Mönkemüller K, Wilcox CM, Muñoz-Navas M (eds): Interventional and Therapeutic Gastrointestinal Endoscopy.
Front Gastrointest Res. Basel, Karger, 2010, vol 27, pp 403–411

# Peroral Cholangioscopy

Rinse K. Weersma

Department of Gastroenterology and Hepatology, University Medical Centre Groningen, University of Groningen, Groningen, The Netherlands

**Abstract**

Peroral cholangioscopy using the mother-baby technique allows the direct visualization of the bile ducts and enables the performance of targeted biopsies and the intraductal treatment of stones. Although the technique has long been available, there is very little evidence-based literature. Due to the limited number of indications and the time-consuming technique, it has only been available in tertiary referral centers. The addition of peroral cholangioscopy to regular endoscopic retrograde cholangiopancreatography with brush cytology is highly accurate in determining the origin of bile duct strictures or filling defects of unknown origin. A second indication is the evaluation of cholangiocarcinoma in patients with dominant bile duct strictures in primary sclerosing cholangitis. Furthermore, the intraductal treatment of complex biliary stones, either with electrohydraulic or laser lithotripsy, is an established therapeutic application of peroral cholangioscopy.



Cholangioscopy is the direct endoscopic visualization of the intra- and extrahepatic bile ducts. This can be achieved using either a percutaneous transhepatic approach or a peroral approach [1]. The first technique is performed by creating a bilio-cutaneous tract which is dilated stepwise until the appropriate diameter for the cholangioscope is achieved. The latter technique is achieved using the so-called 'mother-baby technique'. A 'mother' scope, usually a regular duodenoscope is placed in the duodenum and a second 'baby' scope is advanced through the working channel of the duodenoscope into the common bile duct (CBD). The focus of this chapter will be the peroral approach.

The first reports of direct peroral cholangioscopy already date back to the early years of endoscopy [2]. Since then, the technique has not been widely adopted and has only been employed in specialized centers. There are several reasons for this. First of all the technique is difficult, time-consuming and, until recently, required 2 endoscopists trained in advanced endoscopic retrograde cholangiopancreatography (ERCP). Second, the choledochoscopes used are fragile, expensive and need frequent repairs. Third, the proper visualization of the bile ducts and performing intraductal biopsies are cumbersome. Due to these limitations the range of indications for the procedure have been limited.

The main diagnostic indications for performing cholangioscopy have been the evaluation of biliary strictures of unknown origin and the evaluation of dominant bile duct strictures in patients with primary sclerosing cholangitis (PSC). Furthermore, for therapeutic reasons,

cholangioscopy is being used to apply intraductal laser or electrohydraulic lithotripsy (EHL) of complex intra- or extrahepatic bile duct stones [1].

## Procedural Aspects

*Patient Preparation*

As for conventional ERCP procedures, patients should be kept on overnight fasting before the procedure. Prophylactic antibiotics should be considered, given the chance of post-procedural cholangitis due to extensive manipulation within the bile ducts. Since most of the procedures are extensive and will include additional techniques next to the actual cholangioscopy, the procedure can be scheduled under general anesthesia. However, it can usually be performed under conscious sedation using propofol, or a combination of midazolam with pethidine or fentanyl. In the latter situation, a topical fluid anesthetic is usually administered in the throat. Patients are placed in the supine position.

*Instruments and Accessories*

There are several dedicated choledochoscopes available (table 1). Most of these endoscopes can be advanced through the working channel of a regular duodenoscope and have a small working channel (usually 1.2 mm in diameter). Most of them are steerable in two directions with a limited angle. The endoscopic images of the video endoscopes are superior to the choledochoscopes with fiber optics, but these video endoscopes tend to be more fragile and need frequent repairs. Recently Boston Scientific introduced the Spyglass cholangioscopy system (fig. 1) [3]. This system consists of a four-way steerable endoscope through which an optical fiber can be advanced. The advantage of this system is the fact that it is disposable. The endoscope is for single-use only, while the optical fiber can be used up to 20 times. Another advantage of the Spyglass system is the fact that it can be performed by a single operator, while for the other choledochoscopes, 2 skilled endoscopists are needed. However, the quality of the images is inferior to that of the video choledochoscopes.

