少，术后肉眼血尿发生率为 31%，2 例发生肾绞痛，无一例发生输尿管穿孔和泌尿系感染；而气压弹道组术后肉眼血尿发生率为 53.2%，15 例发生肾绞痛，4 例发生输尿管穿孔，6 例发生泌尿系感染。**结论**：U100 双频激光输尿管碎石优于气压弹道碎石，是一种操作简单、安全、对软组织损伤小、碎石高效的输尿管结石治疗方法。

[关键词]　输尿管结石；碎石术；输尿管镜

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Compare the therapeatic effect of frequency-doubled-doubled-pulse laser and pneumatic ballistic lithotripsy for the treatment of ureteral calculi

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Abstract　**Objective**: To investigate and compare the therapeutic effect of frequency-doubled-doubled-pulse laser and pneumatic ballistic lithotripsy for the treatment of ureteral calculi. **Methods**: To comparatively study the stone-free rate, cure rate and complication of the two methods for treatment of ureteral calculi. To summarize the advantages and disadventages of the two treatment. **Results**: stones were thoroughly removed from the ureter in 178 patients in frequency-doubled-doubled-pulse laser group with low complication, the stone-free rate was 93.8% (167/178) in post-operative 2—4 weeks. 314 patients in pneumatic ballistic lithotripsy group, of which 267 patients were successfully cured. The stone-free rate was 85.0% (267/314) in post-operative 2—4 weeks, but with high complication. **Conclusions**: The frequency-doubled-doubled-pulse laser for the treatment of ureteral calculi is markedly surpassed the pneumatic ballistic lithotripsy, and is a safe, high-performance approach for treatment ureteral calculi.

Key words　Ureteral calculus; Lithoclasty; Ureteroscope

随着科技的进步和各种腔内碎石器的应用，输尿管镜腔内碎石已成为输尿管结石的标准治疗[1]。而激光碎石又是一种继超声碎石、液电碎石和气压弹道碎石后更为高效安全的方法[2]。输尿管镜 U100 激光碎石术是近年新开展的手术方式。U100 双频脉冲激光仪（UO100 Frequency-doubled-double pulse Nd：YAG laser，即“FREDDY”技术）目前已开始在各大医院应用。2002 年 1 月以来，我们采用输尿管镜气压弹道碎石治疗输尿管结石 314 例患者（气压弹道组）；2003 年 9 月以来采用输尿管镜 U100 双频脉冲激光治疗输尿管结石 178 例患者（激光碎石组）。本文对两组的临床疗效和并发症等进行比较，借以探讨 U100 双频脉冲激光输尿管碎石的优越性。现报告如下。

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1　资料与方法

1.1　临床资料

根据治疗方法将病例分为两组：脉冲激光组 178 例，男 102 例，女 76 例，年龄 15～80 岁，平均年龄 48 岁。经 B 超及 KUB 检查确诊，输尿管上段结石 38 例，中段结石 53 例，下段结石 87 例。输尿管上段结石 38 例中包括体外震波碎石治疗后形成石街 5 例。结石大小0.5 cm×0.6 cm×0.4 cm ～1.2 cm×1.6 cm×0.9 cm。其中 48 例的患者有ESWL 史。

气压弹道组 314 例，男 179 例，女 135 例，年龄 16～77 岁，平均年龄 44.5 岁。经 B 超及 KUB 检查确诊，输尿管上段结石 54 例，中段结石 89 例，下段结石 171 例，输尿管上段结石中包括体外震波碎石治疗后形成石街 3 例。输尿管下段结石中包括体外震波碎石治疗后形成石街

cm×0.6 cm×0.4 cm ~ 1.1 cm×1.6 cm×0.9 cm。其中97例的患者有ESWL史。

1.2 治疗方法

在持续硬膜外麻醉下，患者截石卧位，使用液压泵灌注。直视下经尿道将输尿管镜放入膀胱，寻找患侧输尿管开口。经输尿管镜的操作通道向输尿管内置入F_4的输尿管导管或斑马导丝，输尿管镜内旋90~120°。利用输尿管导管或斑马导丝挑起输尿管口，通过液压泵的灌流作用，冲开输尿管开口。输尿管的斜面尖部部分进入输尿管口，在输尿管导管或斑马导丝的引导下，顺输尿管的走行方向旋转、推进输尿管镜，调节流量开关，在低压、低灌注下缓慢推进输尿管镜到结石所在的部位。有时见输尿管有狭窄，轻微的狭窄可用输尿管硬镜在导丝的引导下进行扩张，有的患者在结石部位有炎性息肉，对蒂较长的息肉，可用输尿管异物钳夹住，并旋转异物钳，取出息肉。

双频激光组：使用德国生产的WOLF($F_{7.5X9.0}$)输尿管镜和美国生产的顺康($F_{7.6}$)输尿管镜，经尿道进行U100双频激光和气压弹道碎石治疗输尿管结石。采用德国生产的U100双频激光，激光脉冲由波长为1 064 nm的红外光和波长为532 nm的绿光组成，光纤通过操作通道到达结石部位。对于较小的结石，采用单发，对于较大的结石，用5或10连发，从结石的边缘部分开始，将结石碎成粉末或大小约为0.5~1.5 mm的微小结石，放入双J导管行内引流，双J导管保留2~4周后拔除。

气压弹道组：采用瑞士生产的EMS气压弹道碎石机，气压为2.5~3.0 kPa，经过输尿管镜的操作通道放入0.8~1.2 mm的弹道碎石机探杆，轻触结石。从结石的边缘部分开始，将结石击碎，碎石颗粒大小约为1.5~3.0 mm，放入双J导管行内引流，双J导管保留2~4周后拔除。

术后1~4周常规复查血、尿常规、B超及KUB检查，了解排石情况，记录各种并发症。

1.3 统计学方法

采用统计学软件SPSS 11.0，计数资料分析采用χ^2检验。

比较两种手术方法在手术时间、术中出血量、术后镇静剂使用量、术后下床活动时间、住院时间以及术后恢复正常活动时间的差别。组间比较采用t检验。

2 结果

两组疗效比较见表1。从表1可见，双频激光组和气压弹道比较组各项疗效指标和并发症指标，差异均有统计学意义（$P<0.05$）。

表1 双频激光组与气压弹道组疗效比较

项目	双频激光组	气压弹道组
碎石满意率/%	94.9	86.0
结石排净率/%	93.8	85.0
输尿管上段穿孔/%	0	1.3
术后拔除尿管时间/d	1.6±0.4	4.7±2.1
术后肉眼血尿发生率/%	31.0	53.2
结石回漂发生率/%	3.4	6.7
肾绞痛/%	1.1	4.8
术后泌尿系感染/例	0	1.9
辅以ESWL碎石/例	3.4	8.2

3 讨论

2000年推向市场的一种先进的固体激光器，专门用于尿路结石和胆道结石的治疗[3]。激光脉冲由波长为1 064 nm的红外光(占能量80%)和波长为532 nm的绿光(占能量20%)组成，故称之为双频激光。碎石过程中，绿光先被结石吸收，形成了等离子体，然后等离子体充分吸收红外光能量，产生机械冲击波碎石。由于所产生的冲击波峰值功率极高，在很短的时间内就能准确高效地粉碎结石，因此，对结石的推动力极小[4]，这样也大大降低了碎石过程中结石上移进入肾盂的可能性。同时，由于输尿管壁组织不吸收这两种波长的激光，因而就不会造成损伤[5]。

气压弹道碎石机也是近几年来较为成功地应用于泌尿外科腔内碎石的新型设备，其基本原理是将压缩气体产生的能量驱动碎石机手柄内的子弹体，子弹体(脉冲式冲击)再撞击碎石探杆，经探杆传导至结石，产生碎石效应[6]。由于其碎石作用为机械性，与U100激光碎石相似，极少产生热能。探杆冲击幅度≤2 mm，对软组织产生短暂损伤，如轻度水肿、出血等[7]。而气压弹道碎石机应用物理动量原理，以压缩气体推动子弹体，结石易回漂到肾盂，且对输尿管黏膜产生损伤，出血和穿孔发生机率增加。

采用FREDDY技术的U100双频激光碎石机就是专门用于碎石的设备，即使采用了最大功率，对周围软组织也没有损伤。因其无创口、损伤小，术野清晰，疗效直观可靠，并发症少，术后恢复快，故为多数患者乐意接受。德国Duren泌尿科诊所的碎石中心，采用U100双频激光碎石机对104例尿路结石进行治疗，效果满意[8]。并发症显著减少且排石完全，操作简单，具有安全、高效和简便等优点[9]。本研究显示，U100双频激光碎石机有着比气压弹道碎石机更优越的性能。

本文两组疗效对应指标比较，均有明显差异，表明U100双频激光不仅碎石成功率高，效果好，而

由于气压弹道碎石作用为机械性[9]，不可避免地造成输尿管壁不同程度损伤，是导致肉眼血尿发生率高的主要原因。如果操作不慎，容易发生输尿管穿孔；气压弹道碎石机应用压缩气体推动子弹体撞击碎石探杆而产生碎石效应[8]，对结石的推动力较大，容易造成结石的易位，结石回漂率较高；同时由于碎石后的结石颗粒较粗大，容易发生肾绞痛，也影响结石排出的排出速度，导致结石排净率较低。从而诱发泌尿系感染的机率增加，患者出现腰部疼痛、血尿、膀胱刺激征、尿路感染等症状。相反，而 U100 双频激光在很短的时间内就能将结石高效粉碎，不仅对结石的推动力极小[6]，而且碎石后的结石颗粒较细，相应地结石回漂率发生低，细的结石容易排出，因此，其结石排净率较高。

经输尿管镜输尿管结石碎石治疗成功的关键是：减少输尿管损伤，防止结石移位并彻底粉碎结石。为此，U100 双频激光器较气压弹道碎石更具有优势。为我们在腔镜辅助下碎石提供了一种更加安全有效的治疗手段，避免了既往应用气压弹道、钬激光、液电碎石等同时存在潜在的输尿管损伤的可能，为我们在临床工作中增加了安全保障，减少了患者的痛苦。

本文资料提示，采用 U100 双频激光碎石还必须先将光纤对准结石边缘开始粉碎，采用连续脉冲间断发射法碎石，一般频率不宜太快，脉冲发射时间不必过长，否则可能造成碎石片损伤输尿管甚至导致穿孔。碎石应在视野清晰条件下进行，结石粉碎后，输尿管腔道自然显现，为防止结石上漂，输尿管镜进入输尿管膀胱开口后可降低注水压，甚至关闭进水开关。对一侧多枚结石处理时，应从上而下逐一碎石，即尽量将镜子越过下部结石，上推到最上面的结石，从之开始逐一向下碎石，以避免上部结石上漂进入肾盂。其次，上段高位结石回漂及碎石不全仍是处理上段结石的一大难题，我们的初步经验是：对于嵌顿性结石，宜从结石的边缘开始碎石，对于非嵌顿性结石可快速中央碎石，迅速将结石崩解成小块。碎石后常规放置双 J 管留置导尿 2～3 天，2～4 周后复查，见结石排净后即可双 J 拔管，碎石术后，患者都会出现轻重不等的肉眼血尿，经抗炎止血处理及多饮水，2～3 天后，血尿均可消失。此外，激光绿色波的闪烁和不可见的红外光对人视力有一定损害作用，在操作中我们应该注意自我保护，尽量采用在视频装置下手术，避免直视下操作。

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· 文献综述 ·

微创治疗上尿路结石进展

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随着微创外科技术的不断发展,上尿路结石的治疗方法已由传统的开放手术转为以微创治疗为主。目前,可供选择的微创治疗方法包括体外冲击波碎石术(extracorporeal shock wave lithotripsy, ESWL)、输尿管镜碎石术(ureteroscopy lithotripsy, URL)、经皮肾镜碎石术(percutaneous nephrolithotripsy, PCNL)、微创经皮肾镜碎石术(minimally invasive percutaneous nephrolithotripsy, mini-PCNL)以及腹腔镜取石术等。现将近年来上尿路结石的微创治疗进展综述如下。

1 体外冲击波碎石术(ESWL)

1982 年体外冲击波碎石机问世,1985 年得到美国 FDA 批准用于泌尿系结石的治疗,作为一种有效和安全的治疗设备迅速在全世界应用。ESWL 治疗上尿路结石被认为开创了医学史上非开放手术治疗结石的新纪元。早期 ESWL 仅能治疗约 20% 的肾结石,且仅限于结石直径 < 2 cm 者[1]。随着临床经验的不断积累,目前 ESWL 治疗结石的适应证已经扩大到整个尿路,采用 ESWL 治疗鹿角形肾结石也取得一定的效果,但单用 ESWL 治疗鹿角形肾结石,结石残留率约为 50%[2],而且此类结石治疗的难度较大,并发症多,结石碎块在输尿管内大量堆积可造成梗阻及感染,使肾功能丧失,甚至发生败血症[2]。此外,反复多次的 ESWL 可加重肾损害,甚至造成肾萎缩。部分鹿角形肾结石病人仍需 PCNL、开放手术治疗。体外冲击波碎石机根据冲击波源的不同可分为 3 类,即液电式、电磁式、压电式。液电式碎石机的优点是脉冲功率高,碎石效果好;缺点是冲击波的各波之间的均一性差,电极寿命短,噪音大,对周围组织的损伤较大。目前国内大部分碎石机还是使用液电式冲击波源。电磁式碎石机的出现是 ESWL 技术的重大进步,其特点是脉冲放电稳定,聚焦稳定,冲击波源寿命长,对周围组织的损伤小,有全面取代液电式碎石机的趋势。压电式碎石机的优点是焦区小,碎石颗粒小,对于治疗小结石有独特优势;但功率小,治疗大结石疗效差。虽然对于一水草酸钙、胱氨酸及磷酸钙等成分的结石,ESWL 治疗较难将结石粉碎,但 ESWL 非侵入性、无痛性的治疗方法仍不失为多数上尿路结石的首选微创治疗方式。

ESWL 除了会产生输尿管石街等并发症外,其对肾脏及其周围器官也会产生一定程度的损害。故在选择 ESWL 时,合理选择患者、控制冲击次数和电压尤为重要[3]。临床实践证明,肾结石直径 < 2.5 cm 时才可采用 ESWL,对于较大肾结石,先插入输尿管导管再碎石的方法可保证 ESWL 的安全为 83.0%,3 个月后结石排净率为 86.5%,有 13 例发生输尿管石街,采用 URL 或 PCNL 取净结石。ESWL 碎石两次失败要寻找其原因,并改用其他方法治疗,以免多次碎石对组织造成损害。

2 输尿管镜碎石术(URL)

1977 年 Goodman 报道应用小儿膀胱镜作为输尿管镜观察成人的输尿管。1980 年 Perez-Castro 成功制造了第一条直径为 F_{11} 的输尿管硬镜,并用此镜进行了输尿管检查和取石。这一技术很快在欧美应用,并受到泌尿外科医生的广泛认可,输尿管镜技术大大地改变了治疗尿路结石的局面,并确立了其在腔内泌尿外科的地位。1983 ~ 1985 年间,北京、广州最早将输尿管镜引进中国,当时的输尿管镜镜体较粗(F_{13} ~ F_{16}),腔内碎石设备的效能较低,并发症较高,限制了 URL 的推广与应用[5]。

20 世纪 90 年代以后,由于医学工程、电子、材料技术等的迅猛发展,输尿管镜得到不断的完善。无论是硬镜还是软镜,纤维导光束的引入大大缩小了输尿管镜的口径。越来越精巧的操作器械同样减少了工作通道的管径。同时,输尿管扩张技术从扩张管盲目扩张到导丝引导的扩张器和气囊扩张,发展到如今的单纯液压扩张。输尿管镜下直视碎石工具也越来越精良,从超声波、液电碎石器到气压弹道碎石器、激光碎石器。把输尿管镜进入到易扭曲的管腔,其中许多技巧借鉴了血管介入技术。上述设备和技术的不断改进,大大促进了输尿管镜碎石术的临床应用,输尿管损伤等并发症的发生率也大为下降。目前,URL 处理输尿管中、下段结石具有不可替代的优越性,如结石取净率高,症状持续时间较短,可同时清除结石区息肉等。高效的腔内碎石器的发展,特别是钬激光的出现,更使输尿管镜处理扭曲输尿管内的嵌顿性结石、肾下盏结石有了更大的用武之地,治疗成功率及结石清除率已达 90% 以上,输尿管黏膜剥脱,输尿管穿孔、断裂等严重并发症的发生率 < 3%[6,7]。如今,输尿管镜在处理输尿管结石中已确立了不可取代的地位,许多医院已把 URL 作为输尿管中、下段结石的治疗首选[8]。在 ESWL 和 URL 作为一线治疗方法时,可根据所在医院设备和医师技术、经验进行选择。对于输尿管上段结石,如病史短于 1 个月,一般首选 ESWL;如果病史较长、结石较大且并发同侧肾中重度积水,此时结石周围常有息肉形成,最好采用 URL 或 mini-PCNL[5]。

随着 ESWL 和内镜技术的发展,目前 95% ~ 98% 的输尿管结石可免于开放手术。根据输尿管结石的性质、位置、

裹、患侧肾功能差、结石密度低、与骨重叠无法定位者，ESWL 治疗不易成功；输尿管中段结石因肠气影响，能量损耗过多，ESWL 也不易成功；孕妇也不宜采用 ESWL 治疗[9]。而对于输尿管中下段结石、ESWL 定位困难、ESWL 治疗失败、ESWL 治疗后形成石街者，采用 URL 治疗成功率很高。早期通过输尿管镜采用超声波碎石和液电碎石，但这两种方式容易造成输尿管穿孔，现在已很少使用。20 世纪 90 年代初出现的输尿管镜下气压弹道碎石术，以其疗效好、安全性高、损伤小、治疗费用较低等优点，很快得到推广普及；但对于输尿管上段结石，因结石易滑入肾盂而导致 URL 效果欠佳。90 年代钬激光开始应用于泌尿外科手术，钬激光的波长为 2 100 nm，能经硅石英晶体传输，特别适合于内镜手术。它不但可以击碎任何成分的尿路结石、烧灼息肉，还可以切开狭窄的输尿管壁而达到类似于开放手术的疗效[6]。由于钬激光主要利用光热效应作用于结石，产生气泡空化作用而将结石击碎，碎石时结石不易移位，对于输尿管上段的结石也能处理。钬激光只要与输尿管壁保持 > 1 mm 的距离，穿孔的风险可忽略不计。输尿管镜下钬激光处理输尿管结石效果优于 ESWL 和气压弹道碎石[10]。孙颖浩等[11]采用软输尿管镜和钬激光治疗肾结石亦取得满意疗效。U100 激光碎石机是德国 WOM 公司于 2000 年推出的一种先进的腔内碎石装置，能发出波长为 1 064 nm 的红光和 532 nm 的绿光，故称双频激光机。该碎石机的特点是脉冲峰值功率高，达 100 kW，整个碎石过程短，效率高，可粉碎各种成分和密度的结石，而且人体正常组织由于不吸收这两种波长的激光，对周围组织不产生热效应，因此一般不会造成正常泌尿道管壁的损伤。不足的是，不能同时处理结石合并的息肉。双频激光可以很好地和输尿管软镜相配合，完成难度较大的碎石术，纳宁等[12]比较经输尿管镜双频激光碎石术与气压弹道碎石术治疗肾结石和输尿管结石的疗效和安全性，其中应用双频激光碎石术治疗 53 例，气压弹道碎石术治疗 54 例，结果显示：双频激光碎石术单次手术碎石率为 90.6%，高于气压弹道碎石术的 75.9%；双频激光碎石术平均结石排净时间为 19 d，明显少于气压弹道碎石术的 35 d；双频激光碎石组无明显并发症发生，气压弹道碎石组发生输尿管穿孔损伤 3 例。

3 PCNL 及微创 PCNL（mini-PCNL）

经皮肾镜术的历史可追溯到 20 世纪 40 年代，Papel 和 Brow 最早利用腔内镜从肾造口取出残留结石，1955 年 Goodwin 提出经皮肾穿刺造口的方法，开创了经皮肾造瘘技术的新纪元。1973 年之后，德、美、日等发达国家不断生产和改进各种硬性和可曲性肾镜，促进了这一技术发展[13]。1976 年，Fernstrom 等[14]首先应用肾镜通过经皮穿刺扩张的肾造瘘通道用套石篮成功取出肾盂内结石，开创了经皮肾镜取石术。80 年代，Alken[15]和 Clayman[16]等在此基础上成功施行肾镜下取石术，并将超声碎石术和液电碎石术在 PCNL 中成功应用，由于其微创的本质特点，逐渐受到全球泌尿外科医师和患者的欢迎。1982 年后，我国北京、广州、南京等地相继开展 PCNL 手术。早期 PCNL 多采用先做经皮肾造瘘，1 ~ 2 周后行碎石处理的二期手术方法，且肾造瘘口径较粗，扩张通道达 F_{30}（直径 10 mm）以上，容易损伤叶间血管或撕裂肾盏颈而引起术中、术后肾大出血和尿外渗等并发症。加上国人的肾脏较西方人为小，故这些并发症发生率在国内更高[17]。由于传统的 PCNL 操作困难，安全性较差，曾一度不为泌尿外科医生所接受，这给传统 PCNL 的推广造成一定提出了微造瘘经皮肾取石的观点，创新了经皮肾穿刺微造瘘术和经皮肾微造瘘输尿管镜取石技术，尽管较传统 PCNL 有所改进，如术中、术后肾大出血，术后漏尿以及对肾皮质的损伤减少，但仍需二期取石，结石取净率较低。近些年，李逊等[4,17,18]提出了微创 PCNL 方法，即经皮肾穿刺造瘘工作通道为 F_{14} 或 F_{16}，用 $F_{8/9.8}$ 输尿管镜代替肾镜，通过工作通道进入肾集合系统或输尿管上段一期碎石，以气压弹道碎石机或钬激光击碎大结石后取出，使治疗的成功率不断增加，结石取净率达 93%，严重并发症（如大出血、肾集合系统穿孔、邻近器官损伤等）的发生率低于 5%，手术死亡率约 0.02%，治疗范围不断扩大。

许多泌尿外科医生也纷纷采用经皮肾微造瘘输尿管镜下碎石的一期手术方法，由于输尿管镜有一定弹性，其在肾集合系统操作范围比传统肾镜更大，所以处理结石的范围更广。惟一的缺点是对肾鹿角形结石的手术时间可能较长。PCNL 彻底改变了泌尿外科医师对肾鹿角形结石惟有开放取石的尴尬局面，对开放手术后复发的结石和不能耐受开放手术的患者尤具有重大意义[19]。近年来，通过联合使用气压弹道碎石、超声碎石及负压吸引设备，明显提高了经皮肾镜取石术的效率及单次取净结石率，手术时间显著缩短，使 PCNL 成为肾、输尿管上段复杂性结石的重要治疗方法[20,21]。国外的临床研究表明：肾镜下联合使用新型超声碎石和气压弹道碎石可明显提高单位时间内结石清除率，而且对不同成分的结石均有良好的粉碎作用，将这两种碎石技术结合、形成优势互补是 PCNL 的发展方向之一[21,22]。我们[20]应用该设备治疗 56 例上尿路复杂性结石，取得良好疗效，术中结石清除率达 89.3%，其中输尿管上段结石的清除率为 100%，肾结石清除率为 84.2%。本组平均手术时间 90 min，6 例肾盏内小块结石残留，经软性肾镜取石或 ESWL 后治愈。随访 1 ~ 3 个月，无大出血、严重感染、周围脏器损伤等严重并发症。

4 腹腔镜切开取石术

20 世纪 90 年代腹腔镜问世以后，采用腹腔镜技术治疗上尿路结石得到快速发展。各种原因无法行 ESWL 及 URL 或治疗失败的肾外型肾盂结石，较大、较硬或嵌顿时间长、周围肉芽组织增生明显的输尿管结石是腹腔镜切开取石术的手术指征[23]。腹腔镜治疗上尿路结石可采用经腹腔路径或经腹膜后路径。经腹腔路径空间大，解剖标志清楚，可同时处理输尿管上、中、下段结石，也可在同一切口同时治疗双侧输尿管结石；但手术范围大，对腹腔干扰较大，可能损伤腹腔脏器及造成术后肠粘连，对输尿管上、中段显露不如腹膜后路径。蔡志明等[24]采用腹腔镜经腹腔路径手术治疗输尿管上、中、下段结石均获得成功，成功率为 94%。虽然经腹膜后路径具有操作空间小、建立气腹较复杂、术后渗液吸收较慢等缺点，但入路直接，容易分离显露肾脏及寻找输尿管，而且泌尿外科医师对腹膜后路径较熟悉，因此，做腹腔镜输尿管手术多采用此路径[25]。采用腹腔镜手术治疗上尿路结石可获得类似开放手术的疗效，而且与开放手术相比，具有创伤小、恢复快、痛苦小、并发症少等优点[26]，是治疗上尿路结石的又一可供选择的方法，可取代部分开放手术，代表了微创泌尿外科发展的方向。腹腔镜在泌尿外科的应用发展较快，但有些学者认为其在尿路结石的治疗方面意义不大，因为：一是其设备较昂贵，学习曲线长；二是适合腹腔镜手术的患者采用 URL 或 mini-PCNL 处理更简便、容易。只有在需要同时处理同侧肾或肾上腺疾病时，才采用腹腔镜处理[4]。

输尿管结石根据结石的性质、位置、大小、数目,尿路梗阻程度,肾功能以及设备技术条件等可分别采用输尿管镜取石或碎石、ESWL 或二者联合应用治疗,输尿管镜下碎石以激光碎石效果更佳[6]。微创 PCNL 采用气压弹道碎石、钬激光碎石或联合超声和气压弹道碎石是治疗肾及输尿管上段复杂性结石的首选微创方案。而对于各种原因无法行 ESWL 及输尿管镜取石或治疗失败者,采用腹腔镜手术治疗可取代大部分开放手术,代表了微创泌尿外科发展的方向。但有些学者认为其在尿路结石的治疗方面意义不大[4]。开放手术在腔内泌尿外科发展的今天,由于其创伤较大,术后恢复较慢,对术后复发结石较难处理等缺点,已逐渐被其他方法取代。仅有少数完全性鹿角形结石等仍需开放手术处理。

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U100 双频双脉冲激光治疗输尿管结石
(附 260 例报告)

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[摘要] 目的:探讨 U100 双频双脉冲掺钕钇铝石榴石(Nd:YAG)激光(FREDDY 技术)治疗输尿管结石的临床疗效。方法:应用 U100 双频双脉冲 Nd:YAG 激光经内腔镜治疗输尿管结石 260 例,其中结石位于上段 58 例,中段 157 例,下段 45 例,其中 67 例伴有 BPH,术前行 ESWL 者 61 例。结果:输尿管结石碎石成功率为 96.5%(251/260),其中上段结石成功率为93.1%(54/58),中段成功率为97.4%(153/157),下段成功率为97.8%(44/45),三组结果比较差异无统计学意义($P>0.05$)。平均手术时间 25(7~45) min,平均激光工作时间(5.5±3.5) min,平均 12(2~21)天排净结石,术后平均住院2.5(1~6) 天。43.1%(112/260)的患者术后均有不同程度的肉眼血尿,对症处理后 2~4 天消失。无输尿管穿孔、撕裂、感染、脓肾等并发症。结论:FREDDY 激光碎石手术时间短,组织损伤小,术后并发症少,是一种安全、高效的腔内泌尿外科碎石方法。

[关键词] 输尿管结石;U100 激光;碎石术
[中图分类号] R454.2;R693.4 [文献标识码] A [文章编号] 1001-1420(2006)05-0346-03

Treating ureteral calculi with U100 frequency-doubled double pulse Nd: YAG laser (Report of 260 cases)

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Abstract **Objective:** To evaluate the clinical effect of U100 frequency-doubled double pulse Nd:YAG laser lithotripsy for ureteral calculi. **Methods:** Totally 260 cases with ureteral calculi treated via endoscope with FREDDY was summarized. **Results:** The successful rate was 93.1%(54/58) in the proximal ureteral calculi, 97.4%(153/157) in the middle ureteral calculi, 97.7%(44/45) in the distal ureteral calculi and 96.5%(251/260) in all. There was no difference among the 3 groups($P>0.05$). The meantime of operation was 25 minutes(7~45 min) and the laser worked (5.5±3.5)minutes in average. The stone expectoration time was 12(2~21)days. The mean post operation hospitalization was 2.5(1~6)days. Different degrees of hematuria were seen in 43.0%(112/260) cases after operation. No major complications such as high fever, perforation or pyonephrosis were observed. **Conclusions:** FREDDY is a kind of laser with little damage to the soft tissue and high efficiency of lithotripsy. It is an effective, simple and reliable method for the treatment of ureteral calculi.

