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Biliary Sphincterotomy Techniques

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Abstract

Biliary endoscopic sphinterotomy, which consists in opening the terminal part of the common bile duct by cutting the papilla, is performed whenever a therapeutic procedure is needed on the biliary tree and can also represent itself as a treatment. Since its first description, sphincterotomy has not significantly changed, although both the techniques and the instruments, the so-called sphincterotome or papillotome, have progressively improved. The usual approach to cut the papilla involves deep insertion of the sphincterotome into the bile duct followed by electrocautery to incise the sphincter. A correct position of the catheter in the papilla as well as appropriate selection of the cutting current are determinant factors to reduce the rate of complications. Appropriate selection of the patients prior to performing ERCP, mainly in terms of coagulation parameters, is also crucial. Acute pancreatitis, perforation and bleeding represent the main complications of ERCP. In some cases, sphincterotomy may itself be the cause of such complications.

Biliary endoscopic sphinterotomy (ES) consists in opening the terminal part of the common bile duct by cutting the papilla and the distal portion of the sphincter of Oddi (SOD). ES is the prerequisite to perform several therapeutic maneuvers on the biliary tree such as stone extraction, stenting, biliary drainage by nasoductal catheter, and brushing. Although small stones may be removed after a simple balloon dilation of the papilla and small caliber stents (7–8.5 Fr) can be introduced without previous sphincterotomy, ES is in general performed whenever a therapeutic procedure is performed on the biliary tree. ES can also represent itself as a treatment when performed in patients with papillary stenosis or SOD dysfunction.

Procedural Aspects

Patient Preparation

Since sphincterotomy is performed as a part of ERCP, preparation of the patient in terms of informed consent, sedation, antibiotic prophylaxis, and pancreatitis prophylaxis is that of ERCP and are treated in another chapter of the book. As a cut is performed, particularly relevant is the evaluation of the coagulation parameters. Patients should have a full blood count and prothrombin time or international normalized ratio performed no more than 72 h prior to the procedure [1]. ES can be safely performed on patients taking aspirin and NSAIDs. In patients on anticoagulant

therapy, discontinuation of therapy can be decided on the basis of the level of thromboembolism risk. Anticoagulant can be safely substituted with low-dose heparin or unfractioned intravenous heparin which do not represent a contraindication to ES. Data on newer antiplatelet therapies (such as clopidogrel) are unavailable, but at present it is recommended that, wherever possible, they should be discontinued 7–10 days prior to ES [1]. Abnormal clotting, variously defined as a platelet count <50,000 IU/l and prolonged prothrombin time, defined as an international normalized ratio >1.5, may be associated to an increased hemorrhage risk, but it is difficult to define the point at which abnormal clotting becomes an absolute contraindication to ES [1, 2]. If the patients have a critical deranged clotting, subsequent management should be performed according to the current guidelines prior to performing ERCP.

Sphincterotome

From its first description in 1973, ES has not significantly changed and also the catheters used to cut the papilla, although progressively improved, did not change substantially. The ES catheter, the so-called sphincterotome or papillotome, consists of an outer Teflon catheter of 6–7 Fr that contains a thin steel wire which exits the catheter about 3 cm before the distal end and re-enters it about 3–5 mm from the tip. The tip of the catheter without the wire is called 'nose'. It is usually tapered, sometimes with a dome shape (Cook), a caliber ranging from 3.5–5.5 Fr, and facilitates introduction into the duct system. The exposed wire functions as a cautery knife when high-frequency electrosurgical current is applied (fig. 1). The other end of the wire is insulated and connected to the electrosurgical unit.

