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CLINICAL ENDOSCOPY

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The Role of Peroral Cholangioscopy in Evaluating Indeterminate Biliary Strictures

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Biliary strictures are considered indeterminate when the initial radiologic evaluation and endoscopic retrograde cholangiopancreatography with brush cytology and/or forceps biopsy do not reveal diagnostic findings. Evaluation of these strictures is challenging and often requires a multidisciplinary approach and multiple procedures. Peroral cholangioscopy allows direct visualization of these lesions and targeted tissue acquisition using miniature biopsy forceps. In the past decade, there have been significant improvements in the field of cholangioscopy. These advances have allowed higher-quality image acquisition, easy setup, operation by a single operator, easy maneuverability, and excellent targeted tissue sampling performance. However, the interpretation of cholangioscopic visual findings remains challenging. In this review, we discuss the role of peroral cholangioscopy in the evaluation of indeterminate biliary strictures. **Clin Endosc 2019;52:556-564**

Key Words: Bile duct disease; Bile duct neoplasm; Biliary strictures; Cholangiocarcinoma

INTRODUCTION

Endoscopic retrograde cholangiopancreatography (ERCP) with standard brush cytology and/or forceps biopsy was one of the first approaches in the evaluation of obstructive biliary and pancreatic duct diseases. However, ERCP does not provide an intraluminal view of the pancreaticobiliary pathology. Cholangiopancreatoscopy overcomes this limitation by allowing direct visualization of the biliary and pancreatic ducts. The first cholangioscope was described in 1941, and the peroral approach was subsequently introduced in the early 1970s.[1,2] The early cholangioscopy system, known as the mother-daughter system, consisted of a mother duodenoscope and a daughter cholangiopancreatoscope. The limitations of this system were the need for two operators, scope fragility, and poor image quality. Over the past decade, there have been significant improvements in cholangioscopy technology. These include improved image quality, easy setup, need for only one operator, and ability to perform targeted biopsies and therapeutic procedures, such as lithotripsy. One of the main indications for cholangioscopy is the evaluation of biliary strictures when imaging, and ERCP with brush cytology and/or biopsy does not yield a definitive diagnosis. These indeterminate biliary strictures present a diagnostic challenge for endoscopists as both malignant and benign etiologies should be considered. Cholangioscopy offers the advantage of direct visualization of the biliary epithelium to assess malignant features and targeted biopsy results of suspected lesions. This review summarizes the role of peroral cholangioscopy in the evaluation of indeterminate biliary strictures.

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PERORAL CHOLANGIOSCOPY

Cholangioscopy can be performed perorally or percutaneously. The peroral approach can be performed using an ultraslim endoscope (direct peroral cholangioscopy system

[DPCS], GIF-XP; Olympus Co., Tokyo, Japan) or a catheter-based system with a single-operator cholangiopancreatoscope (SOCP, SpyGlass Direct Visualization System; Boston Scientific Endoscopy, Marlboro, MA, USA). Table 1 summarizes the features, advantages, and disadvantages of the different cholangioscopy systems.

In the DPCS, an ultraslim gastroscope is advanced in a monorail fashion over a guidewire or with balloon assistance into the biliary tree. This approach requires sphincterotomy or distal duct dilation for advancement of the cholangioscope through the biliary sphincter. The DPCS allows targeted biopsy of mucosal abnormalities or direct treatment of stone diseases. This system has a high-definition video technology with a superior image quality compared with the SOCP. Additional complementary imaging modalities, such as narrow band imaging (NBI) and probe-based confocal laser endomicroscopy (pCLE), can be used to improve the diagnostic yield further. NBI allows enhanced visualization of superficial mucosal capillary and pit patterns and thicker capillaries of the deeper tissues by restricting light to two waveforms (i.e., 415 and 540 nm). pCLE provides histologic-level images by passing a laser light through a confocal aperture. Owing to the required expertise and high cost, the use of this technique is currently only limited to select centers.

