Cholangioscopy for biliary diseases

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REVIEW

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Aymeric Becq[a], Adil Soualy[b] and Marine Camus[c]

Purpose of review

Cholangioscopy is a mini-invasive endoscopic procedure, which consists in a direct intraductal visualization of the biliary tract. The purpose of this review is to summarize the technique, the clinical applications, as well as future perspectives of cholangioscopy.

Recent findings

Numerous technologic advances during the last decades have allowed for an improved utility and functionality, leading to a broader use of this procedure, for diagnostic or therapeutic purposes, in the setting of biliary diseases. Novel tools and emerging indications have been developed and more are yet to come.

Summary

Cholangioscopy can be performed by peroral, percutaneous transhepatic or intra-operative transcystic or transcholedochal access. Clinical applications of cholangioscopy are multiple, ranging from visual impression and optical guided biopsies of indeterminate biliary strictures to the management of difficult stones , guidance before biliary stenting and retrieval of migrated ductal stents. Multiple devices such as lithotripsy probes, biopsy forceps, snares and baskets have been developed to help achieve these procedures successfully.

Cholangioscopy has improved the way biliary diseases can be visualized and treated. New technology, accessories, and applications are expected in the future.

Keywords

benign biliary stricture, biliary stones, cholangioscopy, endoscopic retrograde cholangiopancreatography, malignant biliary stricture

INTRODUCTION

Cholangioscopy or choledochoscopy is an endoscopic procedure, which consists in a direct intraductal visualization of the biliary tract. It was first developed during the 1970s. Improvements made over the years have allowed for a broader use of this procedure, for diagnostic or therapeutic purposes, in the setting of biliary diseases [1]. This technique is set to be increasingly utilized in the future, as demand is rising and most interventional endoscopists are getting accustomed to its use and indications demand.

Applications are multiple, ranging from visual impression and optical guided biopsies of indeterminate biliary strictures (as recommended by the European Society of Gastrointestinal Endoscopy [ESGE]) to difficult stone management, guidance before biliary stenting and retrieval of migrated ductal stents [2,3▪▪].

In clinical practice, a prospective multicenter study, published in 2022 including 369 patients showed that this procedure is performed for diagnostic and therapeutic purposes in the same proportion, with a success rate of 97.6%. Adverse events, mostly of mild or moderate severity, occur in 10% of cases, which is comparable to standard endoscopic retrograde cholangiopancreatography (ERCP) [4].

In this review, we will focus on the technical aspects of this procedure, its indications in the setting of biliary diseases, as well as its most recent innovations.

TECHNIQUES

Cholangioscopy can be performed by peroral (POCS), percutaneous transhepatic (PTCS) or intra-operative transcystic or transcholedochal access with various devices [2] (Fig. 1 and Table 1).

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KEY POINTS

- Cholangioscopy or choledochoscopy is an endoscopic procedure, which consists in a direct intraductal visualization of the biliary tract.
- Cholangioscopy can be performed by peroral (mainly), percutaneous transhepatic or intra-operative transcystic or transcholedochal access.
- The development of digital single-operator cholangioscopy using a single-use cholangioscope has changed and improved utility and functionality of cholangioscopy these last 10 years.
- Applications are multiple: indeterminate biliary strictures, difficult stone management, guidance before biliary stenting and retrieval of migrated ductal stents.
- In case of indeterminate biliary strictures, cholangioscopy with guided biopsy during the first endoscopic retrograde cholangiopancreatography may reduce the need to perform multiple procedures.

Regarding POCS, the most frequent modality (indirect POCS), a cholangioscope is advanced over a guidewire through the working channel of a duodenoscope, into the common bile duct ('mother–baby' endoscope system). This is performed during an ERCP and requires prior biliary cannulation, sphincterotomy and a fluoroscopy guided cholangiogram so as to ensure proper positioning within the biliary tracts, before the cholangioscope can be advanced. A cholangioscope can also be advanced into the bile ducts through an extra-anatomical stent (lumen apposing stent, hepaticogastric stent) [5,6]. Digital single-operator cholangioscopy using a SpyGlass© cholangioscope (Boston Scientific, Boston, USA) is the most frequently performed POCS [7].

