Laser Lithotripsy for Giant Common Bile Duct Stones During ERCP: Efficacy Observation and Nursing Care (Postprint)

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Abstract

Objective To compare the efficacy of dual-frequency dual-pulse laser lithotripsy versus conventional endoscopic mechanical lithotripsy in the treatment of common bile duct stones under endoscopic retrograde cholangiopancreatography (ERCP), and to summarize nursing experience.

Methods Clinical data of 200 patients with common bile duct stones who underwent ERCP with lithotripsy at the Digestive Endoscopy Center of Dongfang Hospital, Beijing University of Chinese Medicine between May 2018 and May 2022 were retrospectively analyzed. Among them, 69 patients received dual-frequency dual-pulse laser lithotripsy (laser group), while 131 patients received mechanical lithotripsy (mechanical group). The stone clearance success rate, operation time, postoperative hospital stay, complications, and other parameters were compared between the two groups.

Results No statistically significant differences were observed in baseline characteristics, including general conditions and preoperative clinical data, between the two groups ($P > 0.05$). No perioperative mortality occurred in either group. There were no statistically significant differences in the rates of postoperative bleeding, pancreatitis, and perforation between the two groups ($P > 0.05$). Compared with the mechanical group, the laser group exhibited longer operation time ($P < 0.05$), shorter postoperative hospital stay ($P < 0.05$), and lower overall complication rate and stone residual rate ($P < 0.05$).

Conclusion Dual-frequency dual-pulse laser lithotripsy under ERCP for common bile duct stones demonstrates superior efficacy and lower complication rates compared with conventional mechanical lithotripsy, although there remains room for improvement in operation time.

Full Text

Effect of Laser Lithotripsy for Giant Common Bile Duct Stones Under Endoscopic Retrograde Cholangiopancreatography and Perioperative Nursing Management

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Abstract

Objective: To compare the efficacy of dual-frequency dual-pulse laser lithotripsy under endoscopic retrograde cholangiopancreatography (ERCP) with traditional endoscopic mechanical lithotripsy in treating patients with common bile duct stones, and to summarize perioperative nursing measures.

Methods: A retrospective analysis was conducted on the clinical data of patients with common bile duct stones who underwent ERCP with lithotripsy at the Digestive Endoscopy Center of Dongfang Hospital, Beijing University of Chinese Medicine, from May [year] to [year]. Among them, [number] patients received dual-frequency dual-pulse laser lithotripsy (Laser group) and [number] patients received mechanical lithotripsy (Mechanical group). The stone extraction success rate, operation time, postoperative hospital stay, and complications were compared between the two groups.

Results: There was no significant difference in baseline data such as general conditions and preoperative clinical parameters between the two groups ($P > 0.05$). No perioperative deaths occurred in either group. No significant differences were found in postoperative bleeding, pancreatitis, or perforation rates between the groups ($P > 0.05$). However, the Laser group had significantly longer operation time ($P < 0.05$) but shorter postoperative hospital stay ($P < 0.05$) compared with the Mechanical group. The total complication rate and stone residual rate were also significantly lower in the Laser group ($P < 0.05$).

Conclusion: Dual-frequency dual-pulse laser lithotripsy under ERCP demonstrates superior efficacy and lower complication rates compared with traditional mechanical lithotripsy for common bile duct stones, though there remains room for improvement in operation time.

Keywords: endoscopic retrograde cholangiopancreatography; common bile duct stones; laser lithotripsy; perioperative nursing

Introduction

Common bile duct stones represent a prevalent disease of the digestive system, characterized primarily by jaundice, chills, high fever, and upper abdominal colic. In severe cases, patients may develop multiple organ dysfunction, septic shock, respiratory failure, and even face mortality risk. Once diagnosed, most patients require surgical intervention. With the advancement of endoscopic techniques, ERCP has become the preferred treatment modality for common bile duct stones. Stone diameter exceeding 10 mm constitutes a major factor for "difficult" stones, as the success rate of stone extraction decreases significantly when stones are larger than 10 mm, necessitating various lithotripsy techniques to facilitate removal. Some patients present with extremely large common bile duct stones that require fragmentation before safe extraction. While traditional mechanical lithotripsy can generally achieve therapeutic effects, certain cases involve stones that are too hard for mechanical fragmentation, potentially leading to basket wire fracture or impaction, which poses substantial treatment risks. Consequently, endoscopic laser lithotripsy offers a relatively safer alternative, particularly for crushing large, hard, or impacted extrahepatic bile duct stones, and can also be applied to clear some intrahepatic bile duct stones after failed mechanical lithotripsy.

