Pulse Dye Laser Lithotripsy for Large Biliary Tract Stones

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Abstract

From 1997 to 1998 the first series of 21 patients with large biliary tract stones (1.5-4.0 cm with average 2.5 cm in diameter) who underwent endoscopic stone extraction by using combination of ERCP and EST with automatic stone-tissue detection pulse dye laser was carried out. Male = 8, Female = 13, average age = 57.5 years (32-83) most of the stones were primary stones (71.4%). Laser fibers were controlled by balloon catheter with fluoroscope (blind technique) in 16 cases and by mother-babyscope system in 5 cases. The result in successful fragmentation of stones was 87.5 per cent with the blind technique and 100 per cent with the mother-babyscope technique. Temporary stents were used in the patients who had severe cholangitis and those who required more than one session of lithotripsy (19%). Complications consisted of controllable cholangitis in 2 cases (9.5%) and there was no mortality. We conclude that stone-tissue detection lithotripsy is very safe and effective in patients with large biliary tract stones and high surgical risk especially *via* the direct mother-babyscope system.

Key word : Laser Lithotripsy, Biliary Tract Stones

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Endoscopic surgery has already reached a high technical standard of treatment for biliary tract diseases. Approximately 90 per cent of all common bile duct (CBD) stones can be removed by endoscopic sphincterotomy (EST) and extractions[1]. EST has become an established method of tracting bile duct stones in patients with previous cholecystectomy and in elderly or high risk patients with the gall bladder *in situ*[2]. About 5-10 per cent of bile duct stones are not amenable to conventional endo-

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scopic extraction because the stones are too large (more than 1.5 cm in diameter), impacted, or located above biliary strictures[3].

For this selected group of patients, intraductal litholysis, extracorporeal and various intracorporeal lithotripsy procedures under fluoroscopic or endoscopic guidance were proposed to overcome these limitations[4-10]. In our hospital, we found that common bile duct stones greater than 1.5 cm are difficult to remove by usual techniques.

Nowadays, pulsed dye laser lithotripsy is one of the most promising methods for achievement of a safe and rapid bile duct clearance[10-12]. Various efforts have been made to develop laser systems offering effective gall stone fragmentation and a low risk of injury to the surrounding CBD wall. In pulse dye laser systems, there are still significant risks of duct perforation as shown in cumarin pulse dye laser and Nd:YAG laser in animal experiments[13-15].

We report our initial clinical experience in 21 patients with difficult common bile duct stones which could not be treated successfully by other conventional methods. All patients were treated by a pulsed rhodamine-6G dye laser with an integrated automatic stone-tissue detection system (STDS) using ERCP under radiologic and mother-babyscope control.

PATIENTS AND METHOD

From January 1997 to December 1998, a total of 21 patients (13 females and 8 males) were treated by endoscopic laser lithotripsy via the retrograde route. The technique used was laser fragmentation under plain fluoroscopic control in 16 patients and mother-babyscope control in 5 patients. The mean age of the patients was 57.5 yrs. (range, 32 to 83 years). The nature of stones were mostly primary stones (15 cases=71.4%) Ten of the 21 patients (50%) had previously undergone cholecystectomy, 13 of 21 patients (62%) were refered from other hospitals. In one case, laser fragmentation was performed *via* the opening of choledochoduodenostomy from previous surgery. Antibiotic therapy had been started by the referring hospitals or on admission in cases of acute cholangitis. In patients with mild cholangitis or dramatic response to antibiotic therapy (6 cases), ERCP with laser lithotripsy was performed in the first endoscopic treatment. If severe acute cholangitis was present, temporary endoscopic biliary drainage by plastic stents (4 cases) was placed in the common bile duct. When septic processes subsided, usually after one week, the second endoscopic laser lithotripsy was then performed.

ERCP was performed under sequential intravenous sedation and spasmolytic agents, i.e. 2.5-5.0 mg of midazolam and 2-6 ml of butylscopolamine. If necessary, 0.9 g of lysine acetylsalicylate was given additionally for analgesia. Standard sphincterotomy was done in every case. The estimation of stone size was determined during ERCP (on fluoroscopy) and after each treatment session by analysis of all X-ray films.