In 2007, the first-generation SOCP was introduced to clinical practice. This device was a single-use fibro-optic-based device (fibro-optic SOCP [FSOCP]) that allowed a single operator to complete the procedure. A new digital version of the SOCP (SpyGlass DS, SPY DS; digital SOCP [DSOCP]) has several advantages compared with the fibro-optic-based device. The new system consists of a sterile, single-use SpyScope access and delivery catheter, SpyGlass digital controller, and SpyBite, which is a biliary biopsy forcep. This system utilizes two light-emitting diodes that improve the image quality and provides a wider endoscopic field of view. Further, there is a dedicated aspiration and irrigation channel, and the tapered

Table 1. Comparison between the Two Cholangioscopy Systems

Cholangioscopy system	SpyGlass DS	Ultraslim endoscope
Technology	LED light source/120 degrees of digital field of view	High-resolution video-scope
Outer diameter (mm)	3.5	4.9–5.9
Channel diameter (mm)	1.2	2.0
Working length (cm)	214	110–130
Accessories	- SpyBite biopsy forceps - Lithotripsy devices: electrohydraulic lithotripsy and laser lithotripsy	- 5-French instruments - Larger biopsy forceps - Argon plasma coagulation probes and lithotripsy fibers
Tip deflection	Four ways: up-down, left-right	Four ways: up-down, left-right
Image quality	Excellent	Greater than that in the DSOCP
Advantages	- Easier access to the pancreatobiliary duct compared with the DPCS - Separate irrigation channel - Tip maneuverability - Redesigned working channel for passing accessories - Fixed imager for consistent steering - Single-use digital scope - Simplified 5-minute setup	- Markedly greater image quality compared with that in the DSOCP - Allows NBI and improves visualization of lesion margins and vessels - Larger working channel (enables several interventions with the use of 5-French diagnostic and therapeutic devices, such as photodynamic therapy and argon plasma coagulation) - Allows simultaneous irrigation and therapy
Disadvantages	- Expensive - Narrow working channel diameter	- Large outer diameter necessitates prior sphincterotomy - More challenging procedure, requires highly skilled endoscopists - Difficult to perform biliary cannulation owing to easy loop formation during insertion and trouble fixing the scope inside the biliary tract - Can only be performed in dilated bile ducts

DPCS, direct peroral cholangioscopy system; DSOCP, digital single-operator cholangiopancreatoscope; LED, light-emitting diode; NBI, narrow band imaging.

Table 2. Cholangioscopy Indications and Contraindications

Diagnostic indications	Therapeutic indications	Contraindications
Direct visualization of the biliary epithelium	Electrohydraulic/intra-ductal laser lithotripsy of complex stones	General contraindications to ERCP, including acute cholangitis
Targeted biopsy of biliary strictures initially or after non-diagnostic ERCP	Endoscopic tumor ablation therapy	Small duct, <5 mm in diameter
Preoperative assessment of main-duct IPMNs and differentiation of chronic pancreatitis from main-duct IPMN in the appropriately dilated duct	Removal of proximally migrated stents	Uncorrected coagulopathy
Post-liver transplant biliary complications	Guiding treatment margins for biliary radiofrequency ablation	
Evaluation of hemobilia	Assistance with selective guidewire placement	
Assessment of strictures in patients with primary sclerosing cholangitis	Alternative to surgery in patients with Mirizzi type 2	
Characterization of intra-ductal filling defects found on MRCP and ERCP	Stent placement in the cystic duct	
Assessment of the etiology of recurrent unexplained choledocholithiasis	Photodynamic therapy of cholangiocarcinoma	
	Photocoagulation with argon in cases of IPMN	

ERCP, endoscopic retrograde cholangiopancreatography; IPMN, intraductal papillary mucinous neoplasm; MRCP, magnetic resonance cholangiopancreatography.

tip enables a less traumatic advancement across the papilla and strictures.

