Role of endoscopy in primary sclerosing cholangitis: ESGE/EASL clinical guidelines
Aabakken, Lars
Karlsen, Tom Hemming
Albert, Jörg
Arvanitakis, Marianna
Chazouilleres, Olivier
Dumonceau, Jean-Marc
Färkkilä, Martti
Fickert, Peter
Hirschfield, Gideon
Laghi, Andrea
Marzioni, Marco
Michael, Fernandez
Pereira, Stephen
Pohl, Jürgen
Poley, Jan-Werner
Ponsioen, Cyriel. I.J.
Schramm, Christoph
Swahn, Fredrik
Tringali, Andrea
Hassan, Cesare
Introduction

Primary sclerosing cholangitis (PSC) is a chronic bile duct disease with an estimated prevalence in the range of 1 to 16 per 100,000 with significant regional differences across Europe. The prevalence of PSC is increased in patients with ulcerative colitis and estimated in the range of 1-5% (1) MRI studies have showed that the prevalence of imaging changes compatible with PSC in ulcerative colitis is almost 4-fold higher than that detected based on clinical assessments (2). PSC is more common in men (comprising 60-70% of the patients) and most patients present with pancolitis often with a right-sided predominance (3-5). A major challenge in the clinical management of the patients is a highly increased and unpredictable risk of biliary and colonic malignancies.

The diagnosis of PSC is based on the combination of clinical, laboratory imaging and histological findings. Briefly, a diagnostic work-up for PSC should be performed in all patients with inflammatory bowel disease (IBD) and abnormal liver biochemistry tests, especially elevated ALP and gGT values, as well as non-IBD patients with elevated cholestatic liver enzymes not otherwise explained. A proposed algorithm for PSC diagnosis has already been proposed by prior European Association for the Study of the Liver (EASL) guidelines (6), and comprehensive discussion of issues unrelated to the use of endoscopy in PSC will not be addressed in the present Guideline.

Endoscopic retrograde cholangio-pancreatography (ERCP) plays a significant role in the handling of PSC due to its high accuracy, prognostic value as well as its sampling and therapeutic possibilities. However, ERCP must be integrated in well defined clinical algorithms together with less or non invasive imaging and biochemical tests. In particular, the widespread implementation of MR cholangiography (MRC) has led to an increasing restriction of the the use of ERCP to cases where the diagnosis is equivocal, or when sampling or endoscopic treatment are required.

The aim of this evidence- and consensus-based Guidelines, commissioned by the European Society of Gastrointestinal Endoscopy (ESGE) and the EASL, is to provide practical advice on how to utilize ERCP and colonoscopy in PSC patients, in order to maximize its benefit and minimize its burden and adverse events.

Methods

The ESGE and the EASL commissioned this Guideline and appointed panel representatives from both societies to participate in the project development. The Guideline development process included meetings and online discussions among members of the Guideline committee during January April 2015 and July 2016. Key questions were prepared by the coordinating team. A systematic literature search in PubMed/MEDLINE and the Cochrane Library was conducted using at minimum the search terms “Primary Sclerosing Cholangitis” and “Endoscopy”, and “Colonoscopy” for the part related with the diagnosis and surveillance of IBD in PSC. Articles were first selected by title, their relevance was then assessed by reviewing full-text articles, and publications with content that was considered irrelevant were excluded. Aspects related to endoscopy in PSC patients after liver transplantation were omitted. Evidence tables were generated for each key question, summarizing the quality evidence of the
available studies. The entire process was performed according to the Grading of Recommendations Assessment, Development and Evaluation (GRADE) system (7). Draft proposals were presented to the entire group for general discussion and voting during a plenary meeting held in November 2015.

In May 2016, a compiled manuscript prepared by L.A. and T.H.K. was sent to all group members. After revisions and agreement on a final version, the manuscript was submitted for peer review. The revised manuscript was approved by all authors and the governing boards of ESGE and EASL and was subsequently forwarded to Endoscopy and Journal of Hepatology for publication.

Endoscopic diagnosis and surveillance of PSC

**Diagnosis of PSC**

1. ESGE/EASL recommend that, as the primary diagnostic modality for PSC, MRC should be preferred over ERCP (moderate quality evidence, strong recommendation).

Although ERCP has been regarded as the standard of reference in diagnosing PSC, MRC is now recommended as first line non-invasive imaging method for patients with suspected PSC, offering comparable accuracy (except in in early stage of PSC restricted into intrahepatic bile ducts and the rare cases of contraindications to MRC) (8-12). A meta-analysis based on six studies using ERCP as a reference method concluded that MRC has high sensitivity and specificity (0.86 and 0.94, respectively) for the diagnosis of PSC (13). According to a decision model comparing different approaches in the work-up of patients with suspected PSC (14), the strategy of initial MRC, followed by ERCP only in selected cases (e.g. ambiguous MRC findings), is the most cost-effective approach (14, 15).

The ductographic features defining PSC are described below but a number of other diseases of the biliary tree may present similar features (table 1). The specificity of the cholangiographic features of PSC without the additional diagnostic clinical and biochemical clues is poor (16).

**Table 1: Classification of secondary sclerosing cholangitis and conditions that may mimic primary sclerosing cholangitis on cholangiography**

<table>
<thead>
<tr>
<th>Infection</th>
<th>Bacterial / parasitic cholangitis</th>
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<tr>
<td></td>
<td>Recurrent pyogenic cholangitis</td>
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<table>
<thead>
<tr>
<th>Immunodeficiency related (infections)</th>
<th>Congenital immunodeficiency</th>
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<tbody>
<tr>
<td></td>
<td>Acquired immunodeficiency (e.g. HIV)</td>
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<tr>
<td></td>
<td>Combined immunodeficiencies</td>
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<tr>
<td></td>
<td>Angioimmunoblastic lymphadenopathy</td>
</tr>
<tr>
<td>Mechanic/toxic</td>
<td>Cholelithiasis/choledocholithiasis</td>
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<td>--------------------------------------</td>
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<tr>
<td></td>
<td>Surgical bile duct trauma</td>
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<tr>
<td></td>
<td>Intra-arterial chemotherapy</td>
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<td></td>
<td>Drug-induced sclerosing cholangitis</td>
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<tr>
<td>Ischaemic</td>
<td>Vascular trauma</td>
</tr>
<tr>
<td></td>
<td>Hepatic allograft arterial insufficiency</td>
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<tr>
<td></td>
<td>Paroxysmal nocturnal haemoglobinuria</td>
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<tr>
<td>Other pancreaticobiliary disease</td>
<td>Cystic fibrosis</td>
</tr>
<tr>
<td></td>
<td>Sclerosing cholangitis of critical illness</td>
</tr>
<tr>
<td></td>
<td>ABCB4 associated cholangiopathy</td>
</tr>
<tr>
<td></td>
<td>Chronic pancreatitis</td>
</tr>
<tr>
<td>Systemic inflammatory diseases</td>
<td>IgG4-associated systemic disease</td>
</tr>
<tr>
<td></td>
<td>Hypereosinophilic syndrome</td>
</tr>
<tr>
<td></td>
<td>Sarcoidosis</td>
</tr>
<tr>
<td></td>
<td>Graft-versus-host disease</td>
</tr>
<tr>
<td>Potentially mimicking on cholangiography</td>
<td>Langerhans cell histiocytosis</td>
</tr>
<tr>
<td></td>
<td>Systemic mastocytosis</td>
</tr>
<tr>
<td></td>
<td>Caroli’s disease</td>
</tr>
<tr>
<td></td>
<td>Congenital hepatic fibrosis</td>
</tr>
<tr>
<td></td>
<td>Other types of ductal plate abnormalities</td>
</tr>
<tr>
<td></td>
<td>Hodgkin's disease</td>
</tr>
<tr>
<td></td>
<td>Cholangitis glandularis proliferans</td>
</tr>
<tr>
<td></td>
<td>Neoplastic/metastatic disease</td>
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</table>
Of note, the visualization of the distal common bile duct and the peripheral intrahepatic ducts is still suboptimal using MRC (10, 12). One study has suggested that a numerical score calculated based on three-dimensional MRC may predict progression of bile duct changes but the study lacked ERCP reference (17). A diagnostic MRC, because of its very high specificity for the diagnosis of PSC when diagnostic clinical and biochemical clues are present, obviates a confirmatory ERCP unless therapeutic procedures or ductal sampling are indicated (13, 18).