The earliest catheters had a single lumen which allowed injection of contrast in the duct, although the contrast could leak around the port for the wire. The more recently developed sphincterotomes have two or three lumen to allow both injection of contrast and passage of a guidewire (independently in the triple lumen catheters) so that they can be used not only to cut the papilla but also to cannulate it, inject contrast, and place a guidewire into the duct. A number of different sphincterotomes with different designs and shapes are today available on the market (fig. 1): the length of the nose can vary from 0 to 30 mm: a longer nose should usually offers a more stable position in the bile duct while cutting, but is likely to make the cannulation more difficult. The length of the wire can vary from 2 to 3.5 cm: sphincterotomes with longer wires (3–3.5 cm) are usually more flexible, are more easily oriented when used to cannulate the papilla and tend to remain in a neutral position when tightened; the disadvantage is the necessity to put the tip of the endoscope away from the papilla when performing ES to avoid contact of the wire with the elevator. Catheters with shorter wires tend to be stiffer, to displace from the bile duct when tightened, and to determine excess tension on the roof of the papilla while cutting. We usually prefer a sphincterotome with a 5-Fr dome tip, a nose of 5 mm, and a wire of 2.5 cm. Other changes of the basic structure of the sphincterotome have been proposed: the Clever Cut sphincterotome from Olympus has half the length of the cutting wire coated with insulation so that an incision can be made without the cutting wire penetrating too deep into the bile duct by using the coated portion as a guide.

Cutting Technique

The usual approach to cut the papilla involves deep insertion of the sphincterotome into the bile duct followed by electrocautery to incise the sphincter. ES cannot be performed if deep cannulation of the bile duct has not been previously achieved. The sphincterotome can be used itself to cannulate the papilla and to inject contrast in the duct and, due to the possibility to bend the tip

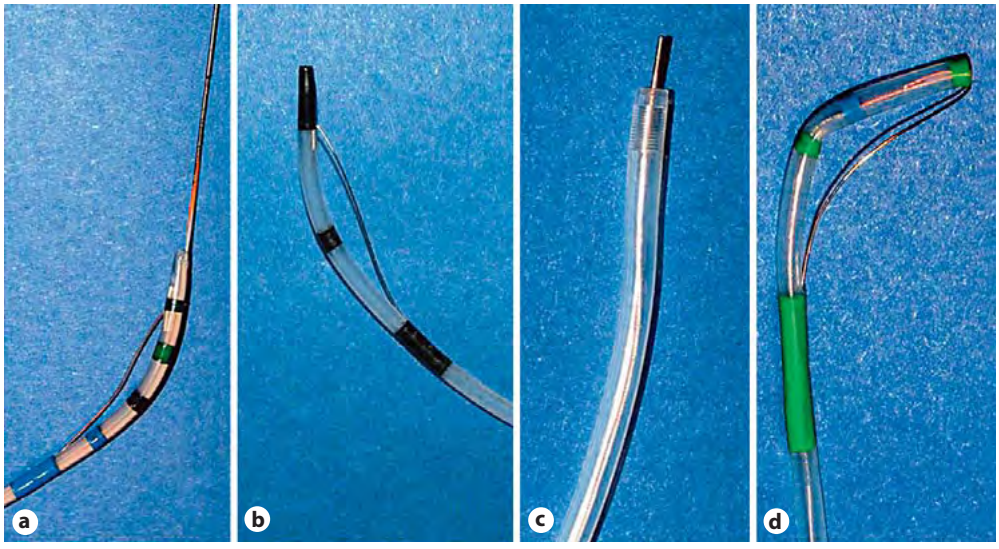

Fig. 1. Sphincterotomes of different designs and shapes. **a** Double-lumen, dome-tip, sphincterotome (FS-OMNI, Cook – the nose is 5 mm long and the wire 2.5 cm long) with Tracer Metro 0.35-inch wire (Cook) inside. **b** Thin sphincterotome with 4-Fr nose (Mini-Tome, Cook – the nose is 5 mm long and the wire 2 cm long). **c** Needle-knife precut sphincterotome (Olympus). **d** Noseless single lumen sphincterotome (Olympus).

of the catheter toward the axis of the bile duct, the cannulation process is likely to be easier than with conventional catheters. Alternatively, the sphincterotome, usually a dual or triple lumen, can be introduced over a guidewire inserted through a standard cannula into the bile duct to establish a path across the papillary orifice. If the bile duct cannot be cannulated, the papilla can be dissected with the use of a variety of techniques known altogether as 'precut sphincterotomy'. Precut is an 'access' sphincterotomy and has been described in another section of the book.

Once the sphincterotome has been deeply introduced into the bile duct and the correct position has been confirmed either by injecting contrast or by fluoroscopy, it is progressively retracted until approximately one half to two thirds of the wire is exposed outside the papilla (fig. 2). At this point the sphincterotome is gently bent to establish a contact between the wire and the papillary roof and short bursts of current are applied. The cutting of the papilla should be oriented to the 11-o'clock direction and it is achieved by exerting a slight torsion of the endoscope in the anticlockwise direction (fig. 2). The papilla is usually cut in a stepwise manner. Whitening of the mucosa indicates that the current is passing and the cut has begun (fig. 2).