Key words Ureteral calculi; Lasers; Lithotripsy

自 2002 年 3 月~2005 年 3 月,我院应用德国微创(WOM)公司生产的 U100 双频双脉冲激光(Frequency-doubled double pulse Nd:YAG laser,FREDDY)经内腔镜治疗输尿管结石结石 260 例,疗效满意,效果确切,安全快速,现报告如下。

1 资料与方法

1.1 临床资料

本组 260 例,其中男 141 例,女 119 例,平均年龄 46(17~81)岁。其中上段结石 58 例,中段结石 157 例,下段结石 45 例,其中双侧输尿管结石 37 例;结石横径 5~25 mm,纵径 6~33 mm;并发 BPH 67 例,并发输尿管息肉 56 例;曾行 EWSL 术 61 例,其余 199 例为首次治疗。197 例使用硬性输尿管肾镜,63 例使用输尿管软镜。

1.2 治疗方法

在连硬外联合腰麻下,取膀胱截石位。在输尿管导管引导下,置入输尿管肾镜,缓缓上行到达结石部位后,从工作通道插入激光光纤接触结石,设置能量/频率为0.12 J/3~5 Hz,直视下用连续脉冲间断发射,将结石粉碎,碎石时光纤对准结石中央,先将大块结石碎成小块,再碎成粉末,多枚结石者,尽量采用自上而下依次碎石。为防结石移位,注意液体灌注压力流量。并发有息肉者,轻者可避开息肉直接碎石,结石表面完全被息肉包裹时,先用输尿管镜轻轻推挤结石或先从工作通道置入异物钳钳取息肉,使光纤接触到结石表面后再碎石。并发前列腺增生者可先予碎石再行 TURP 术。碎石结束后留置双 J 管引流尿液,2~4 周后复查 B 超或 KUB,见结石排净即可拔除双 J 管。术后留置导尿管 2~5 天。

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2 结果

本组 260 例，一次性粉碎成功 251 例，总碎石成功率为96.5%。其中，上段结石成功率为93.1%(54/58)，中段成功率为97.4%(153/157)，下段成功率为97.7%(44/45)，应用 χ^2 检验，三组结果比较差异无统计学意义($P>0.05$)。激光平均工作时间为(5.5±3.5) min。平均手术时间 25(7～45) min。碎石后结石排净时间平均 12(2～21)天。术后患者平均住院时间2.5 (1～6)天。

碎石失败 9 例，其中 5 例(上段 3 例，中段 2 例)因结石上移入肾盂而改行 ESWL 治疗；输尿管镜置入失败 3 例(2 例因输尿管成角扭曲，1 例因输尿管口重度狭窄)，输尿管镜不能上插至结石处而改开放手术；1 例结石坚硬，碎石失败而改行开放手术，术后结石成分分析为胱氨酸结石。

本组均未发生输尿管、膀胱、尿道穿孔、撕裂、感染、脓肾等并发症。43.0%(112/260)的病例术后均出现轻重不等的肉眼血尿，大多于术后 2～4 天血尿消失，23 例(8.8%)病例结石排净、拔除双 J 管后血尿方消失。拔除尿管后均能自行排尿，术后 2～4 周经 B 超或 KUB 复查，结石排净率 100%，216 例患侧上尿路积水消失或明显改善，14.3%(31/260)的病例术后出现发热，经抗炎、对症治疗后，体温恢复正常。

3 讨论

3.1 U100 FREDDY 碎石原理和特点

随着内窥镜技术的飞速发展和腔内碎石器的日臻完善，尤其是先进碎石机的问世，使内窥镜腔内碎石技术成为治疗某些泌尿系结石的首选方法。腔镜下激光碎石是一种继液电碎石、超声碎石和气压弹道碎石后更为高效、安全的方法[1,2]。德国 WOM 公司于 2000 年上市的 FREDDY 碎石系统是一种新型钕-YAG 激光，它由波长为 1 064 nm 的红外光(占能量 80%)和波长 532 nm 的绿光(占能量 20%)两种不同波长的光依各自频率组成，其作用原理是激光机发射出的激光经光纤把激光束能量打到结石表面，绿光先被结石表面吸收，使结石表面形成均匀的等离子体，等离子体能够充分吸收红外光能量，激光能量瞬间转化为机械冲击波将结石粉碎，其碎石原理为机械能而非热爆式，具有应用范围广、高效、快捷、微创、安全等特点。

U100 FREDDY 采用石英光纤传输，光纤直径仅为0.73 mm，弯曲直径可达 10 mm，具有极好的柔韧性，可在输尿管镜中联合使用等多个工作器械及与输尿管软镜相配合，以完成难度较大的取石术[3]，适用于全泌尿系结石。本组我们有 63 例应用输尿管软镜成功碎石，效果满意。

U100 FREDDY 以脉冲形式发射，脉冲宽度为 1.2 μm，发射时间极短，输出功率仅为1.2 W，而生的脉冲峰值功率极高，达到 100 kW，碎石过程时间短，效率高，可粉碎各种成分和密度的结石。黄旭元等[4]报道其碎石效能是普通激光的 6 倍，结石粉碎程度高，而对结石产生的推动力极小，大大减少了上段输尿管结石在碎石过程中上移进入肾盂的可能。Zorcher 等(1999)对 61 例结石患者行体外 FREDDY 激光碎石实验，碎石有效率达 100%。

由于 FREDDY 碎石原理为机械能"爆炸"性碎石作用，人体正常组织不吸收这两种波长的激光，因此不会造成正常泌尿道管壁黏膜的损伤[5]和管镜面热灼损，安全简单。本组 260 例结石患者无一例发生输尿管、膀胱、尿道的穿孔和撕裂。Zorcher 等(1999)在动物实验时发现将 FREDDY 激光光纤直接对准兔膀胱黏膜采用 90 mJ，连续 2 000 个脉冲冲击，仅引起轻度充血性黏膜水肿，光镜下仅发现轻到中度的黏膜下出血及上皮层点状凝固坏死，无肌层损伤和穿孔。史子敏等[6]报道用此激光对切下前列腺尿道黏膜组织进行轰击无明显肉眼改变。有人报道术中可以直接将光纤伸到结石处进行盲视下碎石，根据感觉到的结石异物感以及听到的特殊碎石声来判定是否接触或击碎结石[7]，我们认为应慎重，碎石应在直视下进行，视野不清，盲目连续发射脉冲，可能造成碎石片损伤输尿管甚至导致穿孔。

3.2 碎石方法

我们认为应用 FREDDY 激光碎石宜采用中央碎石法，以避免石片对黏膜的损伤影响手术野，预防高位结石移位。将光纤对准结石中央从大块开始，迅速将结石崩解成小块。当结石嵌顿，几乎充满输尿管腔时，如果将光纤对准结石的边缘碎石，瞬间崩裂的碎石片可能造成输尿管损伤穿孔[4]。

采用连续脉冲间断发射法碎石，频率不宜太快，脉冲发射时间不宜太长。U100 FREDDY 碎石机功率设定在 0.12J/1.3,5.10Hz 范围内，我们一般应用激光脉冲频率设定在每秒 5 个，可减少因频率提高而增加的推动结石的机会，从而减少了结石上移进入肾盂的可能。

中上段输尿管结石移位是该激光碎石失败的主要原因。我们的经验是在对中上段输尿管结石进行激光碎石时，可以采取头高脚低位，减少结石随水流漂入肾盂的可能，术中最大限度地调低灌注液的流速及压力，采用间断手控低压灌洗，以能看清结石为度，以避免结石移位。处理多枚结石时，应从上往下逐一碎石，若下面结石较大，可作初步粉碎，镜子越过下部结石，追踪到最上面结石，自上往下碎石，以避免上部结石移位于肾盂。结石一旦移位至肾盂或肾盏，可用输尿管软镜寻找结石，再行碎石。

FREDDY 激光对于胱氨酸结石无效果，原因

为胱氨酸结石不吸收 532 nm 和 1 064 nm 的波长。本组 1 例未能击碎的结石，将结石取出后在体外直视下用光纤抵住发送脉冲，仍未能有效将结石击碎，故术前对阴性结石应准备其他治疗手段。

结石嵌顿时间长可引起输尿管黏膜不同程度的息肉样增生，应用 FREDDY 碎石时，增生轻者可避开息肉直接碎石，增生重者可先用输尿管镜上下摆动，由于结石并发的息肉往往质脆易碎，大部分息肉可脱落，使光纤能直接接触到结石表面，再行碎石。结石粉碎后即便有部分息肉残留，亦不需特殊处理，结石排尽后，息肉会自然消退[4]。

上尿路结石碎石后常规放置双 J 管，留置导尿 2～3 天，2～4 周后复查 KUB，见结石排净后即可拔除双 J 拔管。碎石术后，部分患者会出现不同程度的肉眼血尿，尤其是并发息肉增生者，抗炎、止血及多饮水，血尿可在 2～4 天后消失，极少部分病例在结石排净，拔除双 J 管后血尿方可消失[6]。

3.3 激光操作防护

绿色波的闪烁和不可见的红外光对视力有一定的损害作用，尤其在光纤没有触及结石空发射或触及软组织发射时[4]。我们均采用视频装置下手术，避免直视下操作，减少了光波对眼睛的刺激作用，如条件不许可，操作者可以佩戴特制的滤波防护镜。

FREDDY 具有快速、安全、微创以及碎石成功率和结石排净率高、患者康复快等优点，是目前治疗输尿管结石的理想方法。

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U100激光碎石治疗输尿管结石的效果观察

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[摘要] 目的:探讨输尿管镜下应用U100激光治疗输尿管结石的疗效。方法:对382例输尿管结石患者在输尿管镜下应用U100激光进行碎石治疗。结果:输尿管结石382例中,356例结石一次性粉碎成功,碎石成功率为93.2%。其中,输尿管上段结石一次碎石成功率为88.1%(104/118),中、下段结石一次碎石成功率为95.5%(252/264)。全部激光碎石成功的患者术后除出现血尿外,均无其他严重并发症发生。结论:U100激光碎石治疗输尿管结石具有快速、高效、安全、创伤小、操作简单等优点,可作为输尿管结石的首选治疗方法。

[关键词] U100激光;碎石术;输尿管结石

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U100 laser lithotripsy for the treatment of ureteral stones

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Abstract **Objective:** To evaluate the efficiency of ureteroscope U100 laser lithotripsy on the treatment of ureteral stones. **Methods:** 382 cases of ureteral stones were treated with ureteroscope U100 laser lithotritor. The export power of the laser was 120mJ, the frequency of the laser was 5Hz. The double-J catheter was inserted for drainage after lithotripsy, and was pulled out 2~4 weeks later. **Results:** Among 382 cases of ureteral stones, 356 cases were successfully fragmented on their first laser lithotripsy. The success rate of lithotripsy was 93.2% in all cases. The success rate for the first lithotripsy of the upper ureteral stones was 88.1%(104/118); the mid-lower ureteral stones was 95.5%(252/264). The average time of operation was 36 minutes and the laser worked 4 minutes in average. The average stone free time was 15 days. All successful cases had no complications except haematuria. **Conclusions:** U100 laser lithotripsy is a quick, effective, safe, less invasive performance, and it is easy to operate. It is indicated as the first choice in the treatment of ureteral stones.

Key words U100 laser; Lithotripsy; Ureteral stones

随着腔内技术和腔内器械的不断完善,输尿管结石的治疗已逐渐向微创和无创发展。近年来,继液电碎石机、超声碎石机和气压弹道碎石机之后,激光碎石机已在临床应用,极大地提高了输尿管结石微创治疗的成功率和安全性。2003年11月~2005年12月,我院应用U100激光腔内碎石机(德国WOM公司产)经输尿管镜治疗输尿管结石382例,效果满意。报告如下。

1 资料与方法

1.1 临床资料

382例中,男229例,女153例;年龄18~76岁,平均43岁。结石位于左侧输尿管214例,右侧152例,双侧16例;单侧输尿管多发结石21例。结石位于输尿管上段118例,中段91例,下段173例。结石直径0.6~2.5 cm,平均1.3 cm。全部患者均有不同程度的肾积水。其中并发输尿管息肉54例,术前有体外冲击波碎石史者89例,曾行输尿管切开取石术23例。术前382例经B超检查发现结石296例,382例患者行KUB及IVP检查明确结石347例,31例患者行CT检查明确结石29例。

1.2 治疗方法

在连续硬膜外麻醉下,患者取截石位。应用U100激光腔内碎石机经输尿管镜治疗输尿管结石。在斑马导丝引导下,将输尿管镜插入输尿管内,缓缓上行到达结石部位后,从输尿管镜工作通道插入激光光纤,激光脉冲能量设置120 mJ,脉冲频率5 Hz。冲水保持视野清晰,直视下将激光光纤顶端触及结石并轻轻抵住,脚踏开关,采用连续脉冲间断发射法粉碎结石。必要时可使用套石篮固定结石,以免碎石过程中结石上移。碎石时光纤对准结石中央,先将大块结石碎成小块,再逐个击碎成3 mm以下的石屑。多枚结石者,自下而上依次碎石。当结石并发有息肉时,息肉小可避开息肉直接碎石。当结石表面被大量息肉包裹时,用活检钳去除部分息肉后,再将光纤抵住结石进行碎石。术后常规留置双J管2~4周,定期复查腹部平片了解碎石排出情况。

2 结果

382例中,356例结石一次性粉碎成功,成功率为93.2%。其中,输尿管上段结石一次碎石成功率为88.1%(104/118),中、下段结石一次碎石成功率为95.5%(252/264)。平均手术时间36 min,平均激光工作时间4 min。术后碎石排出时间平均15 d。

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21 例在碎石碎过程中结石上移至肾盂或肾盏，其中 8 例用输尿管镜在肾盂找到结石并用激光一次碎石成功；另 13 例滑落入肾盏的结石术后二期行 ESWL 治疗。输尿管成角扭曲或狭窄，输尿管镜不能上插和窥见结石而改开放手术 11 例。术中输尿管穿孔改开放手术 2 例。碎石成功的患者术后除出现血尿外，均无其他严重并发症发生。

3 讨论

如今，输尿管镜腔内碎石已成为输尿管结石的标准治疗术式，尤其适用于>1 cm 的输尿管结石。输尿管镜腔内直视下碎石技术的方法很多，临床表明，腔镜下激光碎石是众多方法中一种更为高效、安全的方法[1]。U100 激光碎石机能发出波长为 1 064 nm 的红外光和波长为 532 nm 的绿光，故又称为双频双脉冲激光机，每次发射的激光能量被设定为 120 mJ，脉冲宽度为 1.2 μs。当频率为 10 Hz 时，输出功率也仅为 1.2 W。其作用机理是激光经光纤将激光束能量打到结石表面，绿光部分被结石表面吸收，在结石表面形成等离子体，等离子体再充分吸收不可见红外光后崩裂，产生的冲击波峰值功率极高，能在很短的时间内准确高效地粉碎结石，属一种机械能性碎石作用。

U100 激光对各类性质的泌尿系结石几乎都有效，碎石效能是普通激光的 6 倍，通过一根柔软的细光纤在内窥镜下抵住结石即可操作，碎石过程中对结石产生的推动力极小，具有碎石效率高，对组织损伤小，安全简单的特点[2]。由于人体正常软组织不吸收这两种波长的激光，因此不会造成正常泌尿道管壁的损伤[3]。

动物实验表明，将 U100 激光光纤直接对准兔膀胱黏膜采用 90 mJ，连续 2 000 个脉冲冲击，仅引起轻度充血性黏膜水肿，光镜下也仅发现轻到中度的黏膜下出血及上皮层点状凝固坏死，无肌层损伤和穿孔[2]。因此，术中激光照射软组织不会造成输尿管管壁穿孔等损伤。但此特点不能同时处理息肉。当结石并发有息肉时，息肉小可避开息肉直接碎石；当结石表面被大量息肉包裹时，用活检钳去除部分息肉，将光纤抵住结石进行碎石。

U100 激光碎石时，不必同钬激光一样从结石边缘开始，呈蚕食式碎石[3]，而宜先将光纤对准结石中央开始粉碎。当嵌顿结石几乎充满输尿管腔时，如果将光纤对准结石边缘碎石，瞬间崩裂的碎石片可造成输尿管损伤穿孔并造成视野模糊。输尿管内碎石时，宜采用连续脉冲间断发射法碎石，频率不宜太快，脉冲发射时间不宜太长。激光作用于结石表面会形成一阵“气雾”，影响视野，稍微等待或加大冲水的压力可消散气雾。视野不清时，如果盲目连续发射脉冲，易造成输尿管损伤。较大的结石碎石时可先将其碎裂成数块，再逐一粉碎成 3 mm 以下的沙粒状石屑，以便能够顺利排出。处理一侧输尿管内多枚结石时，若下面结石较大，可作初步粉碎，输尿管镜越过下部结石，追踪到最上面结石，自上往下碎石，避免上部结石退回肾内。术中不需要用输尿管钳钳出结石，因结石只要粉碎到足够小的程度术后应可完全自行排出，若术中反复多次为将碎石取出而出入镜会加重输尿管的损伤，从而影响疗效。术后常规留置双 J 管，双 J 管不但能起到引流、支撑作用，小结石还可沿双 J 管下滑，有助于结石排出。同时，对于 13 例结石滑入肾盏的患者，术中置双 J 管可使二期 ESWL 更安全。

本组 382 例输尿管结石患者中，356 例一次碎石成功，26 例碎石失败。失败的一个主要原因是碎石过程中结石（尤其是上段输尿管结石）上移至肾脏，术中未能找到结石所致。本组资料提示，为防止结石上移应该注意：首先，激光脉冲频率设定在每秒 5 个，可减少因频率提高而增加的推动结石的机会，从而减少了结石上移进入肾脏的可能；最大限度地调低灌注液的流速及压力，采用间断手控水压法，以能看清结石为度。其次，进镜后，采用头高脚低位，减少结石随水流漂入肾盂的可能。其三，对已经向上移位或位置较高的结石，可使用套石篮将结石固定后，再行碎石。此外，若结石上移至肾内并不能完全放弃激光治疗，因为对于部分结石仍有继续治疗的机会（尤其是肾盂肾盏扩张不显著者）。可将输尿管镜插至肾盂，通过耐心细致地反复适量冲水或放水和体位变化，结石可能再次出现在输尿管镜视野内而用激光将其击碎。

综上，U100 激光碎石具有快速、高效、安全、创伤小、并发症少、操作简单等优点，是输尿管结石的较好治疗方法。

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·临床论著·

输尿管镜下双频激光碎石术治疗输尿管结石 268 例报告

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【摘要】 目的 探讨输尿管镜下激光碎石术治疗输尿管结石的疗效。 方法 2004 年 4 月～2006 年 8 月,我院采用德国 Storz 半硬输尿管镜($F_{6.5}$或者 $F_{3.9/6.5}$)和德国 Wom 公司 U100 双频双脉冲激光碎石机治疗输尿管结石 268 例。 结果 单次治疗成功率为 92.9%(249/268)。手术时间 15～95 min,平均 30 min。术后除出现不同程度血尿外(术后 2～3 d 消失),无严重并发症。术后住院时间 2～6 d,平均 3.5 d,229 例随访 3～9 个月,平均 6.2 月,KUB 联合静脉肾盂造影(intravenous pyelography,IVP)或者 B 超检查,无复发及输尿管狭窄发生。 结论 输尿管镜下双频双脉冲激光碎石术是治疗输尿管结石的理想方法,可作为输尿管中下段结石首选治疗。

【关键词】 输尿管结石; 输尿管镜; 激光碎石术

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腔内泌尿外科发展已使 90% 以上输尿管结石病人免于开放手术。2004 年 4 月～2006 年 8 月我院采用输尿管镜下双频双脉冲激光治疗输尿管结石 268 例,碎石效果满意,现报道如下。

1 临床资料与方法

1.1 一般资料

本组 268 例,男 152 例,女 116 例。年龄 17～70 岁,平均 41 岁。左侧 132 例,右侧 125 例,双侧 11 例;结石位于输尿管上段 73 例,中段 31 例,下段 164 例。合并肾结石 13 例(其中 6 例为双肾结石)。结石大小:4～10 mm 223 枚,11～15 mm 43 枚,16～25 mm 11 枚。病程:6 d～10 年,平均 3 年。所有病例均经腹部平片(kidney ureter bladder,KUB)、静脉肾盂造影(intravenous pyelography,IVP)、B 超检查证实。

病例选择标准:结石大小 4～25 mm。

1.2 方法

硬膜外麻醉 243 例,静脉麻醉 25 例。德国 Storz 半硬输尿管镜($F_{6.5}$或者 $F_{3.9/6.5}$)和德国 Wom 公司 U100 双频双脉冲激光石机。截石位。在电视监视下输尿管镜经尿道插入膀胱,找到并用液压灌注泵扩张患侧输尿管开口后,直接进镜或在斑马导丝引导下进镜至输尿管管腔内,进镜后即调低液压灌注泵压力和流量,以保持视野清晰力度,缓慢进镜至结石处。从操作孔置入 730 μm 激光光纤,直视下采用连续脉冲间断发射法击碎结石至 1～3 mm。满意碎石后输尿管内置入 F, 双 J 管,术后 1～2 周拔除。术后常规留置 Foley's 尿管 1～2 d,应用抗生素。

2 结果

249 例结石成击碎或取出,单次治疗成功率 92.9%(249/268),其中上段结石 83.6%(61/73),中段结石 90.3%(28/31),下段结石 97.6%(160/164)。手术时间 15～95 min,平均 30 min。单次治疗失败 19 例,其中 >6 mm 的结石碎块移位至肾盂肾盏 9 例,结石远端输尿管 N 形扭曲或狭窄致输尿管镜推进受阻无法接近结石 6 例,输尿管穿孔改开放手术 3 例,尿酸结石双频激光无法碎石 1 例。268 例术后第 1 天肉眼血尿,术后 2～3 d 消失,未特殊处理。无大出血、术后高热及脓尿等并发症。术后住院时间 2～6 d,平均 3.5 d。术后 1 个月复查 KUB 或 B 超,结石排净率 97.1%(242/249)。229 例随访 3～9 个月,平均 6.2 月,KUB 联合 IVP 或者 B 超检查,结石无复发及输尿管狭窄发生。

3 讨论

输尿管镜技术是目前治疗输尿管结石最为安全、有效的一项新技术[1],很大程度上已取代过去

① (浙江省兰溪市人民医院泌尿外科,兰溪 321100)

的开放手术[2]。

U100Nd:YAG 双频双脉冲激光碎石系统是德国 WOM 公司于 2000 年上市的一种新的腔内碎石装置，采用 FREDDY 技术(frequency-doubled doubled dual-pulse Nd:YAG)，能发出波长为 1064 μm 的红外光和绿光(λ=532 μm)2 种脉冲激光。在碎石过程中，绿光先在结石表面形成均匀等离子体，接着等离子体充分吸收红外光的能量转化为冲击波迅速"崩解"结石。优点包括：①高效，碎石效能是普通激光的 6 倍[3]；②安全，极少有输尿管穿孔的危险；③彻底，将结石石粉碎成 1～3 mm 自行排出。

碎石失败的常见原因：①结石碎块移位至肾盂肾盏；②结石远端输尿管 N 形扭曲或狭窄；③输尿管穿孔；④尿酸结石等。本组 268 例输尿管结石单次治疗成功率 92.9%(249/268)。本组 3 例输尿管穿孔为早期开展手术时因输尿管扭曲，反复试插所致；9 例结石碎块移位至肾盂肾盏；6 例结石远端输尿管 N 形扭曲或狭窄使碎石失败。

我们的经验如下。①输尿管上段结石移位的预防及处理：输尿管镜顺利插入并到达结石部位是碎石成功的前提[2]，激光脉冲频率较高，可增加结石取在肾盂内继续碎石。②结石远端输尿管 N 形扭曲的处理：使用细口径的输尿管镜和韧性较好的导丝。助手于结石近端推压或牵拉肾脏或采用头低脚高位。碎石成功后应常规留置双 J 管，起到引流、支撑作用，且有利于排出碎石块。③结石周围息肉的处理：结石过大、嵌顿停留时间长的病例，几乎都有不同程度的输尿管黏膜增生形成息肉包裹结石。双频双脉激光不能处理息肉，可采用自制电极电灼息肉使其萎缩，或用活检钳夹除息肉，暴露部分结石面，光纤即可直接接触到结石。

总之，输尿管镜下双频双脉冲激光碎石术具有微创、安全、碎石成功率高等优点，可作为输尿管中下段结石的首选疗法。

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输尿管结石术前综合评价对碎石方式选择的作用

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[摘要] 目的:探讨输尿管结石术前的综合评价在确定和指导碎石方式的选择、提高碎石效率方面的作用。方法:将 645 例患者分为随机组(178 例)和综合评价组(467 例)。术前进行综合评价,按结石部位分为输尿管上段、中段和下段,按结石大小分为≤7 mm、8～10 mm、>10 mm,按结石密度分为高密度、中密度、疏松结石,按结石数量分为单发、多发。在碎石方法的选择上遵循下段、≤7 mm、疏松结石和单发结石优先考虑采用气压弹道碎石;中密度、中段、8～10 mm、多发结石优先考虑采用双频激光碎石;上段、>10 mm、高密度、多发结石优先考虑采用钬激光碎石的原则。结果:随机组采用气压弹道碎石 52 例、双频激光碎石 85 例、钬激光碎石 41 例。综合评价组采用气压弹道碎石 107 例、双频激光碎石 148 例、钬激光碎石 212 例。两组碎石成功率分别为 88.2%和 93%,结石排净率分别为 84%和 89.3%。患者平均住院天数分别为 7 天和 5 天,平均住院费用综合评价组比随机组下降 5%～8%。结论:术前对患者进行综合评价,并指导选择合理的碎石方式,可以使碎石成功率、结石排净率和住院时间均达到最佳,使住院费用明显降低。

[关键词] 输尿管结石;综合评价;气压弹道碎石;双频激光碎石;钬激光碎石
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The role of ureteral stone preoperative evaluation for the selection of lithotrity

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Abstract **Objective**: To discusse the role of ureteral stone preoperative evaluation for determining, guiding the selection of lithotrity, and improving the efficiency of lithotrity. **Methods**: 645 cases of ureteral calculi(425 males and 220 females; aged 19－71 years) were divided into two groups: random group(n=178) and multi evaluation Group(n=467). The factors be evaluated include the stone location (in the proximal part of the ureter, in the middle part or in the distal part), the diameter of the stones(≤7 mm, 8－10 mm, >10 mm), the density (high density, middle density and low density)and the amount of stones(one stone and more than one). The general rule is the stone in the distal part of the ureter and ≤7 mm in the diameter underwent pneumatic lithotripsy; the more than one stone in the middle part, middle density and 8－10 mm in the diameter underwent frequency-doubled double-pulse laser; the more than one stone in the proximal part, high density and >10 mm treated via ureteroscope with Ho:YAG laser. **Results**: Random group, pneumatic lithotripsy 52 cases, frequency-doubled double-pulse laser 85 cases, holmium laser 41 cases; multi evaluation Group, pneumatic lithotripsy 107 cases, frequency doubled double-pulse laser 148 cases, holmium laser 212 cases. The success rate (stone fragmentation rate) was 88.2% and 93 %. The stone-free rate was 84.0% and 89.3%. Hospital stay was 7 and 5 d. The average cost in hospital for Multi-evaluation Group is 5-8 percent down than Random group's. **Conclusions**: Pre-operation multi-factor evaluation can give a good guidance for the choice of lithotripsy, and can raise up the success rate, and shorten the hospital day. It also can decrease the cost in hospital.