POCS can also be performed as direct POCS without the use of a duodenoscope. In this case, an ultra-slim endoscope is directly advanced into the bile duct. The main disadvantage is a large outer diameter (5.0–5.9 mm), which may complicate insertion and advancement in small bile ducts [2]. However, a new multiband ultra-slim endoscope seems to yield a high technical success rate [8].

Regarding PTCS, shorter endoscopes with better maneuverability are used (such as CHF-CB30; Olympus Medical Systems, Tokyo, Japan), allowing access to areas that are less easily attainable perorally. These procedures are useful in case of complicated anatomy (i.e. surgically altered anatomy), when POCS is not doable. This is considered second line procedure as it is more invasive, time-consuming and risky (bile leak) compared to POCS [2].

POCS should be performed in a dedicated endoscopy unit, by experienced endoscopists and nurses, knowledgeable on the manipulation of this specific equipment. The patient is under general anesthesia. It is a low risk procedure. However, given the higher risk of cholangitis compared to standard ERCP, prophylactic antibiotics are mandatory [2].

The single-operator POCS cholangioscope has a 1.2-mm working channel through which a variety of accessories can be advanced into the biliary tract under direct visualization: biopsy forceps for tissue sampling, retrieval snare or baskets for stone fragment or foreign body extraction, electrohydraulic or laser lithotripsy probes for stone fragmentation [9].

INDICATIONS

Difficult bile duct stones removal

In 10–15% of the cases, the removal of bile duct stones is not possible using basic ERCP techniques

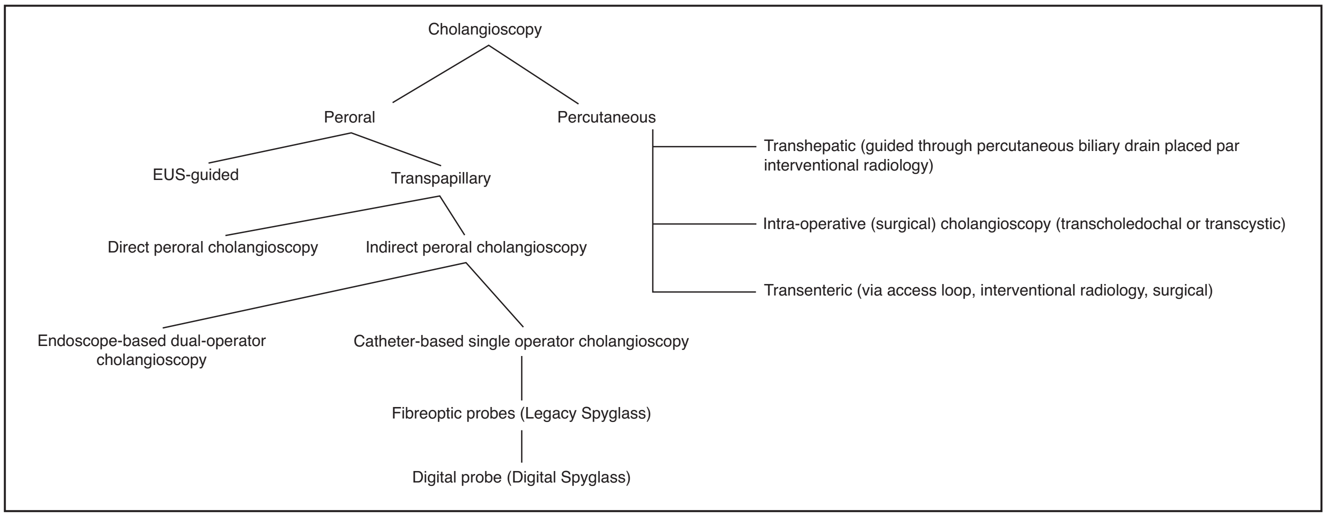

FIGURE 1. Different access routes for cholangioscopy.