A gush of bile usually indicates that the sphincter has been cut. The limit of a safe ES is the upper limit of the intraduodenal portion of the common bile duct which can be defined either by the presence of a transverse fold (fig. 2d) or by the impression of the bile duct on the duodenal wall. Extraction of large stones usually needs such a large incision. For stent insertion a smaller sphinterotomy (up to 1 cm) may be enough and it could reduce the risk of complications. The most sphincterotomies have usually an extension of 1.5–2 cm. The extent of the ES should be decided on the basis of ERCP indication as well as characteristics either of the papilla, mainly dimension and shape, or of the bile duct (a shorter cut for narrow ducts). Another factor influencing the decision to perform a shorter cut is the presence of a juxtapapillary diverticulum.

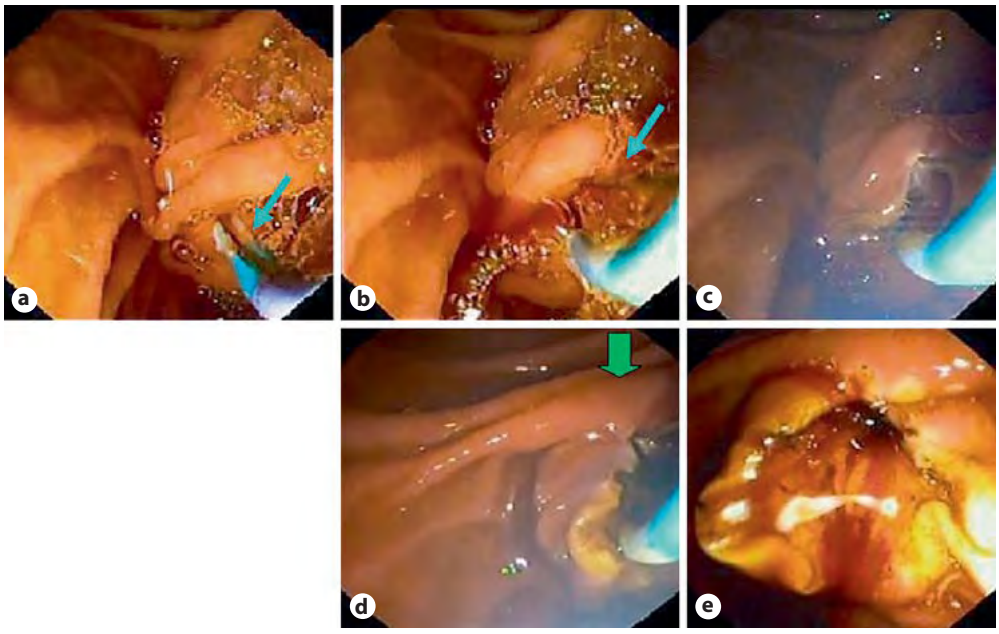

Fig. 2. **a** The sphincterotome is introduced in the biliary duct with half of the wire (arrow) exposed outside the papilla. **b** The sphincterotome is bent to establish a contact between the wire (arrow) and the roof of the papilla. **c** The papilla is cut in a stepwise manner. Whitening of the mucosa indicates that the current is passing. **d** The cutting is performed in the 11-o'clock direction until the transverse fold (arrow). **e** A gush of bile indicates that the sphincter has been cut.

Electrosurgical Unit

A diathermy unit suitable for ERCP should be able to develop pure cutting and coagulation current, as well as blended current. Several different diathermy units are available on the market. The power setting varies depending on the energy output of individual units. Pure cutting and blended (cutting and coagulation) are both usually used to perform ES according to the endoscopist's experience, clinical indications, and conditions of the patient. The unit that we usually use in our daily endoscopic activity is the Erbotom ICC 200 from ERBE (ERBE Elektromedizin, Tübingen, Germany) in the Endocut modality.