CLINICAL INDICATIONS AND CONTRAINDICATIONS

Peroral cholangioscopy can be utilized for both diagnostic indications and therapeutic applications. Table 2 summarizes the key clinical indications and contraindications for performing cholangioscopy. The two most common indications for peroral cholangioscopy are management of complex bile duct stones and assessment of indeterminate biliary strictures.[3,4]

INDETERMINATE BILIARY STRICTURES

Biliary strictures are considered indeterminate when the initial radiologic evaluation and ERCP with standard brush cytology and/or forceps biopsy do not yield a definitive diagnosis. These strictures can be benign or malignant and can originate from the intra- or extrahepatic biliary tree, pancreas, liver, gallbladder, ampulla, regional lymph nodes, or invasion from other gastrointestinal malignancies and metastases. Evaluation of these strictures is of paramount importance, as early diagnosis avoids unnecessary surgical procedures and yields optimal patient outcomes. Table 3 summarizes the differential diagnosis for benign and malignant biliary strictures. The leading causes of malignant biliary strictures are cholangiocarcinoma and pancreatic cancer.[5]

Table 3. Differential Diagnosis for Indeterminate Biliary Strictures

Malignant causes	Benign causes
Cholangiocarcinoma	Chronic pancreatitis
Pancreatic adenocarcinoma	Autoimmune diseases: - IgG4-associated cholangitis - Sarcoidosis - Mast cell cholangitis
Ampullary adenocarcinoma	Cholelithiasis
Gallbladder cancer	Iatrogenic injury to the bile duct: - Cholecystectomy - Liver transplantation
Hepatocellular carcinoma	Infectious diseases: - HIV-associated disease - Parasitic cholangiopathy - Tuberculosis
Metastatic cancer	Vascular-related diseases: - Ischemic cholangiopathy - Vasculitis - Intra-arterial chemotherapy - Portal hypertensive biliopathy
Lymphoma	

The diagnosis of malignant biliary strictures can be predicted on the basis of cholangioscopic visual characteristics.

However, tissue acquisition is required for the final diagnosis and can be performed via ERCP with standard brush cytology and/or forceps biopsy, endoscopic ultrasound-guided fine needle aspiration (EUS-FNA), and cholangioscopy-guided forceps biopsy. ERCP with standard brush cytology and/or forceps biopsy is often the first diagnostic approach employed. However, this is limited by its low sensitivity and high rates of false-negative results. In a systematic review and meta-analysis (nine studies; 730 patients) on the effectiveness of ERCP for detecting malignant biliary strictures, the pooled sensitivities of brushing cytology and forceps biopsy were 45% and 48.1%, respectively. The combination of the two methods increased the sensitivity only to 59.4%.[6] In patients with biliary strictures due to extrinsic compression (e.g., pancreatic tumors or regional lymph nodes), EUS-FNA has a high diagnostic value and should be considered the standard of care.[7] A recent meta-analysis on the diagnostic yield of EUS-FNA (41 studies; 4,766 patients) reported a pooled sensitivity and specificity of 86.8% and 95.8%, respectively, for diagnosing solid pancreatic masses.[8] The limitations of EUS are challenges in accessing proximal biliary strictures and concerns on seeding malignancy along the FNA tract.[9,10]

Table 4. Cholangioscopy Visual Impression of Benign and Malignant Lesions

Malignant features	Benign features
Tortuous dilated vessels ("tumor vessels")	Ulceration
Infiltrative stricture	Atrophy
Polypoid mass	Concentric stenosis
Vegetative mass	Low-papillary mucosal lesion
Fish-egg lesion	Band-like scarring
Finger-like villiform lesion	Erythema
Irregularly papillary or granular lesions	Pseudo-diverticulae
Nodular elevated lesions	
Friability and easily bleeding	

CHOLANGIOSCOPY FOR VISUAL ASSESSMENT OF THE BILIARY EPITHELIUM

Table 4 summarizes the biliary epithelial visual findings during cholangioscopy. Seo et al. and Fukuda et al. were the first to illustrate these findings and described malignant strictures as lesions with irregularly dilated and tortuous vessels (tumor vessels), nodularity, papillary characteristics, neovascularization, easy oozing, and irregular surface.[11,12] Conversely, benign strictures have smooth mucosa, borders without neovascularization, and papillo-granular mucosa with no obvious mass.[11,12] The strongest feature suggestive of malignancy is the presence of dilated and tortuous vessels, with a reported positive predictive value of up to 100%.[13]