Sixteen patients had ERCP performed by a standard duodenoscope under radiologic control only ("blind" fragmentation technique). The laser fiber was already positioned into the delivery tripple lumen balloon catheter (#5047 Microvasive, Boston-Scientific Corporation) before passing up in the common bile duct, with the tip of the laser fiber 3-5 mm protuding out from the catheter tip for fragmentation. The position of the fiber related to the catheter was marked at the outer end of the catheter for proper length to prevent its slipping during treatment. When we inserted the prepared catheter through the scope, before cannulation into the common bile duct, the laser fiber was again checked for appropiate position (3-5 mm out of the catheter tip). The position of catheter/laser fiber system should be adjusted until the tip of the fiber is in close contact with the stone as easily seen under fluoroscopy when we inflated the balloon with 2-3 ml of air. A solution of 1:1 to 2:1 saline/contrast medium was rinsed *via* the catheter intermittently during laser treatment. Because we used the balloon blockage technique, the saline/contrast medium solution usually remained in the common bile duct for a longer period of time, without requiring continuous dripping of the solution. The number of administered energy pulses was limited by the degree of stone fragmentation fluoroscopicallly, by the patient's pain tolerance and finally by the amount of time needed. If the treatment session took a long time (more than 90 minutes) or when the patients could not tolerate the procedure, the procedure was terminated and a second session was scheduled about one week later. The fragmented stones were removed by standard instruments, i.e. basket and balloon. Five patients underwent the same laser system but litholysis was controlled by direct vision using the mother-babyscope system

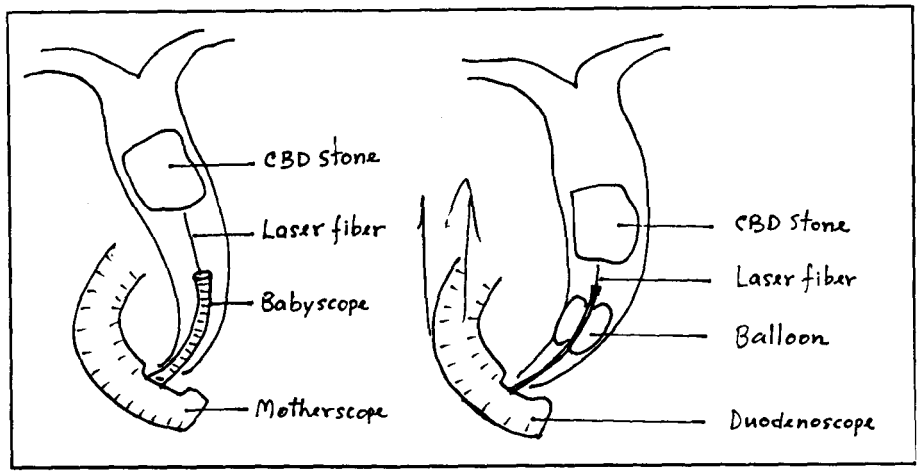

Fig. 1. The direct vision mother-babyscope system compared with balloon and fluoroscopy (blind technique).

(Olympus) and laser fiber was inserted *via* the babyscope. This technique was more effective and safer but required two endoscopists, high experience and many assistants. (Fig. 1)

Laser and STDS (electronic system for automatic stone/tissue discrimination)(1)

A flash-lamp pulsed dye laser (Lithognost, Telemit Corp; Munich, Germany) with a rhodamine-6G dye was used. An emission wavelength of 595 nm in the orange red region of the optical spectrum was applied with a pulse duration 2.5 μs. The pulse energy could be tuned from 40 to 120 mJ in steps of 5 mJ. Before laser lithotripsy, the pulse energy was measured at the distal fiber end by an internal power meter and the selected pulse energy automatically adjusted by the laser system. The pulses energies between 80-120 mJ (at the distal fiber end) were used. As a standard procedure, treatment proceeded with a pulse energy of 80 mJ per pulse. The energy setting was increased in two steps up to a maximum of 120 mJ, depending on the achieved fragmentation effect. The pulse frequency varied between 1 and 10 Hz in steps of 1 Hz. Usually, lithotripsy was performed at a repetition rate of 5-8 Hz. A quartz step index fiber with a core diameter of 250 μm (outer diameter 0.5 mm) was applied in all cases. (Fig. 2)

The STDS system can differentiate the stone from other tissues. Laser pulse will cut off at maximum 5-8 per cent of energy set when the target is not stone. The safety and effectiveness were confirmed by previous studies(16,17).

RESULTS

The laser energies were released by using 80-120 mJ and 5-8 Hz frequency as described above. Laser lithotripsy and bile duct clearance was achieved in 14 of 16 patients (87.5%) with the blind technique and 100 per cent with the mother-babyscope technique. In the first failure case, the size of the stone was 4.0 cm and the patient had been treated by laparoscopic cholecystectomy with duct exploration and stone removal. In the second failure case, the stone size was 3.9 cm and the patient had had 3 previous sessions of endoscopic mechanical lithotripsy. The laser treatment was applied in the 4th session but failed to fragment the stone. Furthermore, in the 5th session, a mechanical lithotripter wire was broken during treatment resulting in impaction of stone and the basket. Finally, this patient was treated by open surgery with uneventful results.