Tricks for a Good Sphincterotomy

A Good Orientation. ES should be performed in the 11-o'clock direction and in any case in the 'safety zone' between 11- and 1-o'clock (fig. 2). A deviated cut is likely to be related to an increased risk of complications such as bleeding, pancreatitis, and perforation. Most sphincterotomes tend to deviate to the right when the wire is tightened (fig. 3) which can result in a deviated cut or even in a displacement of the catheter from the duct. A catheter with a long nose maintains a more stable position in the bile duct; a catheter with a long cut wire tends to remain in a neutral position when tightened. With double or triple lumen sphincterotomes, a guidewire can be introduced in the bile duct and may serve to anchor and stabilize the sphincterotome during the cut. In some cases a displaced papilla makes it impossible to maintain the optimal axis during the cut (fig. 3). Pushing the scope into a long position may, in some cases, helps the endoscopist in obtaining an acceptable cutting axis. In some other cases a possible solution could be to cut

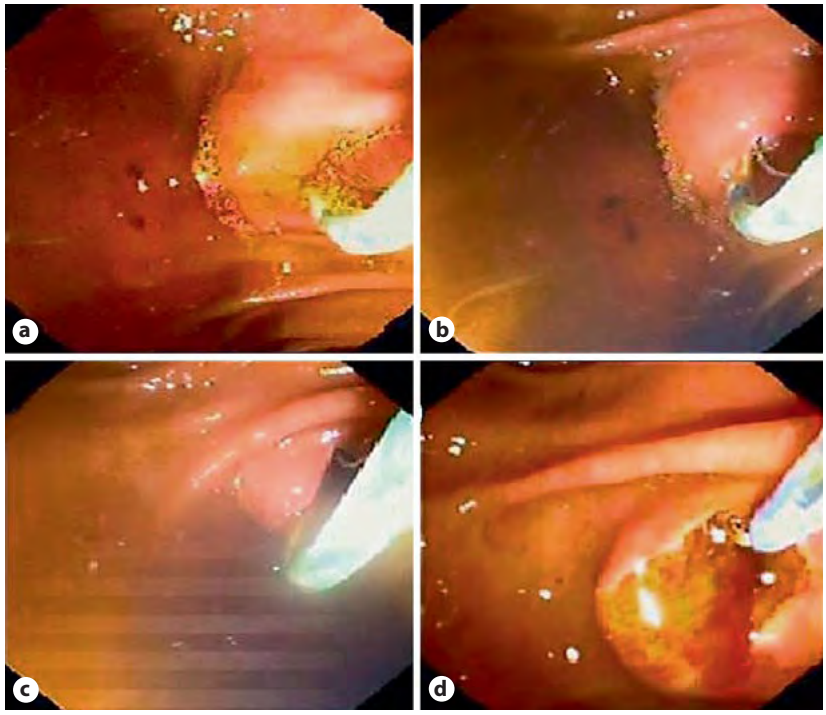

Fig. 3. **a** During sphincterotomy the sphincterotome tends to deviate to the right in the 1-o'clock direction. **b** A gentle torsion of the tip of the endoscope in the anticlockwise direction allows to maintain the optimal axis during the cut. **c** The result is a correct cut in the 11-o'clock direction.

the papilla while the cutting wire is not tightened but overrelaxed to form a loop on its left side which can be more easily oriented in the 11-o'clock position (fig. 4).

A Good Cutting. The contact between the wire and the tissue is determinant for the quality of the cut. An optimal contact is usually achieved when the wire is outside the papilla for one half to one third of its length. Either too little or tot much wire in contact with the tissue may produce an ineffective cut. In this case the passage of current within the wire is not followed within a few second by a whitening of the tissue. Similarly, the tension of the wire while tightening is important to determine a good and safe cut. Excess tension of the wire should be avoided to prevent an uncontrolled 'zipper cut' which could result in a perforation. Gentle movements of the elevator as well as an anticlockwise torsion of the scope may be needed during ES to maintain at the same time the right orientation of the cut and the optimal contact of the wire with the papilla.

The Best Current. ES is based on the passage of high-frequency alternating current through a poorly conductive medium, such as ampullary tissue, thereby generating heat and resulting in cutting and/or coagulation of tissue. Different types of electrosurgical current can induce different types and degrees of thermal tissue injury. ES is a technically challenging and potentially dangerous procedure and has been reported to be an independent risk factor for the development of bleeding, perforation, and post-ERCP pancreatitis.