Table 1. Different types of peroral cholangioscopes

	Peroral – dual-operator	Peroral – single-operator	Direct peroral choledochoscopy
Endoscopes (fibreoptic or digital-based imaging systems)	SpyGlass Legacy 2007 (Boston Scientific Corporation, Natick, MA, USA) (Fireoptic) SpyGlass Direct Visualisation 2015 (Boston Scientific Corporation, Natick, MA, USA) (Digital) SpyGlass Direct Visualisation II 2018 (Boston Scientific Corporation, Natick, MA, USA) (Digital)	Mother-baby (fibreoptic) Short-access-mother-baby (Karl Storz, Tuttlingen, Germany) (Fibreoptic) Videocholangioscope (CHF-B290; Olympus Medical Systems, Tokyo, Japan) (Digital)	Using variety of ultra-thin endoscopes (fibreoptic or digital)
Outer diameter (mm)	3.3–3.6	2.8–3.4	5.0 – 5.9
Accessory working channel diameter (mm)	1.2	0.8 – 1.5	2.0
Tip deflections	4-way (up-down, left-right)	2-way (up-down)	4-way (up-down, left-right)

(endoscopic sphincterotomy, large-balloon dilation, basket or balloon extraction). These are called difficult biliary stones [10]. Multiple factors can contribute to a difficult extraction, such as stone characteristics (size > 15 mm, number of stones, odd shaped stones), location (intrahepatic duct, cystic duct) and patient-related factors (old age, anticoagulation). ESGE guidelines suggest the use of cholangioscopy-assisted intraluminal lithotripsy for difficult bile duct stones, after sphincterotomy has failed, combined with endoscopic papillary large-balloon dilation [11▪▪].

POCS lithotripsy is a highly effective treatment with shorter and fewer necessary procedures to obtain ductal clearance [12–15] (Fig. 2). Adverse event rates are similar compared to conventional ERCP, including pancreatitis (2%) cholangitis (4%) and perforation (1%) [16]. However, POCS is less costly compared to repeat ERCPs, and is noninferior and less invasive compared to laparoscopic common bile duct exploration [17,18].

Intraluminal lithotripsy can be done by means of two distinct techniques: electrohydraulic and laser lithotripsy. Electrohydraulic lithotripsy uses a specific probe producing high-frequency hydraulic pressure waves when a charge is applied, causing fragmentation of the stone. Laser lithotripsy uses a different probe focusing a laser light on the surface of the stone to induce wave-mediated fragmentation. Both techniques can be repeated until

