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CHAPTER 1

ENDOSCOPIC RETROGRADE CHOLANGIOPANCREATOGRAPHY

ABSTRACT

Endoscopic retrograde cholangiopancreatography (ERCP) is a contrast study of the bile ducts and the ductal system of the pancreas (P), achieved by cannulating them with a flexible endoscope and visualizing them with fluoroscopy. The technique also includes a visual assessment of the major duodenal papilla (MDP).

ERCP involves not only diagnostic manipulations, but also therapeutic procedures on the MDP, bile and pancreatic ducts.

ERCP and its accompanying endoscopic interventions make it possible to diagnose and perform therapeutic interventions in choledocholithiasis, benign and malignant obstruction of the biliary tract, chronic pancreatitis accompanied by obstruction of the pancreatic ducts, and in a number of other conditions and pathologies.

KEYWORDS

ERCP, endoscopic lithoextraction, biliary obstruction, biliary decompression, choledocholithiasis, Mirizzi syndrome, tumor obstruction, chronic pancreatitis.

Endoscopic MDP cannulation was first described in 1968 [1].

Subsequently, at the turn of the 60s and 70s, several groups of Japanese researchers coworking with manufacturers of endoscopic equipment and instruments widely introduced retrograde contrast examination of the bile ducts and pancreatic ducts under direct visual control using a duodenoscope.

The technique, later called ERCP, quickly spread throughout the world. However, with the accumulation of primary experience, the possibility of serious complications soon became apparent [2].

In 1974, endoscopic sphincterotomy was performed independently in Germany and Japan [3, 4]. After that, the possibility of removing stones from the common bile duct became obvious.

In 1980, there were reports of endoscopic drainage of the bile ducts, including those with malignant obstruction [2, 5].

The introduction of treatment options has given a powerful impetus to the development and use of ERCP. Endoscopes were improved, tools and techniques were developed – both for diagnostic and therapeutic ERCP.

At the turn of the 70s and 80s, ERCP, in fact, was the only method that allows to look "inside" the bile ducts and pancreatic ducts [2].

In addition to the pathology of the bile ducts, ERCP made it possible to diagnose the dilatation of the main pancreatic duct (MPD), virsungolithiasis, and to identify the relationship between pancreatic cysts and MPD [6]. However, initially high hopes for the use of therapeutic endoscopic interventions in chronic pancreatitis subsequently did not come true [2].

The period of a decade and a half since the mid-1970s has become a "golden age" for ERCP. Despite the risk of complications, it became obvious to everyone that ERCP treatment of common bile stones and correction of tumor biliary obstruction is simpler, cheaper and safer than available surgical interventions [2].

Since the 1990s, the situation has begun to change. On the one hand, non-invasive methods of visual diagnostics were improved – ultrasound, CT, MRI, endo-ultrasound, which somewhat reduced the diagnostic contribution of ERCP. On the other hand, percutaneous interventions on the biliary tract were developed, also allowing significant progress in the correction of biliary tract obstruction – in Klatskin tumors and tumors of other localization [2]. The introduction of minimally invasive surgery – laparoscopy, in some centers, has also become an alternative to a number of endoscopic interventions performed with ERCP [7].

Nevertheless, despite the development of other minimally invasive methods, today ERCP and its associated interventions are the main ones in the diagnosis and treatment of choledocholithiasis, correction of tumor obstruction of the extrahepatic biliary tract, and MPD pathology. And the improvement of equipment, tools and skills contribute to the development of new techniques, which include, for example, endoultrasound in combination with ERCP [2, 8].

1.1 SCOPE AND INDICATIONS

ERCP is mainly used for obstructive conditions of the bile ducts. As mentioned above, with the development of other diagnostic methods, especially CT and MRI, the diagnostic value of ERCP has receded into the background, but the therapeutic potential of ERCP is difficult to overestimate. In this regard, indications for the use of ERCP can vary widely. This variability may be due to the availability of the method in a particular institution, the qualifications of the specialist performing this intervention, the availability and accessibility of an interventional radiology service, the availability and accessibility of CT, MRI, preferences and traditions developed in different centers, and a number of other factors.

The main points of application of ERCP are choledocholithiasis and other complications of cholelithiasis (for example, Mirizzi syndrome), tumor obstruction of the bile ducts, strictures of the

bile ducts, chronic pancreatitis, postoperative bile leakage, suspicion of an anomaly of the pancreatic duct system and the biliary tree, dysfunction of the sphincter of Oddi, etc. In most of these conditions, not only diagnostic but also therapeutic interventions are performed [2, 8].

An analysis of 53,394 cases published in 2017 [9] showed significant variability in indications for ERCP among different investigators:

– clinical indications: pain in the upper abdomen with or without jaundice;
– biochemical – an increase in the activity of liver tests with or without hyperbilirubinemia;
– cholangitis;
– acute biliary pancreatitis;
– history of pancreatitis;
– confirmed choledocholithiasis;
– suspicion of choledocholithiasis;
– malignant obstruction of the bile ducts;
– suspicion of malignant obstruction of the bile ducts;
– biliary fistulas and bile leakage after operations;
– strictures of the biliary tract;
– jaundice of unknown etiology;
– primary sclerosing cholangitis;
– suspicion of dysfunction of the sphincter of Oddi, etc.

In case of pathology of the bile ducts (excluding bile leakage), we consider that ERCP is indicated, first of all, when the fact of biliary obstruction is confirmed, according to the results of non-invasive imaging methods – ultrasound, CT, MRI. In rare cases, ERCP is performed by us when it is impossible to exclude choledocholithiasis in other ways.

In our opinion, in case of pathology of the pancreas, the diagnostic value of ERCP can be useful in suspicion of an anomaly of the ductal system (pancreas divisium), identification of the relation of MPD with pancreatic cysts, confirmation of a pancreatic fistula, and rarely – in assessing the possibility of endoscopic removal of MPD stones.

In some cases, there is a need for urgent ERCP – in cholangitis, in impacted MDP stone. The necessity of ERCP in acute biliary pancreatitis is also being discussed.

We have developed a scale (**Table 1.1**) to determine the urgency of ERCP [11], which is used for patients with confirmed obstruction (dilatation of common bile duct ≥8 mm). Scoring is carried out by summing up the indicators: clinical sign – hyperthermia ≥37.3 °C; one of the three hematological parameters – white blood cell count $\geq 9 \times 10^9$/L or stab neutrophils ≥7 %, or the ratio of the number of segmented and stab neutrophils < 10; two biochemical criteria – bilirubin ≥70 μmol/L and hyperamylasemia; signs identified according to the visualizing methods – gallbladder wall ≥4 mm or the presence of a shrunken gallbladder; the dilatation of the MPD, which can be both a sign of a impacted in MDP stone, or the result of chronic pancreatitis, tumor of the periampullary zone. Since, with obstruction of the extrahepatic biliary tract due to tumor or chronic pancreatitis, for which cholangitis is not typical, if there is evidence of chronic pancreatitis or a tumor, one point is subtracted.