Three monitors are needed: one for the fluoroscopic images, one for the regular ERCP images, and one for the actual cholangioscopy. We use an automatic irrigation pump with a footswitch which can be attached to the working channel of the cholangioscope to flush the bile ducts with sterile saline to ensure good visibility. Since there is no possibility of suction, we use a 10-ml vial for vacuum suction on the working channel when debris is perturbing visibility. Before we start we preferably go through all the steps of the procedure with the assisting endoscopy nurses and make sure that all equipment that is expected to be necessary is available within the endoscopy suite.

*Technique*

The procedure starts as a regular ERCP with selective cannulation of the CBD. Cholangiography is then performed. Although it is not absolutely necessary, a sphincterotomy is usually performed, which facilitates the introduction of the choledochoscope and subsequent therapeutic accessories. If the indication for the procedure is the analysis of bile duct strictures of unknown origin or strictures in PSC, one should try to avoid the passage of catheters or sphincterotomes through the stenosis before the introduction of the choledochoscope, because this can cause damage to the epithelium and severely hamper the endoscopic evaluation of the origin of the lesion. A long guidewire (e.g. 450-cm Jagwire) is left in the biliary tree. The cholangioscope is then advanced over the guidewire through the working channel of the duodenoscope. One of the most difficult

**Table 1.** Commercially available peroral cholangioscopes

| Manufacturer | Type | Diameter mm | Working channel mm | Type |
|---|---|---|---|---|
| Olympus | CHF-B20 | 4.5 | 1.7 | Fiber |
| | CHF-B30 | 3.4 | 1.2 | Fiber |
| | CHF-B160 | 3.1 | 1.2 | Video |
| | CHF-B260 | 3.1 | 1.2 | Video |
| Pentax | FCP-8P | 2.8 | 0.75 | Fiber |
| | FCP-9P | 3.1 | 1.2 | Fiber |
| Boston Scientific | Spyglass | 3.3 | 1.2 | Fiber |
| Clinical Supply Ltd | Optiscope | 2.1 | – | Fiber |
| Polydiagnost | ERCP-Scope | 3.0 | 1.2/1.6 | Fiber |
| Medisecur | 3D-Microendoscope | 3.0 | 1.2 | Fiber |

parts of the procedure is the introduction of the choledochoscope into the CBD. One should try to avoid the use of the elevator at the distal end of the duodenoscope, since too much flexion can cause severe damage to the choledochoscope or break the optical fibers. It is usually best to align the choledochoscope as much as possible with the CBD and advance the scope slowly into the CBD under fluoroscopic control. Once the choledochoscope is within the CBD the guidewire can be removed and the flushing catheter can be attached to the working channel of the cholangioscope. The guidewire can later be reintroduced to cannulate specific segments of the liver and to advance the cholangioscope into the intrahepatic ducts. One should try to avoid flushing when the cholangioscope is in a 'wedge' position in the intrahepatic bile ducts.

*Evaluation of Biliary Strictures*

One of the most important indications for cholangioscopy is the evaluation of biliary strictures of unknown origin or dominant bile duct strictures in PSC with suspicion of a developing cholangiocarcinoma [4, 5]. Most patients will be referred from other centers where a previous ERCP has usually been performed and a biliary stent is already inserted. After removal the endoprosthesis should be sent for cytological examination. Following insertion of the cholangioscope one could additionally obtain bile for cytology, although the diagnostic yield is limited. We start with the endoscopic evaluation of the stricture and get an impression whether the stenosis has a benign, fibrotic appearance (fig. 2) or an irregular vulnerable malignant appearance (fig. 3). One of the best endoscopic discriminating features for malignancy is the presence of neovascularization [6]. One has to bear in mind that endoscopic evaluation of a stricture can be difficult after stent removal or scope passage as the epithelium is usually damaged and can mimic an exophytically growing cholangiocarcinoma. Small caliber biopsy forceps are available that can be advanced through the working channel of the cholangioscope. Biopsies can therefore be obtained under direct visual control. Due to the acute angulation of the cholangioscope at the tip of the duodenoscope it is sometimes difficult or impossible to advance the biopsy forceps. A maneuver to overcome this is to withdraw the cholangioscope several centimeters, advance the biopsy forceps until it cannot be advanced any further due to the angulation, and