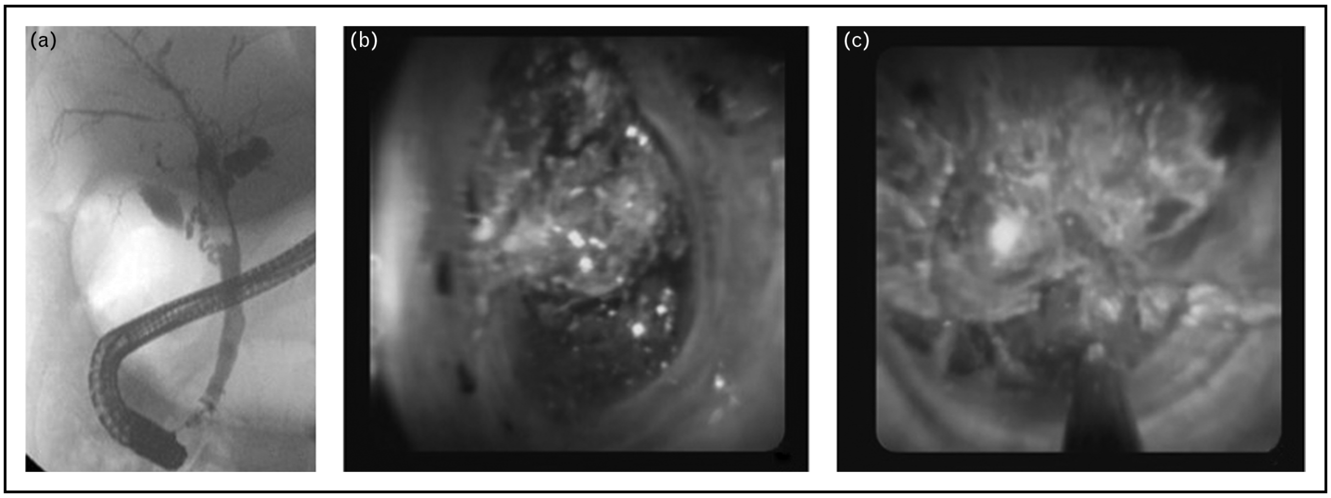

FIGURE 2. Example of a difficult stone extraction treated by cholangioscopy. (a) Endoscopic retrograde cholangiopancreatography (ERCP) showing large bile duct stone. (b, c) Digital cholangioscopic imaging of the stone, treated by lithotripsy under cholangioscopy guidance.

fragmentation is complete. Continuous saline irrigation is required to maintain proper visualization and avoid bile–duct wall damage. At the end of the procedure, stones fragments are extracted using the conventional techniques (i.e. balloon catheters). The rates of total bile duct clearance seem equivalent in retrospectives studies (96.7% for electrohydraulic and 99% for laser lithotripsy) and a single session is required in 77.4% of cases [19]. However, recent data including two meta-analyses suggest that laser lithotripsy had a higher complete ductal clearance rate than electrohydraulic lithotripsy (95.1% vs. 88.4%), with a shorter mean procedure time (49.9 vs. 73.9 min) [15,20]. Also, it was reported that the adverse event rate was significantly higher with electrohydraulic lithotripsy (13.8% vs. 9.6%) [21]. Electrohydraulic probes have a short life duration and need to be replaced proportionally to the power used during lithotripsy, contrary to laser light probes, which are more expensive and available in only a few endoscopy units. These studies did not explore the mean number of probes used and their economic impact. Cost-effectiveness studies are warranted. Currently, there are no data supporting the superiority of one method over the other and guidelines suggest that the choice of lithotripsy technique should depend on local availability and expertise only [11▪▪,22].

Mirizzi syndrome is an extrinsic compression of the common bile duct due to impacted stone(s) in cystic duct. Conventional ERCP techniques are often unable to achieve stone extraction, which may result in laparoscopic management with significant morbidity. Cholangioscopy-assisted intraluminal lithotripsy is an efficient technique for cystic duct stone clearance, so as to achieve bile duct decompression [23].

Bile duct stones removal in patients with surgically altered anatomy is challenging. The main limitation is failure/difficulty to reach the papilla. In patients with a Billroth II or Roux-en-Y reconstruction, a long and/or sharp angled afferent limb, increases the difficulty in reaching the papilla [24]. ERCP and enteroscopy assisted ERCP fail in 15% of cases in this setting.

Two techniques have been described to overcome these drawbacks: percutaneous transhepatic (PTCS) and endoscopic ultrasound (EUS)-guided biliary drainage. Percutaneous transhepatic biliary drainage is a well described second line procedure, after ERCP has failed. However, anterograde extraction of bile duct stones can be difficult, especially in case of large or multiple stones. PTCS allows for an anterograde electrohydraulic or laser intraluminal lithotripsy. Stone fragments are then pushed in the duodenum after papillary dilation [25,26]. The procedure cannot be done in a single session because prior dilatation of the percutaneous tract is necessary to allow passage of the cholangioscope. Cholangioscopy should not be done immediately after the percutaneous tract has been created. The external biliary drain is removed a few days after duct clearance is confirmed.