● **Table 1.1** Indication scale for emergency ERCP in extrahepatic bile ducts obstruction

Clinical sign	
Hyperthermia ≥37.3°C	1 point
Hematological signs	
White blood cell count $\geq 9 \times 10^9$/L or stab neutrophils ≥7 % or the ratio of the number of segmented and stab neutrophils <10	1 point
Biochemical signs	
Bilirubin ≥70 μmol/L	1 point
Hyperamylosemia (Amylase > 32 g×year/L)	1 point
Data from imaging research methods	
Gallbladder wall ≥4 mm or Shrunken gallbladder	1 point
Dilatation of the main pancreatic duct	1 point
Presence of a tumor in the periampullary zone/biliary tract or signs of chronic pancreatitis	–1 point

The developed scale was tested in 171 patients with obstruction of various etiology. Of these, in 28 cases the obstruction was of a tumor nature, in 112 cases it was caused by choledocholithiasis, in 29 cases by MDP stenosis, and in 2 cases by chronic pancreatitis.

It was found that the threshold value of this scale is 3 points ($p < 0.001$), upon reaching which the patients are indicated for emergency ERCP followed by endoscopic interventions. In contrast, at ≤2 points, emergency ERCP is not indicated ($p < 0.001$).

Given the diagnostic potential of the developed scale for cholangitis and/or acute biliary pancreatitis and/or fixed MPD stone, it was found that it has a high specificity (97.1 %) and sensitivity (70.6 %). In addition, it was found that the number of points correlates with the severity of complications (cholangitis, acute biliary pancreatitis). According to the developed scale, 3 points indicate a mild form of cholangitis and/or acute biliary pancreatitis ($p < 0.01$). In these cases, urgent ERCP is indicated – in 24 hours. The presence of ≥4 points indicates a moderate or severe form of cholangitis and/or acute biliary pancreatitis ($p < 0.01$), requiring urgent correction of cholestasis – as soon as possible.

With regard to contraindications, in our opinion, the only absolute contraindication for ERCP is allergic reactions to iodine-containing contrast media. For all other conditions, the potential benefit of ERCP and the risk of its use in each case should be evaluated.

1.2 EQUIPMENT AND INSTRUMENTS FOR ERCP [2, 8]

ERCP and endoscopic interventions on the MDP are performed in a special X-ray endoscopic operating room. This should be a spacious room that meets sanitary standards and regulations, equipped with a modern X-ray machine (C-arch type) – the quality of the X-ray image is one of the most important conditions for the success of endoscopic transpapillary interventions. The operating table must be radiolucent and movable. It is necessary that the X-ray and endoscopic monitor be in the field of direct vision of the operator, and the assistants have free access to the head and right hand of the patient (**Fig. 1.1**).

Fig. 1.1 ERCP procedure

Necessary equipment is video endoscopes, both with lateral and end position of the optical window, preferably with instrumental channels of different diameters. Duodenoscopes with lateral optics (**Fig. 1.2**) are used for performing ERCP, they should have a wide instrumental channel (preferably 3.2–4.2 mm), which is very important when performing therapeutic procedures, using the full variety of necessary instruments, especially when stent placement is needed. Endoscopes with end optics (gastroscopes) may be useful in manipulating the MDP in patients who have previously undergone a Billroth-II partial gastrectomy, in whom access to the MDP may be significantly difficult. The video system should give a good image on the monitor, have a recording device for documenting and processing endoscopic data. Mandatory additional equipment for performing manipulations and operations on the MDP is a modern high-frequency electrosurgical unit and suction.

Contrast agents. When performing ERCP, preference should be given to non-ionic low-osmolar water-soluble agents (Ultravist, Omnipak, Vizipak), which cause fewer negative reactions and

complications. Generally, 20–50 ml of radiopaque substance is required for the study. It is also possible to use ionic water-soluble agents at a concentration of 20–35 % (Urographina, Triombrast).

Fig. 1.2 Distal end of the duodenoscope

Instrumentation for performing ERCP and therapeutic procedures is very diverse and occupies at least 1/3 of the total volume of endoscopic instruments produced according to the catalogs of leading manufacturers (Olympus, Cook). All tools can be conditionally divided into certain groups, depending on their purpose.

ERCP catheters (cannulas) are synthetic tubes with an outer diameter of 1.6–2.3 mm and radiopaque markers at its distal end. At the proximal end of the standard catheter there may be two inputs – for the guide wire and for connecting the syringe. Various design options for catheters differ in size, tip configuration, diameter, and number of channels (**Fig. 1.3**). The advantage of dual-channel catheters is the possibility of using two channels in parallel: the injection of a contrast media through one channel and for a guidewire through another channel. Guidewires are used to facilitate cannulation of the orifice of the MDP, going through of tortuous strictures and are usually passed through the lumen of a standard catheter, cannula or papillotome. With their help, the catheter instrument is changed to papillotome to basket, etc. The guidewire are 260–480 cm long and 0.021–0.038 inches in diameter.

Papillotomes are diathermic knives of various designs, differing in the place, direction, length, and shape of the metal electrode-string exiting the catheter. In a typical Demling-Klassen pull-type papillotome, the wire exits 4–2 cm from the tip of the catheter and reenters it a few millimeters from the tip. When using the "wire pulling" technique, the distal end of the papillotome takes the form of a bow, and the pulling string takes the form of a bowstring (**Fig. 1.4**). The cutting wire can vary in length (1–3 cm) and is a single string or several threads twisted into a bundle.

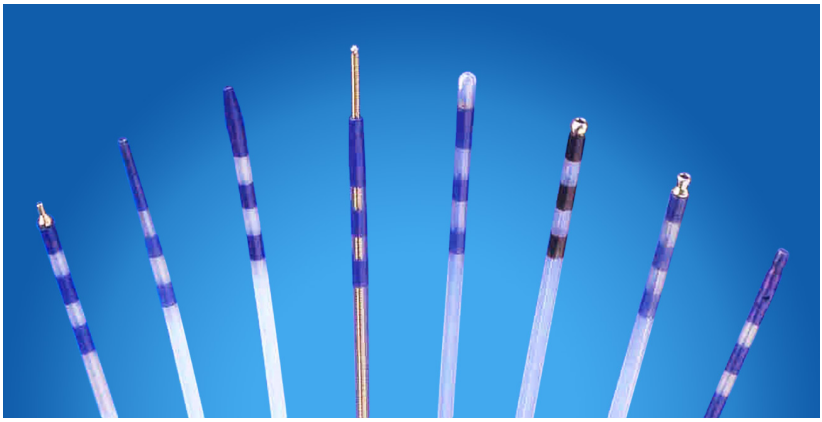
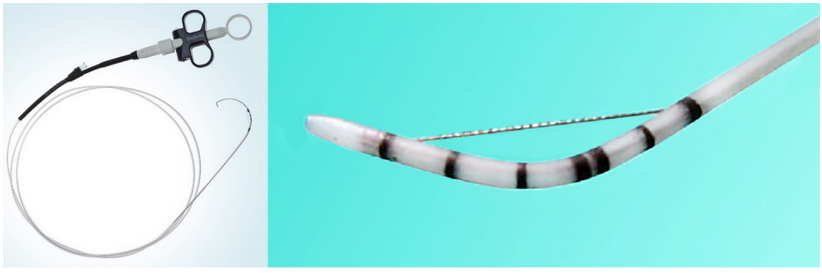


Fig. 1.3 ERCP cannulas



a *b*

Fig. 1.4 Papillotome: *a* – general view of the papillotome; *b* – distal end of the papillotome

Another type of papillotome, which is used for a non-cannulation variant of the MDP papillotomy, is a needle knife with an end exit of the knife (**Fig. 1.5**). Such a papillotome is mainly used for the pre-cut technique of papillotomy and in case of impacted stone in the MDP ampoule.