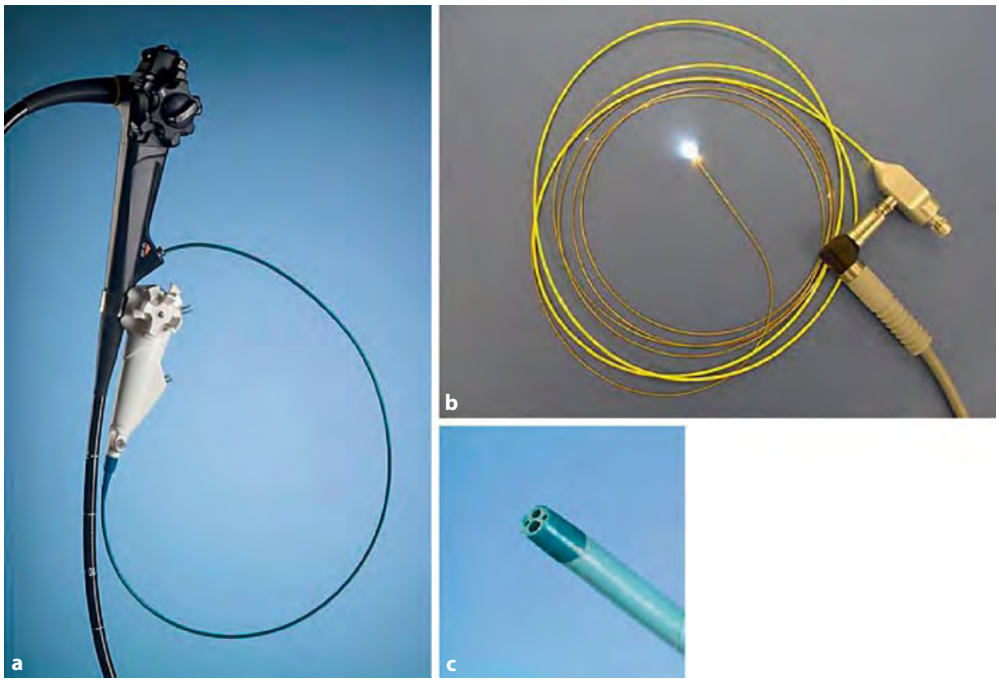


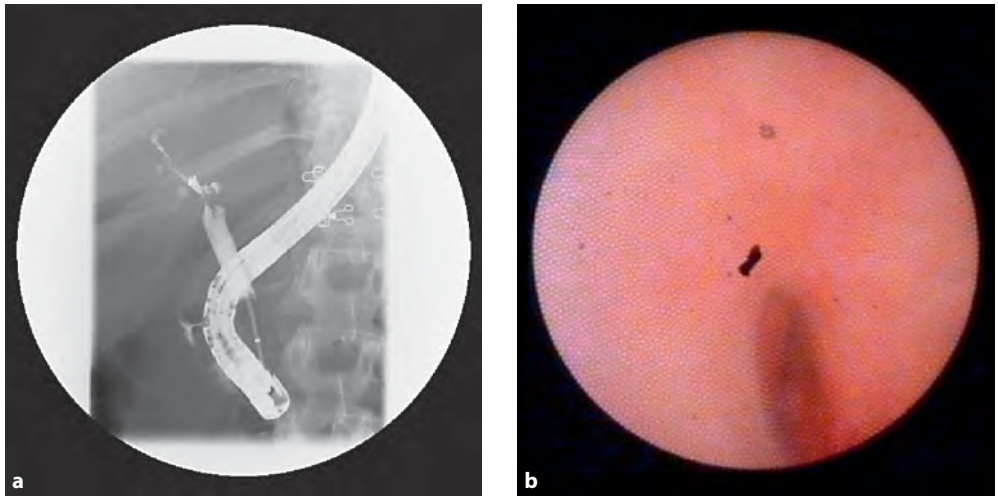

**Fig. 1.** The disposable Spyglass® peroral cholangioscopy system consisting of a disposable four-way steerable endoscope which can be attached to a regular duodenoscope (**a**) and a multi-usable fiber optic (**b**) which is advanced through a dedicated channel of the endoscope. Separate working channels are available for flushing and the introduction of instruments (**c**). Reproduced with permission from Boston Scientific, Natick, Mass., USA.

then readvance the cholangioscope again with the biopsy forceps in situ. Usually, it is then possible to advance the biopsy forceps easily into the bile duct. We perform 4–6 biopsies of suspected biliary strictures. After removal of the cholangioscope we also perform brush cytology. It is important to discuss the clinical background, origin of the biopsies and brush cytology with the pathologist to ensure optimal interpretation. Afterwards the ERCP with, e.g., dilation of the stricture and/or the placement of an endoprothesis if necessary should be finished in a regular manner.

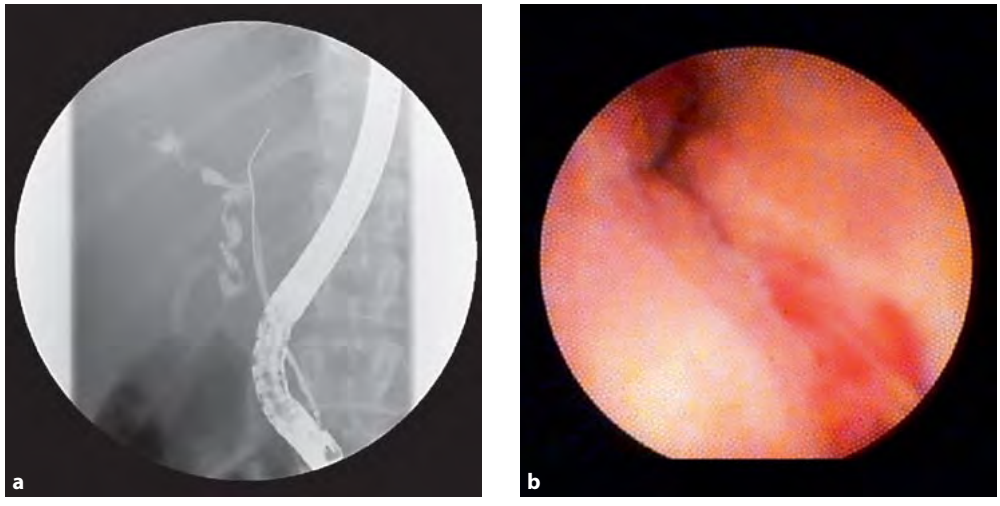
*Intraductal Lithotripsy of Complex Biliary Stones*

The intraductal treatment of complex biliary stones is an established therapeutic application of peroral cholangioscopy [7]. The most often used techniques are lithotripsy through EHL or laser lithotripsy. Additionally, in order to prevent accidental tissue damage of the bile duct, a stone-detection system was developed, allowing 'blind' laser fragmentation under fluoroscopic control [8].

EHL is established through the underwater discharge of 18,000 V leading to a spark gap and subsequent plasma formation. Plasma expansion induces a shockwave which can be used for stone disintegration [9]. In urology EHL has been used for the fragmentation of urinary stones, but due to the potentially severe complications, it has mostly been replaced by laser lithotripsy. Bile duct perforations have also been described during treatment of biliary stones [10].




2




3

**Fig. 2.** Benign stricture of the common bile duct in a patient with primary sclerosing cholangitis. Fluoroscopic image (**a**) and cholangioscopic image (**b**) revealing a stricture with a fibrotic non-malignant endoscopic appearance. **Fig. 3.** Malignant stricture of the common bile duct in a patient with primary sclerosing cholangitis. Fluoroscopic image (**a**) and cholangioscopic image (**b**) revealing a stricture with an irregular, vulnerable surface with neovascularization.