Table 5 summarizes the performance of the DPCS in the diagnosis of malignant biliary strictures. The reported sensitivity and specificity of DPCS visual impression for the diagnosis of malignancy are 83%–92% and 84%–92%, respectively.[14-16] In the first US report on the operating characteristics of the DPCS in 96 patients with indeterminate biliary strictures, the sensitivity and specificity were 85% and 84%, respectively.[14] In a feasibility study on the DPCS with the addition of NBI compared with the use of high-definition white light, Itoi et al. reported an improved visualization of both the surface structures and vessels with the use of NBI.[17] They also reported the detection of four out of 21 lesions on NBI that were not seen with the use of high-definition white light.[17]

Table 6 summarizes the data on the diagnostic yield of SOCP visual impression for indeterminate biliary strictures.[18-34] The reported sensitivity, specificity, and accuracy ranged from 78% to 100%, from 77% to 97.6%, and from 80% to 97%, respectively (Table 7).[6,9,14,35-37] In the report by Chen at al. (226 patients from 15 centers), FSOCP visual impression

Table 5. Studies on the Diagnostic Yield of Direct Peroral Cholangioscopy System-Guided Visual Impression and Biopsy

Study	Study design	Patients (*n*)	Technical success (%)	Visual sensitivity (%)	Visual specificity (%)	Visual accuracy (%)	Biopsy sensitivity (%)	Biopsy specificity (%)	Biopsy accuracy (%)
Mounzer et al. (2017)[14a)]	Single-center, prospective	96	NR	85	84	NR	43	97	NR
Meves et al. (2014)[15]	Single-center, prospective	84	87	NR	NR	NR	89.5	NR	NR
Farnik et al. (2014)[16]	Multicenter, retrospective	89	88.5	NR	NR	NR	NR	NR	NR

NR, not reported.
[a)]In this study, 14 out of 96 patients were examined for pancreatic disease.

was found to be more sensitive and specific than ERCP fluoroscopic impression for diagnosing malignant biliary strictures (sensitivity, 78% vs. 51%; specificity, 82% vs. 54%, respectively). This study also found a higher sensitivity for strictures caused by intrinsic lesions than for those caused by extrinsic lesions (84% vs. 61%, respectively).[19] In a systematic review and meta-analysis on the diagnostic yield of the FSOCP based on visual impression (a total of six studies; 456 patients), the pooled sensitivity and specificity for diagnosing malignant biliary strictures were 84.5% and 82.6%, respectively.[38]

The visual diagnostic yield of the second-generation DSOCP (SPY DS) is reported to be higher than that of the first-generation FSOCP. In a multicenter study (two centers; 44 patients), the sensitivity and specificity of DSOCP visual

Table 6. Single-Operator Cholangiopancreatoscope Visual Impression and SpyBite Biopsy Diagnostic Yield for Indeterminate Biliary Strictures

Study	Study design	Cholangioscopy system	Patients (*n*)	Technical success (%)	Visual sensitivity (%)	Visual specificity (%)	Visual accuracy (%)	Biopsy sensitivity (%)	Biopsy specificity (%)	Biopsy accuracy (%)
Chen et al. (2007)[18]	Multicenter, prospective	FSOCP	22	91	100	77	85	71	100	90
Chen et al. (2011)[19]	Multicenter, prospective	FSOCP	226	93 and 86[a]	78	82	80	49[b]	98	75
Ramchandani et al. (2011)[27]	Single-center, prospective	FSOCP	36	100	95	79	89	82	82	82
Hartman et al. (2012)[28]	Single-center, retrospective	FSOCP	89	NR	88	86	87	57	100	78
Draganov et al. (2012)[29]	Single-center, prospective	FSOCP	44	97.7	NR	NR	NR	76	100	84
Manta et al. (2013)[30]	Single-center, prospective	FSOCP	52	100	NR	NR	NR	88	94	90
Woo et al. (2014)[31]	Single-center, retrospective	FSOCP	32	96	100	90	96	64	100	73
Tieu et al. (2015)[32]	Single-center, retrospective	FSOCP	39	92.3	NR	NR	97	NR	NR	72
Kurihara et al. (2016)[33]	Multicenter, prospective	FSOCP	89	95.5	94	92	94	65	89	70
Navaneethan et al. (2016)[34]	Multicenter, prospective	DSOCP	44	100	90	96	NR	85	100	NR
Laleman et al. (2017)[20]	Single-center, prospective	FSOCP	45	88.9	83	83	83	85	100	95
Ogura et al. (2017)[21]	Single-center, prospective	DSOCP	25	100	83	89	93	80	100	89
Imanishi et al. (2017)[22]	Single-center, retrospective	DSOCP	20	100	NR	NR	NR	NR	NR	100
Shah et al. (2017)[23]	Multicenter, prospective	DSOCP	58	100	97	93	94	86	100	91
Pereira et al. (2018)[24]	Single-center, retrospective	DSOCP	12	100	NR	NR	87.5	NR	NR	55
Lenze et al. (2018)[25]	Single-center, retrospective	DSOCP	41	98.5	88.9	97.6	NR	62.5	90	NR
Turowski et al. (2018)[26]	Multicenter, retrospective	DSOCP	99	NR	95.5	94.5	NR	57.7	100	NR