When used during ES, pure current provides better tissue-cutting capability, whereas low-voltage coagulating current achieves better hemostasis. Pure coagulative current is never used for ES. A third form of electrosurgical current, known as mixed current, combines patterns of both

pure and coagulating currents and is popular for ES. Mixed current is available in two varieties: 'blended' current, where both cutting and coagulating currents are delivered together in one waveform, and 'Endocut' current (ERBE Elektromedizin, Tübingen, Germany), where the cutting and coagulating currents are interspersed and applied one after another in short bursts, with an intermittent pause, thus achieving both effects of cutting and coagulating, similar to that achieved with blended current. Although blended and Endocut currents use different patterns for combining cutting and coagulating waveforms during ES, this difference is only of theoretical significance [3]. At the present time, there is no consensus on which type of current, used in the context of ES, is optimal with regard to maximizing safety, although some suggest that pure current may be associated to an higher rate of hemorrhage and blended current to acute pancreatitis (due to ampullary edema) [4]. In a recent meta-analysis, the incidence of post-ES pancreatitis was similar in patients undergoing ES either with pure or mixed electrosurgical current. Patients who underwent ES with pure current experienced significantly more frequent episodes of post-ES bleeding, without an accompanying increase in morbidity or mortality [5]. According to these data, we suggest that patients at high risk of bleeding should be considered for mixed current during ES and, conversely, for those at risk of developing pancreatitis pure cut should be preferred current. It has also been suggested to use a sequential combination of pure cut and blended current to reduce the risk of bleeding without increasing that of pancreatitis [6], but these data have never been confirmed by other studies so that today's state-of-the-art is that use of both pure cutting and blended current is correct provided that the operator has experience with the one or the other method.

Sphincterotomy in Patients with Distorted Anatomy

Billroth II Anatomy. In the Billroth II gastrectomy the papilla has an upside-down orientation since the afferent loop is approached by the endoscope in an antiperistaltic fashion. It means that the bile duct is oriented at 5-o'clock instead of at 11-o'clock. Conventional sphincterotomes are not suitable to perform ES in these patients since they tend to point away from the bile duct's axis and to cut the posterior wall of the duodenum instead of the roof of the papilla. The Billroth II sphincterotome consists of a catheter with a cutting wire that has a convex shape oriented at 5-o'clock when pushed out from the sheath (fig. 5). When the wire is retracted, the catheter tip is straightened and oriented in the bile duct axis and can be used to cannulate the papilla. The cut is performed in progressive steps pushing the catheter against the papilla (push sphincterotomy).

Maintaining the correct orientation of the Billroth II sphincterotome while cutting the papilla is considered difficult by several authors who prefer to introduce in the bile duct a small caliber stent that provides a correct orientation for the cut using a needle-knife sphincterotome. The endoscopist then performs a cut over the cannula emerging from the papilla in the axis and direction of the bile duct with a technique that resembles that of the precut ES. The stent would also have the function of protecting the pancreatic duct from injury.

Juxtapapillary Diverticula. Juxtapapillary diverticula are frequent findings in elderly occurring in 9–32% of ERCP [7]. The papilla can be located within the diverticulum or along its outer rim, on the left or the right side. The presence of a juxtapapillary diverticulum may represent a problem for the endoscopist since the papilla cannot be seen or can be difficult to cannulate due to a distortion in its anatomy and course. With regard to ES, it has been suggested that the diverticulum may be associated to an increased risk of bleeding [8, 9] and may be a possible contributor to perforations [10], but some studies do not support this hypothesis [7, 11]. Once the papilla has been cannulated

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Fig. 4. To maintain a correct direction of the cut, the cutting wire is not tightened but overrelaxed to form a loop on the left side that is easily oriented in the 11-o'clock direction (arrow). **Fig. 5.** Billroth II sphincterotome with a 2-cm long wire (Cook).