2. ESGE/EASL suggest that ERCP can be considered if MRC and liver biopsy is equivocal or contraindicated in patients with persisting clinical suspicion of PSC. The risks of ERCP have to be weighed against the potential benefit with regard to surveillance and treatment recommendations (low quality evidence, weak recommendation).

Whether or not to perform ERCP in patients with normal high-quality MRC depends on the level of clinical suspicion for PSC and impact of the diagnosis on patients management and prognosis. ERCP is regarded unnecessary in patients with a low level of clinical suspicion, but it could be considered in patients with intermediate or high level of clinical suspicion as suggested by a meta-analysis of MRC diagnostic performance (13). However, this meta-analysis included only studies performed prior to 2007. The continuous improvement in MRC quality due to use of higher magnetic fields, as exemplified by the ability to visualize third- and fourth-order intrahepatic ducts as well as the availability of 3-dimensional image acquisition, is likely to further decrease the probability of abnormal ERCP in patients with normal MRC. In addition, as detailed reports including clinical, biochemical and histological characteristics and outcome of these patients with negative MRC but positive ERCP are lacking, the clinical benefit of ERCP can be questioned in this setting. If high-quality MRC images are not available or in equivocal cases, it is reasonable to consider patient referral to centers with known technical expertise with MRC as a first step (19), followed by liver biopsy. If high-quality MRC images and liver biopsy still cannot definitely exclude or confirm the presence of PSC, ERCP can be considered in patients with persisting clinical suspicion for the diagnosis to take advantage of the filling pressure obtained by the balloon occlusion, and slight superiority as to visualization of the extrahepatic bile ducts.

**Ductographic criteria for PSC**

The first ERCP criteria for ductographic changes in PSC were published in 1984 by Li-Yeng (20). Typical changes seen in PSC consist of minor irregularities of duct contour and local narrowing with prestenotic dilatation (type I), threadlike narrowings alternating with normal caliber of bile ducts or slight dilatation (type II), multiple strictures with saccular dilatations (type III), and the most advanced changes consisting of advanced ductal narrowing with resultant lack of filling of the peripheral ducts (type IV). The classification has later been modified by Majojie et al (21) and Ponsioen et al (22, 23). The classification of Ponsioen et al (23) has been validated and shown to correlate with patient prognosis.
Another type of classification is based on evaluation of the grade, length, and extent of strictures, the degree of bile duct dilatation, and the distribution of lesions (24). None of the ductographic criteria published are specific for PSC and the findings must be interpreted in the context of patient demographics and the clinical context. Review by teams with an expertise in complex biliary disease is often useful, as multiple secondary causes of sclerosing cholangitis must be considered (25) (Table 3).

Table 2. Amsterdam classification of cholangiographic changes in PSC (23)

<table>
<thead>
<tr>
<th>Type</th>
<th>Intrahepatic</th>
<th>Extrahepatic</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>No visible abnormalities</td>
<td>No visible abnormalities</td>
</tr>
<tr>
<td>I</td>
<td>Multiple caliber changes; minimal dilatation</td>
<td>Slight irregularities of duct contour; no stricture</td>
</tr>
<tr>
<td>II</td>
<td>Multiple strictures; saccular dilatations, decreased arborization</td>
<td>Segmental strictures</td>
</tr>
<tr>
<td>III</td>
<td>Only central branches filled despite adequate filling pressure; severe pruning</td>
<td>Strictures of almost entire length of duct</td>
</tr>
<tr>
<td>IV</td>
<td>-</td>
<td>Extremely irregular margins; diverticulum like outpouchings</td>
</tr>
</tbody>
</table>

Table 3: Characteristic cholangiographic features in primary sclerosing cholangitis (PSC) and other ductal diseases

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Main Cholangiographic features</th>
</tr>
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<tbody>
<tr>
<td>PSC</td>
<td>Multifocal intra- and extra-hepatic bile duct strictures (“beaded” appearance), slight biliary dilatation, diverticular outpouchings, pruned-tree appearance at chronic stage</td>
</tr>
<tr>
<td>Ascending cholangitis</td>
<td>Multiple intrahepatic bile duct strictures, stones, biliary abscesses</td>
</tr>
<tr>
<td>Ischaemic cholangitis</td>
<td>Proximal intrahepatic bile duct strictures, bile duct necrosis, biliomas, abscesses, biliary cast</td>
</tr>
<tr>
<td>Caustic cholangitis</td>
<td>Localized intrahepatic bile duct strictures, irregularities of bile duct wall</td>
</tr>
<tr>
<td>AIDS related cholangitis</td>
<td>Stricture of the distal common bile duct, papillitis, acalculous cholecystitis</td>
</tr>
<tr>
<td>IgG4 related cholangitis</td>
<td>Multifocal central bile duct strictures, bile duct wall thickening with visible lumen, pancreatic abnormalities compatible with autoimmune pancreatitis</td>
</tr>
<tr>
<td>Portal biliopathy</td>
<td>Central and extrahepatic bile duct irregularities</td>
</tr>
</tbody>
</table>
**Unusual cholangiographic features**

Some PSC patients may present with cystic dilatations of intrahepatic bile ducts simulating Caroli’s disease (10). Of note, the fusiform and small cystic dilatations of intrahepatic (mostly peripheral) bile ducts as observed in patients with congenital hepatic fibrosis and autosomal recessive polycystic kidney disease should not be misdiagnosed as PSC (11). Another differential diagnosis is the peculiar cholangiographic phenotype of adult forms of ABCB4/MDR3 deficiency which may be characterized by large uni- or multifocal spindle-shaped intra-hepatic bile duct dilatations with or without apparent bile duct stenosis (12, 26). Diagnosis should be suspected on familial clustering of excessive gallstone disease and a history often with prior cholecystectomy at age < 40 years and associated intrahepatic cholestasis of pregnancy and is confirmed by ABCB4 genotyping.

3. **ESGE/EASL do not suggest routine use of other endoscopic techniques (i.e. EUS including IDUS, cholangioscopy, confocal endomicroscopy) than ERC for the diagnosis of PSC (weak recommendation, low quality evidence)**

In the diagnosis of PSC there is no established role for endoscopic techniques beyond ERCP, e.g. brush cytology, ductal biopsy, cholangioscopy or confocal laser microscopy. In selected cases with suspected extrahepatic disease and inconclusive MRC findings, endoscopic ultrasound (including intraductal ultrasound, IDUS) and elastography may add information on common bile duct strictures, wall thickening and liver fibrosis stage (27-30).