Key words Ureteral calculi; Evaluation of multiple factors; Pneumatic lithotripsy; Frequency-doubled double-pulse laser; Holmium laser lithotripsy

采用微创技术治疗输尿管结石为近年来泌尿科的重要进展。在输尿管镜加碎石术中,有多种碎石方法可供选择,如气压弹道碎石、双频激光碎石、钬激光碎石等。如何选择安全、有效且经济的碎石方法,为临床工作中面临的问题之一。

我院自 2005 年 3 月起开展输尿管镜下腔内碎石术,早期我院所用碎石设备采取租借和与设备公司协作等方式,使碎石方法的确定具有一定的随机性和局限性。我院自 2006 年 1 月起自身拥有了气压弹道碎石设备和钬激光碎石机,使碎石方法的选择取决于结石特点和相关因素。因此,此项技术的

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开展经历了随机选择碎石方法和综合评价指导下选择碎石方法两个阶段。为此，我们将两个不同阶段治疗的输尿管结石疗效进行比较，现将结果报告如下。

1 资料与方法

1.1 临床资料

2005年3月～2007年1月共有645例输尿管结石患者行输尿管镜下碎石术，其中男425例，女220例。年龄16～72岁。发病时间1周～30个月。患者以入院时间2006年1月1日为分界，分为随机组(178例)和综合评价组(467例)。两组内输尿管中上段结石分别为62例(35%)和191例(41%)。所有患者均经KUB、IVP及B超进行诊断并作结石定位。

1.2 术前评价方法

根据患者全身情况分为好、中等和差。

根据结石特点从以下几个方面进行评价：按结石部位分为上段、中段和下段；按结石大小分为≤7 mm、8～10 mm、＞10 mm；按结石密度分为高密度、中密度、疏松结石(密度的设定以椎骨密度作为参照)；按结石数量分为单发(单侧)、多发(双侧)。645例患者结石的特点情况见表1。

表1 645例结石患者基本情况 例

特点	随机组(178例)		综合评价组(467例)	
	男	女	男	女
结石部位				
上段	28	12	77	47
中段	22	10	46	21
下段	76	30	214	62
结石大小				
≤7 mm	15	13	75	23
8～10 mm	76	30	169	77
＞10 mm	35	9	93	50
结石密度				
高密度	47	11	105	35
中密度	60	29	190	72
疏松结石	19	12	42	23
结石数目				
单发(单侧)	114	50	317	115
多发(双侧)	12	2	20	15

1.3 碎石器械设备

选用Wolf $F_{6.8}$输尿管镜、Olympus $F_{7.8}$输尿管镜、ELE型腔内气压弹道碎石机、CureStar 30 W钬激光碎石机、U-100双频激光碎石机。

1.4 碎石方法的选择

随机组：下段结石和部分中段结石患者使用气压弹道碎石；上段结石和部分中段结石患者采用双频激光或钬激光碎石。

综合评价组：碎石方法的选择遵循以下原则：下段、≤7 mm、疏松结石和单发结石患者优先考虑用气压弹道碎石；中密度、中段、8～10 mm、多发结石患者优先考虑用双频激光碎石；上段、＞10 mm、高密度结石患者优先考虑用钬激光碎石。

1.5 疗效评价标准

疗效评价包括两个方面：碎石成功率和结石排净率。输尿管镜插入成功、达到结石水平并使用碎石器械达到碎石目的概率为碎石成功率。碎石术后1个月经KUB证实结石排净的概率为结石排净率。

2 结果

2.1 碎石方法选择结果

随机组采用气压弹道碎石52例，双频激光碎石85例，钬激光碎石41例。综合评价组采用气压弹道碎石107例，双频激光碎石128例，钬激光碎石212例，使用气压弹道或双频激光碎石无效后改用钬激光碎石20例。

2.2 碎石成功率

随机组碎石成功率为88.2%，21例患者手术失败，其中插镜失败10例，上段结石漂移7例，使用气压弹道或双频激光无法击碎结石导致手术失败4例。综合评价组碎石成功率为93%，33例失败，其中插镜失败者18例，上段结石漂移者15例，无因碎石方法选择失误导致手术失败者。

2.3 其他指标

两组患者结石排净率分别为：随机组84%，综合评价组89.3%。患者平均住院天数分别为7天和5天。平均住院费用综合评价组比随机组下降5%～8%。

3 讨论

输尿管镜下碎石术已成为治疗输尿管结石的主要方法[1~3]。尿路结石由晶体和基质两类物质组成，其中常见的晶体有草酸盐、尿酸盐、磷酸盐和碳酸盐，基质为粘蛋白复合物，包括糖蛋白、间质组织和细菌等[4]。结石成分的不同使得尿路结石的硬度和密度存在较大差别，使得手术中碎石效率也出现差别。因此，在术前无法确定结石成分的情况下，如何选择最经济有效的碎石方式显得尤为重要。

目前主要的碎石技术包括气压弹道碎石、双频激光碎石和钬激光碎石，每种方法各有利弊。气压弹道碎石的优点为术中无电流产生，释放热量少，组织黏膜损伤轻微，不损伤器械，价格相对便宜等；其缺点为较易产生结石移位，对于部分质地坚硬的结石效果不理想，特别是结石并有黏膜息肉或肉芽组织时，无法同时达到碎石和治疗息肉的目的[3]。双频激光碎石可发出两种波长的脉冲激光[1]，其中绿光先在结石表面形成均匀的等离子体，接着红外

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光的能量被等离子体充分吸收，使得激光在瞬间化为冲击波而击碎结石。因此，具有碎石效率高、不损伤软组织、较少产生热量等优点；其缺点为对一些质地坚硬的（如尿酸盐结石）无法粉碎。钬激光的优点为[5]穿透性强，对各种成分的结石粉碎率高，对嵌顿于黏膜内的结石也能精细碎石，且可同时处理息肉和肉芽；其缺点为热量产生多，对黏膜有损伤，碎石效率低于双频激光，费用相对较高等。

在影响碎石效率的诸多因素中，结石的位置和密度是最重要的因素。此外，结石的大小、数目以及患者年龄、体形、性别、病程长短等也对碎石效率产生一定影响。要想充分发挥各种碎石方法的优点，提高碎石效率，减少费用和创伤，就必须对每个还在进行术前综合分析，方可选择出最佳的碎石方法。我们制定的基本原则为：对于较易处理的结石，选择使用气压弹道碎石，而对难度较大的结石则选择钬激光，对难度居中的结石可选择双频激光。通过总结分析，我们认为：①对下段、疏松的小结石，既可充分发挥气压弹道碎石损伤小、安全有效的优点，又较少存在结石漂移、合并息肉组织等情况，因此，可优先选用气压弹道碎石，既可达到满意的治疗效果，又价格便宜，较易为患者所接受。②对上段、密度高、大于 10 mm 的结石，采用钬激光碎石可获得满意效果，并且可同时处理息肉和肉芽组织，一次碎石率较高。③对中等密度、多发结石，可优先考虑使用双频激光碎石，充分发挥其碎石效率高、创伤较小的优势，同时又避免了部分结石无法粉碎的缺点。

通过对上述两组患者治疗结果分析，我们认为：术前对患者进行综合评价，并指导选择合理的碎石方式，可以使碎石成功率、结石排净率和住院时间均达到最佳，也使住院费用明显降低。

值得注意的是：当碎石手段单一时，会由于手术中结石无法粉碎而导致手术失败。本文随机组中有 4 例由于当时条件所限，未能达到治疗目的。而综合评价组中有 20 例初定的气压弹道或双频激光无法碎石时，改用钬激光碎石，达到满意碎石的目的。因此，具备多层次、多方面的碎石手段，采用多种方法相结合的策略，也是提高碎石成功率的关键。

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3.5 血尿

输尿管镜术后患者肉眼血尿多数较轻，一般尿色微红，持续 1～2 天后可恢复正常，偶尔可出现较重血尿，主要给予止血药物对症治疗，若出现持续严重血尿，可行膀胱镜检查，以明确出血在下尿路还是上尿路而再作具体处理。

综上所述，我们认为输尿管镜手术并发症的发生与操作者的熟练程度有一定关系，操作者应及时总结手术经验，注意并发症发生的原因，才能提高手术技能，减少并发症的发生。

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·临床论著·

输尿管软镜激光碎石术治疗肾结石 338 例报告

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【摘要】 目的 评价输尿管软镜结合钬激光和 FREDDY 激光处理不同部位肾结石的有效性,评价影响输尿管软镜碎石成功率的影响因素和手术技巧。 方法 回顾性分析 2002 年 5 月～2007 年 5 月 338 例输尿管软镜激光碎石术。结石最大直径均 <20 mm。288 例结石位于上盏、中盏或肾盂内,37 例位于下盏,13 例位于多个肾盏内。术前均行泌尿系平片(KUB)+静脉尿路造影(IVU)。放置 Terumo 导丝后,首先使用 $F_{6.9}$ Wolf 输尿管硬镜探查患侧输尿管。顺利进镜的患者放置输尿管软镜鞘并改用 Olympus P3 $F_{6.9}$ 输尿管软镜。若输尿管硬镜无法顺利进镜,则在放置导丝后留置双 J 管,2 周后行二期输尿管软镜碎石术。使用 WOM U-100 FREDDY 激光或 Lumenis 钬激光碎石。术后常规留置 F_7 双 J 管 2 周。术后第 1 天拔除导尿管,术后常规静脉给予广谱抗生素 2 天。2 周后拔除双 J 管,4 周后复查 KUB 或双肾 CT 平扫,评估结石排净率。残留结石≥4 mm 为有意义的结石残留。 结果 一次进镜成功率 91.7%(310/338),余 28 例进镜失败者在成功留置导丝的前提下放置双 J 管,2 周后成功进镜。329 例软镜成功进镜后寻及结石(329/338,97.3%),其中 306 例成功碎石(306/329,93.0%),下盏结石碎石成功率 78.0%(32/41),低于中上盏肾盂内结石的碎石成功率 95.1%(274/288)($\chi^2=13.601$, $P=0.000$)。4 周后总结石排净率为 87.6%(296/338),肾中上盏及肾盂内结石术后排净率为 90.1%(264/293),肾下盏结石术后结石排净率为 71.1%(32/45),两者差异有显著性($\chi^2=12.929$, $P=0.000$)。无输尿管穿孔和出血。平均手术时间为 35 min(12～55 min)。术后肾绞痛 11 例。无菌血症及急性肾功能不全。术后肉眼血尿 1～2 天内消失。 结论 输尿管软镜结合 FREDDY 激光或钬激光是处理 <20 mm 肾结石的安全有效的手段。肾中上盏及肾盂内结石较肾下盏结石寻及率高,碎石成功率高,结石排净率高。一期输尿管镜进镜困难的患者可在成功留置双 J 管 2 周后二期行输尿管软镜碎石术。

【关键词】 输尿管软镜碎石; FREDDY 激光; 钬激光; 肾结石

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Flexible Ureteroscopy and Laser Lithotripsy for Renal Calculi: Report of 338 Cases *Xue Wei, Pan Jiahua, Chen Haige, et al. Department of Urology, Renji Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai 200127, China*

【Abstract】 Objective To evaluate the efficacy of the flexible ureteroscopy and Holmium and FREDDY laser lithotripsy for renal calculi at various locations. **Methods** From May 2002 to May 2007, 338 cases of renal calculi (sized less than 20 mm in diameter) were treated by flexible ureteroscopy and laser lithotripsy in our hospital. The data of the patients were analyzed retrospectively. Among the cases, the calculi were located at the upper or middle calyx or the renal pelvis in 288 patients, at the lower calyx in 37, and in multiple calyxes in 13. All the patients received KUB and IVU before the procedures. With the Terumo™ settled in place, a $F_{6.9}$ Wolf rigid ureteroscope was inserted to observe and dilate the ureteral lumen. Then, an Olympus P3 6.9F flexible ureteroscope was used. When the insertion of the rigid ureteroscope was difficult, a re-ureteroscopy would be tried 2 weeks later with a pig-tail stent in place. The WOM U-100 FREDDY laser and the Lumenis Holmium laser were used to perform the procedure and a pig-tail stent would be set at the end of the procedure. The urethral catheter was removed in the first postoperative day and an intravenous antibiotic prophylaxis was administrated during the first 2 days postoperatively. A follow-up by KUB or non-contrast CT scan was done 4 weeks after the procedure to evaluate the result of the endoscopic nephrolithotripsy. Any residual calculi larger than 4 mm in diameter was taken significant. **Results** In 28 patients the rigid ureteroscope or the ureteral sheath couldn't be inserted in the first time, and the success rate of the ureteroscopic insertion was 91.7% (310/338). The re-ureteroscopy was successful in the patients after 2 weeks. The calculi were detected in 97.3% (329/338) of the patients, and the procedures succeeded in 306 of them (306/329, 93.0%). The success rate of laser nephrolithotomy was 78.0% (32/41) for the lower calyx calculi, which was significantly lower than that for the middle, upper calyxes or renal pelvic calculi [95.1% (274/288), $\chi^2=13.601$, $P=0.000$]. After 4 weeks, the total evacuation rate of the calculi was 87.6% (296/338). For the calculi in the upper or middle pole or in the renal pelvis, the complete evacuation rate was 90.1% (264/293), which was significantly higher than that for the lower pole [71.1% (32/45), $\chi^2=12.929$, $P=0.000$]. No patient had ureteric perforation or active bleeding after the surgery. The mean operation time was 35 min (12-55 min). After the operation, 11 cases developed nephritic colic. None of them had septicemia or acute renal failure. Gross hematuria disappeared in 1-2 days postperation. **Conclusions** The flexible ureteroscopy and Holmium and FREDDY laser lithotripsy are safe and effective for renal calculi sized less than 20 mm in diameter, especially for those in the upper, middle poles and renal pelvis. A re-

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ureteroscopy with the pig-tail stent in place is suggested in two weeks after the failure of the first procedure.

【Key Words】 Flexible ureteroscopy; FREDDY laser; Holmium laser; Renal calculi

输尿管软镜技术已成为处理复杂性上尿路结石特别是肾盂肾盏内结石的重要手段之一，越来越多输尿管软镜专用器械的推出和钬激光以及 FREDDY 激光的临床应用更使其成为处理肾内结石的一种安全有效的微创技术。但输尿管软镜碎石术患者的选择、激光的应用以及进镜困难时可采取的策略仍是泌尿外科医师需要考虑的问题。我们于 2002 年 5 月～2007 年 5 月对 338 例结石直径 <20 mm 的肾结石患者行输尿管软镜激光碎石术，取得了良好的疗效，现报道如下。

1 临床资料与方法

1.1 一般资料

本组 338 例，平均年龄 58 岁（37～75 岁）。男 183 例，女 155 例。265 例因腰背部酸胀、肾绞痛、肉眼血尿等症状就诊，病程 1 周～63 个月，余 73 例无临床症状。泌尿系 B 超提示，288 例结石位于上盏、中盏或肾盂内，37 例位于下盏，13 例位于多个肾盏内。结石最大直径均 <20 mm。术前均行泌尿系平片（KUB）+ 静脉尿路造影（IVU）明确肾积水程度，同时排除盏口狭窄及合并巨大积水的无功能肾患者。肾积水Ⅰ度 89 例，Ⅱ度 63 例，Ⅲ度 28 例，Ⅳ度 2 例，余 156 例无肾积水。合并糖尿病、高血压等慢性疾病 77 例，系统性红斑狼疮（稳定期）1 例。

病例选择标准：单发、多发肾结石或体外震波碎石（ESWL）术后残余结石，最大直径 ≥ 10 mm 且 <20 mm，不伴输尿管狭窄或目标肾盏盏口狭窄。

1.2 方法

静吸复合麻醉。未使用输尿管开口扩张气囊，在膀胱镜直视下安置 Terumo 超滑血管导丝。首先使用 $F_{6/9.8}$ Wolf 输尿管硬镜探查患侧输尿管，并上行至肾盂。确认不伴有输尿管狭窄等输尿管病变后退出输尿管硬镜，改用 Olympus P3 $F_{6.9}$ 输尿管软镜（工作通道为 $F_{3.6}$）。软镜进镜过程中如遇进镜困难，可在输尿管内留置安全导丝后于输尿管软镜工作通道内置入工作导丝，跟随工作导丝进镜。若输尿管硬镜无法顺利进镜且无法在 C 形臂 X 线机下顺利留置输尿管软镜鞘，则在安置导丝后留置双 J 管，2 周后行二期输尿管软镜碎石术。

软镜进镜入肾盂并寻找到结石后，使用 WOM U-100 FREDDY 激光碎石，采用 5 Hz，120 mJ 能量；如为胱氨酸结石或结石质地较硬，则改用 Lunimens 钬激光碎石，通常选择 1.2～1.8 J，10 Hz。术后常规留置 F_7 双 J 管 2 周。术后第 1 天拔除导尿管，术后常规静脉给予广谱抗生素 2 天。2 周后拔除双 J 管，4 周后复查 KUB 或双肾 CT 平扫，评估结石排净率。残留结石 ≥4 mm 为有临床意义的结石残留。

2 结果

310 例较顺利地放置镜鞘并置入输尿管软镜，一次进镜成功率 91.7%（310/338）；28 例输尿管硬镜进镜困难且无法在 X 线下放置输尿管软镜鞘，均能在成功留置导丝的前提下安置双 J 管，2 周后再次尝试，均能成功进镜。

329 例软镜成功进镜后能成功寻及结石（329/338，97.3%）；9 例无法寻及结石，其中 5 例结石位于中上盏，4 例结石位于下盏。肾中上盏及肾盂内结石寻及率（288/293，98.3%）高于下盏结石（41/45，91.1%，$\chi^2=5.240$，$P=0.022$）。

306 例在寻及结石后成功碎石（306/329，93.0%），23 例碎石后存在 ≥4 mm 的结石残留，其中 9 例结石位于下盏，14 例位于中上盏或肾盂。下盏结石碎石成功率 78.0%（32/41），中上盏或肾盂内结石的碎石成功率 95.1%（274/288），差异有统计学意义（$\chi^2=13.601$，$P=0.000$）。无输尿管穿孔和出血。平均手术时间 35 min（12～55 min）。11 例肾绞痛。无菌血症及急性肾功能不全。术后肉眼血尿 1～2 天内消失。

4 周后 KUB 或上腹部 CT 平扫提示总结石排净率为 87.6%（296/338），肾中上盏及肾盂内结石术后排净率为 90.1%（264/293），肾下盏结石术后结石排净率为 71.1%（32/45），两者有显著性差异（$\chi^2=12.929$，$P=0.000$）。42 例结石残留，其中 13 例结石位于肾下盏。

3 讨论

1964 年 Marshall VF 最早使用 F_6 纤维软镜用于一个输尿管结石病人的诊断；1971 年，Takagi 等制成了可弯曲的 F_6 输尿管软镜，长 75 cm，因其没有工作通道而仅用于诊断，术中以甘露醇利尿以保持视野清晰。目前，随着腔内技术的不断提高和工业技术的不断发展，输尿管软镜技术已产生了巨大的变革。

Dasgupta 等[1]曾提出，输尿管软镜更适于处理 <20 mm 的结石，对于这些结石输尿管软镜碎石术有较高的成功率、较短的手术时间，而且对输尿管软镜的损耗也较小。而对于结石体积较大的患者，经皮肾镜技术是更好的选择[2]。故本组结石均 <20 mm。在我们的经验中，以输尿管软镜处理直径 >20 mm 的肾内结石，特别是肾下盏的结石时，输尿管软镜的长时间主动弯曲及钬激光的热作用会对其产生较大的损伤，同时这对操作者也提出了更高的要求。

胡卫列等[3]提出在放置输尿管软镜前首先行

本研究采用该方法，28 例输尿管硬镜进镜困难，且无法在 X 线下安置输尿管软镜鞘，对于这些患者我们在成功留置导丝的前提下安置双 J 管，2 周后再次尝试，均能成功进镜。2 周的双 J 管留置一方面对输尿管存在被动扩张作用，另一方面也留出时间使输尿管黏膜下及输尿管周围组织在尿外渗吸收的同时纤维组织增生，使输尿管黏膜游离度减小，相对固定，便于输尿管镜进镜。

未寻及结石的 9 例中 6 例存在Ⅲ～Ⅳ度肾积水。因输尿管软镜视野较小，较严重的肾积水大大增加寻及结石的难度，特别是激光碎石术中若发生结石漂移，将使结石寻找更为困难。其余 3 例中 2 例结石位于中盏侧方小盏内，输尿管软镜进入中盏后无法进一步进入肾小盏；另 1 例结石位于下盏，其下盏与肾盂的夹角 <90°，导致输尿管软镜无法进入。故较明显的肾积水、结石位于肾盏侧方小盏、过小的下盏与肾盂夹角均为结石寻找带来困难。

Olympus P3 的上下最大主动弯曲度均为 180°，理论上，在正常肾脏内输尿管软镜可以达到肾盂内所有部位。但在实际操作中，当工作通道内置入了光纤以后，输尿管软镜的最大主动弯曲角度会随之减小，实验显示，在工作通道内置入 Lumenis 200 μm 光纤或 273 μm FREDDY 光纤后，其上下最大主动弯曲度均下降为 155°[4]，增加了进入下盏的难度，下盏结石碎石成功率低可能与此有关。

由于解剖学原因，下盏结石的排净率明显小于中上盏结石。另外，研究显示，当下盏漏斗部与肾盂之间的夹角 <90°、下盏漏斗部长度 >3 cm、下盏漏斗部直径 <4 mm 及下盏扭曲时结石难以排出[5]。

输尿管软镜鞘的使用可以保证冲洗速度，维持视野清晰，减小镜体轴线旋转动作阻力[6]，减少镜体反复进出输尿管而可能造成的黏膜损伤。我们在术中常规使用输尿管软镜鞘。Saidi 等[7]提出，在所有进行输尿管软镜操作的患者中，约有 10% 会因为输尿管管腔狭小导致进镜困难。对于这些输尿管管腔较为狭小，置鞘阻力较大的患者，我们尝试不安置镜鞘直接进镜。Johnson 等[8]也报道不使用输尿管镜鞘的输尿管软镜操作。对于这些患者，我们首先使用 $F_{8/9.8}$ Wolf 输尿管硬镜观察输尿管内情况。一方面可以在行输尿管软镜碎石前明确输尿管内是否存在缩窄环等病理情况，明确输尿管黏膜的游离度，另一方面也可以避免 X 线下反复尝试置鞘对患者及医护团队的电离辐射。而且 $F_{8/9.8}$ Wolf 输尿管硬镜在输尿管内的通行对输尿管本身也存在扩张作用。

激光的选择对碎石的成功与否也起着至关重要的作用。我们对拟行输尿管软镜碎石术的患者术前常规行 KUB 和 IVU 检查，以初步判断结石性质。对于 KUB 上不透光或透光性较差的含钙结石，我们建议首先使用 FREDDY 激光。FREDDY 激光为一种新型的 Nd:YAG 激光，其激光器能发出波长为 1064 nm的红外光和波长为 532 nm 的绿光，绿光首先被结石表面吸收而形成均匀的等离子体，从而使结石能充分吸收红外光的能量，产生“爆炸”性的碎石作用[9,10]，能使较小的结石瞬间粉碎。但是对于胱氨酸结石，由于 532 nm 的绿光无法在其表面形成等离子体，故 FREDDY 激光对其碎石效果差。与此同时，由于波长 532 nm 的绿光在组织和镜头表面同样无法形成等离子体，故 FREDDY 激光不会造成肾盂输尿管黏膜的损伤，对输尿管软镜的损耗也较小。而对于较坚硬的结石，如一水草酸钙结石，若 FREDDY 激光无法完全碎石，我们则采用 Lumenis 钬激光进行碎石。使用钬激光碎石时，我们一般从结石的一侧进行侵蚀性碎石，而不首先将结石完全炸开。因为钬激光对结石有较强的冲击力，过早碎裂结石可能对之后寻找结石碎片并进一步完全碎石造成困难。同时，需尽量降低钬激光能量，以减少对结石的轴向冲击力，我们通常选择 1.2～1.8 J/10 Hz。

输尿管软镜结合 FREDDY 激光或钬激光是处理 <20 mm 肾结石的安全有效的手段。肾中上盏及肾盂内结石较肾下盏结石寻及率高，碎石成功率高，术后排净率高。一期输尿管镜进镜困难的患者可在成功留置 2 周双 J 管后二期行输尿管软镜碎石术。

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·临床研究·

超声引导经上盏径路微创经皮肾镜碎石术(附76例报告)

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【摘要】 目的 探讨超声引导下经上盏径路微创经皮肾碎石术(MPCNI)治疗上尿路结石的疗效及安全性。 方法 2006年3月至2009年3月,对76例82侧上尿路结石使用超声引导下经上盏径路MPCNL。穿刺点选择在肩胛下线和腋后线之间第10、11肋间,超声定位下穿刺后组上盏建立通道,使用U-100双频双脉冲Nd:YAG激光碎石。 结果 82侧手术均获成功,平均手术时间(45±10)min。一期结石取净率为81.7%(67/82),二期结石取净率为73.3%(11/15)。输血1例,胸腔积液2例,无重要脏器损伤及其他严重并发症。 结论 超声引导下经上盏径路微创经皮肾镜碎石术高效、微创、安全。

【关键词】MPCNL;上盏径路;上尿路结石

Upper pole access for minipercutaneous nephrolithotomy under B-ultrasound guidance (76 cases report) *CAO Jian-wei, LANG Geng-qiang, ZHANG Yi-feng, CHU Jian, ZHUANG Jian-qiu, ZHANG Jiong, CHU Chuan-ming, CHEN Jin, DENG Xiao-jun. Urological Center, 411th Hospital of PLA, Shang Hai 200081, China*

【Abstract】 Objective To investigate the efficacy and safety of upper pole access for minipercutaneous nephrolithotomy(MPCNL) under B-ultrasound guidance for upper urinary calculi treatment. Methods From March 2006 to March 2009, we treated 82 units (76 patients) of upper urinary calculi by upper pole access for MPCNL under B-ultrasound guidance.The skin puncture point had been located in this scope: the 10th or 11th intercostals, inner from postaxillary line and out of infrascapular line. The targeted puncture access is superior posterior calyx under B-ultrasound guidance. The lithotripsy device which we employed was U-100 Frequency-Doubled Double-Pulse Nd:YAG laser. Results 82 procedures were all successful. The average operation time is (45±10) min. Stone-free rate is 81.7% (67/82) for single procedure, and 73.3% (11/15) for secondary stage. 1 case had blood transfusion and 2 cases had hydrothorax. The patients had no important organ injury and no other severe complications. Conclusions The upper pole access for MPCNL under B-ultrasound guidance is a high efficient, micro-invasive , safe technique with high performance.