DSOCP, digital single-operator cholangiopancreatoscope; FSOCP, fibro-optic single-operator cholangiopancreatoscope; NR, not reported.
[a]Diagnostic FSOCP was performed without biopsy in 86 cases and with biopsy in 140 cases. The respective procedure success rates in those two groups were 93% and 86%.
[b]The authors suggested that this low number may have been attributed to the inclusion of strictures caused by extrinsic compression.

Table 7. Diagnostic Yield of the Different Available Methods for Evaluating Biliary Strictures

Diagnostic method	Sensitivity (%)	Specificity (%)	Accuracy (%)
ERCP with brushing cytology	23–62.5	26–100	31–81.3
ERCP with standard forceps biopsy	43–91	97–100	30–93
Combined ERCP with brush cytology and biopsy	60–70	100	50
ERCP plus FISH	30–79	91–100	72–80
EUS-FNA	43–86[a)]	97	
SOCP visual impression	78–100	78–97.6	80–97
SOCP SpyBite biopsy	49–100	82–100	55–100
SpyGlass with ROSE	100		93
DPCS visual impression	83–92	84–92	
DPCS biopsy	43–89.5	97	
Combined DPCS visual impression plus biopsy	85	84	

DPCS, direct peroral cholangiopancreatoscopy system; ERCP, endoscopic retrograde cholangiopancreatography; EUS-FNA, endoscopic ultrasound-guided fine needle aspiration; FISH, fluorescence in situ hybridization; ROSE, rapid on-site evaluation; SOCP, single-operator cholangiopancreatoscope.
[a)]Depending on the proximal or distal strictures.

impression for the diagnosis of malignant biliary strictures were 90% and 95.8%, respectively.[34] In another similar study, the sensitivity and specificity of DSOCP visual impression were 95.5% and 94.5%, respectively.[26] Recently, Mizrahi et al. compared the diagnostic yield of visual impression between the FSOCP and DSOCP for malignant biliary strictures (324 patients; FSOCP, 198 and DSOCP, 126) and reported a higher diagnostic yield with the DSOCP than with the FSOCP (78% vs. 37%, respectively, p=0.004).[39]

To date, there is a lack of uniformity as well as a poor inter-observer agreement among experts for interpreting the visual impression of biliary strictures. Moreover, in some instances, such as benign extrinsic compression and irregular biliary mucosal pattern in primary sclerosing cholangitis, visual impression can be misleading and may result in false-positive malignant diagnoses.[12,40]

