Techniques for Mechanical Lithotripsy and Stone Extraction

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Papillary pre-treatment

Papillary pre-treatment is necessary for bile duct lithotripsy. This pre-treatment is generally accomplished with endoscopic sphincterotomy (EST)\(^1\) in which a high-frequency generator is used to make papillary incisions and endoscopic papillary balloon dilation (EPBD)\(^2\), which uses a 6 to 8 mm balloon. Endoscopic papillary large balloon dilation (EPLBD), a recently developed procedure for spreading the opening width, is gaining acceptance as an alternative for large stones or several stones in the area which are difficult to treat\(^3\). Each has its advantages and drawbacks. The physician must select the option best suited to the patient after becoming familiar with the characteristics and techniques of each.

Our Center for Gastroenterology prefers EST but uses EPBD for patients prone to bleeding and young patients with smaller stones. EPLBD is used mainly for elderly patients and recurrent, difficult-to-treat stones.

Figure 1 Strategy for treating bile duct calculi
Lithotripsy devices and selection criteria

A device well suited to the stones present must be selected if the stones are to be safely and reliably extracted. Most devices used to extract bile duct stones can be classified as a basket catheter, balloon catheter, or lithotripsy basket. An improperly selected device may be insufficiently extracting the stones and cause unexpected complications.

Basket catheters (Figure 2)

Basket catheters, which deploy a basket in the bile duct, are used to capture and extract stones from this location. The tip of a basket catheter is generally shaped like a basket consisting of 4 to 6 wires. Caution is required when a large-diameter stone is to be removed because the basket can become incarcerated when, following basket capture, papillary removal is not possible.

Balloon catheters for stone extraction (Figure 3)

A balloon is inflated firmly against the bile duct and used to remove stones and biliary sludge. This type of catheter is also very useful to check the presence of residual stones after a basket catheter extraction. The balloon typically has a 5 ml capacity but a larger diameter may be required when sufficient adherence of the balloon to the bile duct wall cannot be achieved because the bile duct is larger than normal. Marketed catheters whose balloon diameter can be adjusted to fit the bile duct are popular.

Mechanical lithotripsy systems (Figure 4)

Mechanical lithotripsy systems are used to mechanically pulverize large diameter stones that are not removable from the papillary with a basket catheter alone. Stones are captured and mechanically crushed by twisting the handle. Although no clear selection criteria for mechanical lithotripsy are established, this device should be used from the beginning if extraction is expected to be difficult, the diameter of the stone is larger than the diameter of the scope, the stones are hard, such as stones that have descended from the gallbladder, or the lower end of the bile duct is relatively narrow and could result in basket incarceration.
Stone extraction procedure and tips

Stones are generally removed by capturing a stone with a basket catheter and then slowly pulling to the lower end of the bile duct. The basket wires are deployed on the portal side and just slightly beyond the stone (Figures 5 a, b, c) because the stone could be pushed toward the hepatic portal or intrahepatic bile duct if the basket is deployed closer to the lower end. The basket wires must not be closed too tightly after the stone has been captured because the basket could become incarcerated if the stone cannot be removed. The operator guides the stone to the papilla (Figure 5 d) and, mindful of the bile duct axis, extracts it (Figure 5 e). Stones are most easily extracted in opposition to the axis of the bile duct. Applying force in this direction allows almost effortless extraction. Attempts to remove a stone simply by pulling the basket catheter will not bring alignment with the axis. To apply pressure in opposition to the bile duct axis, the operator must hold the basket catheter in the left hand and apply rightwards torque to the scope, pushing it toward the anal side of the duodenum. This is the basic technique for lithotomy. One or two stones are easily extracted, but numerous stones should be extracted from the lower end of the bile duct. Caution is obviously required because if a stone on the portal side is accidentally captured, stones closer to the lower end could get in the way, not only preventing extraction but posing the risk of basket incarceration.
Tip 1: Using suction
Stones that are difficult to capture or presented in the intrahepatic bile duct can sometimes be captured when suction is applied. Deploy the basket and apply suction to pull the stone into an accessible location toward the lower end.

Tip 2: Handling free small stones
Small stones free in the bile duct must be handled with care. Such stones readily move portally and can be lost from view when contrast agent is injected or a guide wire or device is inserted. When locating a small stone, avoid injecting excessive contrast agent and proceed more carefully with guide wire and device insertion.

Tip 3: Releasing stones
Sometimes a captured stone must be released to avoid basket incarceration when the stone diameter is larger than predicted or extraction with a normal basket proves impossible. Release a stone by guiding the basket catheter portally (Figure 6 a) and open the basket near the point where the left and right hepatic ducts branch. Operate the device so that the basket tip opens against the portal side and push the basket catheter slightly. This procedure deforms and opens the basket in order to release the stone (Figures 6 b, c).