**ERCP in established PSC**

4. **ESGE/EASL suggest to define a dominant stricture (DS) at ERC as a stenosis with a diameter of ≤1.5 mm of the common bile duct and/or ≤1.0 mm of a hepatic duct within 2 cm of the main hepatic confluence (weak recommendation, low quality evidence).**

Deciding on the clinical impact of a bile duct stricture may be challenging. The DS denomination arose alongside the term “major stricture” early in the history of endoscopic management of PSC (31). The “major” or “dominant” stricture terms were initially used more broadly pertaining to strictures of the common bile duct and right and left bifurcation of the hepatic ducts (extrahepatic PSC lesions), since these were found to be more prone to clinical events than intrahepatic strictures (31, 32). The precise definition of a DS was introduced by Stiehl et al. for the use in endoscopic studies as a severity measure in 2002 (33, 34), although is somewhat arbitrary set, depending on e.g. filling pressure. A number of endoscopic studies both before and after 2002 do not apply the diameter criterion strictly when determining DS (35, 36), and focus on suspected clinical relevance. Determining the clinical significance and potential benefit from endoscopic interventions should therefore not be based on this definition alone and the decision for intervention rather considered a compound clinical decision. Multiple DS can be found in the same patient (12% in the study by Bjornsson et al) (34). Of note, the ERCP definition of DS is usually considered as not applicable to MRC, in particular in the extrahepatic ducts, given the insufficient spatial resolution of MRC (37, 38) and the lack of hydrostatic pressure as provided by ERCP.
A complete occlusion cholangiogram should generally be obtained if an ERCP is performed because it adds little risk to the ERCP, decreases variability, and may reveal that a DS suspected at MRC is indeed not a stricture (39).

5. ESGE/EASL suggest ERCP and ductal sampling (brush cytology, endobiliary biopsies) should be considered in established PSC in the case of (i) clinically relevant or worsening symptoms (jaundice, cholangitis, pruritus) (ii) rapid increase of cholestatic enzymes levels or (iii) new or progression of existing dominant strictures in ERC in the context of appropriate clinical findings (weak recommendation, low quality evidence).

ERCP can be indicated in patients with a confirmed diagnosis of PSC when changes in clinical, laboratory and radiological findings occur during the course of the disease. The purpose is to make an assessment of the likelihood of the presence of biliary dysplasia as a risk factor for cholangiocarcinoma (CCA) and to determine biliary strictures amenable to intervention.

a) Clinical events.
In the early stage of PSC dominant biliary strictures are usually asymptomatic. Exacerbation of jaundice (not related to liver failure), episodes of fever and chills suggestive of cholangitis or worsening of pruritus are indications for ERCP for the treatment of dominant strictures and to perform ductal brush sampling to exclude malignancy (40, 41). Worsening pain in the right upper abdominal quadrant, fatigue and weight loss also need careful evaluation.

b) Laboratory results.
Serum laboratory tests are neither sensitive nor specific enough to evaluate PSC progression (41), but in case of rapid increase of serum bilirubin levels and/or cholestatic liver enzymes (serum alkaline phosphatase, serum gamma glutamyl transferase) ERCP is indicated (6), especially in patients with a diagnosis of clinically significant hilar or extrahepatic strictures on MRC. Elevation of serum CA19-9 in PSC patients has an unsatisfactory sensitivity (14%) and positive predictive value (67%) for the diagnosis of CCA (36, 41, 42), and is not helpful in selecting patients for ERCP.

c) Progression/new onset clinically significant strictures on MRC.
Progressive intra- or extra-hepatic bile duct dilatation on imaging studies (ultrasound or MRC) is an indication for ERCP with ductal sampling (6). A careful evaluation of new onset dominant strictures in PSC is recommended, due to the increased risk of CCA in this situation. In detail, a stricture disproportionately severe relative to others, concomitant biliary filling defects, marked biliary dilation [≥ 2 cm for the common bile duct, ≥1 cm for the right or left intrahepatic ducts, ≥ 5 mm for other intrahepatic ducts] suggests CCA (43). Conversely, this risk was absent in patients without dominant strictures according to a 25 year experience (44). Abnormal cytological findings, such as suspicion of malignancy or aneuploid DNA findings need a close follow-up by ERCP with repeated sampling, unless urgent liver transplantation is considered warranted.

The utility of ERCP in handling DS was shown in a prospective study (45) on 171 PSC patients followed for 20 years: repeated endoscopic therapy was associated with a transplant free
survival of 81% at 5 years and 52% at 10 years after initial endoscopic therapy. In this population, a 6% CCA rate was found in patients with dominant strictures.

6. EAGE/EASL suggest that, in patients with an established diagnosis of PSC, MRC should be considered before therapeutic ERCP (weak recommendation, low quality evidence).

MRC may be useful to confirm the indication, exclude focal parenchymal changes and to give clinicians performing ERCP imaging based guidance to minimize the risk of complications. Regarding MRC in established PSC, a single retrospective centre study reported a 76% accuracy of MR with MRC in the diagnosis of CCA complicating PSC (43). For these reasons, patients with an established diagnosis of PSC should have an MRC exam in his/her clinical records (13, 46).

7. ESGE/EASL suggest performing endoscopic treatment with concomitant ductal sampling (brush cytology, endobiliary biopsies) of suspected significant stricture at MRC in PSC patients who present with symptoms likely to improve following endoscopic treatment (strong recommendation, low quality evidence).

Selected series reporting on the endoscopic treatment in PSC patients are summarized in Table 4; none of these compared performance vs no performance of endoscopic treatment for DS. The benefits reported following DS dilation included short-term improvement of symptoms and of liver biochemical tests as well as a longer liver transplantation (LT)-free survival compared to that predicted using the Mayo clinical risk model. Similar findings have also been reported in several smaller case series (47-51).

The main criticisms made to these studies are as follows:

a) The Mayo clinical risk model was not designed to evaluate patients with DS; specifically, many patients underwent therapeutic ERCP because of elevated bilirubin, which is part of the Mayo risk score, and went down in most patients after the intervention. Hence, baseline Mayo risk score was not determined in a steady state situation;

b) Serum tests for cholestasis may spontaneously fluctuate in patients with PSC complicated or not with a DS. Bjornsson et al reported in 125 PSC patients changes in s-ALP and s-bilirubin from baseline up to 12 months following ERCP. As patients with DS received no stricture dilation, the authors stated that “If our patients had been consequently dilated or stented the decrease in bilirubin and clinical features at follow-up would have been attributed to endoscopic therapy” (34). However, in that study, the variations reported in ALP and in total serum bilirubin after vs before ERCP were not significant, in contrast with various studies listed in Table 4 that used DS dilation/stenting. Also, it was not clear on what basis these patients were treated conservatively, while others did receive endoscopic therapy.

Other limitations of most studies listed in Table 4 include a retrospective design, selection bias, reporting of results mixed for dilation ± stenting of DS as well as treatment with ursodeoxycholic acid started during follow-up in a minority of patients.
A critical issue is to weigh potential benefits vs. the certain risks of therapeutic ERCP in patients with no other therapeutic option except LT. Symptoms likely to improve following DS treatment generally include pruritus, pain, cholangitis and jaundice in patients with a significant (≥20%) increase in cholestasis while in patients with end-stage liver disease, only cholangitis is expected to improve.

Finally, patients with advanced liver disease with cirrhosis may not benefit from endoscopic treatment. Ahrendt et al. reported no change in serum bilirubin at one year following endoscopic and/or percutaneous stricture dilation in 10 patients with cirrhosis and a baseline serum bilirubin ≥5 mg/dl (52). Death following endoscopic balloon dilation of DS has been reported in a patient with PSC and end-stage liver disease (53). Diagnostic ERCP was followed by deterioration of cholestasis in 7 of 8 vs. one of 7 patients with more (Ludwig stage III or IV) vs. less (Ludwig stage I or II) advanced PSC at biopsy (54).

**Balloon dilation vs. stent therapy**

8. EASGE/EASL suggest that the choice between stenting and balloon dilation should be left at the endoscopist’s discretion (weak recommendation, low quality evidence).

Results from selected series reporting on endoscopic treatment of dominant strictures in PSC are summarized in Table 4. Of note, (i) in the majority of studies that reported on balloon dilation for DS, stents were inserted in a minority of patients, (ii) a significant improvement in LT-free survival compared with the Mayo model has been reported only with balloon dilation and (iii) the perforation rate has been higher with stenting compared with balloon dilation.