We use a holmium:yttrium aluminum garnet (Ho:YAG laser) Versapulse Power Suite (Lumenis Inc. Santa Clara, Calif., USA) which is extensively used by urologists to treat urinary stones, urethral strictures or even enucleation of the prostate [11]. The Ho:YAG laser has been proven to be an effective and safe treatment modality for all types of urinary calculi and has also been used to treat biliary calculi. The laser delivers pulsed energy through a small quartz fiber, which is introduced in the bile duct through the working channel of the cholangioscope allowing direct visual control (fig. 4). It is capable of fragmenting stones of mixed cholesterol and calcium bilirubinate composition and mixed bile pigments [12, 13]. The laser can be applied through fibers of various diameters. We use a 250- or 365-μm fiber allowing sufficient flexibility to move the endoscope.

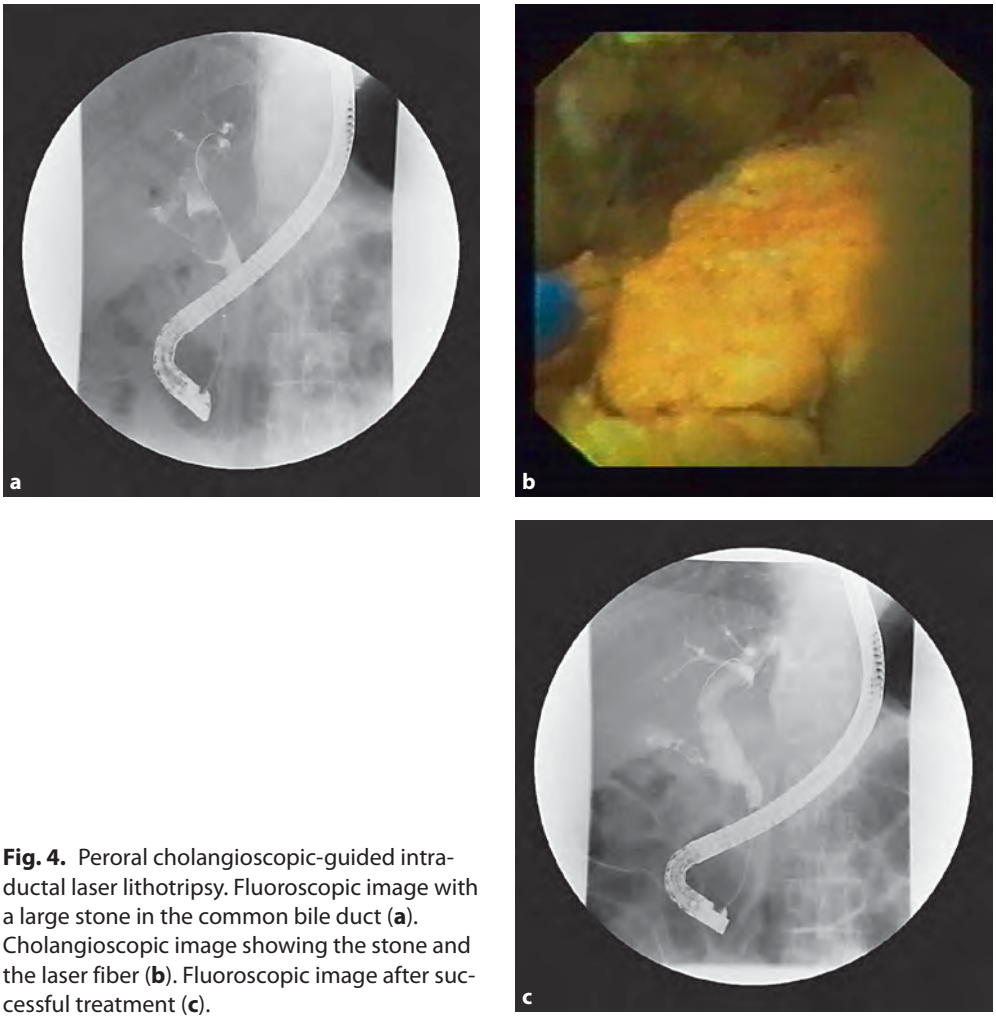



**Fig. 4.** Peroral cholangioscopic-guided intraductal laser lithotripsy. Fluoroscopic image with a large stone in the common bile duct (**a**). Cholangioscopic image showing the stone and the laser fiber (**b**). Fluoroscopic image after successful treatment (**c**).

Lithotripsy is established by the laser which creates a vaporization bubble in the surrounding water. Due to the difference in impedance, this vaporization bubble generates a shockwave at the boundary between the water and stone leading to stone fragmentation. The laser beam should be applied in close range to the stone (0.5 mm) and at a straight angle in order to be effective. This can be quite difficult to achieve, not only because of poor vision but also because of poor maneuverability of the cholangioscope once inside the bile duct. The required irrigation of the bile duct, necessary for clearance of debris and to provide a medium to transfer laser energy to the stone, is established by infusion of a saline solution through a 3-way lock attached to the proximal end of the cholangioscope working channel or through the flushing channel of the Spyglass endoscope. The calculi are fragmented with a laser frequency of 5–10 Hz and energy of 0.5–1.0 J. Fragments are then removed by conventional endoscopic methods, i.e. with a basket or extraction balloon. At the end of the procedure a nasobiliary drain can be inserted for additional irrigation of retained debris.

*Limitations and Complications*

There are several limitations to the use of peroral cholangioscopy, which have already been described at the start of the chapter, namely the difficult and time-consuming technique, the fragility of the choledochoscopes and the still cumbersome proper visualization of the bile ducts. In combination with the limited indications, the procedure is available only in a few specialized tertiary referral centers. Furthermore the quality of the biopsies obtained cholangioscopically is poor and remains a challenge for the pathologist.