EUS-guided biliary drainage consists in creating an hepaticogastrostomy between the left intra-hepatic ducts (which need to be dilated) and the stomach. A metal stent is placed and POCS lithotripsy can then be performed through the stent [27]. In gastric bypass with Roux-en-Y reconstruction patients, EUS guided gastro-gastrostomy between the stomach pouch and the excluded stomach, with lumen apposing metal stent placement, allows the advancement of a duodenoscope into the duodenum, similar to conventional ERCP. Stone fragmentation and extraction can then be performed via the POCS technique, which represents a dramatic improvement in the prognosis.

Indeterminate biliary stricture and biliary tract neoplasia

Biliary strictures which remain unclassified (i.e. benign vs. malignant) after cross-sectional imaging and ERCP-based tissue sampling are defined as indeterminate biliary strictures. Diagnosis of malignant biliary strictures is very challenging. Cytologic or tissue samples obtained during ERCP by brushing, biopsies, or both are limited by a poor sensitivity, of roughly 50%. Cholangioscopy provides direct visualization of strictures and allows for targeted biopsies, which may help to diagnose or rule out malignancy in case of indeterminate strictures [28,29] (Figs. 3 and 4). When available, direct visual assessment and guided biopsies via cholangioscopy during the first ERCP may reduce the need to perform multiple procedures [30]. However, POCS is not the preferred procedure in case of distal biliary strictures, due to inherent technical difficulties.

In a systematic review, including 13 original articles (876 patients) the diagnostic yield of digital/video cholangioscopes for the diagnosis of indeterminate biliary stricture was evaluated. The overall pooled sensitivity and specificity were 88% (95% confidence interval [CI] 83–91) and 95% (95% CI 89–98), respectively. Subgroup analysis showed that visual impression provided significantly higher sensitivity (93% (95% CI 88–96) vs. 82% (95% CI 76–87); $P = 0.007$), but lower specificity 86% (95% CI 75–92) vs. 98 (95% CI 95–99); $P < 0.001$) than the tissue diagnosis from cholangioscopy-guided biopsies [31▪▪]. Thus, decision of surgical management

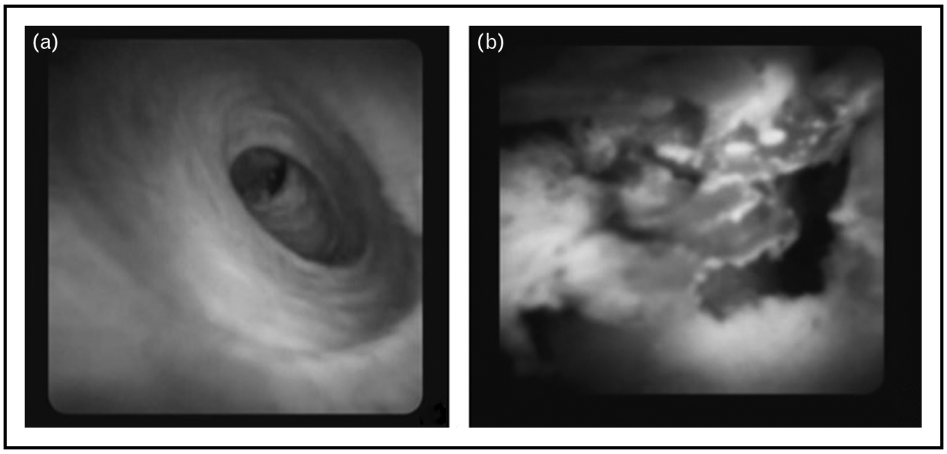

FIGURE 3. Example of peroral digital single operator cholangioscopic imaging. (a) Digital cholangioscopic imaging of normal bile duct. (b) Digital cholangioscopic imaging of a common bile stricture, biopsied with SpyBite^{TM} biopsy forceps, confirmed to be cholangiocarcinoma (CCA).

could take into consideration the endoscopist's visual opinion on an indeterminate biliary stricture. Tumor vessels, papillary projection, nodular or polypoid mass, and infiltrative lesions are highly suggestive of neoplastic/malignant biliary disease [32,33▪,34,35]. Image enhancement during cholangioscopy may increase the diagnostic sensitivity of visual impression of malignant biliary strictures [36]. However, the interpretation of indeterminate biliary stricture is difficult, with well known interobserver variation [37]. Cytology of aspiration fluid from the irrigation performed during cholangioscopy and cholangioscopy guided biopsies significantly improves the sensitivity for detecting malignancy [38]. Future development of AI tools may optimize the macroscopic characterization of biliary strictures [39–41].