A single, retrospective, study compared balloon dilation vs. balloon dilation combined with stenting for DS in PSC patients (n=34 and n=37, respectively) (53). The “balloon dilation alone group” was treated by endoscopic means only while 23 (62%) patients in the “stenting” group underwent percutaneous treatment due to failed endoscopic access and/or DS dilation. Serum bilirubin similarly decreased in both groups of patients but more procedures and more complications were recorded in the stent vs. the balloon dilation group (median number of procedures per patient, 5.0 vs. 2.1, respectively; patients with complications, 54% vs. 15%, respectively). Complications included bile duct perforation in 7 (10%) patients, 5 of whom were in the stent group. However, conclusions are difficult to draw due to the different access routes used (percutaneous in 62% vs. 0 in the stent vs. balloon dilation group, respectively), a selection bias due to more severe stricture in the stent group and the long stenting duration used (mean, 3 months) putting the patient at high risk for stent clogging and cholangitis. A short stenting duration (see recommendation 13) is currently the standard of care. The European multicenter randomized DILSTENT trial comparing single balloon dilatation versus short-term stenting was prematurely stopped recently after a planned interim analysis. Preliminary results show no differences in outcome, but a significantly higher serious adverse event rate in the stent group, mainly consisting of PEP and suppurative cholangitis (ref. pending).
Role of sphincterotomy

9. ESGE/EASL recommend weighing the anticipated benefits of biliary papillotomy/sphincterotomy against its risks on a case-by-case basis (strong recommendation, moderate quality evidence). Biliary papillotomy/sphincterotomy should be considered especially after difficult cannulation (strong recommendation, low quality evidence).

Biliary sphincterotomy was performed routinely as part of the endoscopic treatment of DS in some studies (53) while its use was restricted to specific cases such as stone extraction and difficulties in stent insertion in other studies. For example, in 32 PSC patients treated with stents for DS, sphincterotomy was performed in 12 (38%) patients (55) while in another study of DS dilation±stenenting, sphincterotomy was performed in 63% of 63 patients (56).

Generally, biliary sphincterotomy is not recommended as a routine procedure prior to biliary stenting because of the associated risks as demonstrated in RCTs (57). However, if cannulation is difficult, biliary sphincterotomy is advised, when considering that these patients are likely to require multiple procedures. Many endoscopists prefer a small sphinterotomy in PSC in order to avoid ascending cholangitis.

Specifically in PSC, biliary sphincterotomy was independently associated with an increased risk of short-term adverse events in two retrospective studies (odds ratios [OR] 4.7 and 5.0) (58, 59) while previous biliary papillotomy/sphincterotomy was protective for subsequent ERCPs (58); therefore experienced endoscopists perform biliary sphincterotomies in patients with difficult cannulation in whom ERCP is likely to be repeated during follow-up.

Balloon dilation

10. ESGE/EASL suggest selecting the balloon calibre of up to the the maximum caliber of the ducts delimiting the stricture (weak recommendation, low quality evidence).

11. ESGE/EASL suggest repeating dilation of relapsing DS if (i) the DS is regarded as the cause of recurrent symptoms (cholangitis, pruritus) or of significant increase in cholestasis and (ii) patient’s response to previous dilations has been satisfactory (weak recommendation, very low evidence).

There are no comparative data on the optimal dilation scheme or balloon diameter for treating DS. In the largest prospective study (500 endoscopic balloon dilations in 96 patients), the authors performed stepwise DS dilation up to diameters of 8 mm and 6-8 mm in the common bile duct and the hepatic ducts, respectively (60). Bile duct diameter upstream and downstream of the DS should be taken into account for selecting the balloon diameter to avoid dilating to more than the duct diameter. Balloon dilations are usually repeated at intervals of one to four weeks up to technical success, for an average of 2-3 balloon dilations (33, 51, 60). Technical success has been defined as complete balloon inflation within the DS with no waist observed fluoroscopically followed by the unobstructed passage of contrast medium through the dilated biliary segment to the duodenum (51, 60). Using this technique, bile duct perforation was reported in 0.2% of DS dilations (1% of patients) (60). In contrast, another study that
used 4-12 mm in-diameter balloons for dilation reported dilation-related biliary perforations in 3.5% of procedures (56).

Repeat balloon dilation during follow-up after initial treatment (usually consisting of several ERCPs) has been mentioned in some studies but no results of the repeat dilation in terms of clinical or biochemical improvement has been reported (33, 51).

**Stent therapy**

12. ESGE/EASL suggest selecting a single 10-Fr stent or two 7-Fr stents for, respectively, for DS in the extrahepatic ducts or hilar strictures extending into the left or right hepatic duct (final stent diameters in the case of stepwise stenting) (weak recommendation, very low quality evidence).

In all large studies of endoscopic treatment for DS, plastic stents measuring 7 to 10-Fr in diameter were used, with no comparison of the results obtained with various stent diameters reported. Specifically, the Amsterdam group aimed at inserting a single 10-Fr stent, and if this was not possible at first attempt, it was preceded by 1-week stenting with a 7-Fr stent or insertion of a nasobiliary catheter (55, 61). The Mayo group used 7–10-Fr stents at the endoscopist’s discretion (53). The Indianapolis group did not mention the diameter of stents used (56). Two 7-Fr stents have typically been used in patients with multiple bilateral DS and in patients with a hilar stricture extending into the left or right hepatic duct in order to avoid temporary obstruction of the contralateral biliary system. In general, the stent caliber and length must be adapted to the specific biliary tree configuration.

In other diseases, studies have shown that polyethylene stents provide better short-term (one-month) patency than Teflon models and that, at long-term, 10-Fr models provide longer biliary patency compared with thinner ones (11.5-Fr models do not provide longer patency) (57).

With respect to balloon dilation prior to stenting, it is currently unclear whether a balloon dilation is beneficial before stent placement.

**Duration of stenting**

13. ESGE/EASL suggest that stents used for treating DS should be removed 1-2 weeks following insertion (weak recommendation, low quality evidence).

No comparison of various stenting durations has been identified in studies reporting on stenting for DS. A short stenting duration is currently favored because stents tend to clog rapidly in PSC patients and similar efficacy results have been reported with short (1-2 weeks) vs. standard (8-12 weeks) stenting duration. Specifically, a retrospective study of short-term stenting (mean duration, 11 days) in 32 symptomatic PSC patients with DS showed, at two months, a symptomatic improvement in 83% of the patients as well as a significant improvement of cholestasis tests; at one and three years, actuarial analysis showed that 80% and 60% of patients, respectively, would not require reintervention (55). Stent dysfunction was not reported in this study but two patients treated by stent removal developed hydrops of the gallbladder. The same group of authors had previously reported similar efficacy results with 3-month stenting in 25 patients with symptomatic DS but, in that study, unscheduled stent exchange had to be performed on 32 occasions due to suspected stent clogging (cholangitis, n=23; jaundice, n=9) (62).
All studies mentioned focused on clinical and serum liver tests, not radiological data, to assess the short-term effect of therapeutic ERCP (53, 55, 61, 62). Endoscopic treatment has been repeated in a sizeable proportion of patients: for example, with long median stenting periods (3 months), the median number of repeated ERCPs per patients ranged between 3 and 5 during follow-up periods of 29 and 22 months in two studies (53, 62) while following a short stenting period (mean, 11 days) repeat ERCP rates at one and three years after treatment were estimated at 20% and 40%, respectively (55). Other details about repeated treatments were not reported.

In many centers, stents are removed during an esophagogastroduodenoscopy without biliary opacification in PSC patients.