CHOLANGIOSCOPY-GUIDED BIOPSY

Several studies have evaluated the diagnostic yield of DPCS-guided biopsy for indeterminate biliary strictures (Table 5).[14-17,41] In the report by Mounzer et al. on the diagnostic yield of DPCS-guided biopsy for malignant biliary strictures (96 patients), the sensitivity and specificity were 43% and 97%, respectively.[14] Table 6 summarizes the performance of SOCP-guided biopsy in diagnosing malignant biliary strictures.[18-34] The reported sensitivity, specificity, and accuracy of this technique were 49% to 100%, 82% to 100% and 55% to 100%, respectively (Table 7).[6,9,14,35-37] In a multicenter study (140 patients from 15 centers) on the diagnostic yield of FSOCP-guided biopsy, the sensitivity and specificity for diagnosing malignant biliary strictures were 49% and 98%, respectively. This study also reported a higher sensitivity for intrinsic lesions than for extrinsic lesions (66% vs. 8%, respectively). This difference highlights an important limitation of cholangioscopy biopsy forceps, i.e., inability to reach extrinsic lesions for tissue sampling in a significant number of patients.[19] In a systematic review on the diagnostic yield of FSOCP-guided biopsy for malignant biliary strictures, the pooled sensitivity and specificity were 60% and 98%, respectively.[38]

The first study on the diagnostic yield of DSOCP-guided biopsy for malignant biliary strictures (two centers; 44 patients) reported a sensitivity and specificity of 85% and 100%, respectively.[34] Another similar study (six centers; 250 procedures) reported a sensitivity and specificity of 57% and 100%, respectively.[26]

Limited data suggest that the diagnostic yield of cholangioscopy-guided biopsy may be improved by rapid on-site evaluation using a method of touch imprint cytology, with reported sensitivity and accuracy of 100% and 93.5%, respectively, for diagnosing malignant biliary strictures.[35] However, more studies are needed to illustrate the cost-effectiveness of this approach further.

SAFETY AND ADVERSE EVENTS

Table 8 summarizes the available data on overall cholangioscopy-related adverse events (AEs).[14-16,18-27,29-34,42] The overall

Table 8. Studies with Reported Adverse Events for the Different Cholangioscopy Systems[a)]

Study	Cholangioscopy system	Sample size (*n*)	Overall adverse events (%)	Most common adverse event (%)	Severe adverse events (%)
Mounzer et al. (2017)[14]	DPCS	96	2	Bleeding (1)	Perforation (1) - conservative management
Meves et al. (2014)[15]	DPCS	84	12	NR	0
Farnik et al. (2014)[16]	DPCS	89	7.7	Cholangitis (1.5) Bleeding (1.5)	0
Chen et al. (2011)[19]	FSOCP	297	7.5	Cholangitis (3.5)	0
Kurihara et al. (2016)[33]	FSOCP	89	5.4	Cholangitis (2.7)	0
Laleman et al. (2017)[20]	FSOCP	84	21.4	Mild pancreatitis (7.1)	0
Ogura et al. (2017)[21]	DSOCP	55	6	Cholangitis (6)	0
Imanishi et al. (2017)[22]	DSOCP	28	4	NR	0
Shah et al. (2017)[23]	DSOCP	108	3	NR	0
Lenze et al. (2018)[25]	DSOCP	67	25.4	Abdominal pain (23.8)	16.4[b)]
Pereira et al. (2018)[24]	DSOCP	16	38	NR	0
Turowski et al. (2018)[26]	DSOCP	250	13.2	Cholangitis, 1% with and 12.8% without antibiotics	Perforation (0.4) - conservative management
Chen et al. (2007)[18]	FSOCP	35	6	NR	0
Ramchandani et al. (2011)[27]	FSOCP	36	8.3	Cholangitis (5.6)	0
Draganov et al. (2012)[29]	FSOCP	26	7.7	NR	0
Manta et al. (2013)[30]	FSOCP	52	3.8	NR	0
Woo et al. (2014)[31]	FSOCP	32	9.4	NR	0
Tieu et al. (2015)[32c)]	FSOCP	88	15.9	Abdominal pain (11.1)	1.1
Tanaka et al. (2016)[42]	DSOCP	22	7.7	Cholangitis (3.8) Pancreatitis (3.8)	0
Navaneethan et al. (2016)[34]	DSOCP	105	2.9	Cholangitis (1.9)	0

DPCS, direct peroral cholangiopancreatoscopy system; DSOCP, digital single-operator cholangiopancreatoscope; FSOCP, fibro-optic single-operator cholangiopancreatoscope; NR, not reported.
[a)]Numbers represent the adverse event rate for both diagnostic and therapeutic procedures and includes procedures with both biliary and pancreatic accesses.
[b)]In this study, cholangitis (7.5) and pancreatitis (8.9) were considered as severe adverse events. The high rate of pancreatitis was attributed to the lack of administration of rectal indomethacin.
[c)]All cases received pre-procedural antibiotics.