Although cholangioscopy is very useful in cases of indeterminate biliary stricture, the accuracy of cholangioscopy biopsies to identify the extension of biliary tract cancer into the biliary tract was consider insufficient in two retrospective studies of 23 patients and 54 patients [42,43].

Finally, cholangioscopy allows an early diagnosis of premalignant lesions (i.e. biliary papillomatosis) of the bile duct, thus enabling early treatment [44,45] and dramatic improvement of the prognostic of these rare diseases.

Migrated foreign bodies

Cholangioscopy can be useful for the retrieval of foreign bodies, which have migrated in the biliary tract. In case of migrated stents, this is often used as

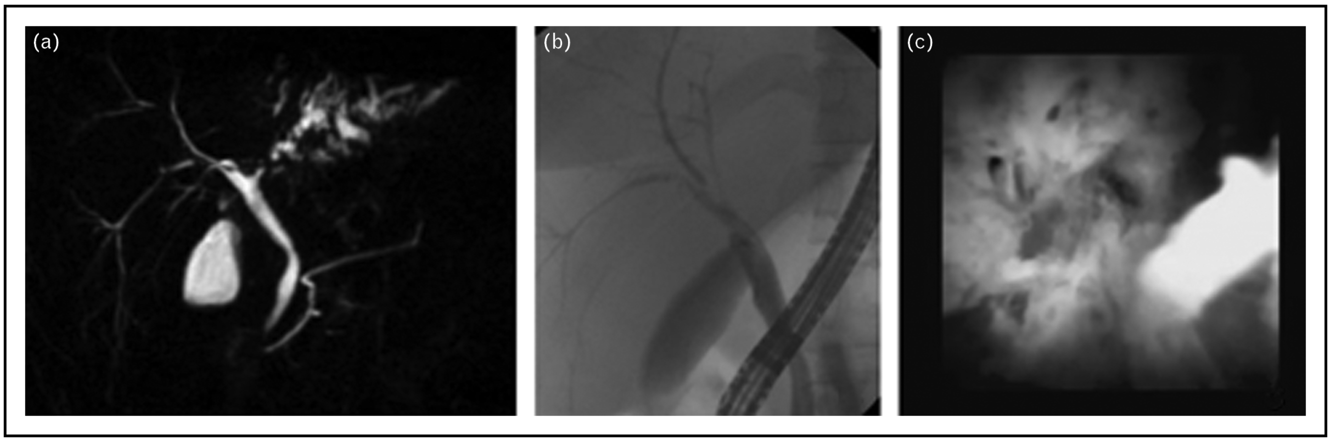

FIGURE 4. Example of an indeterminate biliary stricture evaluated by cholangioscopy corresponding of IgG4 stricture. (a) Magnetic resonance cholangiopancreatography (3D biliary reconstruction) demonstrating common left intrahepatic duct (LHD) stricture without mass. (b) Endoscopic retrograde cholangiopancreatography (ERCP) showing LHD stricture (no LHD opacification). (c) Digital cholangioscopic imaging of the LHD stricture, biopsied with SpyBite^{TM} biopsy forceps.

a last resort technique, when endoscopic retrieval or radiologic interventions have failed [46]. Dedicated accessories such as retrieval baskets and snares, or forceps, which can be advanced through the cholangioscope operating channel, have been shown to be effective in this setting [46,47]. Thin balloons can also be advanced into a plastic stent, after a guidewire has been placed under cholangioscopic guidance within the stent. These balloons are then inflated so as to retrieve the stent by strong traction [48]. Cholangioscopy with electrohydraulic lithotripsy (EHL) has also been successfully used for stone-impacted intra-biliary stent [49,50]. Other foreign bodies such as postcholecystectomy migrated clip and pealed guidewire can also be retrieved [51].