【Key word】Mini-percutaneous nephrolithotomy; Upper pole access; Upper urinary calculi

1976年Femstrom和Johannsoh完成了第一例经皮肾镜手术,近年来,随着手术器械的改良、手术经验的积累,经皮肾镜手术在我国条件较好的医院得到广泛推广,但经上盏径路的经皮肾镜术国内报道较少。我院自2006年3月至2009年3月对76例上尿路结石采用超声引导下经上盏径路的微创经皮肾镜术(mini-percutaneous nephrolithotomy, MPCNI),效果良好,报告如下:

资料与方法

一、一般资料

本组76例82侧结石,男45例,女31例,年龄23~77岁,平均43岁。左47侧,右35侧,其中完全性鹿角形结石4侧,部分鹿角形结石13侧,肾盂结石19侧,上盏结石9侧,复杂下盏结石14侧,输尿管上段结石及UPJ结石22侧,其中体外冲击波碎石术(extracorporeal shock wave lithotripsy, ESWL)后石街9侧,肾输尿管多发结石11侧,输尿管结石最低平面为第5腰椎横突,上盏憩室结石1侧。结石大小2~7.5 cm,平均3.5±0.5 cm,75侧为阳性结石。其中中重度积水肾23侧,轻度或上盏局限性积水肾53侧,无积水肾6侧。马蹄肾2例,脊髓灰质炎后遗症脊柱严重侧弯1例(图1),合并肾功能不全3例,肾积脓9侧,接受过ESWL治疗31侧,接受过开放手术2侧。

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所有患者术前接受中段尿细菌培养、泌尿系超声、双肾及输尿管CT平扫、IVP和/或逆行上尿路造影等检查，以明确诊断，了解肾盏积水状况及周边脏器情况，排除手术禁忌证。

二、手术方法

手术器械包括18G穿刺针、0.035英寸金属导丝、6~18F筋膜扩张器、8/9.8F输尿管镜。Aloka SSD500超声机，3.5 MHz凸阵探头。灌注泵及影像系统。碎石设备为U-100双频双脉冲Nd:YAG激光碎石机。

腰硬联合麻醉或全身麻醉，先取截石位，在输尿管镜或膀胱镜下患侧6F输尿管导管逆行插入至肾盂或输尿管结石下方。改俯卧位，中上腹部垫高10~15 cm。常规消毒铺巾。取肩胛下线和腋后线之间第10、11肋间作为穿刺点。超声探头横切或纵切定位患肾上盏，超声引导下18G穿刺针穿入上盏，退出针芯见尿液流出后置入钢丝导丝，退出针鞘，破皮，沿钢丝导丝逐级扩张至16F，留置16F剥皮鞘，使用8/9.8F输尿管镜观察并在鞘内留置亲水导丝为安全导丝，退出16F剥皮鞘，进一步沿钢丝导丝扩张至18F并留置18F工作鞘。输尿管镜寻及结石后使用U-100双频双脉冲Nd:YAG激光粉碎结石，大部分碎石通过灌注泵直接冲出体外，少数使用取石钳取出，仔细观察各盏、肾盂输尿管连接处(ureteropelvic junction, UPJ)及输尿管无残石后，沿输尿管送入斑马导丝，沿斑马导丝置入双J管，术后常规留置16F硅胶导尿管为肾造瘘管，视其出血情况决定夹闭或开放，夹闭者术后1~6 h开放。术后2~3 d行腹部平片检查，阴性结石者行超声检查，根据残石情况，决定是否需进一步行ESWL或Ⅱ期MPCNL。

本组脓肾、肾功能不全及脊柱严重侧弯畸形等13例采取Ⅰ期经皮肾造瘘，造瘘通道扩张至18F，留置16F造瘘管，5~7 d后Ⅱ期碎石处理。其中脊柱严重侧弯畸形1例因肺功能提示重度限制型通气障碍，Ⅰ、Ⅱ期手术均在局麻下进行。其中4例双侧上尿路结石中3例分次完成手术，1例一期完成手术。本组2例完全性鹿角形结石追加一条下极通道完成手术，其余病例均采用单一上盏通道(图2)。

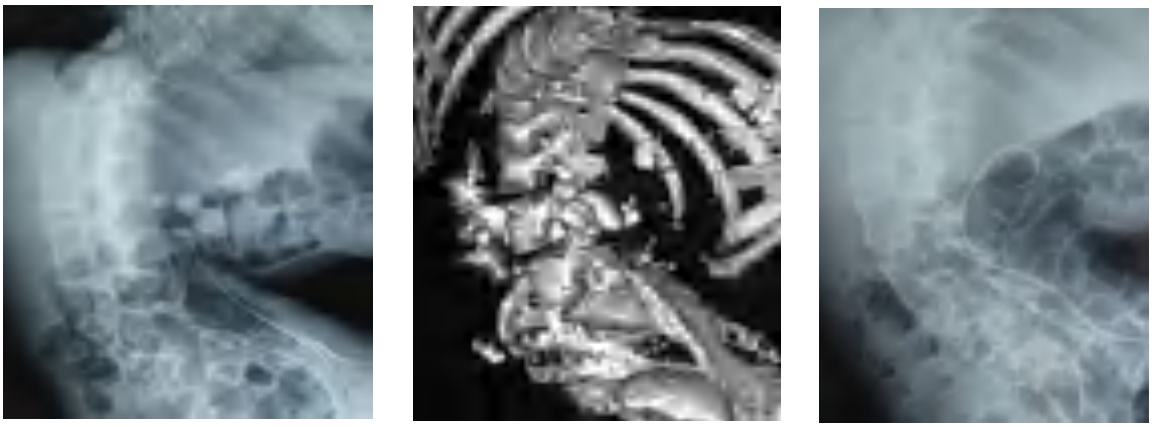


图1　脊柱严重侧弯1例，左侧上盏、下盏、输尿管、肾盂中盏铸形结石



图2　右肾鹿角形结石，上盏轻度积水，经上盏径路建立通道一期碎石

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结 果

本组76例82侧结石碎石术均获成功，手术时间25~120 min，平均45±10 min。一期结石取净率为81.7%(67/82)，二期结石取净率为73.3%(11/15)。术后住院时间4~15 d，平均6±1 d。本组输血1例，为完全性鹿角形结石追加下盏通道，术中失血过多所致。术后发热21例，均为术前存在尿路感染病例，通过加强抗感染控制。胸腔积液2例，为经第10肋间穿刺通道病例，经利尿脱水等保守治疗控制。本组经第10肋间穿刺胸腔积液发生率66.7%(2/3)，经第11肋间穿刺未出现有症状的胸肺部并发症。本组无其他重要脏器损伤、无感染性休克、无肾动脉栓塞止血、失肾、死亡等严重并发症。

讨 论

在过去的20年，泌尿系结石的治疗发生了革命性的变化，开放性手术几乎被ESWL和腔内技术所取代，经皮肾镜下碎石取石术(PCNL)成为了上尿路结石重要的手术方式。而术前设计合适的穿刺点和径路，建立合适的经皮肾通道是PCNL手术成功的关键[1]。

传统PCNL径路多为第12肋下，腋后线与肩胛线之间指向后组下盏或中盏的经皮肾通道，但对许多上尿路结石，该通道并不是一条最佳通道。Aron等[2]对102例经后组下盏径路与经后组上盏径路治疗复杂下盏结石进行了对照研究，结果经上盏径路PCNL在结石清除率、失血量较经下盏径路稍优，而在手术时间、减少通道数目、再手术率等方面有明显优势，具统计学差异。经上盏径路组仅2例(2/69)出现胸部并发症，予留置胸管。故Aron等认为，经上盏径路PCNL对于复杂性下盏结石提供了一条最直接最合适的通道，能显著提高清石效率，缩短手术时间，而胸部并发症相对轻微。Netto等[3]对119例经上盏径路、中下盏径路及多通道径路治疗鹿角形结石的成功率及并发症情况进行了回顾性分析，结果其清石率分别为87.5%、80%及84.8%，平均手术时间分别为86.8 min、139.1 min及134.9 min，并发症发生率分别为25%、21.4%及45.4%，胸膜损伤2例，1例出现在第12肋上径路中，故Netto等认为采用经上盏径路及多通道径路处理鹿角形结石高效、安全，但多通道径路会增加一定的输血率。Stening等[4]认为上盏结石可首选ESWL，但当上盏结石直径大于1.5 cm，伴有盏颈狭窄或过度肥胖等情况下，PCNL成了安全有效的选择，而经第12肋上上盏径路的PCNL为处理上盏结石提供了直接、高效的通道。

经后组上盏的经皮肾通道可以为硬镜提供一个到达集合系统各个地方最简便的径路[1]，并且能够到达输尿管的更远端，而泌尿外科医生犹豫采取此径路主要是担心潜在的胸部并发症。Yadav等学者[5]报道了第12肋上经上盏径路PCNL的安全性，其对328侧第11肋间、4侧第10肋间上盏径路与558侧其他径路进行了对照研究，肋上径路组仅11侧(3.31%)出现胸腔积液，7侧需要胸腔引流，没有出现肺和其他脏器损伤，而且并不因为胸膜损伤而延长住院时间。Yadav等[6]还对28例肋上上盏途径的术后并发症情况进行前瞻性分析，应用胸透及胸部、上腹部CT检视术后胸腔及上腹部脏器情况，结果较好。他们认为肋上上盏径路对UPJ结石、鹿角形结石、复杂下盏结石、上盏结石、输尿管上段结石安全、高效，增加的并发症主要为轻微并且可控的胸腔积液，并不会导致肺及其他脏器损伤。

经上盏径路的MPCNL通道与后组、前组中下盏、肾盂及UPJ、输尿管所成角度更大，锐角更少，这是经上盏径路MPCNL更直观、更高效的原因所在。此径路视野清楚，居高临下，对后组及前组中下盏、UPJ结石皆可有效观察处理。MPCNL术中UPJ处相对低压，结石碎片易在UPJ处积聚，此径路可方便的在碎石完毕后清理UPJ处的残石。此径路留置双J管十分方便，因其对UPJ、输尿管暴露十分清晰，而中下盏通道与UPJ成角过小，导丝易扭曲，不易成功置管，且易使镜体过度摆动而导致肾盏撕裂出血。此径路处理输尿管结石平面更低，可触及腰5横突平面以下结石。

经上盏径路的MPCNL穿刺点几乎都要选择在第12肋上，在腋后线内侧与肩胛线范围内肝脾损伤可能性小[6]，但胸部并发症需要警惕。胸膜背侧下界在肩胛线于第11肋相交在腋中线与第10肋相交[7]，故在肩胛线外侧第11肋间穿刺损伤胸膜可能性小，而经第10肋间穿刺建立通道损伤胸膜可能极大。国外学者多采用26~30F通道，国内多采用16~18F，胸膜损伤风险有所下降。尽量避免第10肋间通道，呼气末进针，使用合适口径的肾造瘘管留置以利于损伤的胸膜闭锁，保持肾造瘘管引流通畅，拔除肾造瘘管时适当填塞瘘口，这

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些措施能预防胸腔积液及气胸的发生[8]。

超声对肾肝脾等实质脏器有典型声像图,对肺、肠管也能清楚分辨,但胸膜很难显现。为避免损伤,通过穿刺前仔细调整探头断面避开肝、脾、肺、肠管等脏器,通过术前嘱患者深吸气,超声标记肺下界来估计胸膜下界的位置来避免损伤胸膜。

根据我们的观察,局限性肾积水的病例中上盏局限性积水更为多见,这可能与较多的复杂性结石易在上盏、下盏及肾盂生长,梗阻上盏出口有关。此时选择上盏通道降低了穿刺难度及减少了扩张时黏膜损伤的风险。局限性肾积水病例中肾积脓常见,取径上盏通道可以Ⅰ期建立通道引流脓液,Ⅱ期碎石,这类患者如取中下盏通道,也就是对着结石建立通道,术中由于灌注液稀释脓液,脓肾易遗漏,从而易造成感染扩散,术后感染性休克的发生率加大。

然而,肋骨上经上盏径路MPCNL定位穿刺时由于肋骨的影响,探头纵切时肋骨声影会挡住部分肾上极,影响穿刺,探头横切时,肋间隙小的患者,肋间无法完全容纳探头,也会导致部分肾上极声像不清,使用高分辨率小探头和熟练的定位技巧对寻找一个合适的肋上超声断面有帮助。同时由于肋骨阻挡,肋间通道在碎石过程中因镜体摆动易使工作鞘扭曲变形,不利于术中排石及留置肾造瘘管,这可用加厚硬鞘克服(图3~4)。

超声引导下经上盏径路微创经皮肾镜碎石清石术高效、微创、安全。对许多上尿路结石,经上盏MPCNL提供了一条直捷的通道,相对其他径路PCNL而言,它提高了结石清除率,缩短了手术时间,减少了通道数,新增加的并发症轻微而且易于处理。但由于存在肋骨阻挡、胸膜及肺等脏器的干扰,建议在积累一定经皮肾镜手术经验后开展此术式。



图3 左肾盂、下盏结石梗阻上盏颈口,上盏局限性积水,经上盏径路MPCNL降低了穿刺难度和扩张风险



图4 右肾巨大铸形结石、右输尿管结石伴肾积脓,使用上盏径路Ⅰ期造瘘引流,Ⅱ期碎石,上图依次为KUB、顺行造影、术中KUB(可见安全导丝及工作鞘,已无残石)

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曹建伟, 郎根强, 章益峰, 等. 超声引导经上盏径路微创经皮肾镜碎石术(附76例报告)[J/CD]. 中华腔镜泌尿外科杂志: 电子版, 2009, 3(6): 477-481.

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·论　著·

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经尿道手术治疗前列腺增生症合并膀胱结石的疗效观察

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Effect of endourological operation in treating BPH and bladder calculus

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ABSTRACT: Objective To evaluate the clinical effect and safety of transurethral resection of prostate(TURP) and U100-plus laser or punch lithotripsy for treatment of benign prostatic hyperplasia(BPH) and bladder calculus. Then to compare the therapeutic effects of the two methods. **Methods** A total of 79 cases of BPH with bladder calculus were reviewed, including 43 cases treated with TURP and punch, and 36 cases treated with TURP and U100 laser. **Results** IPSS and the maximum flow rate (MRF) were significantly improved after both of the procedures, ($P<0.05$). The achievement ratio was 97.2% for U100 laser lithotripsy and 62.8% for punch in the treatment of bladder calculus($P<0.05$). **Conclusion** The therapeutic effects of the two lithotripsies is the same when the diameter of the bladder calculus is less than 1.5 cm and safe when the diameter is move than 2.5 cm, U100-plus laser lithotripsy is more effective than punch.

KEY WORDS: benign prostatic hyperplasia; bladder calculi; transurethral resection of prostate; U100-plus laser

摘要：**目的**　研究经尿道前列腺切除(TURP)联合Punch碎石钳碎石或U100激光碎石治疗前列腺增生症(BPH)合并膀胱结石的安全性及有效性，并进一步比较两种碎石方法的有效性差异。**方法**　回顾性分析79例BPH合并膀胱结石患者，其中Punch碎石钳碎石43例，U100激光碎石36例。**结果**　两组术后1月国际前列腺症状评分(IPSS)及最大尿流率(MRF)与术前比较均有显著性差异($P<0.05$)。碎石成功率U100激光组(97.2%)较碎石钳组(62.8%)显著性增高，有统计学差异($P<0.01$)。直径在2.5 cm以上结石，U100激光组较碎石钳组碎石效率及成功率均明显增高，有显著性差异($P<0.05$)。**结论**　对直径1.5 cm以下结石，Punch碎石钳与U100激光在碎石效果方面无差异。对直径2.5 cm以上结石U100激光推荐首选。U100激光碎石联合TURP是治疗BPH合并膀胱结石的安全、有效的方法。

关键词：膀胱结石；前列腺增生症；经尿道前列腺切除术；U100激光
中图分类号：R694.4　　文献标志码：A

膀胱结石是前列腺增生症(benign prostatic hyperplasia, BPH)并发症之一。西安交通大学医学院第二附属医院自2007年5月～2009年5月共收治BPH合并膀胱结石患者79例，采用经尿道前列腺切除(transurethral resection of prostate, TURP)联合Punch碎石钳碎石或U100-plus激光碎石进行治疗。本研究探讨两种方法的安全性及有效性，并进一步分析两种碎石方法的有效性差异。

1　资料与方法

1.1　一般资料　2007年5月～2009年5月79例前列腺增生症合并膀胱结石患者，年龄61～86岁，平均(75.01±6.12)岁。合并冠心病或心律失常16例，其中冠脉支架3例，脑梗死8例，肾功不全2例。单发结石42例，多发性结石37例。术前经B超、KUB平片、膀胱镜检确诊为前列腺增生症合并膀胱结石。手术前均无手术禁忌症。详细记录患者术前及术后1月国际前列腺症状评分(international prostate symption score, IPSS)、最大尿流率(maximum flow rate, MRF)、膀胱结石大小(单发结石按电切镜下测量结石最大径计算，多发结石按电切镜下测量每个结石最大直径总合计算)、碎石时间、手术结果(无残余结石或残余结石<3 mm为手术成功；碎石失败改换其他手术方式视为手术不成功)、前列腺切除重量、术中及术后1月并发症。

1.2　分组　采用经尿道膀胱结石碎石取石联合经尿

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道前列腺切除术(TURP)同期治疗BPH合并膀胱结石。按膀胱结石碎石方式不同将病例分为两组：TURP联合Punch碎石钳碎石组(以下简称碎石钳组，43例)，TURP联合U100激光碎石组(以下简称U100激光组，36例)。

1.3 手术方法 79例患者均采用硬膜外麻醉，取截石位，碎石钳组患者先于尿道内置入F26奥林巴斯Punch碎石钳碎石，U100激光组患者均先于尿道内置入F21膀胱镜，然后通过内鞘置入U100激光光纤，在监控下将结石逐个击碎，Elick冲洗出结石碎屑。碎石成功后换用F26奥林巴斯电切镜，依次电切前列腺增生各叶，注意保护前列腺包膜及外括约肌。冲洗出切碎前列腺组织后，留置F22三腔尿管持续膀胱冲洗1~3 d，尿管留置3~5 d。术后1月门诊复查各项指标。

1.4 统计学处理 应用SPSS11.0软件进行统计学处理，采用t检验及χ^2检验，假设检验的显著性水准取$\alpha=0.05$。

2 结 果

2.1 一般情况及基线资料 比较79例患者结石直径0.8~4.2 cm。电切前列腺组织10~121 g，平均(28.47±1.84)g。总的手术成功率78.48%。碎石钳碎石组43例，U100激光碎石组36例。两组患者基线资料在年龄、术前IPSS、术前最大尿流率、膀胱结石大小构成比方面无差异($P>0.05$，表1)。

2.2 碎石钳组及**U100**激光组手术效果比较 见表2。

表**1** 碎石钳组及**U100**组患者临床资料比较

组 别	n	年龄(岁)	结石数(个)	结石最大直径之和(cm)	术前IPSS(分)	术前MRF(mL/s)	结石直径(cm)〔例(%)〕		
							<1.5	1.5~2.5	>2.5
碎石钳组	43	75.23±6.11	1~5	3.7	28.44±4.22	6.92±2.60	9(20.93)	19(44.19)	15(34.88)
U100激光组	36	74.75±6.21	1~8	4.6	27.22±4.14	6.29±2.83	8(22.22)	12(33.33)	16(44.45)
P值		0.878			0.201	0.963		0.589	

表**2** 碎石钳组及**U100**激光组手术情况比较

组 别	碎石手术成功率(%)	切除前列腺重量(g)	术中膀胱尿道损伤(%)	术后1月IPSS(分)	术后1月MRF(mL/s)	术后1月尿道狭窄(%)	术中及术后心脑血管意外
碎石钳组	62.8	29.02±17.42g	4.7	7.90±2.79	20.9±4.36	14.6	0
U-100缴光组	97.2	27.81±19.71	0	7.33±3.44	21.33±4.67	11.1	0
P值	0.000	0.771	0.190	0.416	0.226	0.646	/

2.3 碎石钳组及**U100**组间不同大小结石碎石效果比较 碎石钳组不同直径结石碎石成功率差异有统计学意义($P<0.05$)，U100激光组则无统计学差异($P>0.05$)。两组不同直径结石碎石时间均有统计学差异($P<0.05$)(表3)。碎石钳碎石失败16例，单个结石直径在2.4~3.5 cm，平均(2.91±0.49)cm，所有失败病例均改为U100激光碎石成功。

表**3** 碎石钳组及**U100**激光组不同大小结石碎石成功率及碎石时间比较

组 别	直径小于1.5 cm		直径1.5~2.5 cm		直径大于2.5 cm	
	成功率(%)	碎石时间(min)	成功率(%)	碎石时间(min)	成功率(%)	碎石时间(min)
碎石钳组	100	7.55±2.19	63.2	27.83±12.18	33.3	58.60±27.01
U100激光组	100	8.50±2.78	100	20.17±8.47	93.8	31.20±16.51
P值	/	0.445	0.017	0.087	0.000	0.013

3 讨 论

BPH是老年男性常见疾病，膀胱结石是BPH并发症之一。BPH伴有的膀胱结石是继发性结石，系因膀胱出口梗阻造成的，其并发率可达10%以上[1]。由于BPH患者多为老年患者，基础疾病较多，病情复杂，围手术期危险性大。对这些患者的治疗已完全转向以各种腔内技术下的微创治疗手段为主的治疗模式。

本研究应用腔内碎石联合TURP治疗BPH合并膀胱结石。一般先处理膀胱结石后行TURP。膀胱结石的治疗有多种方法。耻骨上膀胱切开取石术对患者损伤大、恢复慢，对老年患者增加了手术的风险性。体内碎石设备可分为机械碎石、气压弹道碎石、高能超声碎石和各种激光碎石。这几种方法及设备均有各自的优缺点。因此我们一直以来都在寻找

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一种高效、安全的体内碎石设备。本文比较了 Punch 碎石钳碎石和 U100 激光碎石效果的差异。Punch 碎石钳碎石为机械碎石, 利用手的握力夹碎结石, 具有价廉、经久耐用、耗材少、碎石力量大等优点。本研究采用 Punch 碎石钳治疗的 43 例患者, 27 例碎石成功, 碎石成功率 62.8%。其中小于 1.5 cm 结石碎石时间(7.55±2.19)min, 成功率 100%; 而大于 2.5 cm 结石, 碎石时间(58.60±27.01)min, 碎石成功率仅 33.3%。碎石时间及碎石成功率与结石体积明显相关($P<0.05$)。碎石失败病例中, 单个结石直径均在 2.4~3.5 cm, 平均(2.91±0.49)cm, 这主要与较大结石碎石钳钳抓困难有关。此外结石的硬度、形态、表面是否光滑也影响碎石效率。桑椹状或不规则形、表面不光滑、质脆结石较圆形或卵圆形、表面光滑、质硬结石更易碎, 这主要与碎石钳钳抓难易程度有关。所有失败病例改为 U100 激光碎石成功。因此结石体积可以作为判断 Punch 碎石钳碎石效果的指标。对于直径 1.5 cm 以下结石, 碎石钳碎石仍是一种高效的碎石方法, 与 U 100 激光碎石比较, 碎石时间及碎石成功率均无差异($P>0.05$)。而直径超过 2.5 cm 的结石碎石钳碎石成功率低, 手术时间长, 且易造成膀胱黏膜损伤及出血, 导致术中视野欠清晰, 并发症相应增加[2], 本研究膀胱三角区穿孔 2 例, 均出现在此组。故对直径超过 2.5 cm 的结石不推荐使用碎石钳碎石。