The mean size of stones was 2.5 cm, ranging from 1.5 to 4.0 cm. The lowest number of pulses that could fragment the stone was only 8 when the stone was impacted at the ampulla and it was easy to perform the treatment. The highest number of pulses applied was 11224 in a patient who had two common bile duct stones, each was 2

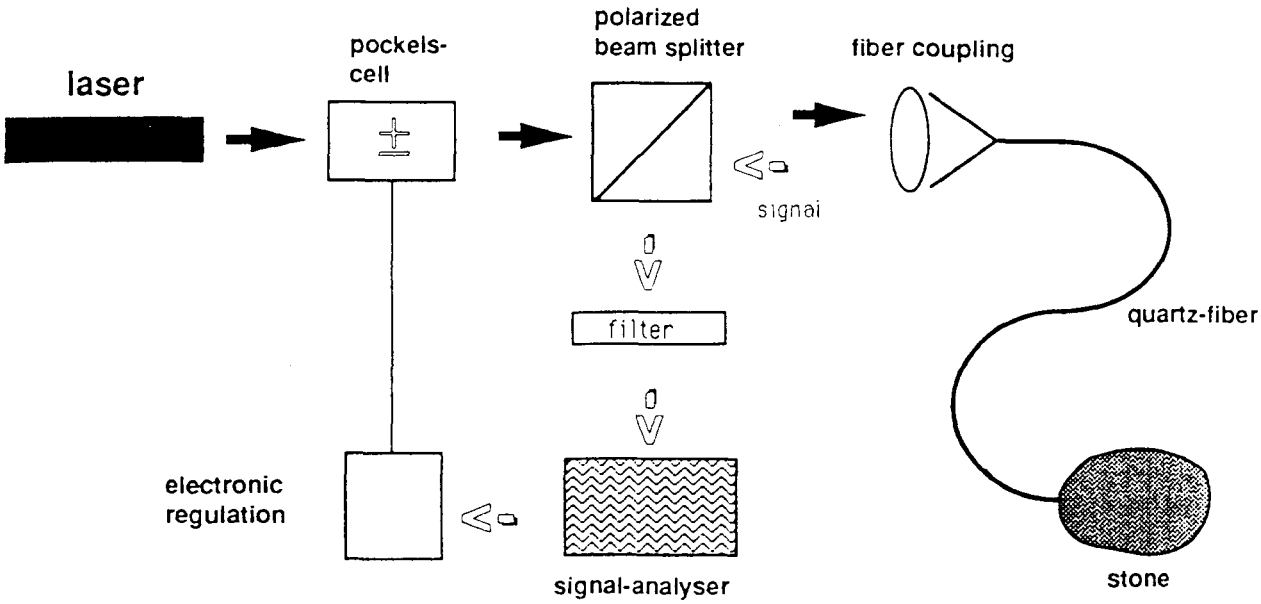

Fig. 2. Schematic illustration of the application principle of the STDS integrated in a rhodamine-6G dye laser[1].

cm in size. No serious complication was observed. There were 2 patients who needed definite treatment of cholangitis post lithotripsy and they all subsided. The 30-day mortality rate was 0 per cent. (Table 1)

Table 1. Results of laser lithotripsy comparing the two techniques.

Technique	Patients	Success	Complication
Balloon and fluoroscopy	16	14 (87.5%)	2 (9.5%)
Mother-babyscope	5	5 (100%)	0

DISCUSSION

The first report of laser lithotripsy by endoscopic retrograde technique for treatment of CBD stones by Nd:YAG laser was in 1986. In this report they found that Nd: YAG laser was better for pigmented stone than cholesterol stone[18]. Another report using flashlamp-pumped tunable dye laser also confirmed that cholesterol stones had distinctly higher thresholds than pigmented stones. The reason was because dark-colored pigmented stones are better absorbers of visible light than light-colored cholesterol stones[19]. In our study, a complete bile duct clearance was achieved in 14 of 16 cases (87.5%) with the blind technique and 100 per cent with the mother-babyscope technique. We found that the tripple lumen balloon catheter as descisbed above in our series may solve some technical problems. With the aid of the inflated balloon, we could clearly see the tip of the catheter by fluoroscopy so that it was possible to adjust the fiber in close contact to the stone. Other advantages are : the balloon helps the tip of the laser fiber to stabilize in the centre of the duct lumen and needs only intermittent saline contrast solution rinse instead of continuous drip as in a previous study[1]. During

lithotripsy, if the catheter/fiber system is pushed too much it will kink or bend and result in tangential contact instead of perpendicular, thereby limiting the efficacy of the laser power.