The complications of the procedure are similar to that of regular ERCPs. Although there is no evidence in the literature, transient bacteremia with fever might be observed after the procedure more often than after regular ERCP due to extensive irrigation and manipulation of the bile ducts. This is usually successfully treated with prolonged administration of antibiotics. Epithelial damage and even perforation of the bile duct is a severe complication of intraductal laser lithotripsy or EHL. Further post-procedural care is similar to that of conventional ERCP.

## Outcomes

Although the technique of peroral cholangioscopy has been available for some time, there is very little evidence-based literature and most data are presented as case reports or case series. Therefore when the diagnostic and therapeutic accuracy of peroral cholangioscopy is presented, one should consider the small number of cases, the lack of control groups, and the limited data on clinical outcome.

Peroral cholangioscopy can aid in determining the origin of bile duct strictures or filling defects. The two largest series from Japan and the USA that have been published show that the addition of peroral cholangioscopy to regular ERCP with brush cytology improves diagnostic ability and is highly accurate in diagnosing pancreaticobiliary malignancy [4, 14]. The first study evaluated 97 patients with indeterminate biliary strictures (n = 76) and filling defects (n = 21). The final diagnosis was obtained from the surgical resection specimens or clinical follow-up. In the group with indeterminate strictures, peroral cholangioscopy correctly identified all 38 malignant strictures and 35 of the 38 benign strictures. For the 21 patients with filling defects of the bile ducts, cholangioscopy diagnosed all 8 malignant lesions and 13 benign lesions [14]. In the second study 72 examinations were performed in 62 patients with pancreaticobiliary pathology suspicious for malignancy with inconclusive previous studies. Cholangioscopy with and without biopsies detected 16 of 18 patients with a final diagnosis of malignancy. Both missed cancers were intrahepatic cholangiocarcinomas. The positive predictive value in this study was 89% and the negative predictive value 96% [4]. The administration of methylene blue has been reported to be helpful in distinguishing malignant or benign lesions in the bile duct [15].