U 100 激光是一种新型碎石设备。应用直径 0.73 mm 石英光导纤维传导激光, 具有极好的柔韧性, 因此可以广泛应用于腔内外科技术[3]。具有对软组织损伤小、碎石效率相对较高等优点。U100 激光对胱氨酸结石无效[4], 而对其以外各种成分的结石均有效, 因此其碎石成功率高。本研究中 U100 激光碎石成功率 98.28%, 不同大小结石碎石成功率无差异($P>0.05$), 故在选择手术时可以不考虑结石体积对碎石成功率的影响。1.5~2.5 cm 结石 U100 激光碎石效率与碎石钳类似但碎石成功率更高($P<0.05$)。本组资料中, 对于 1.5~2.5 cm 结石虽然 U 100 激光组碎石时间〔(20.17±8.47)〕min 较碎石钳组〔(27.83±12.18)〕min 短, 但无统计学差异。直径在 2.5 cm 以上结石, U100 激光组较碎石钳组碎石效率及成功率均明显增高。因此, 结石体积越大, U100 激光优势越明显。对于直径在 2.5 cm 以上结石我们更推荐应用 U100 激光碎石。U100 激光是非热灼性的工作方法, 无组织切割性[5]。本组病例中无膀胱损伤、穿孔病例, 具有较高手术安全性。

TURP 是治疗 BPH 的金标准[1]。两组病例分别手术切除前列腺重量(29.02±17.42)g 及(27.81±19.71)g, 术后 1 月复查 IPSS 评分及 MRF 与术前比较均有明显改善($P<0.05$), 取得了良好效果。而不论采用何种腔内碎石方法, 两组间术后效果无差异性($P>0.05$)。且均无术中及术后心脑血管意外病例及死亡病例。因此, 腔内碎石联合 TURP 治疗 BPH 合并膀胱结石是安全、有效的方法。对于碎石方法的选择, 虽然 U100 激光碎石经济费用较高, 但碎石效率、成功率及安全性方面均较 Punch 碎石钳碎石具有优势。临床中我们可以根据结石大小选择经济有效的碎石方法。对直径 1.5 cm 以下结石, Punch 碎石钳与 U100 激光均是高效的碎石方法。对直径 2.5 cm 以上结石 U100 激光具有绝对优势。

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·临床研究·

微通道和标准通道在经皮肾取石术中效果及安全性评价

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【摘要】 目的 比较微通道和标准通道在经皮肾取石术(PCNL)中的效果及安全性。 方法 2008年8月至2009年6月,我院采用C-型臂X光引导穿刺,微通道(14~18 F)和标准通道(20~24 F)两种不同PCNL通道行经皮肾取石术治疗肾内结石67例,其中微通道组31例,标准通道组36例;男性39例、女性28例,年龄31~67岁,平均46.3岁;左肾结石40例,右肾结石27例;根据腹部KUB测量结石大小:纵径2.0~6.8 cm,横径1.5~5.4 cm。对两组患者一期结石清除率、手术时间、手术并发症等指标进行比较。 结果 两组患者分别成功建立微通道和标准通道一期行单通道经皮肾碎石取石术。微通道(14~18 F,本组为16~18 F)组31例,标准通道(20~24 F,本组为22~24 F)组36例。 结石清除率分别为67.7%(21/31)和88.9%(32/36),$P<0.05$;手术时间分别为93±17.5 min和82±12.1 min,$P<0.05$;术后发热(体温≥38.5℃)分别为25.8%(8/31)和5.6%(2/36),$P<0.05$;术中出血>800 ml分别为3.2%(1/31)和2.8%(1/36),$P>0.05$;住院时间分别为7.3±0.4 d和7.1±0.6 d,$P>0.05$。 结论 本组研究结果显示,采用标准通道,运用8/9.8 F Wolf输尿管硬镜或李逊肾镜与U-100双频双脉冲激光碎石机治疗直径≥2 cm的肾内结石比采用微通道具有清石效率高、手术时间短、术后发热发生率少等优点,与微通道相比,不增加术中术后出血、穿孔等并发症发生率。

【关键词】微通道;标准通道;经皮肾取石术;肾内大结石

Evaluation of efficacy and safety of minimally invasive PCNL and standard tract PCNL for renal calculi

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【Abstract】 Objective To compare the efficacy and safety between minimally invasive percutaneous nephrolithotomy (PCNL) and standard PCNL. Methods Under X-ray guided, we performed 67 patients (39 males and 28 females, mean age, 46.3 years) of PCNL with renal calculi, of which 31 cases used minimally invasive PCNL (14-18 F) and 36 cases used standard PCNL (20-24 F). Stone size ranged from 2.0 to 6.8 cm in longitudinal diameters and 1.5-5.4 cm in transverse diameters. Results Respectively for the minimally invasive PCNL and standard PCNL, the stone free rates were 67.7% (21/31) and 88.9% (32/36) ($P<0.05$), operation durations were 93±17.5 min and 82±12.1 min ($P<0.05$), postoperative fever rates (≥38.5°C) were 25.8% (8/31) and 5.6% (2/36) ($P<0.05$), intraoperative hemorrhage rates were 3.2% (1/31) and 2.8% (1/36) ($P>0.05$); length of stay were 7.3±0.4 days and 7.1±0.6 days ($P>0.05$). Conclusions Using standard PCNL and Wolf 8/9.8 F ureteroscope with U-100 FREDDY laser for treatment of renal calculi with diameter ≥ 2 cm have the advantages of highly effective stone removal, shorter operation duration and reduction of postoperative fever than those of using minimally invasive tract. The safety level for complications such as intra-operative hemorrhage is as the same as that of minimally invasive PCNL.

【Key words】 Minimally invasive; Standard; PCNL; Renal calculi

2008年8月至2009年6月,我院采用C-型臂X光引导穿刺、微通道和标准通道两种不同PCNL通道进行经皮肾取石术治疗肾内结石67例,就两种通道疗法的临床资料进行回顾性分析,在手术时间,出血情况,术中术后并发症,住院时间和结石清除率等方面进行比较,探讨两种通道的效果及安全性,报告如下。

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资料与方法

一、临床资料

本组67例患者中,男性39例、女性28例,年龄31~67岁,平均46.3岁。其中完全性鹿角状结石19例,不完全鹿角状结石47例,肾盏憩室结石1例;结石部位:左肾40例,右肾27例。所有患者行KUB、CT及静脉肾盂造影(IVP)检查,以了解患肾与同侧周围重要器官的位置关系,并显示有无肾盂、肾盏积水。根据腹部KUB测量结石大小:纵径2.0~6.8 cm,横径1.5~5.4 cm。合并症:高血压者13例,冠心病者4例,糖尿病者3例,泌尿系感染者12例,肾功能不全者2例,均伴有不同程度肾积水。

上述患者随机分组接受微通道(14~18 F)和标准通道(20~24 F)两种不同工作通道的PCNL手术治疗,其中14~18 F组31例,20~24 F组36例。

二、手术方法

气管插管全麻,先取截石位,膀胱镜下患侧输尿管插入5 F输尿管导管至肾盂并留置导尿管;改取俯卧位,肾区垫高使腰背呈水平。经输尿管导管向肾盂注入稀释的造影剂显示肾盂肾盏,在C臂X线机定位下,穿刺点位于第11肋间或第12肋缘下、腋后线与肩胛线间向目标盏穿刺(以肾中后组盏为主),肾盏憩室结石直接穿刺憩室。18G肾穿刺针穿刺目标肾盏,有尿液溢出证实穿刺成功后引入导丝,退出穿刺针,使用筋膜扩张器顺导丝逐号扩张至14~18 F和20~24 F,留置相应口径的Peel-away鞘,插入镜芯,建立经皮肾取石通道,观察寻找结石。全部患者均行一期穿刺取石,采用8/9.8 F Wolf输尿管硬镜或李逊肾镜,采用德国WOM公司U-100双频双脉冲激光碎石机,利用液压灌注泵冲洗出小结石,稍大者用取石钳夹出,最后依次检查上、中、下肾盏及肾盂输尿管连接部是否有残留结石并予清除,常规顺行置入5 F的双J管,退镜,置入14~18 F肾造瘘管并退出镜鞘。术后4~5 d复查CT或KUB,显示无大块结石残余后拔出肾造瘘管,若有结石残余≥2 cm或结石位于下盏估计排石困难者,行二次经皮肾镜取石术(PCNL)处理,< 2 cm的残留结石辅以体外冲击波碎石治疗。

三、统计学方法

应用PEMS3.1统计软件处理数据。组间率的比较采用χ^2检验,手术及住院时间参数比较采用t检验,α=0.05为检验水准。

结 果

微通道(14~18 F,本组为16~18 F)组31例(包括完全性鹿角状结石8例,不完全鹿角状结石22例,肾盏憩室结石1例),标准通道(20~24 F,本组为22~24 F)组36例(包括完全性鹿角状结石13例,不完全鹿角

表1 标准PCNL组与微创PCNL组结石去除情况、术后发热情况及术中出血情况的分析

分组	n	结石清除情况		发热情况		出血情况(≥800ml)	
		清除数	清除率(%)	发热数	发热率(%)	出血数	出血率(%)
标准通道PCNL组	36	32	88.9	2	5.6	1	2.8
微通道PCNL组	31	21	67.7	8	25.8	1	3.2

注:两组比较指标差异中结石清除率χ^2=4.51和术后发热χ^2=3.90,二者均P<0.05,术中出血χ^2=0.38,P>0.05。

表2 标准PCNL组与微创PCNL组手术时间、住院时间的分析($\bar{x}\pm s$)

分组	n	手术时间(min)	住院时间(d)
标准通道PCNL组	36	82±12.1	7.1±0.6
微通道PCNL组	31	93±17.5	7.3±0.4

注:两组比较指标差异中手术时间t=2.946,P<0.05;住院时间t=1.624,P>0.05。

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状结石23例。两组患者的肾脏结石大小和肾盂积水程度无统计学差异。两组均一期成功建立皮肤肾脏单通道并行碎石术。两组中各有1例患者术中出血量较大,血红蛋白下降在90 g/L以下,输血400 ml。其余患者术中未输血,术后查血红蛋白下降分别为1.2%~19.2%(平均9.8%)和1.0%~20.1%(平均9.6%)。微通道组中肾脏穿孔并发腹腔积液1例,发生率为3.2%(1/31),需行腹穿引流抽水。手术1周后复查X线片,肾盂肾盏残留结石(残留结石直径>0.4 cm):微通道组10例,其中7例术后需行ESWL,3例行二期PCNL;标准通道组4例,其中2例术后需行ESWL,2例行二期PCNL。(表1~2)

标准通道PCNL比微通道PCNL一期手术时间缩短、结石清除率高、术后高热的发生率低,以上三项差异均有统计学意义($P<0.05$);术中出血和住院时间差异无统计学意义($P>0.05$);微通道PCNL发生一例穿孔原因为U-100光纤过度顶压结石,激光能量转化为机械冲击波经结石传导损伤肾脏所致;二期PCNL取石均发生在完全鹿角状结石;术后发热患者均血常规WBC≥10×10^9/L,血细菌培养阴性;均未发生胸腹脏器及血管损伤。

讨 论

经皮肾镜取石术(percutaneous nephrolithotomy,PCNL)的主要适应证是治疗复杂性肾结石[1]和直径≥2 cm的大体积肾结石[2]。通道的大小影响手术的成功率及碎石效率,也影响着出血、发热、感染等并发症的发生率。传统PCNL需将通道扩张至26~34 F,取石效率增加,但容易损伤叶间血管或撕裂肾盏颈而引起术中、术后肾大出血和尿外渗等并发症,手术风险大。加上国人的肾脏较西方人为小,故这些并发症发生率在国内更高[3]。针对传统PCNL通道大、并发症严重,以及国人肾脏的解剖特点,1992年李逊等[3]提出微创经皮肾穿刺输尿管镜碎石取石术(minimally invasive percutaneous nephrolithotomy,MPCNL),并于近年不断改进此项技术。目前MPCNL采用14~20 F(常规为16~18 F)经皮肾通道,8~12 F微创肾镜或8/9.8 F输尿管镜,使治疗的成功率不断增加,结石取净率达93%,严重并发症(如大出血、肾集合系统穿孔、邻近器官损伤等)的发生率低于5%[4],但小口径通道造成视野小,碎石后需要加压冲水取出结石碎片,以及取石钳不能取出较大结石碎片,降低了结石清除效率,对大结石碎石时间过长,仍不能完全替代标准传统肾镜治疗复杂性肾结石。

近年来,随着新型肾镜和高效碎石设备的出现,介于微通道与传统通道之间的标准通道(20~24 F)秉承大通道高效的清石效率,同时又具有微通道的并发症发生率低的特点,更适合临床应用。

本组资料结果显示,运用8/9.8 F Wolf输尿管硬镜或李逊肾镜与德国WOM公司U-100双频双脉冲激光碎石机进行一期碎石,标准通道PCNL比微通道PCNL手术时间明显缩短,结石清除率增高,术后高热的发生率降低,说明镜体细小,可以使镜体摆动角度扩大,视野扩大,可以通过较细的肾盏颈寻找肾盏内结石,而不至于勉强通过盏颈导致肾实质或盏颈撕裂发生大出血;工作通道大,镜体与Peel-away鞘的间隙扩大,小块碎石可以顺利冲出,稍大碎石可以钳夹取出,提高结石清除效率。同时,大间隙可以降低肾内压,减少细菌和毒素进入循环系统引发感染和术后发热的机会。

关于PCNL术中术后出血是否与通道口径大小有关看法不一。有不少学者认为大通道与微通道在术中出血和术后出血上无明显差别[5]。徐桂彬等[6]研究发现显著增加PCNL手术失血量的主要因素有结石体积较大、手术时间过长、肾实质肥厚、多通道取石及术中出现操作并发症等。然而,又有研究显示,PCNL术后出血危险因素与通道口径大小、扩张次数、术后留置肾造瘘管有关[7]。本组研究中微通道与标准通道PCNL各有一例出血,无统计学差异,提示通道口径大小并不是引起手术出血的主要因素。

关于术后发热原因,有作者报道PCNL术后发热≥38.5℃者占10%~35%,发热原因可能与结石性质、发热病史、术前预防性使用抗生素、手术操作、内毒素释放、术中肾盂内压等因素有关[8-11]。钟文等[12]研究显示肾盂内高压状态累积到一定限度(50)则总的平均肾盂内压升高,反流吸收量产生累积效应,将导致术后发热发生率增高。本组研究结果显示,微通道PCNL术后发热占同类手术的25.8%,比标准通道PCNL的5.6%明显增高,二者差异有统计学意义($P<0.05$),说明通道口径小可导致肾盂内高压状态,从而引起术后发热、感染。

本组研究结果显示,采用标准通道,运用8/9.8 F的Wolf输尿管硬镜或李逊肾镜与U-100双频双脉冲激光碎石机治疗直径≥2 cm的肾内大结石比采用微通道具有清石效率高、手术时间短、减少术后发热等优点,

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同时,在术中术后出血、穿孔等并发症发生率方面与微通道同样具有安全性。

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·短篇论著·

输尿管软镜治疗上尿路结石 737 例报道

黄丽娟 自富春 朱浩杰 杨晓东 张威

【摘要】 目的 探讨输尿管软镜下钬激光和 U-100 FREDDY 激光治疗上尿路结石的疗效。方法 经输尿管扩张鞘或沿导丝置入 F7.9 或 F8.7 输尿管软镜,抵达输尿管上段、肾盂及肾盏,以 300 μm,14 ~ 16 W [1 J/(14 ~ 16) Hz] 功率钬激光或 U-100 FREDDY 激光碎石。结果 737 例患者中,结石大小 0.5 ~ 2.5 cm,平均1.5 cm,输尿管上段结石寻及率 100% [(216 + 242)/(216 + 242)],上盏结石寻及率 99%(179/181),中盏结石寻及率 100%(200/200),下盏结石寻及率 96%(134/140),碎石成功率 95.5%,无严重并发症发生。结论 输尿管软镜下治疗输尿管上段结石、肾结石安全有效,恢复快,尤其适用于体外震波碎石效果不佳的肾盂肾盏结石且无明显肾盂肾盏积水者。

【关键词】 尿路结石; 输尿管镜检查; 钬激光; FREDDY 激光

随着输尿管软镜器械的不断完善和激光的临床应用,输尿管软镜技术已成为处理上尿路结石的重要方法之一。2008 年 9 月至 2010 年 12 月,我院 737 例上尿路结石患者行输尿管软镜手术,取得较好疗效,现报道如下。

一、资料与方法

1. 一般资料:本组 737 例,男 521 例,女 216 例,肾结石 279 例,输尿管上段结石 216 例,肾结石并输尿管上段结石 242 例,结石大小 0.5 ~ 2.5 cm,平均 1.5 cm,年龄 22 ~ 75 岁,平均 48 岁。患者因不同程度腰腹疼痛,血尿等主诉就诊,经超声 KUB + IVU,部分阴性结石行 CT 检查而确诊,279 例肾结石,242 例肾结石合并输尿管上段结石,其中下盏结石 140 例,肾盂、中盏结石 200 例,上盏结石 181 例。

2. 方法:采用腰麻或连续硬膜外麻醉,患者取截石位,F8/9.8Wolf 或 Olympus 输尿管镜下,输尿管导管引导下镜体扩张输尿管口,探查输尿管置入斑马导丝,导丝引导下置入 F12 或者 F14 输尿管扩张鞘,经扩张鞘置入日本 Olympus F7.9 或美国顺康 F8.7 输尿管软镜,个别输尿管口或下段狭窄,输尿管折角较大,F12 及 F14 输尿管扩张鞘不能置入,在斑马导丝引导下直接置入输尿管软镜,入输尿管上段、肾盂及肾脏各盏,寻到结石后置入 200 μm 或 300 μm 钬激光光纤,设置功率 14 ~ 16 W [1.0 J/(14 ~ 16) Hz] 或 U-100 FREDDY 激光,调整操作手柄,对准结石,进行碎石,将结石击碎至 1 ~ 2 mm,可见碎石随水移动,留置 F5 号双"J"管,术后 3 ~ 4 d 复查 KUB 了解双"J"管位置及碎石、排石情况,术后 15 d 左右再次行 KUB 复查,观察排石情况。

二、结果

本组 737 例有 21 例因输尿管相对狭窄等原因输尿管软镜无法上行,手术不能一期完成,置入双"J"管 20 ~ 30 d 后再次手术,均获成功;8 例输尿管软镜下未寻到结石:2 例为上盏结石(其中 1 例为上盏憩室内结石)、6 例为下盏结石(其中 1 例有开放手术史、2 例为憩室内结石);4 例只能击碎部分结石,其中 1 例结石位于上盏,嵌于侧方一小盏内,置入光纤后调整操作手柄,光纤无法对到结石,另外 3 例为下盏结石,因盏颈狭长,部分结石光纤无法击到;3 例结石偏大,2 个月后结石碎块未完全排出,再次输尿管软镜手术治疗;1 例输尿管上段结石因输尿管狭窄结石未排出,再次行狭窄内切开手术;32 例因形成石街配合体外碎石治疗;25 例因输尿管口或下段狭窄,折角较大,输尿管扩张外鞘无法置入,于导丝引导下置入输尿管软镜。无输尿管穿孔及感染性休克等并发症发生,手术时间 20 ~ 60 min,平均 30 min,术后住院 3 ~ 5 d,平均 4 d,结石排净时间 1 ~ 6 周,平均3 周。

疗效评价:拔除双"J"管 1 个月后 KUB 显示无残石或结石残块≤3 mm,且无临床症状(静默结石)视为碎石成功[1]。

三、讨论

随着微创技术及设备的发展,结石的治疗已步入了微创时代,目前常用的治疗方法:体外冲击波碎石,经尿道输尿管镜,输尿管软镜和经皮肾镜碎石术。对于一些并发不利解剖因素的患者,体外冲击波碎石效果并不理想[2-3],经皮肾镜手术适用于较大结石,但对于肾脏不积水的较小结石,经皮肾镜手术并发症出现的概率较大,对于直径 2 cm 以下无明显肾积水的各肾盏结石及输尿管上段结石,应用输尿管软镜下钬激光或 U-100 FREDDY 激光碎石治疗是理想的选择。

多数患者通过输尿管扩张外鞘置入输尿管软镜,但个别输尿管狭窄或折曲明显的患者,输尿管扩张鞘无法置入,通过斑马导丝引导或直接进镜的办法置入输尿管软镜,Saidi 等[4] 提出,在所有进行输尿管软镜操作的患者中,约有 10% 会因为输尿管管腔狭小导致进镜困难。对于这些输尿管管腔相对狭窄,置鞘阻力较大的患者,直接进镜。薛蔚等[5] 也报道了不使用输尿管镜鞘的输尿管软镜操作。但临床操作中体会到,放置输尿管扩张外鞘有以下好处:(1)降低了对软镜的损伤;(2)利于镜体的进出,提高了手术速度;(3)有利于光纤的置入;(4)加强排水,降低了肾内压力,减少了逆行感染的发生。

737 例手术中,分别采用了 200 μm、300 μm 钬激光碎石,笔者体会到,300 μm 钬激光具有明显的优越性:(1)200 μm钬激光光纤较细,力量较小,碎石比较慢,特别是相对较大结石,手术时间长;(2)200 μm 光纤较软,随着呼吸运动,肾脏出现上下移动,光纤会出现曲折,折断现象,会损伤镜面;(3)光纤损耗较大,增加手术时间及费用。4 例只能击到部分结石,更换为 200 μm 光纤,亦不能击到结石,所以 300 μm 与 200 μm 光纤比较,并未明显使镜体末端弯曲受限,300 μm 钬激光碎石功率为 14 ~ 16 W [1.0 J/(14 ~ 16) Hz],采用"蚕蚀"法碎石,从结石边缘开始,避

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免将结石从中间碎成几大块,增加手术难度[5]。术中灌注压力不要大,以免形成逆行感染。

激光的选择对手术成功起到至关重要的作用。对于 KUB 不透光或透光性较差的含钙结石,我们多使用 U-100 FREDDY 激光。FREDDY 激光为一种新型的 Nd: YAG 激光,其激光器能发出波长为 1064 nm 的红外光和波长为 532 nm 的绿光,绿光首先被结石表面吸收而形成均匀的等离子体,从而使结石能充分吸收红外光的能量,产生爆炸性的碎石作用[6-8],能使较小的结石瞬间粉碎。对于胱氨酸结石,由于 532 nm 的绿光无法在其表面形成等离子体,故 FREDDY 激光对其碎石效果差[6]。由于 532 nm 的绿光在组织和镜头表面同样无法形成等离子体,故 FREDDY 激光不会造成肾盂输尿管黏膜的损伤,对输尿管软镜的损耗也较小。

对于如何防止输尿管软镜的损伤,笔者体会如下:(1)如果输尿管腔相对狭窄或迂曲明显,一定要掌握好进镜力度,镜体折曲较大会导致部分导光光束受损,必要时建议置入双"J"管后二期处理;(2)光纤置入输尿管软镜时,镜体前端要保持 0°水平,防止光纤尖端戳伤镜体,必要时将镜体退至镜鞘内再置入光纤;(3)碎石时光纤距离镜面要有一定距离,我们操作时保持在约 0.5 cm;(4)如患者术中呼吸动度较大,击打结石时嘱患者屏住呼吸,避免击到镜面。

本组 3 例下盏结石,按 Elbahnasy 等[9]方法测量,测得肾下盏肾盂夹角 <90°,虽可窥及结石,但置入光纤后部分结石位于视野外,导致碎石困难,并易损伤镜身,故认为肾下盏肾盂夹角 <90°的肾下盏结石使用输尿管软镜碎石应慎重[10]。

针对输尿管结石,软性输尿管肾镜体现了以下优势:(1)因输尿管软镜具有可弯曲性及镜体直径较细的特点,多数输尿管迂曲明显或输尿管管腔相对狭窄的,输尿管硬镜无法上行的病例,输尿管软镜可顺利通过;(2)输尿管硬镜下碎石,结石碎块会进入肾盏,输尿管硬镜无法处理,而输尿管软镜可进入肾盏内继续碎石;(3)避免了经皮肾镜碎石的并发症。

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·临床论著·

联合不同口径多通道经皮肾镜取石术治疗复杂性肾结石*

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【摘要】 目的 探讨联合微通道及标准通道进行多通道经皮肾镜取石术(percutaneous nephrolithotomy,PCNL)治疗复杂性肾结石的临床疗效和安全性。 方法 2008 年 1 月~2013 年 2 月,采用联合微通道及标准通道进行多通道 PCNL 术治疗复杂性肾结石 121 例。包括鹿角形肾结石 73 例,肾多发结石 48 例。合并脓肾 31 例。 结果 121 例共建立 281 个通道。其中一期单通道 36 例,双通道 70 例,三通道 15 例;二期手术 56 例,其中 49 例新建通道 60 个。手术时间 34~127 min,平均 72 min。结石总清除率 90.9%(110/121)。术后无严重并发症。 结论 联合不同口径多通道 PCNL 治疗复杂性肾结石安全有效,清石率高,并发症低,住院周期短,可作为一种理想的治疗术式。

【关键词】 多通道; 经皮肾镜取石术; 复杂性肾结石

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Multi-tract Percutaneous Nephrolithotomy for Complex Renal Calculi *Yu Weiwen, Zhang Dahong, He Xiang, et al. Department of Urology, People's Hospital of Zhejiang Province, Hangzhou* 310014, *China*

【Abstract】 **Objective** To discuss the clinical efficacy and safety of multi-tract percutaneous nephrolithotomy using minimally invasive tract and standard tract for complex renal calculi. **Methods** We retrospectively analyzed the clinical data of 121 patients undergoing multi-tract percutaneous nephrolithotomy using minimally invasive tract and standard tract for complex renal calculi from January 2008 to February 2013, including 73 cases of staghorn calculi, 48 cases of multiple renal calculi. 31 cases combined with pyonephrosis. **Results** 281 percutaneous renal tunnels were successfully established in 121 cases, of which single tunnel was used in 36 cases, 2 tunnels were used in 70 cases, and 3 tunnels were used in 15 cases in one-stage. 56 cases had a two-stage PCNL, including 60 new tunnels in 49 cases. The average operation time was 72 min (range, 34-127 min), and the overall stone clearance rate was 90.9% (110/121). No severe postoperative complications occurred. **Conclusions** Multi-tract percutaneous nephrolithotomy for complex renal calculi is effective and safe. It has the advantage of high stone clearance rate, less complications and shorter hospital stay.