There are also rare models of papillotomes (push-type and "shark fin" type, for case after the Billroth-II partial gastrectomy and some other situations that are used very limitedly.

Currently, most papillotomes have two or three channels for injection of a contrast and for a guidewire. Such instruments (cannulatomes) are the most convenient, they provide ability of ERCP and papillotomy during one cannulation of the duct system (**Fig. 1.6**).

To perform MDP dilatation, balloon catheters with X-ray contrast marks, a maximum expansion diameter of 6–10 mm, and a balloon length of 2–4 cm are used. They are inserted with a guide-

wire through the papilla (**Fig. 1.7**). This alternative to papillotomy preserves the integrity of the MDP sphincter apparatus, but this type of access to the ducts has a greater risk of post-ERCP pancreatitis. Balloon dilatation of the MDP is advisable in patients with a high risk of hemorrhagic complications, in young patients with single small calculi without dilatation of the common bile duct, and when the stone migrates into the common bile duct during laparoscopic cholecystectomy. Balloon dilators are also used to dilate strictures of the bile and pancreatic ducts of various etiologies under X-ray control.

Fig. 1.5 Needle knife papillotome

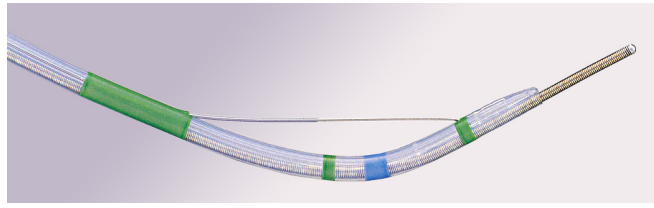


Fig. 1.6 Double lumen papillotome with guidewire

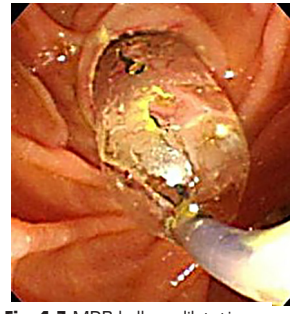


Fig. 1.7 MDP balloon dilatation

Extraction of stones (lithoextraction) is performed using Fogarty-type balloon catheters or Dormia-type baskets. The diameter of the balloon for extraction is 8–20 mm, the catheter of such an extractor contains one or two additional channels for the guidewire and the injection of contrast (two- and three-channel balloon extractors) (**Fig. 1.8**).

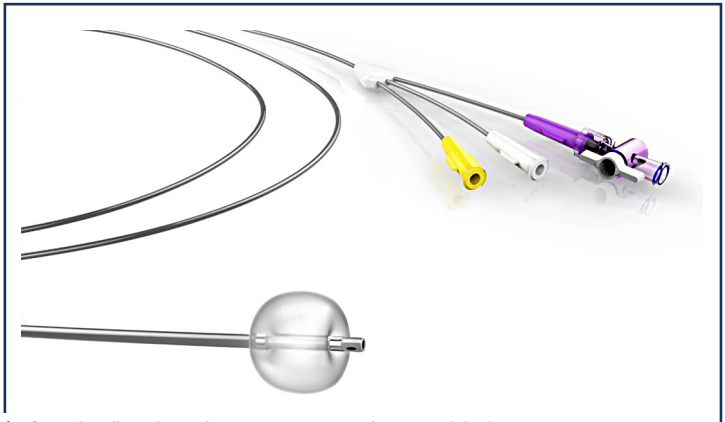


Fig. 1.8 Balloon for endoscopic extraction of common bile duct stones

Metal wire baskets have four strings (most often) in the shape of a rhombus, baskets differ in length and opening size (**Fig. 1.9**). Spiral baskets and baskets with or more than 4 strings are less commonly used.

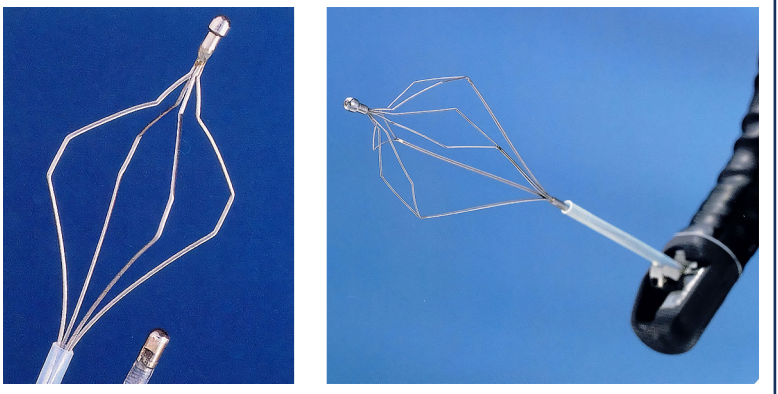


Fig. 1.9 Baskets for endoscopic extraction of common bile duct stones

To crush stones, mechanical lithotripters are used, which, in fact, are different versions of the reinforced Dormia-type basket. The lithotripter has a metal outer shell and is equipped with a special handle, which allows to create a significant force when closing the basket, sufficient to destroy the stone. The most common are lithotripters from Olympus, Cook, Boston Sientific (**Fig. 1.10**).

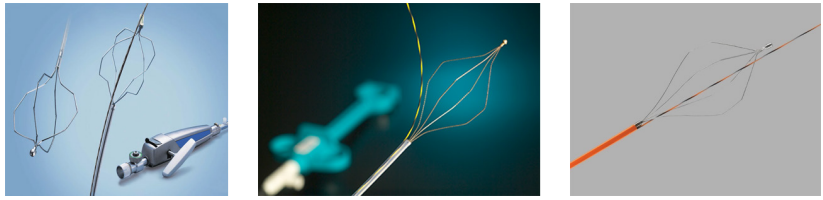


Fig. 1.10 Mechanical lithotriptors

In some cases – with benign and malignant obstruction, difficult stones, cholangitis, biliary fistulas, it becomes necessary to decompress the biliary tree, which can be achieved by installing a nasobiliary drainage or stenting of the bile ducts.