Another indication for peroral cholangioscopy is the evaluation of dominant bile strictures in patients with PSC. The incidence of cholangiocarcinoma is increased in PSC and this is frequently difficult to diagnose. ERCP with brush cytology and/or fluoroscopic-guided biopsies in combination with tumor markers such as CA19–9 and carcinoembryonic antigen yield variable results [16, 17]. Cholangioscopy might have two advantages in the setting of PSC. First, it enables performing targeted biopsies under direct visual control and direct endoscopic evaluation of the stricture (fig. 2, 3). One study showed that cholangioscopy was significantly superior to ERCP in detecting malignant bile duct strictures in 12 of 53 PSC patients [18]. A second case series showed that cholangioscopic tissue sampling yielded adequate biopsies but the diagnosis

of cholangiocarcinoma remained challenging [5]. Second, it detected biliary stones and casts that were not seen in up to one third of patients on regular cholangiography and the subsequent treatment of these stones resulted in clinical improvement [5].

The management of complex biliary tract calculi when standard endoscopic therapy fails, is challenging. Endoscopic procedures with mechanical lithotripsy fail in 5–10% because of the large size or the number of calculi [19]. For these patients different treatment modalities are available, such as laparotomic and laparoscopic choledochotomy with stone extraction, extracorporeal shockwave lithotripsy (ESWL) or percutaneous or peroral cholangioscopy with intraductal lithotripsy [9].

The intraductal treatment of complex biliary stones either with electrohydraulic or laser lithotripsy is an established therapeutic application of peroral cholangioscopy [7]. There have been 2 randomized studies comparing intraductal laser lithotripsy with ESWL for complex bile duct stones. Both studies used laser systems with an integrated stone detection system that can be used under fluoroscopic control and does not need direct cholangioscopic visualization of the stone. Both studies showed that the intraductal laser lithotripsy was more effective than ESWL regarding bile duct clearance and treatment duration [20, 21]. Case series have shown good results for the intraductal treatment of complex bile duct stones with both the Ho:YAG laser and EHL [22, 23].

## Conclusions

Peroral cholangioscopy using the mother-baby technique allows direct visualization of the bile ducts and enables the performance of targeted biopsies and the intraductal treatment of stones. Although the technique has been available for some time, there is very little evidence-based literature. Due to the limited number of indications and the time-consuming technique, it is only available in tertiary referral centers. With the availability of new single-operator cholangioscopy systems, it is becoming more widespread. The addition of peroral cholangioscopy to regular ERCP with brush cytology is highly accurate in determining the origin of bile duct strictures or filling defects of unknown origin. A second indication is the evaluation of cholangiocarcinoma in patients with dominant bile duct strictures in PSC. Furthermore, the intraductal treatment of complex biliary stones either with electrohydraulic or laser lithotripsy is an established therapeutic application of peroral cholangioscopy.

## References


1 Shim CS, Neuhaus H, Tamada K: Direct cholangioscopy. Endoscopy 2003;35:752–758.

2 Kawai K, Nakajima M, Akasaka Y, Shimamotu K, Murakami K: A new endoscopic method: the peroral choledocho-pancreatoscopy. Leber Magen Darm 1976;6:121–124.

3 Chen YK, Pleskow DK: SpyGlass single-operator peroral cholangio-pancreatoscopy system for the diagnosis and therapy of bile-duct disorders: a clinical feasibility study. Gastrointest Endosc 2007;65: 832–841.

4 Shah RJ, Langer DA, Antillon MR, Chen YK: Cholangioscopy and cholangioscopic forceps biopsy in patients with indeterminate pancreaticobiliary pathology. Clin Gastroenterol Hepatol 2006;4:219–225.

5 Awadallah NS, Chen YK, Piraka C, Antillon MR, Shah RJ: Is there a role for cholangioscopy in patients with primary sclerosing cholangitis? Am J Gastroenterol 2006; 101:284–291.

6 Kim HJ, Kim MH, Lee SK, Yoo KS, Seo DW, Min YI: Tumor vessel: a valuable cholangioscopic clue of malignant biliary stricture. Gastrointest Endosc 2000;52:635–638.