【Key Words】 Multi-tract; Nephrolithotomy; Complex renal calculi

复杂性肾结石包括鹿角形肾结石、多发性肾结石伴有肾盏颈狭窄和肾盏扩张,以及并发有肾脏解剖异常的结石(如马蹄肾、海绵肾等),临床处理困难,通常需要反复体外冲击波碎石(ESWL),多次输尿管软镜、经皮肾镜取石,各种复杂的腹腔镜或开放性手术取石等手段,治疗周期长,净石率较低。目前,经皮肾镜取石术(percutaneous nephrolithotomy,PCNL)已广泛用于上尿路结石的治疗,对于鹿角形肾结石等已成为首选治疗[1],其术式亦趋向多元化。一期多通道 PCNL 在提高结石取净率,缩短治疗时间方面国内外文献报道已取得良好临床效果。在此基础上,我们 2008 年 1 月~2013 年 2 月采用联合微通道(F_{16}~F_{18})及标准通道(F_{22}~F_{24})进行一期或多期多通道 PCNL 治疗复杂性肾结石(浙江省人民医院 64 例,杭州市第一人民医院 57 例),疗效满意,现总结如下。

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1 临床资料与方法

1.1 一般资料

本组 121 例，男 71 例，女 50 例。年龄 26 ~ 75 岁，平均 41.6 岁。反复腰酸腰痛 47 例，尿频尿急尿痛、间断肉眼血尿 35 例，浮肿少尿者 6 例，无症状体检发现 33 例。经 B 超、KUB + IVU、CTU 检查，确诊鹿角形肾结石 73 例(双侧 2 例)，肾多发结石 48 例(双侧 3 例)。其中孤立肾结石 7 例，有患肾开放取石史 12 例。无肾积水 21 例，轻度积水 38 例，中重度积水 62 例。结石大小 1.2 cm × 2.0 cm ~ 2.2 cm × 4.9 cm，平均 1.7 cm × 3.6 cm。术前严重尿路感染(尿常规 WBC ≥ 2 +，脓球 ≥ +) 19 例，中段尿培养细菌阳性 22 例，术前给予经验用药或敏感抗生素治疗 3 ~ 7 天，复查至尿检基本正常或仅轻度异常。9 例临床表现寒战高热(体温 > 38.5 ℃)、肾区叩击痛(+)，影像学检查提示结石梗阻，肾盂肾盏液浑浊，实验室检查血白细胞 $> 10 \times 10^9$/L 或 $< 4 \times 10^9$/L，术前脓肾诊断明确，3 例伴肾功能损害(血肌酐 157.8 ~ 278.9 μmol/L，尿素氮 9.6 ~ 18.7 mmol/L)。合并糖尿病 15 例，高血压 23 例，慢性肾功能不全(失代偿期) 6 例。

病例排除标准：未纠正的全身出血性疾患；未控制的糖尿病和高血压，严重心、肺、肝、肾功能不全；游走肾、移植肾或重度肾下垂。

1.2 手术方法

硬膜外或气管插管全麻。先取截石位行输尿管镜下逆行插管，再改俯卧位，上腹部下方垫一小枕使腰背呈一平面，肾区垫高固定。逆行沿导管滴注生理盐水造人工肾积水，或逆行推入造影剂，在 B 超或 C 形臂 X 线机定位下，于 12 肋下或 11 肋间腋后线到肩胛下线之间选择最为接近目标肾盏的穿刺点，用 18 G 肾穿刺针穿刺入盏后，抽出针芯置入斑马或 J 形导丝，并在其引导下，以筋膜扩张鞘或金属套叠式扩张器依次扩张至 F_{22} ~ F_{24}，留置 F_{22} ~ F_{24} Peel-away 工作鞘或金属鞘，建立第一皮肾通道。使用 Wolf $F_{20.8}$ 标准肾镜，结合 EMS 第四代超声联合气压弹道碎石清石系统粉碎并清理结石。再在 B 超或 X 线监测下，视残石位置、肾实质厚度及肾盏分布情况选择目标肾盏，建立第二、三皮肾通道(Fr_{16} ~ Fr_{18} 微通道或 Fr_{22} ~ Fr_{24} 标准通道) 碎石清石。微通道下采用 Wolf $F_{8/12.5}$ 微肾镜结合德国 WOM 双频双脉冲激光仪、科医人 60/100 W 钬激光仪、EMS 第四代气压弹道碎石仪等碎石，并结合液压灌注泵的脉冲水流和异物钳取出碎石。必要时再沿第一通道清理残石。视术中具体情况适时中止一期手术，留置 F_5 ~ F_6 双 J 管及 F_{16} ~ F_{18} 肾造瘘管。术后 3 ~ 5 天复查 B 超或 KUB，若有大块或较多结石残留，间隔 5 ~ 7 天行二期手术。术后 5 ~ 7 天夹管后拔除肾造瘘管，1 ~ 3 个月门诊拔双 J 管。

2 结果

本组 121 例成功建立 281 个通道。9 例术前脓肾、肾功能不全者一期肾穿刺造瘘引流，二期 PCNL；5 例术中穿刺发现积脓而结石负荷较大或患者体质虚弱者行一期经皮肾造瘘 + PCNL 简单处理流出道梗阻结石并内置双 J 管引流，二期再行 PCNL 碎石清石；另 17 例一般情况良好静止期感染的脓肾患者则行一期 PCNL。其中一期单通道 36 例(标准通道)，双通道 70 例(标准联合微通道 62 例，双标准通道 8 例)，三通道 15 例(9 例标准联合双微通道，6 例微通道联合双标准通道)。二期手术 56 例，其中 49 例新建通道 60 个。其中 5 例双肾结石行对侧 PCNL 术均建立双通道(标准联合微通道)；36 例单通道者 30 例再新建 1 个微通道，6 例再新建 2 个通道(标准联合微通道 5 例，双微通道 1 例)；8 例双通道者再新建 1 个微通道；4 例双通道及 3 例三通道者沿用原皮肾通道清石。手术时间 34 ~ 127 min，平均 72 min，其中单通道手术时间 34 ~ 65 min，双通道 56 ~ 114 min，三通道 67 ~ 127 min。住院时间 8 ~ 23 d，平均 10.7 d。术后 24 h 血红蛋白下降 8.2 ~ 39.5 g/L。二期术后结石总清除率 90.9%(110/121)。11 例残余结石术后结合 ESWL 及药物排石，术后随访 3 ~ 6 个月，7 例残石排净。6 例术后 3 ~ 7 天发生迟发性出血，出血量计估 200 ~ 400 ml，经保守对症治疗血止，术后 7 ~ 15 d 拔肾造瘘管。18 例术后高热(38.7 ~ 39.5 ℃)，其中 9 例经抗感染治疗后恢复正常，4 例二期手术清除梗阻石街后体温至正常。3 例少量患侧胸腔积液，2 例少 ~ 中等量腹腔积液，其中 1 例行胸腔闭式引流，4 例保守治疗痊愈。无严重大出血需栓塞或手术止血病例。

3 讨论

复杂性肾结石因结石的大小、成分、肾内分布复杂程度、合并肾功能不全、尿路感染等因素决定了临床处理的难度，任何一种单一治疗或联合治疗的手段清石率均较低[2]。近年来，复杂性肾结石的治疗逐渐向微创、多通道、联合治疗发展，多数学者采用标准通道 PCNL 或微创经皮肾镜取石术(minimally invasive percutaneous nephrolithotomy, MPCNL) 或联

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合处理，成功率达 64.3 ~ 89%[3~9]。MPCNL 通道（F_{14} ~ F_{18}）口径小，可用微肾镜或输尿管镜代替肾镜取石，术中操作引起出血机会相对减少[10]，但其对负荷大的肾结石清石时间长是其惟一的缺点。标准通道 PCNL 采用 $F_{20.8}$ 肾镜，大口径的工作通道（F_{22} ~ F_{24}）结合气压弹道联合超声碎石清石系统，明显提高了结石的粉碎和清除效率，缩短手术时间，同时保证低压灌注降低感染几率，在处理巨大肾结石、感染结石及结石合并感染的过程中显示了独特的优势[11]。我们在 PCNL 术中将 2 种不同口径通道联合进行碎石清石，正是结合 2 种碎石方式的优势，旨在保证高效地清除主体结石前提下，尽量减小 PCNL 通道建立过程中的侵入性操作对患者肾脏所造成的损伤，降低并发症发生率。微通道作为标准通道的补充，能安全可靠地处理某些夹角过大或平行肾盏的残留结石，达到更高清石率，最大程度地保护肾功能。

多通道 PCNL 术中经皮肾通道的选择与建立是关键。如何灵活并合理使用不同口径经皮肾通道，我们有以下几点体会：①术前根据 CTU、IVU、B 超相结合立体定位，确定最佳的第一经皮肾通道[12]。我们常规把中后盏入路选择为第一通道，并选用 F_{22} ~ F_{24} 标准通道，因为俯卧位下该路径镜体在集合系统摆动所能探及范围最大，能处理大部分流出道的结石，包括肾盂输尿管连接部。配合标准肾镜下气压弹道联合超声碎石清石系统，对于手术开始处理主体结石和最后清理冲散积聚在连接部的残石均快速有效。②根据术中情况，再建第二、第三通道。对于位于穿刺通道所经肾盏的平行肾盏内结石，尤其是盏颈狭长肾盏深远者，单一通道难以处理，往往要再建通道。此时需处理结石负荷不大，我们多采用 F_{16} ~ F_{18} 微通道碎石清石，以减少对肾实质的损伤。要注意新建通道的位置和角度，避免因与原通道过近导致皮质贯通撕裂，也不可盲目穿结石所在肾盏，有时会误扩至前组盏至盏颈撕裂。③秉承选择最少的通道取出尽量多的结石的原则。每一个通道都会对肾实质造成损伤并带来出血等风险，因此，对于体积不大的残留结石，可以考虑结合 ESWL，也可以尝试以下方法来避免再建通道：穿刺针进入残留结石所在盏，置入导丝或注入亚甲蓝，帮助寻找目标肾盏，必要时可更换输尿管硬/软镜进行操作。若盏颈口径宽大，可通过高压循环冲洗冲吸肾盏结石，或用针尖、J 形导丝在监测下将肾盏结石顶至肾盂来处理。④操作熟练和手术顺利者，可进行一期多通道穿刺取石；否则，分期多通道取石更为安全。手术的次数和每次手术时间，需视患者的耐受程度而定。一侧通道数目一般不超过 3 个；分期取石，建议单侧取石≤3 次；每次手术时间不宜过长（≤2 h）。随着内镜和体内碎石技术的发展，联合 ESWL 治疗应用会越来越少，而通过已建立的经皮肾造瘘通道进行二期或联合输尿管软镜技术碎石清石效果则更好。⑤在通道数量选择上，国外学者报道[13~15]使用 3 ~ 6 个（单侧）F_{24} 经皮肾通道行 PCNL 亦能安全碎石。美国泌尿外科学会（AUA）指南认为，一侧建立 2 个或以上经皮肾通道是安全有效的。因此，我们每侧常规建立 2 ~ 3 个经皮肾通道，同时 2 个通道尽可能避免建立在间距 < 1 cm 的肾实质表面的相临肾盏，以免肾实质贯穿裂开出血。

PCNL 手术多通道的建立对肾脏皮质的损伤临床上已有多项研究，曾国华等[16]研究报道 F_{16} 和 F_{32} 肾瘘道瘢痕体积占整个肾皮质体积的比率分别为 0.07% ±0.03% 和 0.10% ±0.04%，对肾皮质损伤都很小，结果无统计学差异。其他研究亦表明，多通道 PCNL 治疗鹿角形肾结石与单通道 PCNL 相比，出血量、并发症并无明显增加[17,18]。本组 3 例（5.1%）术后 3 ~ 7 天发生迟发性出血，出血量估计 200 ~ 400 ml，经保守对症治疗血止痊愈，无严重大出血栓塞或手术止血病例，国外学者报道 PCNL 术后大出血的发生率 1% ~ 3%[19,20]。PCNL 患者术后并发全身炎症反应综合征（systemic inflammatory response syndrome，SIRS）较常见。曾鹏等[21]报道单通道 PCNL 术中肾盂内压高于双或多通道，后者 PCNL 术中肾盂内压均较低，小于引起肾实质反流的压力安全值（40 cm H_2O），可降低因肾盂内高压状态累积致使反流达到一定限度而引起菌血症的风险。因此我们认为，尽管复杂性肾结石中结石负荷、手术时间、合并尿路感染等因素均会增加术中后 SIRS 发生率，但合理的围手术期使用抗生素，设计好合适的通道建立方案，控制好手术时间和手术创伤，保证术中肾盂低压灌注及术后引流通畅等措施能有效降低和防止严重感染的发生。

综上所述，联合不同口径多通道 PCNL 术通过利用两种通道优势互补，结合不同的碎石工具及方式，在提高结石清除率、缩短住院时间、减少手术并发症方面具有优势，在很大程度上提高了 PCNL 的治疗效果，可作为复杂上尿路结石的一种理想术式。

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3.8 创伤愈合与 2 种术式的关系

切口愈合的好坏与快慢,直接影响患者的生活质量及病程。标准开胸切口由于需要切断多层肌肉,而且切口靠后,患者仰卧时受压,导致切口局部血运障碍,影响切口愈合。标准开胸组 2 例因切口感染而裂开,VATS 组因创伤小,切口小,患者仰卧位切口不受压,切口愈合又快又好。

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输尿管镜下钬激光碎石术后并发输尿管狭窄回顾性分析

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[摘要] 目的:探讨输尿管镜下钬激光碎石术后输尿管狭窄的原因及其预防和处理。方法:回顾性分析我院2009 年 1 月～2012 年 12 月期间对 635 例输尿管结石患者行输尿管镜钬激光碎石术的临床资料,总结输尿管镜碎石术后发生输尿管狭窄的特点及处理方法。结果:术后出现输尿管狭窄 26 例(4.09%);其中输尿管完全闭锁 11 例(1.73%)。结论:钬激光碎石对输尿管有损伤作用,可导致输尿管狭窄,尤其对嵌顿性结石要注意操作技巧和术后正确的预防及随访。

[关键词] 输尿管镜;钬激光;输尿管狭窄;并发症;输尿管结石
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Retrospective analysis of ureteral stricture after ureteroscopic holmium: YAG laser lithotripsy

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Abstract **Objective**: To study the causes and prevention of the ureteral stricture after ureteroscopic holmium: YAG laser lithotripsy. **Method**: From January 2009 to December 2012, 635 patients of ureteral stones underwent ureteroscopic lithotripsy using holmium: YAG laser in our hospital. The clinical data were retrospectively analysed. **Result**: There were 26 cases (4.09%) who suffered from ureteral stricture after holmium: YAG laser lithotripsy, including 11 cases (1.73%) of ureteral atresia. **Conclusion**: Holmium: YAG laser lithotripsy can do damage to ureter and induce ureteral stricture, especially in those patients with impacted stone. Thus, surgical techniques, postoperative prevention and follow-up plan should be paid attention to.

Key words ureteroscopy; holmium laser; ureteral stricture; complication; ureteral stone

输尿管狭窄常见于输尿管的炎症、结石、外伤以及医源性操作后,输尿管结石术后输尿管狭窄是常见的远期并发症[1]。无论是开放取石,还是经腔镜取石、内镜碎石术,发病率均报道不一,发生率为3%～11%[2,3],而且缺乏独立的大样本报告,大多作为术后并发症之一予以讨论,并且把输尿管穿孔、撕裂等损伤归为狭窄的主要原因。杨后猛等[4]也注意到钬激光对输尿管黏膜的损伤是引起输尿管狭窄的高危因素,事实上输尿管穿孔、撕裂等损伤发生率很低,经留置双 J 管或手术处理后极少有狭窄发生。我院于 2009 年 1 月～2012 年 12 月对 635 例输尿管结石患者行输尿管镜下钬激光碎石术,术后出现输尿管狭窄再次手术者 26 例,现将这些患者的临床特点及处理进行回顾性分析,现报告如下。

1.1 临床资料

本组 635 例,男 368 例,女 267 例,年龄 16～72 岁,平均 40.2 岁。其中输尿管上段结石 226 例,中段 135 例,下段 274 例。全部患者均行 B 超、CT 确诊,结石大小 5～35 mm,平均 13.2 mm,均有不同程度积水,集合系统分离 10～80 mm,平均 25.3 mm。排除标准:既往曾行体外冲击波碎石术或输尿管手术者不纳入本组研究对象,术中无输尿管穿孔及撕裂者。

1.2 方法

应用钬激光碎石设备 HLM-1-30(合肥科瑞达公司);Wolf $F_{8/9}$ 半硬性输尿管镜。连续硬膜外麻醉,膀胱截石位,直视下通过尿道置入输尿管镜,以斑马导丝或输尿管导管引导,液压灌注泵扩张输尿管管口(入镜后关水或严格控制进水量及速度,避

置为 1.0～1.5 J/15～20 Hz；用钬激光光纤抵住结石，结石粉碎至 3 mm 以下，合并息肉者行钬激光切除术，碎石后检查输尿管有无狭窄，常规留置 F_5 或 F_6 双 J 管，术后 2～4 周拔除。

2 结果

635 例患者术后发生输尿管狭窄而再次住院者 26 例(4.09%)，其中大部分于拔除双 J 管后 1～30 天出现患侧腰部胀痛，其他患者无临床症状，复查 B 超或 CT 检查未见结石梗阻，但积水恢复到术前大小，甚至加重，经逆行插管造影明确输尿管狭窄存在，其中输尿管闭锁者 11 例(1.73%)。狭窄部位上段 10 例(4.42%，10/226)，中段 3 例(2.22%，3/135)，下段 13 例(4.74%，13/274)，发生输尿管闭锁的患者结石平均大小 15.5 mm，梗阻侧肾积水平均 38.6 mm，呈嵌顿结石状，与梗阻部位无关。26 例患者中行输尿管钬激光内切开 15 例，术后留置双 J 管 3～6 个月；11 例输尿管闭锁者行输尿管狭窄段切除端端吻合术 7 例，4 例输尿管下段闭锁行输尿管膀胱再植术；15 例钬激光内切开患者，2 例因再次输尿管狭窄改开放手术，其中 1 例因肾功能严重受损行肾切除术。

3 讨论

自从我院应用钬激光碎石后，发现输尿管结石术后输尿管狭窄患者明显增多，尤其是输尿管完全闭锁的患者。除了新技术应用及相应的输尿管镜下碎石患者增多的样本因素外，我们认为钬激光碎石对输尿管有损伤作用。在结石长期存在，引起输尿管黏膜破坏的基础上，钬激光碎石加重输尿管损伤，此二者为输尿管结石激光碎石术后输尿管狭窄的主要原因。理论上，输尿管的损伤是输尿管狭窄的必要条件，损伤的程度与狭窄正相关，尤其是环状的输尿管黏膜的损伤，轻微的损伤对输尿管修复无明显影响，因此输尿管狭窄极少见于 1 mm 以下的结石患者。虽然理论上钬激光组织穿透深度不足 0.5 mm，一般不会导致穿孔，术后输尿管黏膜损伤轻微，很少会造成瘢痕致输尿管狭窄，但反复多次的重叠效果就难以估计。实际上，早期我们应用钬激光处理结石合并息肉的时候，就发现钬激光切除息肉导致输尿管黏膜明显苍白和输尿管的挛缩，在结石明显与输尿管粘连时，边缘结石碎石后输尿管黏膜广泛被破坏。后来，我们处理这种结石时，尽量从结石中间开始，边缘结石用输尿管钳夹离输尿管后再碎，输尿管息肉只在其根部烧灼一下，破坏其血供即可，避免反复凝切导致输尿管损伤。在改变处理方式后，术后输尿管狭窄比早期减少。腔内气压弹道碎石对输尿管没有热损伤，但存在着机械的物理损伤，理论上可减少术后输尿管狭窄，国孔、反复体外冲击波碎石等可能引起输尿管结石术后狭窄的可能因素的基础上，统计输尿管钬激光碎石术后狭窄发生率为 4.09%，尤其是术后输尿管闭锁的发生率明显多见(1.73%)，在拔除输尿管双 J 管后很快需再次处理，这在过去的气压弹道碎石术后极少见，也充分说明钬激光碎石对输尿管存在这不同程度的损伤，尤其在嵌顿结石的情况下。但是比较钬激光和气压弹道碎石术后狭窄的发生率还需要进一步的配对资料研究。

术后输尿管双 J 管的留置是预防输尿管术后狭窄的措施之一，常规我们留置 $F_{5\sim4}$ 双 J 管 2～4 周，在发现多例输尿管术后狭窄后，对术中存在输尿管损伤明显的患者延长至 8～12 周，对防止术后输尿管狭窄有一定作用。最长者在术后拔除双 J 管后出现输尿管狭窄的患者留置进口双 J 管半年，随访大部分未再狭窄，但也有 2 例仍再度狭窄而行开放狭窄段切除端端吻合术，提示输尿管黏膜损伤严重，甚至有肌层损伤可能，导致瘢痕的形成，输尿管黏膜无法再生。因此，对术中有明显输尿管黏膜损伤者，可适当延长双 J 管留置时间，由此带来的是给患者长期带管的不适，包括尿频、尿急、尿痛及肉眼血尿，以及可能潜在的感染，拔管后及时复查 B 超或静脉肾盂造影，如再度狭窄及时行狭窄段切除，并行相应吻合手术。

腔内微创碎石已成为输尿管结石的主要处理方式，开放手术理论上可以避免输尿管的环状损伤，其术后狭窄的主要原因与吻合技术相关，且多见相对狭窄。随着腹腔镜技术的发展，腹腔镜下输尿管切开取石术也在进行，但相对于腔内碎石而言，对大多数的输尿管结石，腹腔镜在医疗费用、手术时间及损伤程度，术后恢复、并发症及普及方面没有优势，但在较大的输尿管结石，存在着明显肾积水以及粘连的嵌顿结石，腹腔镜下取石或开放取石或许给我们更多合适的选择[7,8]。

综上所述，我们认为钬激光碎石可以导致输尿管的损伤，导致术后输尿管的狭窄，对结石较大、结石嵌顿时间较长、合并明显肾积水的患者在行钬激光碎石时或处理合并的息肉时，应尽量减少对输尿管的损伤，适当延长术后双 J 管留置时间，或者选择其他合适的取石方式。输尿管结石术后拔除双 J 管 1 个月内及时复查，早期发现输尿管狭窄并及时治疗。

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微通道经皮肾镜双频激光碎石术治疗上尿路结石的体会

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【摘　要】 目的：探讨微通道经皮肾镜双频激光碎石术治疗上尿路结石的安全性和有效性。方法：采微通道经皮肾镜双频双脉冲（U100）激光碎石术治疗上尿路结石108例。结果：108例（100%）患者均获成功。手术时间60~190 min，结石清除率分别为：输尿管上段结石100%，肾盏或肾盂结石95%，部分鹿角形肾结石（联合ESWL）71.4%，无胸膜损伤、结肠穿孔、输尿管穿孔、大出血、感染性休克、失肾、死亡等并发症发生。结论：采用微通道经皮肾镜双频双脉冲（U100）激光碎石术治疗包括部分鹿角形肾结石在内的上尿路结石可获得较高的结石取净率，手术安全性高，是治疗上尿路结石的有效手段。

【关键词】 上尿路结石　微通道经皮肾镜取石术　双频双脉冲激光

PCN技术的雏形出现于20世纪40年代利用内窥镜从手术肾造口取出残留结石而开始用于上尿路结石治疗，1976年Ferstrom报告了经皮肾镜取石的经验，吴开俊等90年代提出了经皮肾微造瘘输尿管镜取石术，使用F14或者F16微通道及F8、F9输尿管镜代替26 F的标准肾镜，使经皮肾镜取石术的两个重要并发症之一出血和损伤的发生率大为降低。宁国市人民医院采用微通道经皮肾镜双频激光碎石术治疗上尿路结石108例、疗效满意，现报告如下：

1　资料与方法

1.1　一般资料　2006年9月-2017年1月，我科采用微通道经皮肾镜双频激光碎石术治疗108例上尿路结石患者，男性62例，女性46例。年龄24~68岁，肾盂及肾盏结石患者60例，部分鹿角形肾结石患者17例，嵌顿性输尿管上段结石患者31例，结石大小12~35 mm，12例患者有ESWL治疗失败史，所有患者均有轻到中度肾盂或肾盏积水，合并肾功能不全者5例，手术器械为F8-9.8输尿管硬镜、德国WOM公司双频双脉冲U100Nd:YAG激光碎石机系统等。

1.2　手术方法　采用全身麻醉，肾区腹侧垫高完全俯卧位，根据KUB、IVU及CT等影像学检查，设计手术通道，穿刺肾脏的区域为11肋间或12肋下，肩胛下线与腋后线的范围内，在B超定位引导下穿刺目标肾盏及肾盂，置入斑马导丝，用筋膜扩张器沿导丝扩张，以2F递增，通道大小为F18或F16，多采用F18通道，直视下通过双频激光将结石击碎清除。对于估计手术时间超过2h者，予静脉注射速尿10~20 mg，预防水吸收，术毕放置双"J"管及肾造瘘管。

2　结　果

108例（100%）患者均获成功。手术时间60~190 min，结石清除率分别为：输尿管上段结石100%；肾盏或肾盂结石95%，1例肾盏结石患者残留少许2~3 mm结石碎片；部分鹿角形肾结石（联合ESWL）71.4%，2例残留少许4~5 mm结石。2例术后肾造瘘管引流出鲜红血液，经夹闭肾造瘘管2小时后引流液转清，1例体温超过39℃，经抗感染治疗48小时内体温恢复正常，本组无胸膜损伤、结肠穿孔、输尿管穿孔、大出血、感染性休克、失肾、死亡等并发症发生。

3　讨　论

目前，体外冲击波碎石、输尿管软、硬镜取石术、mPCNL及腹腔镜技术共同成为泌尿系结石主要治疗方法[1]，其中mPCNL不仅可以处理各种类型肾结石，对嵌顿性输尿管上段结石也有独到的优势[2]。

3.1　微通道经皮肾镜治疗上尿路结石的方式　微通道经皮肾镜治疗上尿路结石目前常采用方式为气压弹道碎石、超声碎石及气压弹道联合超声碎石，钬激光、双频双脉冲（U100）激光碎石等。气压弹道碎石气压弹道碎石术主要利用压缩气体经探杆传导推动子弹体击碎结石，适用于结石较小且易于碎裂的结石，超声碎石是利用超声探头产生高频超声波振荡，通过探杆前端震动击碎与其接触的石头，但对于硬度较大的结石碎石率较低。钬激光是脉冲式激光，利用钬激光的波长恰好位于水的吸收范围内，使得水分吸收激光的能量极速气化膨胀，将结石击碎为细小粉末状，一般能将结石粉碎至不超过1 mm[3]。钬激光对于各种成分的结石均能有效粉碎，碎石过程中的主要缺点是有潜在的切割软组织能力及热损伤，可造成肾盂黏膜损伤和输尿管穿孔及术后狭窄。德国WOM公司生产的双频双脉冲U100Nd:YAG激光碎石机发出的激光是一种新型钕-YAG激光，由

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1064 um的红外光和532 um的绿光两种不同波长的光依各自的频率组成，故称双频激光。其作用机制是经光纤维将激光束能量打到结石表面，绿光部分被结石表面吸收，在结石表面形成等离子体，等离子体再吸收不可见红外光后崩裂，产生的冲击波粉碎结石，对周围组织不产生热效应，一般不会造成正常泌尿道管壁的损伤[4]。纳宁等[5]比较双频激光与气压弹道碎石术治疗肾结石和输尿管结石的疗效和安全性显示，双频激光碎石术单次手术碎石率及结石排尽率高于气压弹道碎石术。许嘉骏[6]、张宇[7]等认为，双频激光为有效的碎石方法，具有碎石效率高、安全简单等优点，尤其在安全性方面具有明显优势。

3.2 微通道经皮肾镜双频激光碎石术治疗上尿路结石的体会 ①手术通道的正确建立对手术的成功至关重要，术前仔细阅读KUB、IVU、及CT等影像学检查，以满足最大取石范围的需要来设计手术通道，不可盲目穿刺，否则会影响结石的清除，甚至导致严重的出血。②尽量减少肾盂内冲洗水压力，手术时间估计超过2h，术中使用小剂量速尿，以减少冲洗液的反流和吸收，以预防水中毒。③对于MPCNL输尿管镜下双频激光碎石，建立F16-18皮肾通道比较合适，F14以下虽然对肾创伤小，但输尿管镜进入后工作鞘间隙过小，不利于冲洗液流出，可使肾盂内压力过高，加重水吸收，同时不利于碎石冲出，超过F20，扩张时造成肾实质撕裂可能性增加，对肾脏损伤较大。④术中尽可能在输尿管内置入导丝，通道不易丢失，早期留置D-J管，碎石不易在输尿管内形成石街。⑤术前使用抗生素，可以减少感染及败血症的发生。

总之，对于各种类型的复杂性上尿路结石，微通道经皮肾镜碎石术均能获得理想的治疗效果，微通道经皮肾镜双频双脉冲（U100）激光碎石术治疗上尿路结石具有创伤小、恢复快、成功率高等特点，是治疗上尿路结石的有效手段。

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Minimally invasive percutaneous nephrolithotomy with the frequency doubled-double pulse laser in treatment of the upper urinary tract calculirt

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Abstract:*Objective:* To evaluate the effect and safe of minimally invasive percutaneous nephrolithotomy (MPCNL) with the frequency doubled-double pulse laser in the treatment of the upper urinary tract calculi. *Methods:*Thirty-eight cases with the upper urinary tract calculi were treated with MPCNL and frequency-doubled-double pulse laser.*Results:*108 cases(100%)were successful of total 38 patients, the operation time 60-190 min. The stone clearance rate in upper ureterolithiasis was 100%, nephrolithiasis was 95%, partial staghorn nephrolithiasis was 71.4% (combined the ESWL), and there was no seriously complication after operated, for instance pleural effusion, colon injury, ureter injury, massive haemorrhage, septic shock, no death and renal failure cases.*Conclusions:*Minimally invasive percutaneous nephrolithotomy with the frequency doubled-double pulse laser in treatment of the upper urinary tract calculi.including partial staghorn nephrolithiasis, can receive high rate of stone clearance, high safety, and lower surgical seriously complication, It is a safe and effective therapy for upper urinary tract calculi.