Transpapillary nasobiliary drainage (NBD) can be performed not only for decompression, but also for lavage of the biliary tract. Nasobiliary dranages are tubes that are longer than twice the length of the endoscope (250 cm) and have a diameter of 1.6–3.0 mm (5–8 Fr). The distal end of the drain has several lateral holes. Different types of drains differ in shape, diameter and angle of the fixing bend (**Fig. 1.11**).

Fig. 1.11 Nasobiliary drainage

Endoprosthesis replacement (stenting) is used to restore the natural outflow of bile in patients with tumor biliary obstruction, Vater papilla tumor, benign strictures, sometimes in case when it

is impossible to extrect common bile duct stone. Pancreatic duct stenting is performed to prevent pancreatitis after ERCP, as well as in some cases of chronic pancreatitis and pancreatic fistulas.

For endoprosthetics, plastic and metal stents are used.

Standard plastic stents have a slightly curved shape and "antennae" at both ends, which are to fix the stent (**Fig. 1.12**). Their length varies from 3 to 15 cm, and their diameter varies from 1.5 to 4.0 mm (5–12 Fr). Pigtail type stents are mainly used for stones that cannot be removed in order to restore the outflow of bile (**Fig. 1.12**). The set for stent placement includes a guidewire and a pusher tube.

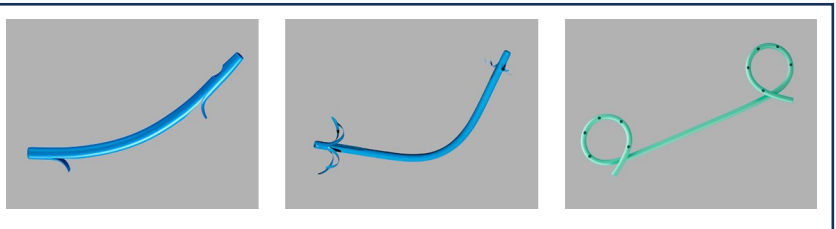


Fig. 1.12 Plastic stents of various designs

Another type of stent is metal stents, which are placed using stent and guidewire systems. They are installed in the stricture zone in the folded state, and then they expand either selfexpandeable or with the help of a balloon (**Fig. 1.13**). Metal stents can be covered or uncovered.

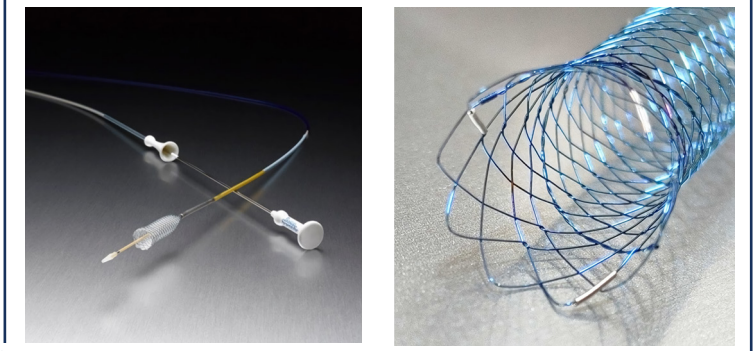


Fig. 1.13 Metal self-expanding stent system

In addition to the basic instruments described above, there are others for rare retrograde interventions (endoscopic sphincteromanometry, retrograde choledochoscopy, endosonography,

papilectomy), and there are also a lot of additional accessories and devices that facilitate the work of an endoscopist.

1.3 CHANGES DETECTED BY ERCP [2, 8]

ERCP begins with an examination of the MDP, which allows to assess its size, shape, the presence of a parapapillary diverticulum, the presence of edema and hyperemia, density – by "instrumental palpation", the state of the orifice, the presence of neoplasms, etc., as well as the outflow of the flow of bile from it.

Normally, the MDP has a round, oval or proboscis shape, its size does not exceed 1 cm, the mucosa does not visually differ from the duodenal mucosa. Above the MDP, like a hood, is framed by a fold, and from below there is most often a vertical fold – a frenulum. The extence of these folds is highly variable.

The absence of bile in the duodenum may indicate an obstruction of the biliary tract. The flow of purulent bile from the orifice of the MDP is an undoubted sign of purulent cholangitis.

When a parapapillary diverticulum is present, attention is paid to the location of the papilla, its deformation is assessed, as well as passage of bile from it. Parapapillary diverticulum presents in 7–11 % of patients, its size varies from 1.0 to 5.0 cm. MDP can be located at the bottom of the diverticulum, on one of the walls, or at the edge of the diverticulum; sometimes two diverticula are located on both sides of the MDP.

When examining the MDP zone, the following pathological changes can be detected: edema and hyperemia, an increase in size, a impacted stone with visualization of a stone at the orifice, MDP tumors, and pathological fistulas.

Edema and hyperemia of the MDP can be in case of cholangitis, a impacted stone of the MDP, biliary obstruction at the level of the MDP due to papillitis.

Enlarged papilla is also observed in case of papillitis, with impacted stone, or in case of tumor of the MDP.

MDP neoplasms (adenomas, adenocarcinomas) develop from the mucosa covering the MDP from the side of the duodenum or, more often, from the mucosal ampulla of the MDP ampulla (**Fig. 1.14**). Accordingly, the endoscopic picture will be different. Small tumors of the MDP ampulla will not have other endoscopic signs but its enlargement.

In case of the papilla cancer , there is always obstruction of the biliary tract and obstructive jaundice. A cancerous lesion of the MDP may look like a polypoid or infiltrative-ulcerative tumor of various shapes from 1.0 to 5.0 cm, which almost always bleeds upon contact with it. Bleeding from tumors is rarely severe, usually it is weak – capillary even when taking a biopsy or papillotomy. With adenocarcinoma larger than 2.0 cm, it is usually not difficult to made the correct diagnosis visually, in cases with small tumors of 1.0–2.0 cm, the final diagnosis is most often established after the biopsy.

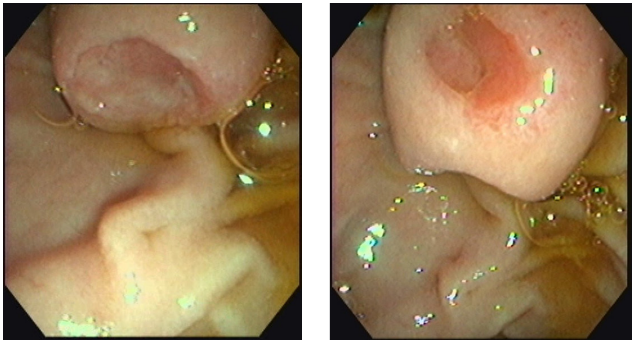


Fig. 1.14 MDP adenocarcinoma

Fistulas in the MDP area may be the result of a long-termimpacted stone in the distal common bile duct or in the ampulla. In addition, in severe destructive pancreatitis, fistulas with purulent cavities can form in the region of the pancreatic head.