with the help of one of the several techniques proposed (see in another section of the book), the crucial step for a safe and effective ES is to precisely demarcate the intramural segment and proper direction of the bile duct, which are endoscopically observable cephalad to the papilla. This anatomic landmark is not always endoscopically evident in some patients with a periampullary diverticulum and this could explain the potentially increased risk of perforation. Although in the most cases ES can be successfully performed in the conventional fashion, some techniques have been proposed to help in cutting the papilla within a diverticulum. This involves the introduction in the bile duct, once the papilla has been partly cut, of a retrieval balloon catheter that is inflated and then pulled toward the duodenal lumen to indicate the residual intramural segment of the duct [12]. Another technique consists in cutting the papilla using a sphincterotome with an inflated balloon at the tip (Stonetome, Microvasive) which bulges the intramural tract of the bile duct [13]. According to our experience, ES can be effectively and safely performed in the most papillas in the presence of a diverticulum. It is important to direct the catheter in the 11-o'clock position by opportunely withdrawing the endoscope in some cases (usually when the papilla is located on the floor of a large diverticulum) or pushing the scope into a long position in some other cases (to avoid contact with the cutting wire on the outer rim of the diverticulum). Another way of reducing the risk of cutting the rim of the diverticulum while performing ES is that of using a catheter with the proximal half length of the cutting wire coated with insulation (Clever Cut, Olympus).

Complications of Sphincterotomy

Biliary ES is performed during ERCP, and ERCP can be associated to the development of complications in each step of its performance, from the introduction of the endoscope in the duodenum to the cannulation of the papilla, from the sphincterotomy to the introduction of stents

or other devices in the biliary tract. It is thus difficult to evaluate for each possible complication, especially for acute pancreatitis, if it has occurred as a consequence of ES or of any maneuvers performed prior to cut the papilla, i.e. the several attempts to cannulate the papilla, or after the papilla cutting. The three main complications potentially associated to ES are acute pancreatitis, bleeding and perforation.

Acute Pancreatitis

Acute pancreatitis is most often determined by repeated cannulation or injection of contrast in the pancreas which usually occurs in the cannulation process. ES can determine the development of pancreatitis from inadvertent cutting of the pancreatic orifice or its edema. Coagulation current can cause edema of the pancreatic orifice. Selection of appropriate current is thus fundamental to avoid pancreatitis (see above). Insertion of a thin stent (3-Fr) in the pancreatic duct which ensures an appropriate pancreatic drainage is likely to reduce the occurrence of pancreatitis [14, 15].

Bleeding

Bleeding is a typical complication of ES which occurs in 2–5% of cases [2]. It is defined as the clinical (not endoscopic) evidence of bleeding (hematemesis or melena) with a decrease of at least 2 g/dl in hemoglobin concentration, or need for blood transfusion [16]. Deviated cut, large ES, and coagulopathy are factors associated to the development of bleeding. Bleeding can develop immediately after ES or in the 10 days following the procedure [2, 17, 18]. The development of bleeding during the procedure is frequent and usually self-limiting or easily treated endoscopically. The above-reported definition does not consider as complication the bleeding that occurs while cutting the papilla; it has however been recognized as a risk factor for a further bleeding [2]. Bleeding can usually be controlled endoscopically by inflating a balloon in the papilla, application of pure coagulation current, injection of 1/10,000 diluted epinephrine around the incision, or by placement of one or more hemoclips. Injection of epinephrine and coagulation current could theoretically produce edema in the pancreatic orifice which may determine acute pancreatitis. In a minority of cases, usually when bleeding results from cutting a branch of the retroduodenal artery (usually because of an aberrant branch or a deviated cut), the bleeding can be massive and may require emergency surgery or embolization.

Perforation

Perforation is a rare complication which occurs in less than 1% of cases [11, 17, 18]. The 'conventional' ES is a rare cause of perforation, mainly following a deviated, excessive, or zipper cutting. Perforation is likely to occur more frequently after precut (see the corresponding chapter). Peripapillary diverticula [9, 10], small papilla, narrow bile duct, and Billroth II anatomy are all suspected to be associated to an increased risk of perforation during sphinterotomy. Some perforations develop during the insertion of the endoscope in the duodenum and during its straitening. While ES may result in a retroperitoneal perforation, introduction of the endoscope usually produces a bowel-wall perforation. Perforation can be suspected either during ERCP by demonstrating a leak of air or of contrast in the retroperitoneal space or after the procedure when patients complain of pain. CT scan of abdomen is the technique to be performed to demonstrate retroperitoneal air. Most retroperitoneal perforation can be managed conservatively by the placement of a nasobiliary drainage, systemic antibiotics, nasogastric suction and parenteral nutrition. Development of sign of peritonitis should be an absolute indication to surgery.

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