Table 4: Selected series reporting on endoscopic treatment of dominant strictures in primary sclerosing cholangitis

<table>
<thead>
<tr>
<th>First author, Year</th>
<th>Study design</th>
<th>N</th>
<th>Intervention</th>
<th>Outcomes</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Dilation ± stenting</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Gotthardt, 2010 (extension of Stiehl 2002 study (33)) (60) | Prospective | 96 (AP>2xULN) | Balloon dilation (8 mm in CBD, 6-8 mm for IHBD), plus stent in 5 patients with severe cholestasis and bacterial cholangitis | Short-term improvement in cholestasis; transplant-free survival; complications | - At 2 weeks, mean bilirubin level significantly decreased (by 56%)
- Change in symptoms and LT-free survival - Comparison with Mayo model not reported (5- and 10-year LT-free survival, 81% and 52%)
- Overall complication rate, 3.8% |
<p>| Gluck, 2008 (35) | Retrospective | 84, symptomatic patients | Balloon dilation and stenting (70% and 51% of patients, respectively) | LT-free survival | - Higher proportion of patients alive with no LT at 3 and 4 years than predicted using Mayo model (P &lt; 0.05); at 1 and 2 years similar survival |</p>
<table>
<thead>
<tr>
<th>Study</th>
<th>Type</th>
<th>Patients</th>
<th>Procedure Details</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stiehl, 2002 (33)</td>
<td>Prospective</td>
<td>52 (AP&gt;2xUL N)</td>
<td>Balloon dilation (8 mm in CBD, 6-8 mm for IHBD), plus stent in 5 patients with severe cholestasis and bacterial cholangitis</td>
<td>Bilirubin and liver enzymes 2 weeks after dilation, symptoms, LT-free survival</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- At 2 weeks, significant decrease in liver enzymes and bilirubin</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Improvement of jaundice in 24/24 and of pruritus in 12/13 patients</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Longer LT-free survival than predicted using 1992 Mayo model (P &lt; 0.0001)</td>
</tr>
<tr>
<td>Baluyut, 2001 (56)</td>
<td>Retrospective</td>
<td>56 with and 7 without symptoms</td>
<td>Balloon dilation (4-12 mm, N=61) 1x/year, with stent if no significant radiological improvement following dilation (N=33)</td>
<td>LT-free survival, complication rate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Longer LT-free survival than predicted using 1999 Mayo model (P=0.027)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- 12% complications</td>
</tr>
<tr>
<td>2. Stenting</td>
<td></td>
<td></td>
<td></td>
<td>------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Ponsioen, 1999 (55)</td>
<td>Retrospective</td>
<td>32 symptomatic patients with successful stenting for DS</td>
<td>One-week stenting (10 Fr stent) with no balloon dilation</td>
<td>Two-month symptomatic and biochemical improvement, actuarial curve of reintervention-free patients</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Improvement of symptoms in 83%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Significant decrease in bilirubin (44% had increased conjugated bilirubin at baseline) and cholestasis enzymes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Reintervention-free patients (actuarial): 60% at 3 years</td>
</tr>
</tbody>
</table>
| van Milligen de Wit, 1996 (62) | Retrospective | 25 with symptoms or progression of serum tests for cholestasis | Stenting for a median of 3 months (plus 8-mm dilation in 3 patients) | Change in symptoms and biochemical tests within 6 months following stent insertion; Adverse events | - Improvement of symptoms in 76%  
- Significant decrease in bilirubin (52% had increased bilirubin at baseline) and serum tests for cholestasis;  
- 32 episodes of cholangitis/jaundice related to stent clogging |

### 3. Dilation v. stenting

| Kaya, 2001 (53) | Retrospective | 71 with symptoms | Balloon dilatation (4-8 mm, N=34) vs balloon dilation with 3-4-month stenting (N=37). Intervention via PTBD in 0/34 vs 23/37 patients in balloon vs stent group | Biochemical course up to 24 months | - Both strategies improved liver biochemistry, fever resolved only in the dilatation without stent group. No additional benefit of stenting after balloon dilatation  
- More complications in stent vs dilation alone group (P=0.001) as well as in PTBD vs ERCP group (P<0.001) (no multivariate analysis) |

**AP**, alkaline phosphatases; **DS**, dominant stricture; **ULN**, upper limit of normal values; **CBD**, common bile duct; **IHBD**, intrahepatic bile ducts; **UDCA**, ursodeoxycholic acid; **LT**, liver transplantation; **SAE**, serious adverse events; **PTBD**, percutaneous transhepatic biliary drainage.
Complications of endoscopic therapy

14. ESGE/EASL suggest that ERCP in PSC patients should be undertaken by experienced pancreaticobiliary endoscopists (strong recommendation, very low quality evidence).

Several studies have evaluated the risk of complications in PSC patients undergoing ERCP (63-74). ERCP carries an increased risk for complications in the context of PSC, especially pancreatitis, cholangitis and extravasation of contrast, although not all the studies were documented such an increased risk in PSC (69, 74). In the systematic survey (75) of post-ERCP complications on various indications for ERCP including 21 prospective studies and 16,855 patients the number of total complications was 6.85% (CI 6.46-7.24%). Pancreatitis occurred in 585 subjects (3.47%, CI 3.19-3.75%). In another large retrospective single center study (76) with 11,497 procedures over 12 years the total complication rate was 4.0 % and pancreatitis occurred in 3.6%. The overall risk of adverse events in patients with PSC has varied in different, much smaller, studies from 1.8 % to 18.4 % (63-74), which is higher than reported in other indications (75, 76).

Retraction of the papilla and an altered, more difficult, position of the endoscope due to hypertrophy of the left liver lobe may be encountered during ERCP in PSC patients. Whether this actually influences cannulation success rates has not been investigated by specific studies. Cohort studies describing PSC patients provide only limited details on cannulation difficulties with failure rates of 0% to 6% (36, 44, 64-66, 74, 77-80). Furthermore, there is likely a selection bias since most retrospective series describing the results of endoscopic treatment have the initiation of therapy as prerequisite, therefore potentially excluding cannulation failures.

The largest series is the study by Ismail et al (71). In this retrospective review of 441 ERCP procedures over a three-year time period, primary cannulation success was 88.2%. Of note, in 137 patients (37.8%) a previous biliary sphincterotomy had been performed. Pancreatic sphincterotomy as an access technique was used in 11.8% and freehand needle knife sphincterotomy in a further 2.5%. Primary failure rate was 0.5%. These figures suggest that cannulation in PSC patients may indeed be more difficult than in other types of patients.

Post-ERCP pancreatitis

15. ESGE/EASL recommends routine rectal administration of 100mg of diclofenac or indomethacin immediately before or after ERCP in all patients without contraindication. In addition to this, in the case of high risk for post-ERCP pancreatitis, the placement of a 5-Fr prophylactic pancreatic stent should be considered (strong recommendation, high quality evidence).

Post ERCP-pancreatitis (PEP) is the most common and feared complication associated with ERCP. The risk for PEP in PSC vary from 1 to 7 %, although the diagnostic criteria vary between studies (81). Although the quality of the evidence is low, risk factors increasing the risk for PEP are probably not different in PSC patients from the general population: female sex (odds ratio [OR] 2.6, P= 0.015) and a guide wire in the pancreatic duct (OR 8.2, P<0.01). Native papilla increases whereas previous sphincterotomy decreases the risk (71), suggesting that preemptive EPT might be warranted in PSC patients where repeat procedures might be anticipated. This has however yet to be proven.
Prolonged papilla contact time as well as therapeutic procedures such as biliary brush cytology, sphincterotomy, stenting and dilatation are associated with increased risk of PEP. Precut biliary and pancreatic sphincterotomy is markedly associated with PEP (71), possibly reflecting the difficult cannulation and prolonged procedure time. The recent Cochrane analysis comparing the contrast-assisted technique with the guidewire-assisted cannulation technique showed that guidewire technique both increased the primary cannulation rate and reduced the risk of PEP, and it appears to be the most appropriate first-line cannulation technique (82).