After examining the MDP, as a rule, its cannulation is performed. ERCP can be performed with shallow cannulation, but in bile duct pathology, selective cannulation of the common bile duct followed by cholangiography is preferable, since cannulation of the MPD and pancteaticografy are risk factors of postERCP pancreatitis. If indicated, a contrast study of the pancreatic ducts is performed. Normally, the diameter of common bile duct does not exceed 8 mm (after cholecystectomy 10 mm), and MPD – 2 mm (**Fig. 1.15**).

Fig. 1.15 Normal ERCP

In general, changes of the ducts revealed by ERCP can be – dilatation, obstruction, narrowing, deformation of the contours, the presence of filling defects (usually stones), extravasation of the contrast (biliary or pancreatic fistulas, etc.).

Obstruction of the ductal system is characterized by narrowing of the lumen at the site of obstruction and proximal dilatation (**Fig. 1.16**). Deformation of the contour can be the result of intraluminal lesion (tumor), compression from the outside (tumor, chronic pancreatitis) or, less commonly, structuring, including postoperative changes (**Fig. 1.17**).

Fig. 1.16 Obstruction of common bile duct with proximal dilatation. The distal duct is not dilated

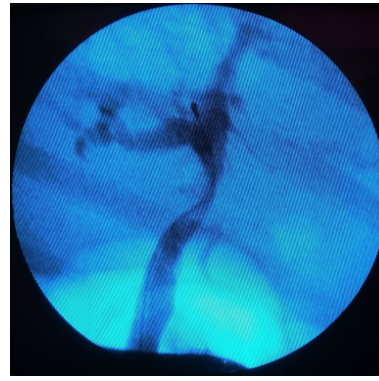


Fig. 1.17 Deformation and narrowing of the common hepatic duct

Stones in the lumen of the bile ducts or pancreatic duct are defined as filling defects (**Fig. 1.18**). Gallstones, as a rule, are moveable.

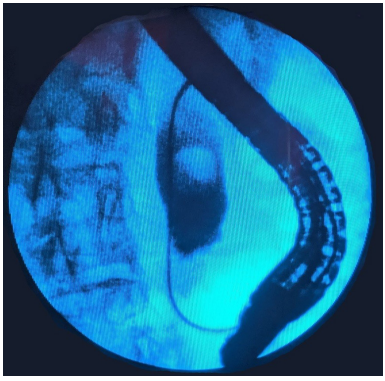


Fig. 1.18 Large stone in the common bile duct

For a correct interpretation, the data obtained by ERCP must be compared with the clinic, anamnesis, and, especially, with the data of other imaging methods (ultrasound, CT, MRI).

1.4 ERCP COMPLICATIONS

In general, being a safe procedure, in some cases ERCP can lead to complications. The complication incidence varies greatly depending on patient selection, operator experience, the nature of concomitant endoscopic interventions, and a number of other factors. According to various data, it ranges from 0.5 to 15 % [12, 13].

Complications associated with ERCP and endoscopic procedures include: acute pancreatitis, cholangitis, perforation, bleeding, and acute cholecystitis.

According to many researchers, the incidence of post-ERCP pancreatitis (PEP) is within 1–40 % of cases and depends on many factors: the nature of the disease, the type of endoscopic intervention, and the age of the patient. For example, young age, sphincter of Oddi dysfunction, absence of jaundice, history of acute pancreatitis, prior history of post-ERCP pancreatitis are factors that increase the risk of acute pancreatitis after ERCP [12–14].

Understanding the risk factors for PEP is essential to reduce the risk and improve the safety of the procedure. It is also important to identify high-risk patients prior to the procedure so that the procedure can be avoided if possible or the procedure time reduced to a minimum.

The exact pathogenesis of post-ERCP pancreatitis is not clear. Several mechanisms have been proposed in the literature. One of them is direct mechanical trauma, as a result of prolonged or complex manipulations with the instrument, for example, manipulations with the guidewire, cause swelling of the duct, leading to pancreatic outflow disorders. Another proposed mechanism is chemical damage due to contrast injection. Hydrostatic injury can also be caused by increased pressure in the pancreatic duct as measured by manometry. Infection resulting from bacteria from an endoscope or a contrast agent entering the pancreatic duct may also be another mechanism of injury. In addition, thermal injury may also result from the use of electrocautery during sphincterotomy [15, 16].

Criteria for the diagnosis of acute pancreatitis after ERCP and endoscopic interventions do not differ from those for the diagnosis of acute pancreatitis in general and include:

– abdominal pain;

– blood amylase / lipase level increase more than 3 times;

– data characteristic of acute pancreatitis according to imaging research methods (ultrasound, CT, MRI).

The presence of at least two of these signs within 24 hours after ERCP is indicative of acute pancreatitis [15, 16].

When acute pancreatitis after ERCP confirmed, the severity of the disease should be assessed immediately, as this affects the treatment and determines the prognosis [16].

With regard to acute pancreatitis after ERCP, preventive measures can be tactical, medical and technical.

Tactical measures include the selection of patients who are indeed indicated for ERCP after using other, non-invasive imaging methods [17].

A large number of different agents have been proposed as drug prophylaxis. A proven tool that significantly reduces the incidence of acute pancreatitis after ERCP is the use of nonsteroidal anti-inflammatory drugs (diclofenac, indomethacin) per rectum [17, 18].

Bleeding is another serious complication associated with ERCP. The frequency of bleeding after ERCP is estimated at 0.3–2 %.

Bleeding can be further classified as insignificant or clinically significant based on a change in hemoglobin and the absence/presence of overt gastrointestinal bleeding.

The most common reported causes of the ERCP bleeding is endoscopic sphincterotomy. Patient-related risk factors for post-sphincterotomy bleeding include coagulopathy, use of anticoagulants within 3 days of ERCP, and active cholangitis [12, 14, 19].

Cholangitis is well-known complications of ERCP, with an incidence of 0.5 % to 3 %. Clinical presentation includes fever, jaundice, and abdominal pain, and occasionally hypotension and altered mental status in severe cases [12, 14].

Risk factors are old age, previous ERCP history, and hilar obstruction. Patients with incomplete biliary drainage or prior history of liver transplantation have the highest risk of post-ERCP cholangitis [20, 21].

The risk of cholangitis can be up to 10 % in patients who have retained stone fragments following mechanical lithotripsy. Previously placed stents may also become obstructed (due to stone fragments, bacterial biofilm, sludge, tumor or tissue growth) and block the lumen of the stent, resulting in delayed infection. Furthermore, in patients with an obstructed bile duct, stent migration may occur and result in cholangitis. Of note, metal stents are associated with fewer risks.