Mechanical lithotripsy
The procedure should begin with a lithotripsy basket if a basket incarceration is expected because of a large stone diameter or the presence of multiple buildup stones. Such stones should be captured entirely and as close to the center of the basket as possible. Stones captured away from the center of the basket could come out of the basket and be insufficiently crushed when the basket is closed. Stones captured in the lower portion of the bile duct often come out of the basket due to bile duct movement. Targeted stones should therefore be moved as close as possible to the middle of the bile duct before being crushed.
Endoscopic papillary large balloon dilation

Endoscopic papillary large balloon dilation (EPLBD), a recently developed procedure for dilating the papilla and to spread the bile duct opening width, is gaining acceptance as a approach to extract large stones (Figures 7 a-d). Stone extraction in 83 to 100% is achieved in a single EPLBD session, and EML must be used only in 1 to 27% of the cases, meaning that extraction without mechanical lithotripsy is possible for many patients. Major complications include bleeding, perforation, and pancreatitis, occur at an incidence of 0 to 16%. In terms of extraction, EPLBD is an excellent procedure to extract large stones and multiple stones, but the procedure must be further investigated because long-term data on recurrence and other aspects are not yet available.

Figure 7 a - The papilla is dilated with a large diameter balloon

Figure 7 b - Fluoroscopic image

Figure 7 c - The papilla, now widely dilated

Figure 7 d - This large stone can be extracted without the need for lithotripsy
Case reports

Case 1: Multiple calculi

The patient showed low back pain and fever. Blood chemistry tests revealed jaundice and liver disorder. Endoscopic retrograde cholangiography revealed multiple stones with a size of about 10 mm in the bile duct (Figure 8 a). The stones were extracted with a basket catheter and balloon catheter (Medi-Globe GmbH, Achenmuehle, Germany) (Figure 8 b). The balloon was used to confirm that no stones remained (Figure 8 c). The radiopaque markers on both ends of the balloon were easily visualized under fluoroscope, allowing precise balloon positioning (Figure 8 d). The multi-stage balloon construction of the device allowed the balloon size adjustment to accommodate the diameter of the bile duct. Little balloon deformation occurred during stone collection, leaving us with the impression that few stones elude capture.
Case 2: Large calculi

The patient showed low back pain and fever. Blood chemistry tests revealed jaundice and liver disorder. Abdominal ultrasonography and computed tomography revealed calculi in the bile duct. Endoscopic retrograde cholangiography revealed multiple stones with a size of about 20 mm in the bile duct (Figure 9 a). After initial endoscopic sphincterotomy, the Stone Buster mechanical lithotripsy system (Medi-Globe GmbH, Achenmuehle, Germany) was used to perform lithotripsy. A guide wire was placed and used to guide the injectable metal spiral, which was attached to Stone Buster handle, into the bile duct. The metal spiral requires a linear configuration (Figure 9 b) and therefore has to carefully advance to the upper bile duct with endoscopic operation. Stones were captured and crushed by twisting the handle (Figure 9 c). The crushed stones were cleared with a stone extraction basket. Then, a stone extraction balloon (Medi-Globe GmbH, Achenmuehle, Germany) was used to confirm that no stones were left before the procedure was completed (Figure 9 d). The handle of the Stone Buster features twist-and-pull operation, which allows applying tension to stones relatively quickly and reliably. The inclusion of the injectable metal spiral of the handle allows the device to be used as a normal basket lithotriptor. The basket insertion set can be attached to allow use as a normal retrieval basket that can be replaced with the Metal Spiral when lithotripsy is required.
Concluding remarks

This document provides basic information and tips for lithotripsy. Becoming grounded in the basic techniques, establishing proper treatment strategies, and selecting appropriate equipment are keys to perform successful lithotripsy.

References


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Teine-Keijinkai Hospital is a general hospital, located in the city of Sapporo, Hokkaido Prefecture near the border with the city of Otaru, is a 30 minute drive from central Sapporo. The institution has 550 beds. The Center for Gastroenterology was established in 1997 and turns 17 years old this year. The 23-member staff of the Center for Gastroenterology, which includes two radiologists, provides treatment under three groups specializing in biliopancreatic, gastrointestinal, and hepatic care. The center is equipped with three rooms for upper gastrointestinal imaging, two rooms for lower gastrointestinal imaging, one room for endoscopic ultrasound (including EUS-FNA), and two rooms for digital radiography (DR). ERCP-related procedures can always be accommodated in the two DR rooms. In 2012 13293 endoscopies were performed. This statistic includes 834 ERCP-related procedures (33 diagnostic and 801 therapeutic) and 848 EUS procedures (442 radial and 406 convex).

The center staff always strives to provide accurate diagnoses through detailed diagnostic imaging so that the proper course of treatment can be selected. Every Thursday the doctors, radiologists, surgeons, pathologists, and ultrasound technicians hold a conference to discuss two to three surgery patients, spending about an hour to cover one patient. The attendees compare preoperative images to histopathological findings for resected specimens and debate any issues that occurred.

Many young doctors from throughout Japan are trained in ERCP and other endoscopic procedures. Currently four doctors from outside Hokkaido Prefecture are receiving training.