Materials and Methods

This retrospective analysis examined clinical data from patients with common bile duct stones who underwent ERCP with lithotripsy at the Digestive Endoscopy Center of Dongfang Hospital, Beijing University of Chinese Medicine. Among [total number] patients, [number] received dual-frequency dual-pulse laser lithotripsy (Laser group) and [number] received mechanical lithotripsy (Mechanical group). The Laser group comprised [number] males and [number] females with mean age [x] years, common bile duct diameter [x] cm, and mean stone number [x]. The Mechanical group consisted of [number] males and [number] females with mean age [x] years, common bile duct diameter [x] cm, and mean stone number [x]. No statistically significant differences were found in general conditions or preoperative clinical data between the two groups ($P > 0.05$).

Equipment Preparation: The following instruments should be prepared before ERCP: duodenoscope, guidewire, contrast catheter, papillotome, stone retrieval basket, lithotripter, balloon, dilating bougie, dilating balloon, drainage tube, stent, endoscopy-dedicated high-frequency electrosurgical unit, injection needle, and hemostatic clips. All instruments must meet sterilization requirements, disposable items should be handled according to regulations, and backup supplies should be available for commonly damaged instruments. The main

equipment included the ED-[model] duodenoscope, ERBE S high-frequency electrosurgical unit, U100 dual-frequency dual-pulse laser lithotripter, SpyGlass™ DS, Trapezoid™ RX integrated retrieval/lithotripsy basket, MSB-[model] stone retrieval basket, bow-shaped papillotome, balloon dilatation catheter, COOK Acrobat™ guidewire, COOK Liguory nasobiliary drain, and various plastic stents.

ERCP Procedure: Patients fasted preoperatively. Under lidocaine mucilage anesthesia of the pharynx, ERCP with endoscopic sphincterotomy (EST) was performed. After cannulation, cholangiography, and sphincterotomy, balloon dilation was conducted. For patients with large common bile duct stones identified on preoperative imaging (stones exceeding the common bile duct diameter or >1 cm in diameter), laser lithotripsy was performed before extraction. The procedure involved advancing the endoscope to the duodenal papilla, successfully cannulating the papilla with a bow-shaped knife, performing cholangiography to delineate the lesion, and placing a guidewire. The SpyGlass system delivery catheter with optical fiber camera was inserted through the working channel of the duodenoscope and slowly advanced to the location of the large bile duct stone for direct visualization. After removing the guidewire, the laser fiber was introduced through the SpyGlass therapeutic channel. Under direct vision, the fiber tip was aimed at the stone surface, and U-100 Plus dual-frequency laser was activated for lithotripsy. The process required repeated water irrigation and suction to maintain a clear visual field. When the field was clear, water irrigation was stopped, the suction three-way valve was opened, and physicians were reminded to effectively aspirate fluid from the bile and pancreatic ducts. For patients with prolonged procedures, nasobiliary drainage tubes or biliopancreatic stents were placed to ensure adequate drainage and reduce postoperative cholangitis risk. The crushed paste-like stones could be expelled, and stone fragments were retrieved under direct vision using stone baskets; excessive fragments could be cleared by reinserting the duodenoscope. After lithotripsy with either method, stone retrieval baskets and balloons were used to remove stones from the common bile duct.

Perioperative Nursing Care: Nurses educated patients about the main causes, diagnosis, and treatment options for biliary stones, explained the laser lithotripsy procedure and precautions, provided psychological counseling to alleviate negative emotions, and helped establish confidence in overcoming the disease. Preoperative medications included routine injections of pethidine hydrochloride, diazepam, and scopolamine butylbromide (contraindicated in patients with contraindications). Vital signs were carefully monitored during the procedure; patients with rapid breathing or hypotension received appropriate blood transfusion and fluid replacement. Patients were assisted in maintaining comfortable positions while receiving oxygen therapy with simultaneous monitoring of oxygen saturation and cardiac rhythm. After stone extraction, nasobiliary drainage tubes were placed, and cholangiography was repeated to confirm complete stone clearance. If stones could not be completely removed in one session or extraction failed, plastic biliary stents were placed for repeat ERCP

after 3 months. Postoperative care included fasting, anti-infection treatment, and serum amylase measurement on day 1. If results were normal, patients resumed eating on day 2; if abnormal, monitoring continued until normalization before feeding.

Data Collection and Statistical Analysis: Postoperative stone extraction status, operation time, postoperative hospital stay, and complications (including postoperative bleeding, pancreatitis, perforation, and stone residual) were recorded. Statistical analysis was performed using SPSS software. Normally distributed continuous data were expressed as mean ± standard deviation (x ± s) and compared using independent samples t-test. Categorical data were expressed as percentages (%) and compared using ^{2} test. The significance level was set at $\alpha = 0.05$.

Results

Stone Extraction Success Rate, Operation Time, and Postoperative Hospital Stay: The Laser group achieved successful stone extraction in [number] cases (success rate %), while the Mechanical group succeeded in [number] cases (success rate %), with a statistically significant difference between groups (t = [value], $P < 0.05$). The Laser group had significantly longer operation time ($P < 0.05$) but shorter postoperative hospital stay compared with the Mechanical group ($P < 0.05$) .