To reduce the risk of post-ERCP cholangitis antibiotics before ERCP are recommended for patient with a history of liver transplantation or in case of suspected biliary obstruction that may be incompletely drained. However, routine use of antibiotics before ERCP is not recommended [21, 22].

Post-ERCP **cholecystitis** is not common complication and has been reported with an incidence of 0.5 %. Though not common, early recognition of Post-ERCP cholecystitis is vital as it can lead to significant morbidity such as purulent cholecystitis requiring emergent cholecystectomy. The pathogenesis involves contamination of the gallbladder by nonsterile contrast [12, 14, 23].

The risk factors for post-ERCP **cholecystitis** occurrence within 2 weeks include a history of acute pancreatitis, history of chronic cholecystitis, gallbladder opacification, biliary duct metallic stent placement, high leukocyte counts before ERCP, presence of stones in the gallbladder and having contrast fill the gallbladder during the procedure [23, 24].

The most crucial measure for prophylactic acute cholecystitis is endoscopic gallbladder drainage, which has proven to be effective and safe. Prophylactic antibiotics also may be useful.

Treatment of post-ERCP cholecystitis typically involves surgery or percutaneous cholecystostomy, and in nonsurgical candidates, transpapillary and EUS-guided gallbladder drainage may additionally be considered as treatment options.

1.5 COMMON BILE DUCT STONE

For more than 30 years, ERCP has been the "gold standard" in the diagnosis and treatment of choledocholithiasis. In most centers where ERCP is performed, treatment of common bile duct stones is routine. It includes cholangiography, in which the size, number and location of stones are assessed. Access to the common bile duct is provided by endoscopic sphincterotomy and/or balloon dilatation of the MDP. Extraction of the stone is carried out with a basket or balloon. When the size of the stone exceeds the size of the papillotomy hole, mechanical lithotripsy can be used. In case of multiple or "difficult" stones, several sessions are sometimes required for complete removal of stones [25].

In cases of "difficult stones", in addition to standard mechanical lithotripsy, balloon dilatation, peroral cholangioscopy with laser lithotripsy, electrohydraulic lithotripsy, stenting, or surgical treatment can be used [26, 27].

In general, the efficiency of endoscopic stone removal is more than 90–95 % [25–27]. One of the most difficult forms of choledocholithiasis for endoscopic treatment are patients with Mirizzi

syndrome – with cholecystobiliary fistula [8, 25, 28]. The features of ERCP in Mirizzi syndrome will be described in more detail below.

Our own experience also shows high efficiency in the treatment of choledocholithiasis. Retrospective analysis of the treatment of 302 patients with choledocholithiasis. Of these, acute cholangitis was in 29 (9.6 %), acute biliary pancreatitis in 15 (5 %), in 4 (1.3 %) cholangitis was combined with biliary pancreatitis. There were 106 men (35.1 %), women – 196 (64.9 %). The age of the patients was from 21 to 91 years (64.2 ± 14.7).

In general, restoration of bile outflow was achieved in 300 (99.4 %) patients, complete removal of stones was carried out in 290 (96 %) patients. In case of Mirizzi syndrome (MS) with cholecystobiliary fistula – stone removal was achived only in 4 out of 12 patients. Among 290 patients with choledocholithiasis (excluding MS), lithoextration was not performed in 8 (2.8 %) cases: due to the size and location of the stones (7) and because of the paraparillar diverticulum (1).

Complications after endoscopic interventions were: pancreatitis – 5 (1.7 %) patients, bleeding – 6 (2 %), perforation – 2 (0.7 %), acute cholecystitis – 3 (1 %). Of the 302 patients, 4 (1.3 %) died – from complications of biliary pancreatitis (1), cholangitis (1), cardial felure (1), as a result of perforation followed papillotomy (1).

Thus, our results showed that ERCP and endoscopic interventions allow complete removal of common bile duct stones in 96 % of patients with choledocholithiasis. The most difficult form of choledocholithiasis for endoscopic treatment is MS. Mortality is associated with complications of endoscopic interventions 0.3 %.

1.6 MIRIZZI SYNDROME

Mirizzi syndrome is severe complication of cholelithiasis and is due to developed inflammatory and degenerative changes between the wall of the gallbladder and common bile duct. Among patients with cholelithiasis, MS occurs in 0.2–5.0 % of cases [29].

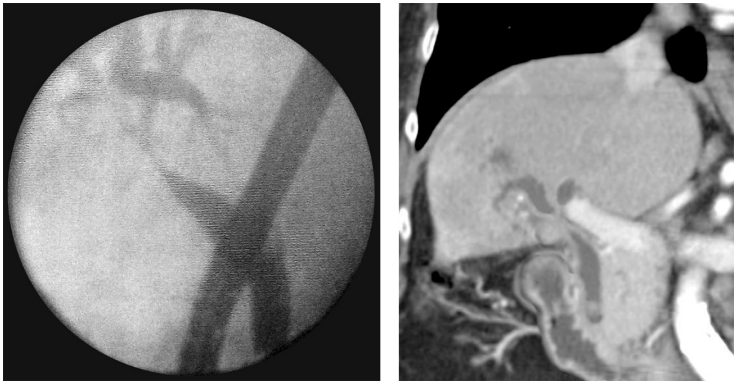
In 1948, Pablo Luis Mirizzi first described the common bile duct obstruction as a result of its compression by a stone impacted in the neck of the gallbladder [30]. Subsequently, not only this condition, but also the formation of a fistula between the lumen of the gallbladder and common bile duct with stones migration and cholestasis began to be called by the name of this surgeon.

The pathophysiological aspects of the development of MS are not completely clear. It is indisputable that it develops as a result of chronic inflammation of the gallbladder with symptoms of pericholecystitis, involvement in the inflammatory process of the hepatoduodenal ligament, which results in compression of the hepaticocholedochus at first, and then, as a result of a bedsore, the formation of a fistula between the lumen of the gallbladder and hepaticocholedochus [29]. However, the predisposing factors contributing to this are not entirely clear.

Diagnosis of MS is based on the detection of compression of the common bile duct by the gallbladder or its duct, the presence of a fistula between the gallbladder and common bile duct with stones, mainly using ERCP, MRI, CT and evaluation of intraoperative data [8, 29]. Preoperative diagnosis of MS is extremely important in terms of choosing the method of treatment and prevention of intraoperative damage to the bile ductsr and vascular structures.

There are several classifications of Mirizzi syndrome: McSherry, C. (1982), Csendes, A. (1989, 2007), Nagakawa, T. (1997), Nechitailo, M. (2005), Khvorostov, E. (2020) [31, 32]. The main factor underlying them is the presence or absence of a fistula between the gallbladder and bile ducts. This was the principle in creating the first, most common and practically convenient McSherry classification (1982): Type I – compression of the common bile duct by a stone located in the bladder itself, its neck or cystic duct; Type II – formation of a fistula between the gallbladder and common bile duct with its obstruction by a calculus [31].