**Rectal NSAIDs.** In its 2014 update to the Guideline on the prophylaxis of post-ERCP pancreatitis, the ESGE recommends routine rectal administration of 100mg of diclofenac or indomethacin immediately before or after ERCP in all patients undergoing ERCP without contraindication to NSAIDs (83). The recommendation was supported by the results of six meta-analyses published between 2009 and 2014 that compared NSAIDs vs. placebo administration for prophylaxis of post-ERCP pancreatitis. These meta-analyses concordantly showed the benefit of NSAIDs in preventing either mild or moderate/severe PEP. These results were further supported by subsequent meta-analyses (84, 85) and the cost-efficiency of this approach has been demonstrated (86). This recommendation applies to PSC patients.

**Pancreatic stenting:** The ESGE 2014 recommendation about prophylactic pancreatic stenting was supported by (i) three meta-analyses of RCTs that showed a significant reduction in the incidence and the severity of PEP when prophylactic pancreatic stenting was used and (ii) a study showing that pancreatic stent placement is cost-effective only in patients/procedures at high risk for post-ERCP pancreatitis.

The following conditions relevant to PSC are considered to represent high risk for PEP: precut biliary sphincterotomy, pancreatic guidewire-assisted biliary cannulation, endoscopic balloon sphincteroplasty, pancreatic sphincterotomy, and presence of more than three of the following risk factors: female gender, previous pancreatitis, younger age, nondilated extrahepatic bile ducts, absence of chronic pancreatitis, normal serum bilirubin, cannulation attempts duration > 10 min, pancreatic guidewire passages > 1, pancreatic injection, failure to clear bile duct stones, intraductal ultrasound.

16. ESGE/EASL suggest routine administration of prophylactic antibiotics before ERCP in patients with PSC (strong recommendation, low quality evidence).

Bacterial cholangitis and bacteriobilia are not an infrequent finding among patients with PSC. In studies evaluating the complications of ERCP in PSC the risk for cholangitis has varied from 0.2 to 8 % (63-74), depending among other items on the criteria used to define cholangitis. The use of prophylactic antibiotics markedly varies between studies in terms of prevalence, type of antibiotic and duration of administration (from one oral dose before the procedure to one-week dosing afterwards). In a Cochrane meta-analysis (9 RCTs, 1573 patients), the prophylactic use of antibiotics was shown to prevent cholangitis (relative risk (RR) 0.54, 95% CI 0.33 to 0.91), septicemia (RR 0.35, 95% CI 0.11 to 1.11), bacteriemia (RR 0.50, 95% CI 0.33 to 0.78), and pancreatitis (RR 0.54, 95% CI 0.29 to 1.00). It was concluded that prophylactic antibiotics reduce bacteriemia and seem to prevent cholangitis and septicemia in patients undergoing elective ERCP (87). Our recommendation is in line with the ASGE
recommendation to prescribe antibiotic prophylaxis in procedures where drainage achieved at ERCP is incomplete or achieved with difficulty, such as PSC (88). Bile fluid sampling could be considered during ERCP, to guide antibiotic treatment in case cholangitis occurs despite the prophylaxis (89)

Table 5. Complications of ERCP in PSC patients.

<table>
<thead>
<tr>
<th>First author, year, country</th>
<th>Study design</th>
<th>Patients/ERCPs</th>
<th>Complications, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>Lee, 1995, USA (65)</td>
<td>Retrospective</td>
<td>53/175</td>
<td>13.7</td>
</tr>
<tr>
<td>van den Hazel, 2000, The Netherlands (66)</td>
<td>Retrospective</td>
<td>83/106</td>
<td>9</td>
</tr>
<tr>
<td>Baluyut, 2001, USA (56)</td>
<td>Retrospective</td>
<td>63/63</td>
<td>1.8</td>
</tr>
<tr>
<td>Stiehl 2002, Germany (64)</td>
<td>Retrospective</td>
<td>106/ ERCP yearly, median 5 years</td>
<td>9</td>
</tr>
<tr>
<td>Enns, 2003, Canada (67)</td>
<td>Retrospective</td>
<td>104</td>
<td>17</td>
</tr>
<tr>
<td>Gluck, 2008, USA (68)</td>
<td>Retrospective</td>
<td>106/317</td>
<td>7.3</td>
</tr>
<tr>
<td>Etzel, 2008, USA (74)</td>
<td>Retrospective</td>
<td>PSC:30/85 Non-PSC:45/70</td>
<td>12.9</td>
</tr>
<tr>
<td>Bangarulingam 2009, USA (69)</td>
<td>Retrospective</td>
<td>PSC: 168 Non-PSC: 981</td>
<td>11</td>
</tr>
<tr>
<td>Alkhatib, 2011, USA (70)</td>
<td>Retrospective</td>
<td>75/185</td>
<td>8</td>
</tr>
<tr>
<td>Ismail, 2012 Finland (71)</td>
<td>Retrospective</td>
<td>441/441</td>
<td>9</td>
</tr>
<tr>
<td>Navaneethan 2015, USA (72)</td>
<td>Retrospective</td>
<td>294/697</td>
<td>4.3</td>
</tr>
<tr>
<td>von Seth, 2015, Sweden (73)</td>
<td>Retrospective, national registry study</td>
<td>PSC: 141/141 Non-PSC: 8791</td>
<td>18.4</td>
</tr>
</tbody>
</table>

PSC and cholangiocarcinoma

17. EASL/ESGE recommend that CCA should be suspected in any patient with worsening cholestasis, weight loss, raised serum CA19-9 and/or new or progressive DS, particularly with an associated enhancing mass lesion (strong recommendation, moderate quality evidence)
18. A raised serum CA19-9 may support the diagnosis of CCA, but has a poor specificity (weak recommendation, low quality evidence).

PSC is associated with a markedly increased risk for CCA with a lifetime risk of 10%-20% (90, 91), or up to 400-fold compared with the general population (92). CCA represents a common cause of death among PSC patients (93), whereby 27-50% of all CCAs are detected within one year of a PSC diagnosis (44, 94, 95) depending on the indications for ERCP.

CCA should be suspected in PSC patients experiencing rapid deterioration of liver function tests, increasing jaundice, weight loss and abdominal pain. However, the development of such a clinical trend may also suggest an advanced form of CCA. An observational study performed in the U.S. on 230 PSC patients affected by PSC, twenty-three of which had CCA, showed no major differences in the clinical features of the patients with or without CCA when the malignancy is at an earlier stage (43).

Increased s-Ca19-9 have been reported to indicate the development of CCA in PSC patients. Employing 129 or 100 U/mL cut-off levels detected CCA with high sensitivity (nearly 80%) and specificity (nearly 100%) (96), but only in advanced cases of CCA. These data are in contrast with other observations, which showed that one third of PSC patients with high CA19-9 levels did not have CCA. In a recent study performed on 433 PSC patients, 41 of whom had biliary malignancy, the use of FUT2/3 genotype-dependent cut-off values for CA19-9 improved sensitivity and reduced the number of false positive results (99). In a study screening for biliary dysplasia using ERCP and brush cytology, serum CA19-9 had no prognostic value for biliary dysplasia or CCA (39). Currently, there are no definite radiologic features that indicate CCA in a PS patient, although the detection of a DS by MRCP may be suggestive for CCA.