7 Williams EJ, Green J, Beckingham I, Parks R, Martin D, Lombard M; British Society of Gastroenterology: Guidelines on the management of common bile duct stones (CBDS). Gut 2008;57:1004–1021.

8 Ell C, Hochberger J, May A: Laser lithotripsy of difficult bile duct stones by means of a rhodamine-6G laser and an integrated automatic stone-tissue detection system. Gastrointest Endosc 1993;39:755–762.

9 Hochberger J, Tex S, Maiss J, Hahn EG: Management of difficult common bile duct stones. Gastrointest Endosc Clin N Am 2003;13:623–634.

10 Josephs LG, Birkett DH: Electrohydraulic lithotripsy (EHL) for the treatment of large retained common duct stones. Am Surg 1990;56:232–234.

11 Delvecchio FC, Preminger GM: Endoscopic management of urologic disease with the holmium laser. Curr Opin Urol 2000;10:233–237.

12 Shamamian P, Grasso MJ: Management of complex biliary tract calculi with a holmium laser. Gastrointest Surg 2004;8:191–199.

13 Blomley MJ, Nicholson DA, Bartal G: Holmium-YAG laser for gall stone fragmentation: an endoscopic tool. Gut 1995 ;36:442–445.

14 Fukuda Y, Tsuyuguchi T, Sakai Y, Tsuchiya S, Saisyo H: Diagnostic utility of peroral cholangioscopy for various bile-duct lesions. Gastrointest Endosc 2005; 62:374–382.

15 Hoffman A, Kiesslich R, Bittinger F, Galle PR, Neurath MF: Methylene blue-aided cholangioscopy in patients with biliary strictures: feasibility and outcome analysis. Endoscopy 2008;40:563–571.

16 Wiesner RH, Grambsch PM, Dickson ER, Ludwig J, MacCarty RL, Hunter EB, Fleming TR, Fisher LD, Beaver SJ, LaRusso NF: Primary sclerosing cholangitis: natural history, prognostic factors and survival analysis. Hepatology 1989;10:430–436.

17 Björnsson E, Kilander A, Olsson R: CA 19–9 and CEA are unreliable markers for cholangiocarcinoma in patients with primary sclerosing cholangitis. Liver 1999; 19:501–508.

18 Tischendorf JJ, Krüger M, Trautwein C, Duckstein N, Schneider A, Manns MP, Meier PN: Cholangioscopic characterization of dominant bile duct stenoses in patients with primary sclerosing cholangitis. Endoscopy 2006;38:665–669.

19 Classen M, Hagenmuller F, Knyrim K, Frimberger E: Giant bile duct stones – non-surgical treatment. Endoscopy 1988;20:21–26.

20 Neuhaus H, Zillinger C, Born P, Ott R, Allescher H, Rösch T, Classen M: Randomized study of intracorporeal laser lithotripsy versus extracorporeal shock-wave lithotripsy for difficult bile duct stones. Gastrointest Endosc 1998;47:327–334.

21 Jakobs R, Adamek HE, Maier M, Krömer M, Benz C, Martin WR, Riemann JF: Fluoroscopically guided laser lithotripsy versus extracorporeal shock wave lithotripsy for retained bile duct stones: a prospective randomised study. Gut 1997;40:678–682.

22 Das AK, Chiura A, Conlin MJ: Treatment of biliary calculi using holmium: yttrium aluminum garnet laser. Gastrointest Endosc 1998;48:207–209.

23 Hixson LJ, Fennerty MB, Jaffee PE: Peroral cholangioscopy with intracorporeal electrohydraulic lithotripsy for choledocholithiasis. Am J Gastroenterol 1992;87:296–299.



Rinse K. Weersma, MD, PhD
Department of Gastroenterology and Hepatology
University Medical Centre Groningen, University of Groningen
Hanzeplein 1, NL–9700RB Groningen (The Netherlands)
Tel. +31 503612406, Fax +31 503619306, E-Mail r.k.weersma@int.umcg.nl