Key Words: Upper urinary tract calculi; Minimally invasive percutaneous nephrolithotomy; Frequency doubled-double pulse Laser

/（编审:李宗武）

· 临床研究 ·

电子输尿管软镜联合U100Plus激光治疗上尿路2～3 cm结石的疗效研究

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【摘要】 **目的**　探讨电子输尿管软镜联合U100Plus激光治疗上尿路2～3 cm结石的安全性及有效性。**方法**　回顾性分析广州中医药大学金沙洲医院及广州医科大学附属第五医院2018年2月至2018年6月应用电子输尿管软镜结合U100Plus腔内激光碎石系统治疗66例上尿路2～3 cm结石的临床资料，记录术后1个月结石清除率，观察手术效果及围手术期并发症（Clavin-Dindo分级）情况。**结果**　平均结石直径（2.3±0.3）cm，单次碎石成功率100%。平均碎石时间（56±24）min，平均术后住院时间（2.3±1.2）d。术后1个月结石清除率为87.9%。手术并发症发生率为9.09%（6例），其中Ⅰ级4例，3例术后体温>38.5℃，1例反复疼痛需镇痛；ⅢA级2例，术后1个月形成输尿管石街，再次手术清石。**结论**　电子输尿管软镜联合U100Plus激光治疗上尿路2～3 cm结石，碎石效率高，并发症少，结石清除率高。

【关键词】　输尿管软镜；　U100Plus激光；　结石；　结石清除率

Digital flexible ureteroscope combined with U100Plus laser in the treatment of 2-3 cm upper urinary calculi

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【Abstract】 **Objective**　To evaluate the efficacy and safety of digital flexible ureteroscope combined with U100Plus laser in the treatment of 2-3 cm upper urinary calculi. **Methods**　The clinical data of 66 patients with 2-3 cm upper urinary tract calculi treated by digital flexible ureteroscope combined with U100Plus laser lithotripsy from February to June 2018 in Jinshazhou Hospital of Guangzhou University of Chinese Medicine and the Fifth Hospital of Guangzhou Medical University were retrospectively analyzed. The stone free rate in one month after operation was calculated, and the outcome of operation were observed, as well as complications (Clavin-Dindo classification). **Results**　The mean diameter of stones were (2.3±0.3) cm, and the success lithotripsy rate of single-stage was 100%. The average time of lithotripsy was (56±24) min, and postoperative hospital stay was (2.3±1.2) days. The stone free rate (SFR) was 87.9% after one month. The incidence of surgical complications was 9.09% (6 cases), including Grade I in 4 cases, 3 cases had fever (>38.5℃), and one required analgesia for recurrent pain. 2 cases had ureteral steinstrasse (Grade IIIA) were performed ureteroscopic procedure to remove the stone. **Conclusion**　Digital flexible ureteroscope combined with U100Plus laser in the treatment of 2-3 cm upper urinary calculi has high lithotripsy efficiency, fewer complications and high stone clearance rate.

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【Key words】 Flexible ureteroscope; U100Plus laser; Calculi; Stone free rate

输尿管软镜（flexible ureteroscope，FURS）在上尿路结石治疗中应用广泛，为了达到更安全有效的临床结果，外科医师联合器械工程师在相关设备的研发上不断合作并且推陈出新。碎石器械的高效和无组织损伤，成为了对输尿管软镜这一循自然通道手术的更高要求[1]。近年来，不少中心对U100Plus激光碎石器在胆道结石及输尿管结石的应用上进行了报道，认为它有高效碎石且对黏膜损伤小的优点[2-3]。然而，在输尿管软镜的应用却少见报道。本文回顾性分析广州中医药大学金沙洲医院及广州医科大学附属第五医院2018年2至6月间采用电子输尿管软镜结合U100Plus腔内激光碎石系统治疗66例上尿路2～3 cm结石的临床资料，对其安全性及有效性进行分析。

资料与方法

一、临床资料

本组66例，男性42例，女性24例，平均年龄（48±12）岁。平均体质量指数（body mass index，BMI）（24.5±2.5）kg/m^2。肾积水程度：轻度46例，中度20例。本组均为单发结石，其中左侧结石28例，右侧结石38例。结石位置：肾盂25例，肾上盏11例，中盏16例，下盏14例。平均结石直径（2.3±0.3）cm；平均CT值为（1 099±225）Hu，其中<1 000 Hu 18例，≥1 000 Hu 48例。既往输尿管切开手术史2例，体外冲击波碎石术（extracorporeal shock-wave lithotripsy，ESWL）史2例，输尿管镜碎石术史6例，既往软镜手术史3例，经皮肾镜碎石术手术史2例。本组Ⅱ型糖尿病4例，高血压10例。10例因结石梗阻感染于外院留置双J管，平均留置时间（12.0±2.1）d。术前尿培养阳性8例，4例为大肠埃希菌，1例变形杆菌，3例肺炎克雷伯菌。合并泌尿系感染患者术前积极抗感染5～7 d后再行手术。无感染者术前常规预防使用抗生素一次。

二、手术方法

腰麻联合连续硬膜外麻醉完成后，取截石位，8.0/9.8 F输尿管硬镜镜检输尿管后，置入0.035英寸（1英寸=0.889 mm）斑马导丝，沿导丝置入12/14 F或者14/16 F输尿管工作鞘，如果输尿管狭窄，则使用18 F球囊扩张器扩张狭窄段，扩张后置入14/16 F输尿管工作鞘。用电子输尿管软镜镜检肾盏，寻至石头，置入光纤。碎石工具为U100Plus激光碎石器，能量设置为100～150 mJ，频率设置为3～5 Hz，将结石粉碎至光纤大小，取石篮套取部分结石行结石成分分析。留置6 F双J管一条。

术后第1天复查腹部平片（plain film of kidneys，ureter and bladder，KUB），复查尿常规，尿沉渣检查正常后，拔除尿管。结石分析为无水尿酸结石者，予枸橼酸氢钾颗粒溶石以及预防结石。术后1个月返院复查CT，无明显结石残留者，拔除输尿管双J管，若有结石残留者可再次行输尿管软镜术（retrograde intrarenal surgery，RIRS）或者ESWL治疗。完全结石清除是指CT未见结石或残留结石大小<2 mm。

三、数据分析

计数资料采用平均值±标准差（$\bar{x}\pm s$）表示。记录手术患者基本情况，主要观察指标为结石清除率，手术并发症的发生，并发症采用Clavin-Dindo分级评分记录[4]。

结　果

本组病例均成功行FURS术并完成碎石，8例因输尿管狭窄行输尿管狭窄球囊扩张术。36例留置14/16 F输尿管工作鞘，30例留置12/14 F输尿管工作鞘。平均碎石时间（56±24）min，平均术后住院时间（2.3±1.2）d。术后均留置6 F双J管1条。手术并发症发生率为9.09%（6例），其中Ⅰ级4例，其中3例术后体温>38.5℃，1例术后反复腰痛需静脉使用镇痛药；ⅢA级2例，因输尿管石街形成需再次行输尿管软镜碎石取石术。术后1个月结石清除率87.9%，最大残留结石位于下盏，大小约0.4 cm。术后残石患者均未再次手术治疗，临床观察随访1年，仍有1例患者残留下盏结石，未见明显增大，大小约0.4 cm。结石成分见表1，其中单一成分结石34例，混合成分32例。

讨　论

美国、欧洲、中国医学会泌尿外科分会（AUA、EAU、CAU）的指南均认为FURS应作为处理上

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表 1　本组 66 例上尿路结石患者结石成分分析

结石成分	例数
一水草酸钙	28
尿酸	4
六水磷酸镁铵	2
一水草酸钙、二水草酸钙	4
一水草酸钙、尿酸	4
一水草酸钙、碳酸磷灰石	4
碳酸磷灰石、六水磷酸镁铵	2
一水草酸钙、二水草酸钙、碳酸磷灰石	18

尿路 2 cm 以下结石的优选 [5]。但是由于医疗器械的更新和设备的改进，医师技术水平的提高及患者的个体差异（合并出血性疾病，心血管等不适合行 PCNL）的情况，FURS 适应证在技术开展成熟的单位均有扩大的迹象，并逐步在处理 3 cm 左右的肾内结石，甚至鹿角状结石 [6-7]。

随着适应证的放宽，临床问题不断显现。碎石器械的功率低，手术时间长，给麻醉和患者病情造成了影响。再者，不少单位采用纤维内镜联合钬激光来处理肾内大体积结石，当钬激光随患者呼吸触碰肾黏膜，引起肾组织灼伤，导致出血，术野不清而被迫中止手术。术后需要延长住院时间，处理出血的并发症以及再次手术。所以我中心尝试采用电子输尿管软镜结合 U100Plus 腔内激光碎石系统的方法来解决以上两大临床问题。本研究发现，此种操作能获得良好的手术疗效，针对肾内 2～3 cm 结石，术后 1 个月结石清除率 87.9%，手术并发症发生率只有 9.09%，无因术中出血而中止手术的病例。

电子输尿管软镜内置了电荷耦合器件图像传感器（charge coupled device，CCD），并在内镜顶端感受信号成像，较纤维软镜而言，具有更高的清晰度和对比度，在术中术野清晰，能清楚的观察到腔内结石的情况，同时具有内部旋转灵活操控性，从而减少对黏膜的误伤。再者，电子输尿管软镜的使用，缩短了手术时间和提高了结石清除效率。Binbay 等 [8] 发现，在采用软镜处理同样大小结石下，使用电子输尿管软镜能够减少 10% 的手术时间，电子软镜组的平均碎石效率为（2.43 ± 0.81）mm^2/min，优于纤维软镜组的（1.96 ± 0.80）mm^2/min。再者，有赖于电子软镜的高清成像，它更容易识别隐秘的肾盏开口，有利于寻找残留结石和判断腔内碎石的效果，提高结石清除率。另一方面，U100Plus 腔内激光碎石器的使用能够更加有效的击碎和粉末化结石。它能够发出两种波长的脉冲激光：绿光和红光。绿光（λ=532 nm）为可见光，约占激光能量的 20%，先在结石表面形成均匀的等离子体（结石周围一定要充满含水液体）。红外光（λ=1 064 nm）为不可见光，约占激光能量的 80%，在结石表面形成的等离子体足够均匀的条件下，等离子体充分吸收红外光的能量，使激光能量瞬间转化为冲击波，由于峰值功率极高，形成的机械冲击波足以崩解结石。吴越等 [9-10] 回顾性总结 U100Plus 激光治疗 257 例输尿管结石，在治疗输尿管结石方面具有快速、高效、损伤小等优点。

U100Plus 激光是一种“冷激光”。它包含的绿光和红外光的波长分别为 532 nm 和 1 064 nm，并不在肾组织吸收能量的波长范围内。此外，它作用于软组织的时间短，一般情况下，软组织吸收激光并产生热效应的响应时间需要 100 微秒以上，而 U100Plus 激光的脉冲宽度仅为 1.2 微秒，所以 U100Plus 激光不会使软组织产生热效应 [11]。Zorcher 等 [12] 利用 U100Plus 激光正面击打实验兔子的膀胱黏膜，他们将激光能量设置为 90 mJ，激发 2 000 个脉冲，最后行病理组织检查只发现膀胱黏膜层充血水肿，肌层未受到损伤。值得注意的是，钬激光的波长为 2 120 nm，而软组织吸收激光的峰值波长为 2 000 nm 左右，因此钬激光碎石时，肾组织也会吸收能量，长时间的碎石有可能导致肾黏膜的损伤。

再者，早期的体外实验证实 U100Plus 上一代碎石器 U100 已能够粉碎各种类型的尿路结石 [13]。但临床试验表明该碎石器在粉碎包括胱氨酸、尿酸和一水合物草酸钙的效率较低 [11]。而新一代 U100Plus 明显改善了碎石效率，采用直径为 0.56 mm 的石英光纤，提高了设备的灵活性。临床研究表明，除胱氨酸结石外，它能高效的击碎所有类型的结石 [14-15]。在本研究病例中无胱氨酸结石，但无论在单一成分结石，还是混合成分的结石，该激光均有很好的击碎作用。实际操作中，软镜的弯曲角度并不因光纤的置入而明显消减。

但是电子输尿管软镜下 U100Plus 激光碎石，仍有以下几点需要注意：（1）光纤到位率要高，光纤与结石的距离应≤ 3 mm，碎石效果较好 [11]；（2）采用双脉冲模式下碎石时，光纤消耗较快，应暴露视野 0.5～0.8 cm 长度，以免损伤输尿管软镜；（3）碎石时，光纤发出的绿光对眼睛刺激较大，可

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安装滤光片保护眼睛。

综上,电子输尿管软镜联合U100Plus激光治疗上尿路2~3 cm结石,碎石效率高,并发症少,结石清除率高。

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· 临床研究 ·

输尿管软镜冷激光碎石术与钬激光碎石术治疗肾结石疗效比较

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【摘要】 **目的**　比较输尿管软镜冷激光碎石术与钬激光碎石术治疗肾结石患者的临床疗效。**方法**　回顾性分析福建省漳州市医院 2015 年 1 月至 2018 年 1 月收治的 192 例肾结石患者的临床资料，按照术式分为观察组（*n*=98，采用输尿管软镜冷激光碎石术）、对照组（*n*=94，采用输尿管软镜激光碎石术），比较两组患者手术相关指标、疗效及并发症等情况。**结果**　观察组手术时间、术中出血量明显少于对照组，差异有统计学意义（*P*<0.05）；观察组术后出血发生率 3%，低于对照组 10%，差异有统计学意义（*P*<0.05）；观察组术后感染发生率 6%，低于对照组 16%，差异有统计学意义（*P*<0.05）；观察组结石清除率 91%，高于对照组 78%，差异有统计学意义（*P*<0.05）；两组患者住院时间、术后输尿管穿孔发生率、肾功能不全发生率比较差异无统计学意义（*P*>0.05）。**结论**　输尿管软镜联合冷激光碎石治疗肾结石的临床疗效安全，与传统方法相比具有合理性和优越性，值得临床推荐。

【关键词】 输尿管软镜；　冷激光；　碎石；　肾结石；　回顾性研究

Comparisons of the curative effect of ureteroscopic cold laser lithotripsy and holmium laser lithotripsy in the treatment of renal calculi

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【**Abstract**】 **Objective**　To compare the clinical efficacy of ureteroscopic cold laser lithotripsy and holmium laser lithotripsy in the treatment of renal calculi. **Methods**　Clinical data of 192 patients with renal calculi from January 2015 to January 2018 in Zhangzhou Hospital of Traditional Chinese Medicine were analyzed retrospectively. According to the surgical method they were divided into observation group (*n*=98, cold laser lithotripsy with flexible ureteroscope) and control group(*n*=94, holmium laser lithotripsy with flexible ureteroscope). The operation related indexes, curative effect and complications were compared between the two groups. **Results**　The operation time, intraoperative bleeding volume, complication rate and stone clearance rate of the observation group were significantly better than those of the control group, the difference was significant(*P*<0.05). **Conclusion**　Ureteroscopy combined with cold laser lithotripsy is safe and effective in the treatment of renal calculi. Compared with traditional methods, it has rationality and superiority and is worthy of clinical recommendation.

【**Key words**】 Flexible ureteroscope;　Cool laser;　Lithotripsy;　Renal calculi;　Retrospective study

肾结石是泌尿系统常见病、多发病之一[1-2]，临床治疗方法包括：体外冲击波碎石术（extracorporeal shock wave lithotripsy，ESWL）、经皮肾镜碎石取石术（pereutaneous nephrolithotomy，PCNL）和输尿管

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万方数据

软镜碎石取石术（flexible ureteroseope lithotripsy，FURL），不同的治疗方法都具有一定的优势[3]，但也都具有一定的劣势和弊端[4]。ESWL操作简单、并发症发生率低[5]，但无法避免冲击波对肾脏的损伤[6]；PCNL创伤较大，出血和脏器损伤的风险也相对较高[7]；随着加速康复外科理念的发展，通过自然腔道治疗肾结石已成为主要趋势[8]，目前主要治疗方法是输尿管软镜联合钬激光碎石治疗，但也存在结石清除率低、并发症发生率高等缺点[9]。本文旨在对比分析不同激光碎石系统对肾结石患者治疗效果。

资料与方法

一、临床资料

本组患者192例来自福建省漳州市医院，均由同一组手术医师完成手术，按手术方式不同分为：观察组（98例，采用输尿管软镜冷激光碎石术治疗）、对照组（94例，采用输尿管软镜钬激光碎石术治疗）。两组患者性别、年龄、结石部位等一般资料对比差异均无统计学意义（表1）。

表1 输尿管软镜冷激光（观察组）和钬激光（对照组）治疗的肾结石患者一般资料对比

组别	例数	性别（例）		年龄	结石部位（例）			
		男	女	（岁，$\bar{x}\pm s$）	肾盂	上盏	中盏	下盏
观察组	98	76	22	37 ± 12	26	32	22	18
对照组	94	75	19	40 ± 11	25	30	21	18
统计值		χ^2=0.143		t=2.34		χ^2=0.019		
P值		>0.05		>0.05		>0.05		

纳入标准：（1）经超声或X线检查诊断明确；（2）单个结石最大径≤2.0 cm；（3）同意进行激光碎石治疗；（4）术前无感染；排除标准：（1）合并有心、肺、肝、肾等重要脏器疾病或功能不全无法耐受手术；（2）患有出血性疾病或原因不明的凝血功能异常；（3）泌尿系统严重感染尚未控制；（4）尿道或输尿管狭窄或畸形；（5）双侧肾结石或单个结石最大径>2.0 cm。

二、方法

1. 手术方法

（1）气管插管全身麻醉后取截石位，消毒铺巾；（2）应用6.5 F或8 F输尿管硬镜探查尿道、输尿管是否有狭窄；（3）斑马导丝引导下置入12/14 F输尿管软镜鞘；（4）退出鞘内心，置入输尿管软镜，探查肾脏及各盏情况，明确结石大小及部位；（5）观察组：采用双频双脉冲激光碎石机，置入200 μm冷激光光纤碎石，参数设置为功率120 mJ、频率10 Hz；对照组：采用钬激光碎石机，置入200 μm钬激光光纤碎石，参数设置为功率120 mJ、频率10 Hz；（6）应用激光将结石击碎至≤0.4 cm，稍大结石可予取石网篮取出；（7）仔细观察无残余结石（最大径>0.4 cm）且无出血后退出激光光纤及输尿管软镜，常规留置双J管、输尿管。

2. 观察指标

记录两组手术时间、术中出血量、住院时间、结石清除率及并发症发生率。其中结石清除判断标准为：术后4周复查KUB或超声，结石≤0.4 cm。并发症包括术后出血、感染、输尿管穿孔、急性肾功能不全。

3. 统计学处理

采用SPSS 22.0软件进行统计分析，其中手术时间、术中出血量、住院时间等计量资料符合正态分布，采用t检验，结石清除率及并发症发生率等采用χ^2检验，P<0.05为差异有统计学意义。

结　果

两组患者手术时间、术中出血量指标差异有统计学意义，住院时间差异无统计学意义（表2）。

表2 两组患者手术时间、术中出血量、住院时间比较（$\bar{x}\pm s$）

组别	例数	手术时间(min)	术中出血量(ml)	住院天数(d)
观察组	98	83 ± 13	47 ± 13	3.4 ± 0.5
对照组	94	116 ± 17	83 ± 11	3.5 ± 0.5
t值		15.46	20.89	0.98
P值		<0.05	<0.05	>0.05

两组患者术后出血、术后感染、结石清除率差异有统计学意义，输尿管穿孔及急性肾功能不全的发生率差异无统计学意义（表3）。

表3 两组患者术后并发症和结石清除率比较（例）

组别	例数	术后出血	感染	输尿管穿孔	急性肾功能不全	结石清除率
观察组	98	3	6	1	2	89(91%)
对照组	94	10	15	3	1	73(78%)
χ^2值		4.364	4.76	1.11	1.34	6.30
P值		<0.05	<0.05	>0.05	>0.05	<0.05

讨　论

近年来我国肾结石发病率呈上升趋势[10]，随着微创手术器械的不断改进和发展，如何更精细化地处理肾结石已成为研究热点。开放性手术治疗肾结石也因术中出血量大、术后并发症多、恢复时

间长等弊端而不作为首选[11]，而微创手术具有安全、恢复快、可重复等特点[12]，特别是通过自然腔道碎石术已成为主要治疗方法。目前各大指南均推荐输尿管软镜激光碎石治疗 <2.0 cm 的肾结石[13]，其中 PCNL 主要治疗最大径 >2.0 cm 肾结石[14]，虽然 PCNL 结石清除率较高，但也有手术创伤大、出血量多、术后并发症发生率高等缺点[15]；FURL 主要治疗最大径≤ 2.0 cm 肾结石[16]，虽然 FURL 操作简便、具有可重复性、术中出血量少、并发症发生率低[17-18]，但是结石清除率较低[19]。

因此，如何更高效更安全治疗肾结石是泌尿外科学者始终重视的问题。根据报道冷激光联合内镜治疗结石具有更高的碎石率和安全性[20]。对比钬激光碎石冷激光主要优势是：（1）在工作原理上，冷激光碎石分为红外光和绿光，红外光波长为 1 064 nm、绿光波长为 532 nm，均由双频双脉冲激光器激发，结石吸收占总能量 20% 的绿光后在表面形成等离子体，占总能量 80% 的红外光作用于等离子体使能量转化为机械能作用于结石，瞬间将结石击碎，而正常人体组织不能吸收绿光能量，不能产生等离子体，故红外光不会对人体组织产生伤害[21-22]；而钬激光碎石时产生的能量易被正常组织吸收和传导，可引起输尿管穿孔或出血。（2）在碎石方式上，冷激光产生的机械能作用于结石中心，结石产生“炸裂”效果，易将较大结石“炸裂”成细小结石自然排除；钬激光在结石表面产生“割裂”效果，需要多次反复操作，手术时间较长，结石清除率也较低。

术后出血和感染是输尿管镜手术常见并发症[23]，研究认为可能与术前感染、手术时间、术中高压损伤相关[24]。本组研究认为，术后出血和感染发生率与手术时间长短有关，较长的手术时间导致肾窦内持续高压，长时间的窦内高压不仅易损伤黏膜，引起出血还易使内毒素通过黏膜出血口向血液扩散引起感染。研究结果表明观察组手术时间较短，碎石效率更高，同时术后出血和感染的比例低于对照组。较短的手术时间还能明显降低医疗成本，节约医疗资源。输尿管镜属易耗品，有单价高、维修周期长、维修成本高等特点。使用冷激光碎石能缩短手术时间，使单根输尿管镜在有效使用期限内能服务更多患者。

碎石成功与否与多种因素相关，如：肾脏解剖、结石部位、结石质地、术者水平、碎石设备等。本研究中观察组和对照组结石清除率分别为 91% 和 78%，与文献报道相当[21,25]。在诸多因素中设备因素是较容易控制的因素，在其余因素差异无统计学意义的情况下，冷激光相较钬激光具有更高结石清除率。失败的病例中多数患者结石位于肾下盏，存在解剖夹角不易碎石且结石顽固不易套取，如何更高效治疗肾下盏结石也是今后研究热点。

根据冷激光的工作原理和特点，笔者的经验是：（1）碎石时应仔细寻找结石，判断部位和数量，“先大后小”然后“化整为零”，激光直接在结石中央激发，更易形成细小结石，自然排除；（2）碎石过程中易行成许多细小结石，小结石残渣易影响手术视野，不可盲目进镜，需稍退镜加大水压待视野清晰；（3）结石位置易改变，宜采用“边碎边取”的办法，对于肉眼 >0.4 cm 的结石用取石网篮取出，以免遗漏；（4）对于肾下盏结石，由于解剖关系，不易直接处理，可通过改变体位和垫高患肾等方法显露结石，用网篮将结石套取至上盏处进行碎石。

综上，冷激光联合输尿管镜治疗肾结石操作方便、节约时间、安全可靠，是治疗肾结石的一种新选择。

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输尿管镜 U100 激光碎石术和气压弹道碎石术治疗输尿管上段结石的疗效比较

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摘要:目的 比较输尿管镜下 U100 激光碎石术和气压弹道碎石术治疗输尿管上段结石的疗效及安全性。**方法** 选取 2013 年 12月-2018 年 9 月柳州市人民医院收治的输尿管上段结石患者 100 例作为研究对象,按照随机数字表法分为观察组和对照组,各 50例。对照组行输尿管镜下气压弹道碎石术,观察组行输尿管镜下 U100 激光碎石术,比较两组手术时间、单次碎石成功率、结石彻底清除率、手术并发症发生率,并分析单次碎石失败原因。**结果** 观察组单次碎石成功率及结石清除率为 90.00%、86.00%,高于对照组的 68.00%、60.00%($P<0.05$);观察组手术时间为(35.84±5.34)min,短于对照组的(55.08±9.78)min($P<0.05$);观察组并发症发生率为 12.00%,低于对照组的 30.00%($P<0.05$);两组碎石失败的主要原因是碎石过程中结石上移至肾脏,术中未能找到结石所致。**结论** 输尿管镜下 U100 激光碎石具有手术时间短、高效、安全及并发症少等优点,是治疗输尿管上段结石的有效手段。

关键词:输尿管镜;U100 激光碎石术;气压弹道碎石术;输尿管上段结石

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Comparison of the Efficacy of Ureteroscopic U100 Laser Lithotripsy and Pneumatic Lithotripsy in the Treatment of Upper Ureteral Calculi

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Abstract:Objective To compare the efficacy and safety of ureteroscopic U100 laser lithotripsy and pneumatic lithotripsy in the treatment of upper ureteral calculi.**Methods** A total of 100 patients with upper ureteral calculi admitted to the People's Hospital of Liuzhou from December 2013 to September 2018 were selected as the research objects and divided into observation group and control group according to the random number table method, with 50 cases in each group. The control group was treated with ureteroscopic pneumatic ballistic lithotripsy, and the observation group was treated with ureteroscopic U100 laser lithotripsy. The operation time, single lithotripsy success rate, stone clearance rate and incidence of surgical complications were compared between the two groups, and the causes of single lithotripsy failure were analyzed.**Results** The success rate of single lithotripsy and stone clearance rate in the observation group were 90.00% and 86.00%, which were higher than 68.00% and 60.00% in the control group (P<0.05). The operation time of the observation group was (35.84±5.34) min, which was shorter than (55.08±9.78) min of the control group ($P<0.05$). The incidence of complications in the observation group was 12.00%, which was lower than 30.00% in the control group ($P<0.05$). The main reason for the failure of crushed stone in the two groups was that the stones moved up to the kidney during the lithotripsy, and the stones were not found during the operation.**Conclusion** The ureteroscopic U100 laser lithotripsy has the advantages of short operation time, high efficiency, safety and few complications, which is an effective method for the treatment of upper ureteral calculi.