With Type I MS, compression of hepaticocholedochus is most often localised in its middle third – in the area adjacent to the gallbladder. However, compression can be legalized both high, up to the hilum of the liver (**Fig. 1.19**), and low – in case of low confluence of the cystic duct. In addition, compression of the common bile duct can also be after cholecystectomy – by a stone in the stump of the cystic duct or by the stump itself.



a *b*

Fig. 1.19 Mirizzi syndrome Type I with compression of the confluence of the hepatic ducts: *a* – ERCP; *b* – CT reconstruction

Therapeutic endoscopic procedures in case of Type I MS can be nasobiliary drainage, stenting, or dilatation of the obstruction.

In order to exclude the tumor nature of the obstruction and clarify the anatomical features, it is advisable for patients with Type I MS to perform CT scan.

In most cases, Type II MS, the fistula between the gallbladder and common bile duct is located on the level of the proximal and middle third (**Fig. 1.20**). But the localization of the fistula can be detected both high (**Fig. 1.21**) and low (**Fig. 1.22**).

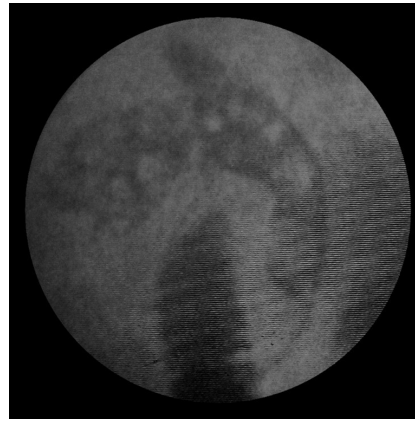


Fig. 1.20 Type II MS with multiple stones and fistula at the level of the proximal and middle third of the common bile duct

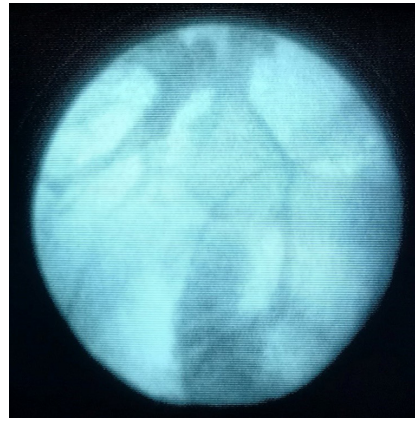


Fig. 1.21 Type II MS with a fistula and a large stone at the level of the proximal and middle third of the common bile duct with involvement of confluence

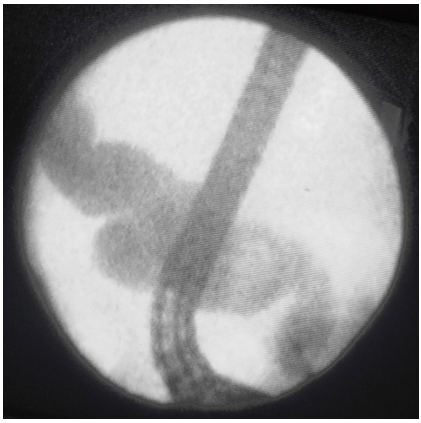


Fig. 1.22 Type II MS with a fistula and a stone at the level of he distal third of the common bile duct

The number and size of stones in Type II MS varies significantly – there can be a single large stones or multiple stones of different sizes.

The formation of a fistula between the gallbladder and common bile duct with "falling out" of stones leads to biliary obstruction – partial or complete. The proximal ducts are always dilated. However, the distal part of the common bile duct may or may not be dilated.

In our opinion, in Type II MS, it is advisable to distinguish subtype A – without dilatation of the common bile duct distal to the fistula, subtype B – with dilatation of the duct distal to the fistula (**Fig. 1.23**).

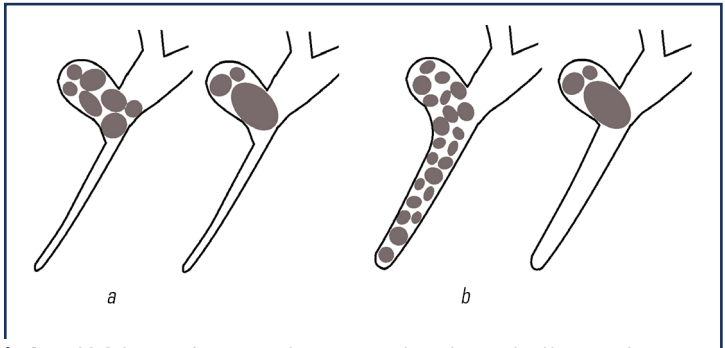


Fig. 1.23 Subtypes of Mirizzi syndrome Type II, depending on the dilatation of the distal common bile duct: *a* – subtype II A; *b* – subtype II B

This division is associated with the possibility of endoscopic lithoextraction – with an dilated distal duct – in Type II B, it is doable. In Type II A endoscopic lithoextraction is unlikely to be done.

In MS II, if lithoextraction has been failed, NBD or stenting can be performed, providing biliary decompression. If endoscopic stone removal is not possible, surgery should be considered, and this is contrindication for surgery, stenting should be done.

The analysis showed that both compression of the common bile duct in MS Type I and fistula in Type II can be observed throughout all lenghth of the extrahepatic biliary tract. The atypical confluence of the cystic duct, identified in patients with MS Type I, indicates that close contact of the bladder neck with common bile duct, with variant anatomy of the cystic duct, in conditions of recurrent inflammation of the gallbladder and involvement of the hepatoduodenal ligament, creates the prerequisites not only for compression of the common bile duct, but also to the subsequent formation of a cholecystobiliary fistula – MS Type II (**Fig. 1.24**). The observed different, especially low localization of compression in type I and fistula in type II indirectly indicates the role of atypia (variant anatomy) of the cystic duct confluence in the MS formation.

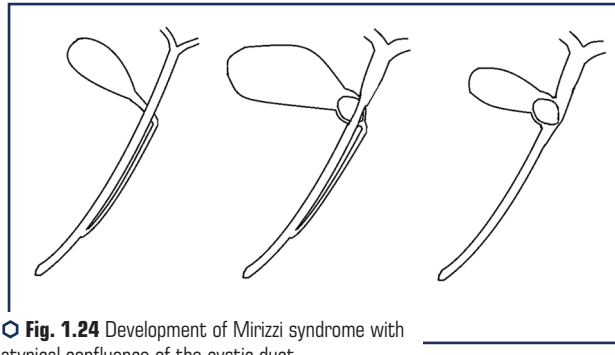


Fig. 1.24 Development of Mirizzi syndrome with atypical confluence of the cystic duct

An analysis of our experience of management of 17 patients with MS showes that out of 5 patients with Type I MS, endoscopic interventions, in addition to ERCP, included endoscopic sphincterotomy in 4 patients, NBD in 3, and stent placement in 1 case. There were no complications after ERCP. It should be noted that in 2 out of 5 cases of Type I MS, had acute cholecystitis, so the compression of the common bile duct was caused by an enlarged inflamed gallbladder.