AE rate of the SOCP for both diagnostic and therapeutic procedures was between 2% and 30%. The AEs included cholangitis, pancreatitis, hemobilia, bile leak, and rare and serious AEs, such as air embolization and bile duct perforation. Sethi et al. compared the AE rate between 402 patients who underwent ERCP with cholangioscopy and 3,475 patients who underwent ERCP only and reported a higher overall AE rate in the former group of patients (7% vs. 2.9%, respectively; odds ratio [OR], 2.5; 95% confidence interval [CI], 1.56–3.89).[43] Their subgroup analysis also revealed a higher rate of cholangitis in the former group (1.0% vs. 0.2%, respectively; OR, 4.95; 95% CI, 1.06–19.67), with similar rates of pancreatitis and perforation.[43] In a systematic review including 49 studies on the SOCP and DPCS, the overall and severe AE rates were 7% and 1%, respectively, with cholangitis being the most common AE (4%).[44] Turowski et al. reported an AE rate of 13.2% in 250 patients who underwent surgery using the DSOCP, with cholangitis being the most common AE (8%).[26] Prophylactic pre-procedural antibiotics were administered in 40% (102) of the patients, which resulted in a significantly lower rate of cholangitis in comparison with those who did not receive antibiotic prophylaxis (*n*=148, 60%) (1% vs. 12.8%,

$p<0.01$). Therefore, administration of peri-procedural antibiotics should be recommended in all patients undergoing cholangioscopy.[26] The recent retrospective multicenter study (three centers; 341 patients) by Bernica et al. compared cholangioscopy-related AEs among 209 patients divided into three different age groups (178 patients aged <65 years; 86 patients aged 65–75 years; and 77 patients aged >75 years).[45] The overall AE rate was 7.3%, with no significant difference among the three age groups (7.30% for the patients aged <65 years, 6.98% for those aged 65–75 years, and 7.79% for those aged >75 years; $p<0.17$).[45]

Air embolism is a rare but serious AE of the DPCS and has been reported in 0%–2.3% of procedures. The use of water for better visualization and CO_2 instead of air for insufflation is recommended to minimize this fatal AE.[46]

COST

There are limited data on the economic impact of the use of cholangioscopy compared with other conventional modalities. Recently, Deprez et al. compared the use of ERCP and the SOCP for the diagnosis of malignant biliary strictures and reported that the use of the SOCP reduces the number of needed procedures by 31% and saves approximately 5% of the allocated budget.[47] Further studies are needed to evaluate the cost-effectiveness of the SOCP in other clinical settings.

CONCLUSIONS

The evaluation of indeterminate biliary strictures presents a diagnostic challenge, and early precise diagnosis is important for achieving optimal patient outcomes and avoiding unnecessary surgical procedures. Radiologic evaluation is useful to detect and characterize strictures and select the best endoscopic diagnostic technique. In patients with biliary strictures due to extrinsic compression (e.g., pancreatic tumors or regional lymphadenopathy) and those with distal biliary lesions, EUS-FNA should be considered as the first endoscopic procedure. If EUS-FNA reveals no diagnostic findings, ERCP with cholangioscopy should be performed next and possibly during the same session. The new-generation DSOCP has improved the image quality and is safe even in the geriatric population. However, the interpretation of cholangioscopic visual findings remains challenging, and to date, there is a lack of uniformity and a poor inter-observer agreement among experts for the visual interpretation of indeterminate biliary strictures. Although miniature biopsy forceps are essential in the sampling of indeterminate strictures, the yield is suboptimal in certain patients. Studies focusing on the optimization of biopsy techniques and handling of procured specimens are needed.

Conflicts of Interest

Mouen A. Khashab is a consultant for Boston Scientific and Olympus America. The other author has no financial conflicts of interest.

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