However, 50% of PSC patients experience a DS and its absence does not rule out CCA. In a cohort of 230 patients, US, CT and MRCP were found to have high specificity but low sensitivity (10-32%).(43)

**ERCP findings indicative of CCA**

DSs are frequent in PSC (60) and do not per se indicate development of a malignancy. In a large single center study, CCA was seen in 6/95 DSs (6%). In general it could be inferred that the chance of any DS of harbouring a CCA is around 5%. Most CCAs develop in perihilar region or in extrahepatic bile ducts, and are reachable with cytological brush. In a large series of patients with CCA (100), 50% had perihilar CC (pCC), 42% had distal CC, and only 8% of the CCA’s were intrahepatic CCA. No specific imaging features have been found to differentiate benign strictures from malignant ones. Based on ERCP findings only it is not possible to exclude CCA from benign strictures caused by PSC, and the diagnosis requires always additional techniques such as biliary cytology or histology.

19. ESGE/EASL recommend ductal sampling (brush cytology, endobiliary biopsies) as part of the initial investigation for the diagnosis and staging of suspected CCA in patients with PSC (strong recommendation, high quality evidence).

20. ESGE/EASL suggest that fluorescence in situ hybridization (FISH) or equivalent chromosomal assessments are considered in patients with suspected CCA when brush cytology results are equivocal (weak recommendation, low quality evidence)
21 ESGE/EASL suggest that additional investigations such as cholangioscopy, endoscopic ultrasound and probe-based confocal laser endomicroscopy (pCLE) may be useful in selected cases (weak recommendation, low quality evidence).

**Brush cytology**

Bile duct brushing is the most common method for tissue sampling in patients with PSC for detecting inflammation, biliary dysplasia or CCA. In a recent meta-analysis (11 studies, 747 patients) (101), the pooled sensitivity, specificity, positive predictive value and negative predictive value of bile duct brushings for diagnosis of CCA in patients with PSC were 43% (95%CI, 35%-52%), 97% (95% CI, 95%-98%), 78.2% (95% CI, 63.6%-86.7%), and 87.2% (95% CI, 85.4%-89.1%), respectively. The authors concluded that bile duct brushing is a simple and highly specific technique for detecting CCA in patients with PSC. However, the modest sensitivity from bile duct brushing precludes its utility as a diagnostic tool for early detection of CCA in patients with PSC. In a recent study of 261 mostly (81%) asymptomatic patients with PSC referred for their first ERC to confirm diagnosis and screen for biliary dysplasia with systematic bile duct brushings, 43% were found to have advanced disease, and malignant/suspicious cytology was present in 6.9% (39).

Addition of FISH analysis of cytology specimens enhanced the sensitivity for detecting CCA in patients with PSC in several patient series (42, 43, 102, 103). The ideal methodology (e.g. FISH vs. digital image analysis [DIA] vs. flow-cytometri) and appropriate threshold values for markers assessed by each of these methodologies have not been robustly established and this makes meta-analysis of available data challenging (104). For this reason, chromosomal assessments can so far only be recommended in equivocal cases (104). As DNA technologies evolve, new markers are likely to emerge.

**Ductal biopsy**

Ductal biopsy has shown to improve the sensitivity, specificity and accuracy to diagnose CCA compared to brush cytology alone (105). Since the sampling area for ductal biopsies is limited, complementary biliary brushings should be considered in all patients. The sensitivity and specificity for the detection of CCA by ductal biopsy in published studies varies from 30-88%, and 97-100%, respectively (106). Combining brush cytology and biopsy has a sensitivity varying from 47-86% and specificity of 97-100%. A study (106) assessing the accuracy of triple modality: brush cytology, biopsy and FISH or their combination demonstrated that brush cytology alone had a sensitivity of 42%, specificity of 100%, positive predictive value of 100% and negative predictive value of 88%. Triple sample assessment modality markedly improved the overall sensitivity (82%), specificity (100%), positive predictive value (100%), and negative predictive value (87%).

**Cholangioscopy**

Peroral cholangioscopy (POCS) allows a direct visualization of extrahepatic bile duct strictures. The recent development of video-based systems offers better image resolution and offers clearer views than fiberoptic cholangioscopy. Compared to ERC and tissue sampling POCS was shown to improve the diagnostic accuracy (107, 108) (109). However, these studies were not focused on CCA in PSC-patients.
Single-operator cholangioscopy (SpyGlass) is gaining popularity, primarily for stone treatment and assessment of indeterminate strictures. The utility in PSC was studied in a recent case series (110) with visual assessment and targeted biopsies of 64 strictures in 47 patients. Only 1 of 3 patients with CCA were diagnosed by the ERCP procedure. It is likely that newer digital versions of this instrument (e.g. SpyGlass DS) will perform better, at least in terms of visual diagnostics.

**Other techniques**

Other techniques such as intraductal ultrasonography and confocal laser endomicroscopy have shown potential utility in the diagnosis of CCA in PSC, but are not established in routine clinical practice. Regular endoscopic ultrasonography with sampling of detectable masses or locoregional lymph nodes is advocated by some, but such sampling is also regarded as a contraindication to LT in some centers, thus any such sampling should be discussed locally.

**Table 6. Detection of biliary malignancy in PSC with brush cytology (BC)**

<table>
<thead>
<tr>
<th>First author, year</th>
<th>Study design</th>
<th>Intervention</th>
<th>Participants</th>
<th>Outcomes</th>
<th>Results: Sens, Spec, PPV, NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ponsioen, 1999, (111)</td>
<td>Prospective</td>
<td>ERC with BC from dominant strictures</td>
<td>43</td>
<td>Detection of malignancy/CC</td>
<td>60%, 89%, 59%, 89%</td>
</tr>
<tr>
<td>Lindberg, 2002, (112)</td>
<td>Prospective</td>
<td>BC + DNA flow cytometry from biliary strictures</td>
<td>57</td>
<td>Detection of malignancy/CC</td>
<td>71%, 100%, NA, NA</td>
</tr>
<tr>
<td>Siqueira, 2002, (113)</td>
<td>Retrospective</td>
<td>BC from bile ducts</td>
<td>151</td>
<td>Detection of malignancy/CC</td>
<td>46.4%, 100%, NA, NA</td>
</tr>
<tr>
<td>Furmanczyk, 2005, (115)</td>
<td>Retrospective</td>
<td>BC from bile ducts</td>
<td>51</td>
<td>Detection of malignancy/CC</td>
<td>62.5%, 100%, NA, NA</td>
</tr>
<tr>
<td>Boberg 2006, (116)</td>
<td>Prospective</td>
<td>BC from biliary strictures</td>
<td>61</td>
<td>Detection of malignancy/CC</td>
<td>100%, 84%, 68%, 100%</td>
</tr>
<tr>
<td>Moff, 2006, (117)</td>
<td>Retrospective</td>
<td>BC from bile ducts</td>
<td>47</td>
<td>Detection of malignancy/CC</td>
<td>50%, 91%, NA, NA</td>
</tr>
<tr>
<td>Moreno Luna, 2006 (102)</td>
<td>Prospective</td>
<td>BC from biliary strictures</td>
<td>86 PSC</td>
<td>Detection of malignancy/CC</td>
<td>18%, 100%, 100%, 83%</td>
</tr>
<tr>
<td>Charatcharoen-witthaya, 2008, (43)</td>
<td>Prospective</td>
<td>BC from biliary strictures</td>
<td>230</td>
<td>Detection of malignancy/CC</td>
<td>8%, 100%, 100%, 89%, 89%</td>
</tr>
<tr>
<td>Levy, 2010, (42)</td>
<td>Prospective</td>
<td>BC from biliary strictures</td>
<td>32 PSC</td>
<td>Detection of malignancy/CC</td>
<td>7%, 100%, NA, NA</td>
</tr>
</tbody>
</table>
Table 7. Detection of biliary malignancy in PSC with brush cytology – metaanalysis and reviews.