Of the 12 patients with Type II MS, subtypes II A and II B were distributed equally – 6 patients each. In case of MS II A, in addition to ERCP, all patients underwent endoscopic sphincterotomy, for biliary decompression in 5 patients, NBD was used, and in 1 case, stenting was performed. In MS II B, lithotripsy and lithoextraction were performed in 4 out of 6 cases. NBD was placed in one patient, stent was placed in another.

Of the 17 patients with MS, complications after ERCP occurred in one (cholangitis). There were no lethal cases.

Seven patients with MS II were operated on.

1.7 TUMOR OBSTRUCTION OF THE BILIARY TRACT

The main causes of tumor obstruction of the biliary tract are pancreatic head cancer, papilla cancer, cholangiocarcinoma, gallbladder cancer. A more rare cause is a metastatic lesion of the lymph nodes of the hilum of the liver and hepatoduodenal ligament, the sources of which are malignant tumors of other localizations (stomach, colon, etc.) [33]. Painless jaundice is the main clinical feature in patients with tumor biliary obstruction. The main method of treatment of malignant tumors accompanied by biliary obstruction is surgical – radical intervention. Preoperative drainage of the bile ducts is aimed at eliminating jaundice, normalizing liver function and thus reducing the incidence of perioperative complications [34, 35]. If it is necessary to carry out neoadjuvant chemotherapy, a prerequisite is the normalization of liver function, which, in the presence of obstructive cholestasis, is possible only with the restoration of the passage of bile. By the time of the initial hospitalisation about 40–50 % of patients with tumor biliary obstruction need only palliative treatment, the main goal of which is to restore the outflow of bile [33].

ERCP allows to determine the location and extent of the obstruction. In order to decompress the bile ducts in malignant biliary obstruction, bypass biliodigestive anastomoses, percutaneous biliary drainage and endoscopic drainage could be used. Due to the less invasive intervention, ERCP and endoscopic drainage are preferred [33]. For this purpose, nasobiliary drainage and placement of plastic or metal stents are used [2, 8, 33]. Preference is given to metal stents, because plastic stents need to be changed after 1.5–4 months [33, 35].

The effectiveness of endoscopic drainage in tumor obstruction of the distal choledochus is 80–95 %. In Klatskin tumors, the effectiveness of endoscopic drainage is somewhat less, and the likelihood of developing cholangitis is higher. In MDP tumors, the efficiency of endoscopic drainage exceeds 90 % [33].

Our results show that out of 67 patients with malignant biliary obstruction who underwent ERCP, endoscopic decompression was achieved in 56 (80 %).

Complications occurred in 6 (9 %) of 67 patients: cholangitis – in 3 patients, acute pancreatitis – in 2 patients, and in another patient, non-severe bleeding from the EPST wound.

Of the 11 patients with unsuccessful endoscopic decompression, 6 used percutaneous drainage, 3 – bypasses, and another 2 used symptomatic therapy. Twenty three (34.3 %) patients underwent radical surgical treatment. 5 patients died – 4 from multiple organ failure (in 2 cases after drainage, 2 without drainage of the biliary tract) and one – in the postoperative period – after radical surgical treatment.

1.8 CHRONIC PANCREATITIS

Chronic pancreatitis (CP) is an irreversible inflammatory process leading to destruction and fibrotic changes in the pancreatic parenchyma with impaired exocrine and endocrine functions [36].

In CP, ERCP can play 2 main roles – diagnosis – with insufficient information content of other methods and therapeutic. The purpose of the latter is drainage of the common bile duct in case of its compression or intervention on the main pancreatic duct aimed at its decompression and/or removal of stones [2, 8].

ERCP is sensitive for detecting ductal changes in CP, but cannot assess parenchymal changes. In general, pancreatography reveals dilatation, strictures and irregular contour, filling defects (stones), communication of the duct with pancreatic cysts, etc. However, the diagnostic value of ERCP in identifying these findings is of low sensitivity and specificity, yielding to CT and MRI. In some cases, CP with wirsungography does not show obvious changes [36].

In CP, MPD obstruction was caused by strictures (47 %), stones (18 %), or a combination of both (32 %) [2].

MPS strictures may be single or multifocal. Most strictures occur in the head of the pancreas. Endoscopic treatment of strictures may include dilatation and stenting. At the same time, to provide access, a dissection of the mouth of the MPD is mandatory. The effectiveness of endoscopic treatment of isolated strictures is 65–80 %. The more numerous the stricture, the lower the clinical effectiveness of endotherapy. The presence of virsungolithiasis is always accompanied by MPD strictures. Complete or partial elimination of symptoms after pancreatic sphincterotomy, dilatation of strictures and mechanical extraction of the stone is observed only in 50 % to 67 % of patients.

At the same time, the effectiveness of endoscopic drainage that occurs in CP compression of the common bile duct is high and amounts to more than 90 % [2, 8, 36].

1.9 OTHER USES OF ERCP

ERCP is used in the diagnosis and treatment of postoperative bile duct injuries and allows determining the level of damage and the source of bile leakage. The latter is possible only with marginal injuries of the bile ducts or insufficiency of the cystic duct, that is, in those cases where the continuity of the bile tree is not broken. In the same cases, endoscopic treatment is successfully used, which is aimed at creating conditions for the fistula closing. This is most commonly achieved with sphincterotomy, endoscopic stenting, or NBD. The effectiveness of these measures in this cases is 80–95 % [37, 38].

Similarly, ERCP can be used for pancreatic fistulas after pancreatic surgery, such as distal pancreatic resection. Pancreatography allows visualization of contrast extravasation. Therapeutic interventions include sphincterotomy, stenting, or transnasal drainage of the MPD [2, 8].

In postoperative biliary strictures, ERCP allows to determine the location and extent of the stricture, and endoscopic treatment of patients includes: endoscopic balloon dilatation and/or placement of biliary stents, including several of them at the same time.

The efficiency of primary endoscopic treatment is high – 80–94 %. However, these patients develop complications in 20–33 %, mainly cholangitis, which is associated with prolonged use of stents. Approximately 25 % of patients after removal of stents develop a recurrence of the stricture [2, 8].

CONCLUSIONS

Summing up, it is possible to conclude that the technological capabilities of ERCP and related endoscopic interventions have now reached a plateau in their development. Nowadays despite the limited diagnostic potential, due to advances in CT and MRI, ERCP is the gold standard in the diagnosis and, especially, treatment of common bile duct stones, and is the method of choice for decompression in malignant biliary obstruction. ERCP may be useful in some cases of chronic pancreatitis, biliary and pancreatic fistulas.

Further development of ERCP, apparently should be associated with the prevention of complications, clarification of indications for certain methods of treatment, as well as the development at the combination of various methods – ERCP, endoultrasound, cholangio-, pancreatoscopy, etc.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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