Postoperative Complications: No perioperative deaths occurred in either group. The Laser group demonstrated significantly lower total complication rate and stone residual rate compared with the Mechanical group ($P < 0.05$). No statistically significant differences were observed between groups in postoperative bleeding, pancreatitis, perforation, or stone residual rates ($P > 0.05$) . Patients with postoperative pancreatitis in both groups recovered after conservative treatment. Patients with bile duct perforation improved after surgical intervention. All [number] patients with residual stones underwent placement of common bile duct plastic stents and subsequent secondary surgery for stone removal.

Discussion

Surgery remains the primary treatment for common bile duct stones. However, during acute episodes, it is difficult to clearly delineate the biliary system, stone number, and location, increasing the likelihood of secondary surgery. Therefore, elective surgery is typically performed after inflammation is controlled. ERCP with mechanical (or laser) lithotripsy is commonly used clinically. Compared with laparoscopic or open surgery, these approaches cause less damage and can fragment large stones into smaller pieces that are easier to remove.

With the development of minimally invasive techniques, endoscopic stone extraction technology has advanced rapidly, offering advantages including repeatable procedures, minimal trauma, and rapid postoperative recovery, making it the preferred surgical approach for common bile duct stones.

Endoscopic sphincterotomy destroys the normal anatomical structure and function of the papillary sphincter, causing duodenal fluid reflux into the bile duct, which represents the main predisposing factor for postoperative cholangitis, pancreatitis, and stone recurrence. When large common bile duct stones cannot pass through the incised papilla, lithotripsy techniques are required. However, mechanical lithotripsy is relatively complex, time-consuming, labor-intensive, and may be ineffective. The main reasons include: (1) the common bile duct stone is too large while the bile duct lumen is too small for the lithotripsy basket to open and engage the stone; and (2) distal common bile duct stricture prevents clearance of large fragmented stones. Therefore, when mechanical lithotripsy fails to extract common bile duct stones, alternative methods such as extracorporeal shock wave lithotripsy, laser shock wave lithotripsy, or biliary stent placement must be considered.

In recent years, endoscopic treatment of common bile duct stones has been widely applied clinically in China. The German U100 Plus dual-frequency dual-pulse laser lithotripter can target the middle portion of stones as a breakthrough point, achieving better surgical field visualization and safer operation. The U100 Plus is a newly developed economical, short-pulse, dual-frequency solid-state laser. The 532 nm wavelength (green spectrum) laser induces plasma formation on the stone surface, while infrared laser energy enhances this plasma to create rapidly collapsing bubbles that generate intense shock waves to fragment stones. This mature technology has been successfully applied in ERCP and other endoscopic procedures for managing difficult common bile duct stones. Dual-frequency dual-pulse laser lithotripsy under ERCP represents a safe and effective method for treating refractory bile duct stones. Low-energy dual-frequency dual-pulse laser lithotripsy reduces the risk of bile duct mucosal and surrounding tissue injury, proving safe, convenient, and effective for patients with difficult-to-clear refractory bile duct stones.

This study demonstrated significantly superior treatment outcomes with dual-frequency dual-pulse U100 Plus laser lithotripsy compared with mechanical lithotripsy. In the Mechanical group, postoperative bleeding occurred, possibly related to papillary sphincter tears from pulling incompletely fragmented stones through the incised papilla. The incidence of postoperative pancreatitis was also higher than in the Laser group, likely associated with repeated basket insertion into the bile duct or accidental cannulation of the pancreatic duct. Additionally, the long, rigid tip of the lithotripsy basket could cause intrahepatic or common bile duct perforation if excessive force was used during opening within the bile duct, and repeated lithotripsy maneuvers could damage the bile duct mucosa, leading to postoperative infection and bleeding. In this study, some patients had extremely hard stones that could not be fragmented by the lithotripsy basket,

resulting in wire fracture and failed extraction, requiring secondary or multiple stone retrieval procedures via biliary stent implantation. These problems did not occur in the Laser group, as even the hardest stones were more easily fragmented by laser. The SpyGlass system delivery catheter enabled direct stone visualization, allowing precise fiber tip positioning for optimal lithotripsy effect, followed by complete stone clearance using retrieval baskets or balloons.

In summary, dual-frequency dual-pulse laser lithotripsy under ERCP offers safer, more economical, and more efficient advantages over traditional mechanical lithotripsy for treating common bile duct stones. Proficiency in this technique through physician and assistant nurse cooperation is fundamental to ensuring surgical success. Proper preparation of the U100 Plus laser lithotripter can further reduce operation time.

Conflict of Interest Statement: The authors declare no conflict of interest.

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Note: Figure translations are in progress. See original paper for figures.