Infact, STDS laser lithotripsy under fluoroscopic control is safe and effective although the number of misapplied laser pulses may be higher than direct vision *via* a "baby" endoscope system[1,3,11,12]. The main problem during laser fragmentation is the exact position of the laser fiber tip due to being non-radiopaque. The solutions may be in two ways : coating the laser fiber with the radiopaque material or using a direct visual control under the "mother/baby" endoscopic system. However, gold coating of the fiber, as one possibility of achieving radiodensity, makes the fiber fragile in most cases and is unsatisfactory at the moment[1].

Other techniques used in fragmentation of the CBD-stone are extracorporeal shockwave lithotripsy and intracorporeal electrohydraulic lithotripsy. In extracorporeal lithotripsy, which has been shown to be efficacious and safe, the major drawback is the need for a three stage approach (nasobiliary drain insertion, lithotripsy, and fragment extraction) which makes this method time consuming[12]. Intracorporeal electrohydraulic lithotripsy, whose main advantage is the lower cost of the instrument, has also proved to be efficacious in expert hands[20-23]. However, this technique is also time consuming and invasive because it should be used under direct endoscopic visualization to avoid injury to the ductal wall. In a canine model, only one electrohydraulic shock applied to the common bile duct wall may produce bleeding and even perforation[24].

In conclusion, endoscopic laser lithotripsy by using an automatic stone recognition system for difficult bile duct stone that fails by conventional method is safe and effective, especially in elderly or cholecystectomized patients. However, further information of a larger series is necessary to assess the true benefit of this new method despite the early promising results.

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การสลายนิ่วขนาดใหญ่ในท่อน้ำดี ด้วยแสงเลเซอร์ชนิดยิงเป้าอัตโนมัติ การศึกษาทางคลินิกรายงานแรกในประเทศไทย

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รายงานนี้เป็นรายงานแรกของประเทศไทยที่มีการนำเอาเลเซอร์ยิงเป้าอัตโนมัติสลายนิ่วในท่อน้ำดี ตั้งแต่ปี 2540-2541 ได้ทำการรักษาผู้ป่วยที่มีนิ่วขนาดใหญ่ในท่อน้ำดี (ขนาดเส้นผ่าศูนย์กลาง 1.5-4.0 ซม., เฉลี่ย 2.5 ซม.) โดยใช้วิธี ERCP และเปิดปากท่อน้ำดี (EST) และใช้เลเซอร์ยิงเป้าอัตโนมัติทำการสลายนิ่ว โดยไม่ต้องผ่าตัดเปิดช่องท้อง เป็นชาย 8 ราย และหญิง 13 ราย อายุเฉลี่ย 57.5 ปี (32-83) นิ่วส่วนใหญ่เป็นชนิดนิ่วปฐมภูมิของท่อน้ำดี (71.4%) สายนำแสงเลเซอร์ที่ใช้สลายนิ่วถูกควบคุมโดยวิธีสอดในสายบอลลูนและดูจากภาพรังสี ใช้กับผู้ป่วย 16 ราย และดูในท่อน้ำดีโดยตรงจากการใช้กล้องแม่ลูก 5 ราย ผลการสลายนิ่วได้สำเร็จโดยวิธีดูจากภาพรังสี คิดเป็น 87.5% และจากดูนิ่วโดยตรงจากกล้องแม่ลูก คิดเป็น 100% ในรายที่มีการอักเสบของท่อน้ำดีรุนแรงหรือผู้ป่วยที่ต้องสลายนิ่วหลายครั้งจะใช้ท่อระบายน้ำดีใส่ไว้ชั่วคราวเป็นจำนวน 4 ราย (19%) โรคแทรกซ้อนที่เกิดขึ้นจากหัตถการนี้มีการอักเสบของท่อน้ำดีไม่รุนแรง 2 ราย (9.5%) ไม่มีอัตราตายสรุปว่า การใช้เลเซอร์ระบบยิงเป้าอัตโนมัติ ทำการสลายนิ่วขนาดใหญ่ในท่อน้ำหรือในรายที่มีอัตราเสี่ยงต่อการผ่าตัดใหญ่สูง นับว่าปลอดภัยและมีประสิทธิภาพสูงมาก โดยเฉพาะอย่างยิ่งเมื่อใช้ร่วมกับระบบส่องดูในท่อน้ำดีโดยตรงด้วยระบบกล้องแม่ลูก

คำสำคัญ : การสลายนิ่วด้วยแสงเลเซอร์, นิ่วในท่อน้ำดี

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