Key words: Ureteroscopy;U100 laser lithotripsy;Pneumatic ballistic lithotripsy;Upper ureteral calculi

输尿管上段结石(upper ureteral calculi)是泌尿外科常见疾病,肾结石排出过程受阻而嵌顿滞留于输尿管上段是其主要病因,临床主要表现为运动后血尿、肾绞痛,伴或不伴恶心、呕吐甚至发热等全身症状,部分患者可并发肾功能损害。输尿管上段结石因其独特的空间位置结构等因素, 现代微创治疗有多种选择方式,主要包括体外冲击波碎石术、经尿道输尿管镜碎石术、微通道经皮肾镜碎石取石术和腹腔镜下输尿管切开取石术等,每种方法均有利有弊[1]。近年来,U100Plus 双频双脉冲激光碎石术因其高效碎石且对人体组织损伤小的优点已广泛应用于临床[2,3]。本研究旨在比较输尿管镜下 U100 激光碎石术与气压弹道碎石术治疗输尿管上段结石的疗效及

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安全性，现报道如下。

1 资料与方法

1.1 一般资料 选取 2013 年 12 月–2018 年 9 月柳州市人民医院收治的输尿管上段结石患者 100 例作为研究对象。纳入标准：①术前经泌尿系 B 超及 KUB+IVP 和/或泌尿系 CT 平扫确诊；②单侧单发且同侧未合并肾结石；③结石最大径<2 cm。排除标准：①严重的凝血功能障碍，如血友病、长期使用抗凝药物等；②严重心肺功能障碍不能耐受麻醉或手术者；③妊娠期或严重畸形无法摆截石位者；④患肾重度积水、ECT 提示肾功能近乎丧失者；⑤尿路狭窄或输尿管畸形导致输尿管镜进镜失败，或输尿管镜到达结石部位但尚未开始碎石结石即冲入肾内而改行其它治疗方式者。采用随机数字表法将研究对象分为观察组和对照组，每组 50 例。观察组中男 31 例，女 19 例；年龄 25~68 岁，平均年龄（43.92±9.82）岁；结石位置：左侧 30 例，右侧 20 例；结石最大径 0.6~1.8 cm，平均结石最大径（1.34±0.26）cm。对照组中男 35 例，女 15 例；年龄 19~75 岁，平均年龄（44.65±10.26）岁；左侧 28 例，右侧 22 例；结石最大径 0.7~1.6 cm，平均结石最大径（1.26±0.31）cm。两组性别、年龄、结石位置、结石最大径比较，差异无统计学意义（P>0.05），可对比。本研究已通过医院伦理委员会审查，研究对象术前均已知情同意并自愿签署知情同意书。

1.2 方法

1.2.1 观察组 予以输尿管镜下 U100 激光碎石术：采用硬膜外麻醉或全身麻醉，截石位，W0LF（F8/9.8）输尿管硬镜在摄像系统直视下经尿道进入膀胱，寻到患侧输尿管开口后插入斑马导丝作引导，输尿管镜通过壁间段后即减小灌注液压力以避免结石上移，缓缓进境达结石部位。经工作通道置入激光光纤（直径 0.42 mm），激光脉冲能量设置 120~150 mJ，频率调整为 3~5 Hz，间断适量冲水保持视野清晰，直视下将光纤顶端抵住结石中央，采用连续脉冲间断发射法，将大块结石击碎成小块，再逐个粉碎至 3 mm 以下的碎石屑。必要时使用套石篮，防止手术过程中结石漂移。当结石表面完全被息肉包裹时，可将光纤直接插入结石处进行“盲打”，待结石被击碎，输尿管腔道开放后再进一步碎石。

1.2.2 对照组 予以输尿管镜下气压弹道碎石术：麻醉、手术体位及操作步骤同观察组一致。窥见结石后置入 0.8~1.2 mm 碎石杆，气压弹道碎石机设置为 1.5~2.5 个大气压，将结石轻轻抵于输尿管内壁，应用空气压缩泵，连续脉冲式击碎结石。

两组患者术后均常规留置 F5 双 J 管 1 根，导尿管留置 1~3 d 拔除。所有患者术后 4 周返院复查泌尿系 CT 平扫，决定拔除双 J 管或者进一步治疗。

1.3 观察指标 比较两组治疗情况[手术时间、单次碎石成功率（术中输尿管镜能到达结石部位并完成碎石即为碎石成功）及结石彻底清除率（手术后 4 周随访并复查 CT 平扫显示无泌尿系结石或结石直径 3 mm 以下作为结石彻底清除的判定标准[4]，术后残留结石直径≥4 mm 认为是有临床意义的残留结石，结石直径≥5 mm 的患者需进一步结合 ESWL 治疗[5]）]、并发症发生情况（指碎石过程输尿管穿孔、撕脱或断裂及术后出现发热、肾绞痛）及单次碎石失败原因。

1.4 统计学方法 以 Excel 建立数据库，利用 SPSS 24.0 统计学软件进行数据分析。计量资料以（$\bar{x}\pm s$）表示，采用 t 检验；计数资料以[n(%)]表示，采用 χ^2 检验。以 P<0.05 表示差异有统计学意义。

2 结果

2.1 两组治疗情况比较 观察组单次碎石成功率及结石清除率高于对照组，而手术时间短于对照组（P<0.05），见表 1。

2.2 两组并发症发生情况比较 观察组并发症发生率低于对照组（P<0.05），见表 2。

表 1 两组治疗情况比较[$\bar{x}\pm s$, n(%)]

组别	n	手术时间（min）	单次碎石成功率	结石彻底清除率
对照组	50	55.08±9.78	34（68.00）	30（60.00）
观察组	50	35.84±5.34	45（90.00）	43（86.00）
统计值		t=12.215	χ^2=4.574	χ^2=7.844
P		0.000	0.032	0.015

表 2 两组并发症发生情况比较[n(%)]

组别	n	输尿管穿孔	发热	肾绞痛	发生率
对照组	50	2(4.00)	7(14.00)	6(12.00)	15(30.00)
观察组	50	1(2.00)	3(6.00)	2(4.00)	6(12.00)*

注:* 与对照组比较,χ^2==4.882,P=0.027

2.3 两组单次碎石失败原因比较 观察组碎石过程中有 7 例患者出现结石上移至肾盂或肾盏，其中 3 例通过改变体位后输尿管镜在肾盂找到结石并通过激光一次碎石成功;另 4 例滑落入肾盏的结石未能找到；碎石过程输尿管穿孔改后腹腔镜切开取石 1 例。对照组碎石过程中有 15 例结石上移,其中 1 例通过改变体位在肾盂找到结石并碎石成功;另 14 例未能找到而导致手术失败;2 例穿孔改腹腔镜切开取石 1 例、开放手术 1 例。两组输尿管穿孔多发生于结石表面被大量息肉包裹者。

3 讨论

输尿管上段结石需外科干预者多以微创治疗为主,及时清除结石并解除输尿管梗阻是其治疗的关键。传统开放手术因出血较多、创伤性大、术后恢复慢、感染发生率高等弊端已逐渐被微创手术所取代[6,7]。而手术精准高效、创伤小、术后恢复快等优点促使输尿管镜激光碎石术成为该疾病的主要治疗方式,也是目前主要的研究方向[8]。然而,在输尿管镜碎石术治疗输尿管上段结石方面,激光碎石与气压弹道碎石何种方式效果更优尚无明确定论。

临床上激光碎石机主要分为钬激光和 U100 激光 2 类,其中 U100 激光碎石机能发出 2 种波长的光，一种为波长 532 nm 的绿光，另一种为波长 1064 nm 的红外光,因此又称为双频双脉冲激光机,而绿光为可见光,约占激光能量的 20%,其被输尿管结石表面吸收后形成等离子体;红外光为不可见光,约占激光能量的 80%,结石表面的等离子体在足够均匀的条件下,即可充分吸收红外光的能量,并在瞬间转化为机械冲击波。由于 U100 激光碎石机的冲击波峰值功率极高,因此可在极短时间内精准高效地崩解结石。同时,它包含的绿光和红外光的波长并不在人体组织吸收的范围内,而且作用于软组织的时间很短，因此 U100 激光不会使软组织产生热效应[9],属于一种“冷激光”,不会损伤泌尿道正常的管壁。有动物实验证明[10],当激光频率调整为 10 Hz,能量设置 120 mJ,持续发射 1500 个激光脉冲作用于动物膀胱黏膜，只造成接触部位的膀胱黏膜轻度充血、水肿,电子显微镜下未见膀胱肌层的损伤及穿孔。由于绿光在镜头表面无法形成等离子体,所以对镜头的损耗也较小[11]。U100 激光的作用原理充分保障了碎石过程的安全性，通过输尿管镜直视下碎石精准度高,不易发生管腔穿孔[12]。本研究中观察组并发症发生率低于对照组(P<0.05),进一步验证了 U100 激光的安全性。但 U100 激光碎石术也存在一定不足，即无法同时处理结石合并的息肉及输尿管狭窄,且对于硬度较高的胱氨酸结石,因绿光无法在结石表面形成等离子体，故 U100 激光对胱氨酸结石碎石效果差[13,14]。

气压弹道碎石自 90 年代初开始应用于临床,其原理是通过压缩空气驱动密闭盒中的弹丸驱动金属杆做机械运动,导致结石被击碎[15]。气压弹道碎石具有操作简单、无石率较高、价格低廉等优点,但手术过程中结石上移至肾脏的风险相对较高[16]。另外,在处理输尿管结石时，频繁的使用气压弹道对固定在局部黏膜上的同一块结石进行碎石，可促使该结石进一步嵌入输尿管黏膜从而影响结石的排出。而 U100 激光碎石机采用双频和双脉冲激光使碎石能量成倍数增加,效率更高,疗效更显著,结石碎片更小[17],加上激光光纤柔软纤细,而且在碎石过程中产生的冲击对结石的推动力很小[18]。本研究结果显示,观察组单次碎石成功率及结石清除率高于对照组,而手术时间短于对照组(P<0.05),与既往研究报道基本一致[19]。碎石失败的主要原因是碎石过程中结石上移至肾脏,术中未能找到结石所致,观察组结石上移发生率低于对照组，也证实 U100 激光碎石术的高效性。此外,观察组中结石上移后仍能成功碎石占比高于对照组。分析认为,碎石过程中,当结石上移入肾盂、肾盏隐约可见时,碎石杆往往无法触及,而激光光纤却可以到达,并根据光纤与结石之间产生的摩擦感和碎石声响来判定是否接触、击碎结石[20]。鉴于本研究纳入样本量少,且受到随访时间短等因素的制约，所得结论还有待大样本研究进

一步验证。

U100 激光碎石虽有许多优势，但操作过程仍需要注意以下几点：①光纤到位率要高，光纤与结石的距离应≤3 mm，碎石效果较好[9]；②虽然波长为 532 nm 的绿光在镜头表面无法形成等离子体，不会对镜头造成直接损害，但瞬间崩裂的碎石片仍可能损伤镜头，故碎石时光纤应伸出足够的距离；③由于纤细的光纤有可能损伤肾盂及输尿管黏膜，在盲目碎石的情况下仍需谨慎；④U100 激光的绿光对眼睛有一定的刺激，可佩戴滤光片眼罩保护眼睛；⑤碎石过程若结石漂移入肾，尤其是肾积水不显著者，可进镜至肾盂，反复适量冲水、放水并配合变换体位，结石有可能再次出现在视野内而被激光光纤成功击碎[21]。

综上所述，输尿管镜下 U100 激光碎石术具有手术时间短、高效、并发症少及结石清除率高等优点，是治疗输尿管上段结石的有效手段。

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·临床研究·

输尿管软镜冷激光碎石术与钬激光碎石术治疗肾结石疗效比较

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【摘要】 **目的**　比较输尿管软镜冷激光碎石术与钬激光碎石术治疗肾结石患者的临床疗效。**方法**　回顾性分析福建省漳州市医院 2015 年 1 月至 2018 年 1 月收治的 192 例肾结石患者的临床资料，按照术式分为观察组（*n*=98，采用输尿管软镜冷激光碎石术）、对照组（*n*=94，采用输尿管软镜激光碎石术），比较两组患者手术相关指标、疗效及并发症等情况。**结果**　观察组手术时间、术中出血量明显少于对照组，差异有统计学意义（*P*<0.05）；观察组术后出血发生率 3%，低于对照组 10%，差异有统计学意义（*P*<0.05）；观察组术后感染发生率 6%，低于对照组 16%，差异有统计学意义（*P*<0.05）；观察组结石清除率 91%，高于对照组 78%，差异有统计学意义（*P*<0.05）；两组患者住院时间、术后输尿管穿孔发生率、肾功能不全发生率比较差异无统计学意义（*P*>0.05）。**结论**　输尿管软镜联合冷激光碎石治疗肾结石的临床疗效安全，与传统方法相比具有合理性和优越性，值得临床推荐。

【关键词】　输尿管软镜；　冷激光；　碎石；　肾结石；　回顾性研究

Comparisons of the curative effect of ureteroscopic cold laser lithotripsy and holmium laser lithotripsy in the treatment of renal calculi

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【**Abstract**】　**Objective**　To compare the clinical efficacy of ureteroscopic cold laser lithotripsy and holmium laser lithotripsy in the treatment of renal calculi. **Methods**　Clinical data of 192 patients with renal calculi from January 2015 to January 2018 in Zhangzhou Hospital of Traditional Chinese Medicine were analyzed retrospectively. According to the surgical method they were divided into observation group (*n*=98, cold laser lithotripsy with flexible ureteroscope) and control group(*n*=94, holmium laser lithotripsy with flexible ureteroscope). The operation related indexes, curative effect and complications were compared between the two groups. **Results**　The operation time, intraoperative bleeding volume, complication rate and stone clearance rate of the observation group were significantly better than those of the control group, the difference was significant(*P*<0.05). **Conclusion**　Ureteroscopy combined with cold laser lithotripsy is safe and effective in the treatment of renal calculi. Compared with traditional methods, it has rationality and superiority and is worthy of clinical recommendation.

【**Key words**】　Flexible ureteroscope;　Cool laser;　Lithotripsy;　Renal calculi;　Retrospective study

肾结石是泌尿系统常见病、多发病之一[1-2]，临床治疗方法包括：体外冲击波碎石术（extracorporeal shock wave lithotripsy，ESWL）、经皮肾镜碎石取石术（pereutaneous nephrolithotomy，PCNL）和输尿管

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软镜碎石取石术（flexible ureteroseope lithotripsy，FURL），不同的治疗方法都具有一定的优势[3]，但也都具有一定的劣势和弊端[4]。ESWL 操作简单、并发症发生率低[5]，但无法避免冲击波对肾脏的损伤[6]；PCNL 创伤较大，出血和脏器损伤的风险也相对较高[7]；随着加速康复外科理念的发展，通过自然腔道治疗肾结石已成为主要趋势[8]，目前主要治疗方法是输尿管软镜联合钬激光碎石治疗，但也存在结石清除率低、并发症发生率高等缺点[9]。本文旨在对比分析不同激光碎石系统对肾结石患者治疗效果。

资料与方法

一、临床资料

本组患者 192 例来自福建省漳州市医院，均由同一组手术医师完成手术，按手术方式不同分为：观察组（98 例，采用输尿管软镜冷激光碎石术治疗）、对照组（94 例，采用输尿管软镜钬激光碎石术治疗）。两组患者性别、年龄、结石部位等一般资料对比差异均无统计学意义（表 1）。

表 1　输尿管软镜冷激光（观察组）和钬激光（对照组）治疗的肾结石患者一般资料对比

组别	例数	性别（例）		年龄	结石部位（例）			
		男	女	（岁，$\bar{x}\pm s$）	肾盂	上盏	中盏	下盏
观察组	98	76	22	37 ± 12	26	32	22	18
对照组	94	75	19	40 ± 11	25	30	21	18
统计值		χ^2=0.143		t=2.34		χ^2=0.019		
P值		>0.05		>0.05		>0.05		

纳入标准：（1）经超声或 X 线检查诊断明确；（2）单个结石最大径≤ 2.0 cm；（3）同意进行激光碎石治疗；（4）术前无感染；排除标准：（1）合并有心、肺、肝、肾等重要脏器疾病或功能不全无法耐受手术；（2）患有出血性疾病或原因不明的凝血功能异常；（3）泌尿系统严重感染尚未控制；（4）尿道或输尿管狭窄或畸形；（5）双侧肾结石或单个结石最大径 >2.0 cm。

二、方法

1. 手术方法

（1）气管插管全身麻醉后取截石位，消毒铺巾；（2）应用 6.5 F 或 8 F 输尿管硬镜探查尿道、输尿管是否有狭窄；（3）斑马导丝引导下置入 12/14 F 输尿管软镜鞘；（4）退出鞘内心，置入输尿管软镜，探查肾脏及各盏情况，明确结石大小及部位；（5）观察组：采用双频双脉冲激光碎石机，置入 200 μm 冷激光光纤碎石，参数设置为功率 120 mJ、频率 10 Hz；对照组：采用钬激光碎石机，置入 200 μm 钬激光光纤碎石，参数设置为功率 120 mJ、频率 10 Hz；（6）应用激光将结石击碎至≤ 0.4 cm，稍大结石可予取石网篮取出；（7）仔细观察无残余结石（最大径 >0.4 cm）且无出血后退出激光光纤及输尿管软镜，常规留置双 J 管、输尿管。

2. 观察指标

记录两组手术时间、术中出血量、住院时间、结石清除率及并发症发生率。其中结石清除判断标准为：术后 4 周复查 KUB 或超声，结石≤ 0.4 cm。并发症包括术后出血、感染、输尿管穿孔、急性肾功能不全。

3. 统计学处理

采用 SPSS 22.0 软件进行统计分析，其中手术时间、术中出血量、住院时间等计量资料符合正态分布，采用 t 检验，结石清除率及并发症发生率等采用 χ^2 检验，P<0.05 为差异有统计学意义。

结　果

两组患者手术时间、术中出血量指标差异有统计学意义，住院时间差异无统计学意义（表 2）。

表 2　两组患者手术时间、术中出血量、住院时间比较（$\bar{x}\pm s$）

组别	例数	手术时间(min)	术中出血量(ml)	住院天数(d)
观察组	98	83 ± 13	47 ± 13	3.4 ± 0.5
对照组	94	116 ± 17	83 ± 11	3.5 ± 0.5
t值		15.46	20.89	0.98
P值		<0.05	<0.05	>0.05

两组患者术后出血、术后感染、结石清除率差异有统计学意义，输尿管穿孔及急性肾功能不全的发生率差异无统计学意义（表 3）。

表 3　两组患者术后并发症和结石清除率比较（例）

组别	例数	术后出血	感染	输尿管穿孔	急性肾功能不全	结石清除率
观察组	98	3	6	1	2	89(91%)
对照组	94	10	15	3	1	73(78%)
χ^2值		4.364	4.76	1.11	1.34	6.30
P值		<0.05	<0.05	>0.05	>0.05	<0.05

讨　论

近年来我国肾结石发病率呈上升趋势[10]，随着微创手术器械的不断改进和发展，如何更精细化地处理肾结石已成为研究热点。开放性手术治疗肾结石也因术中出血量大、术后并发症多、恢复时

间长等弊端而不作为首选[11]，而微创手术具有安全、恢复快、可重复等特点[12]，特别是通过自然腔道碎石术已成为主要治疗方法。目前各大指南均推荐输尿管软镜激光碎石治疗 <2.0 cm 的肾结石[13]，其中 PCNL 主要治疗最大径 >2.0 cm 肾结石[14]，虽然 PCNL 结石清除率较高，但也有手术创伤大、出血量多、术后并发症发生率高等缺点[15]；FURL 主要治疗最大径≤ 2.0 cm 肾结石[16]，虽然 FURL 操作简便、具有可重复性、术中出血量少、并发症发生率低[17-18]，但是结石清除率较低[19]。

因此，如何更高效更安全治疗肾结石是泌尿外科学者始终重视的问题。根据报道冷激光联合内镜治疗结石具有更高的碎石率和安全性[20]。对比钬激光碎石冷激光主要优势是：（1）在工作原理上，冷激光碎石分为红外光和绿光，红外光波长为 1 064 nm、绿光波长为 532 nm，均由双频双脉冲激光器激发，结石吸收占总能量 20% 的绿光后在表面形成等离子体，占总能量 80% 的红外光作用于等离子体使能量转化为机械能作用于结石，瞬间将结石击碎，而正常人体组织不能吸收绿光能量，不能产生等离子体，故红外光不会对人体组织产生伤害[21-22]；而钬激光碎石时产生的能量易被正常组织吸收和传导，可引起输尿管穿孔或出血。（2）在碎石方式上，冷激光产生的机械能作用于结石中心，结石产生“炸裂”效果，易将较大结石“炸裂”成细小结石自然排除；钬激光在结石表面产生“割裂”效果，需要多次反复操作，手术时间较长，结石清除率也较低。

术后出血和感染是输尿管镜手术常见并发症[23]，研究认为可能与术前感染、手术时间、术中高压损伤相关[24]。本组研究认为，术后出血和感染发生率与手术时间长短有关，较长的手术时间导致肾窦内持续高压，长时间的窦内高压不仅易损伤黏膜，引起出血还易使内毒素通过黏膜出血口向血液扩散引起感染。研究结果表明观察组手术时间较短，碎石效率更高，同时术后出血和感染的比例低于对照组。较短的手术时间还能明显降低医疗成本，节约医疗资源。输尿管镜属易耗品，有单价高、维修周期长、维修成本高等特点。使用冷激光碎石能缩短手术时间，使单根输尿管镜在有效使用期限内能服务更多患者。

碎石成功与否与多种因素相关，如：肾脏解剖、结石部位、结石质地、术者水平、碎石设备等。本研究中观察组和对照组结石清除率分别为 91% 和 78%，与文献报道相当[21,25]。在诸多因素中设备因素是较容易控制的因素，在其余因素差异无统计学意义的情况下，冷激光相较钬激光具有更高结石清除率。失败的病例中多数患者结石位于肾下盏，存在解剖夹角不易碎石且结石顽固不易套取，如何更高效治疗肾下盏结石也是今后研究热点。

根据冷激光的工作原理和特点，笔者的经验是：（1）碎石时应仔细寻找结石，判断部位和数量，“先大后小”然后“化整为零”，激光直接在结石中央激发，更易形成细小结石，自然排除；（2）碎石过程中易行成许多细小结石，小结石残渣易影响手术视野，不可盲目进镜，需稍退镜加大水压待视野清晰；（3）结石位置易改变，宜采用“边碎边取”的办法，对于肉眼 >0.4 cm 的结石用取石网篮取出，以免遗漏；（4）对于肾下盏结石，由于解剖关系，不易直接处理，可通过改变体位和垫高患肾等方法显露结石，用网篮将结石套取至上盏处进行碎石。

综上，冷激光联合输尿管镜治疗肾结石操作方便、节约时间、安全可靠，是治疗肾结石的一种新选择。

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