Complex biliary drainage

Cholangioscopy can also be used for guidance in the setting of complex biliary strictures or anatomy. Malignant hilar strictures are a well known challenge. Cholangioscopy guided advancement of guidewires through strictures to help achieve optimal biliary drainage has been described and is commonly used in expert centers, sometimes as a first line procedure [52,53]. The ultra-slim cholangioscope has also been successfully used to guide drainage in patient with difficult stones [54]. In cases of severe post liver transplantation anastomotic biliary strictures, cholangioscopy can also help guide a wire through the stricture [55]. Finally, in patients with acute cholecystitis, endoscopic transpapillary gallbladder drainage seems to be better achieved if guided by cholangioscopy [56].

Primary sclerosing cholangitis

Patients with primary sclerosing cholangitis (PSC) are at a high risk of developing cholestatic liver injury and biliary cancer. Prompt and accurate differentiation between benign and malignant strictures is crucial. A few case or case series suggest an interest of POCS: visual evaluation and optical guided biopsies of indeterminate biliary strictures to rule out malignancy, electrohydraulic lithotripsy of impacted stones [57,58]. POCS seems effective and safe for the endoscopic management of PSC patients and should be considered for complex PCS cases.

Biliary anastomotic stricture post liver transplantation

Cholangioscopy for biliary anastomotic strictures in the setting of liver transplantation has been described as useful in up to 78.9% of patients [59]. In case of very tight strictures, cholangioscopy can help pass the guidewire across the stricture under direct visualization [59,60]. Repeated biopsies of the anastomosis under direct vision using biopsy forceps, until a passage for the guidewire is made, has also been described in difficult cases [61]. High-frequency needle-knife electrotomy guided by percutaneous transhepatic cholangioscopy has also been successful [62]. Finally, cholangioscopy guided corticosteroid injection following balloon dilation of anastomotic strictures could help patients remain stent-free [63].

Pregnancy and pediatrics

The prevalence of choledocholithiasis during pregnancy is between 1% and 5% [64▪▪]. ESGE guidelines suggest that ERCP during pregnancy is a safe and effective technique [64▪▪]. However, radiation exposure must be kept to a minimal. Extraction of difficult bile duct stones can be challenging without fluoroscopy. ERCP without radiation has also been proposed, using various techniques such as POCS [64▪▪]. A retrospective study including 10 patients showed successful stone extraction using laser lithotripsy, balloon extraction and retrieval basket in 100% of cases with no complication [65].

Biliary stones and strictures can also be encountered in children. Cholangioscopy has been evaluated in a retrospective study including 36 procedures. Radiation exposure was thus avoided. Adverse events were less prevalent in patients who underwent cholangioscopy compared to those who underwent ERCP [66].

INNOVATIONS

Two types of innovations can be distinguished. The first one encompasses technological advances such as the development of new multibending cholangioscopes to facilitate bile duct cannulation, technical improvements of forceps jaws for better sampling, novel enhanced imaging systems and video display techniques (i.e. 3D), artificial intelligence for automated neoplasia detection [2,67–70]. The second one comprises uncommon procedures performed with the use of a cholangioscope. For instance, cases of bile duct reconstruction by rendezvous technique using endoscopic and percutaneous cholangioscopy or treatment of refractory benign biliary stricture using cholangioscopy-guided thulium laser stricturoplasty have been achieved [71–73].

CONCLUSION

Cholangioscopy is an endoscopic procedure which allows direct intraductal visualization of the biliary tract. Cholangioscopy has emerged as a major tool for indeterminate biliary stricture evaluation and treatment of difficult biliary stones, with adverse event rates comparable to standard endoscopic retrograde cholangioscopy. Cholangioscopy has improved the way biliary diseases can be visualized and treated. New technology, accessories, and applications are expected in the future.

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Conflicts of interest

There are no conflicts of interest.

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