<table>
<thead>
<tr>
<th>First author, year</th>
<th>Study design</th>
<th>Intervention</th>
<th>N</th>
<th>Outcomes</th>
<th>Results: Sens, Spec, PLR, NLR</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trikudanathal, 2014 (101)</td>
<td>Meta-analysis including 11 studies (prospective and retrospective)</td>
<td>bile duct brushing</td>
<td>827</td>
<td>Diagnostic yield of bile duct brushing in diagnosing CC in PSC strictures</td>
<td>43%, 97%. 8.87, 0.56</td>
<td>The moderate sensitivity in detecting CC, precludes its utility as a surveillance tool for early diagnosis of CC.</td>
</tr>
<tr>
<td>Navaneethan, 2014 (104)</td>
<td>Meta-analysis including 4 studies (prospective and retrospective)</td>
<td>FISH</td>
<td>629</td>
<td>Diagnostic yield of FISH in diagnosing CC in PSC strictures</td>
<td>31%, 71%. 1.19, 0.95</td>
<td>FISH positivity has reasonable diagnostic accuracy. However, the specificity is poor.</td>
</tr>
<tr>
<td></td>
<td>Meta-analysis including 6 studies (prospective and retrospective)</td>
<td>FISH polysomy</td>
<td>690</td>
<td>Diagnostic yield of FISH polysomy in diagnosing CC in PSC strictures</td>
<td>51%, 93%. 6.81, 0.56</td>
<td>FISH polysomy is highly specific; however, it has limited sensitivity.</td>
</tr>
<tr>
<td>Navaneethan, 2014 (118)</td>
<td>Meta-analysis including 9 studies (prospective and retrospective)</td>
<td>Intraductal biopsy</td>
<td>730</td>
<td>Diagnostic yield of intraductal biopsies performed during ERCP</td>
<td>48%, 99%. 18.9, 0.54</td>
<td>Limited sensitivity.</td>
</tr>
<tr>
<td></td>
<td>Meta-analysis including 9 studies (prospective and retrospective)</td>
<td>Brush cytology</td>
<td>730</td>
<td>Diagnostic yield of brush cytology performed during ERCP</td>
<td>45%, 99%. 15.7, 0.54</td>
<td>Limited sensitivity.</td>
</tr>
<tr>
<td></td>
<td>Meta-analysis including 6 studies (prospective and retrospective)</td>
<td>Intraductal biopsy AND Brush cytology</td>
<td>628</td>
<td>Diagnostic yield of both brush cytology and intraductal biopsies</td>
<td>59%, 100%. 53.8, 0.42</td>
<td>Both brushings and biopsy are comparable and have limited sensitivity.</td>
</tr>
<tr>
<td>Walker, 2007 (119)</td>
<td>Systematic review</td>
<td>MRI</td>
<td>na</td>
<td>Diagnosing cholangiocarcinoma in primary sclerosing cholangitis</td>
<td>N/A</td>
<td>Lack of evidence</td>
</tr>
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<tr>
<td>Systematic review</td>
<td>CT</td>
<td>45</td>
<td></td>
<td>Diagnosing cholangiocarcinoma in primary sclerosing cholangitis</td>
<td>82%, 80% 4.10, 0.25</td>
<td>CT provides good Se and Sp in detecting biliary tract carcinoma complicating primary sclerosing cholangitis</td>
</tr>
</tbody>
</table>
Endoscopic surveillance of PSC-associated IBD

The relationship between PSC and IBD is well established (120). The prevalence of IBD in patients with established PSC varies widely, but is reported at 80% in Scandinavian countries (121). The often asymptomatic phenotype of IBD means that prevalence data are strongly influenced by the level of proactive search for the disease. The typical scenario was for IBD to precede the presentation of PSC. However, the clinical presentation of IBD is variable, and the disease may be subclinical or asymptomatic for years (122) and is nowadays often diagnosed after the recognition of the liver disease. Notably, IBD may have been present for an unknown period of time when PSC is diagnosed. The increased risk of colon cancer in PSC-associated IBD, hence makes it crucial to perform a full ileocolonoscopy already at the time of PSC diagnosis in patients. As to the diagnosis of IBD per se, complete ileocolonoscopy is critical since rectal sparing, as well as right-sided involvement is frequent in these patients (40).

Timing of screening

22. ESGE/EASL recommend screening ileocolonoscopy at the time of PSC diagnosis (strong quality evidence, strong recommendation). If IBD is documented endoscopically or histologically, annual surveillance colonoscopies are warranted (strong recommendation, low quality evidence).

23. ESGE/EASL suggest that if no IBD is documented, next ileocolonoscopy should be considered at 5 years or whenever bowel complaints suggestive of IBD occur (weak recommendation, low quality evidence)

Based on initial screening subsequent surveillance can be planned. If IBD is documented, annual colonoscopies are warranted (6, 125), since it has been shown that PSC/IBD patients whose CRC is detected in a surveillance program have a significantly lower risk of CRC-related mortality as compared to non-surveilled patients (95). If not, repeat colonoscopy should be done with the occurrence of symptoms suggestive of IBD, or elevated F-calprotectin, otherwise at 3-5 years (126), although this recommendation lacks any scientific evidence beyond extrapolation from general IBD recommendations (127).

Endoscopic modality

24. EASL/ESGE recommend ileocolonoscopy with four-quadrant biopsies from all colonic segments and the terminal ileum for screening for the presence of IBD (strong recommendation, low quality evidence)

25. EASL/ESGE recommends ileocolonoscopy with dye-based chromoendoscopy with targeted biopsies for dysplasia surveillance of PSC-associated IBD (strong recommendation, low quality evidence)

PSC-associated colitis seems to be distinctive from other IBD: Colitis is predominant in the right colon (128), and colon cancer is typically right-sided (129). Lack of inflammation in the rectum (‘rectal sparing’) is reported in some studies but less frequently observed in others (3). Endoscopic surveillance of PSC-associated colitis is presumed to increase the chance of early detection of dysplasia or malignancy (130).
Screening for IBD at diagnosis of PSC is best performed by high-definition ileo-colonoscopy with four quadrant biopsies from all colonic segments and the terminal ileum. Biopsies should be taken at the index-endoscopy even without macroscopic signs of inflammation (126, 131, 132).

In established PSC-IBD, ileocolonoscopy with dye-based chromoendoscopy (0.1% methylene blue or 0.1% – 0.5% indigo carmine) with targeted biopsies is required for neoplasia surveillance of PSC-associated IBD. In appropriately trained hands, in the situation of quiescent disease activity and adequate bowel preparation, nontargeted four-quadrant biopsies can be abandoned (133). This procedure is also endorsed by the ECCO (127). It should be noted that there are no studies on colonic neoplasia surveillance specifically in the setting of PSC-associated IBD.

Routine use of pancolonic chromoendoscopy with targeted biopsies for neoplasia surveillance in patients with long-standing colitis (disease duration of >8 years) increased the proportion of patients found with dysplasia by a factor of 2.1–3.3 compared to standard definition video-colonoscopy. The pooled incremental yield of conventional chromoendoscopy with random biopsies over SD-WLE with random biopsies for the detection of patients with neoplasia was 7% (95%CI 3.2%–11.3%) (134). Benefit of conventional chromoendoscopy over WLE with latest-generation HD-WLE colonoscopes is unknown to date.

Handling of polyps and colorectal dysplasia

26. ESGE/EASL recommend endoscopic resection of any visible lesions and assessment of the surrounding mucosa. We recommend proctocolectomy in case of dysplasia in the surrounding mucosa, or when the lesion cannot be completely resected. Otherwise, repeat colonoscopy and close follow-up is warranted (strong recommendation, low quality evidence)
27. In the case of invisible lesions with HGD confirmed by two expert pathologists, proctocolectomy should be advised (strong recommendation, low quality evidence)
28. In the case of invisible lesions with LGD confirmed by two expert pathologists, repeat colonoscopy after 3 months with chromo-endoscopy is recommended (strong recommendation, low quality evidence).

Colorectal cancer (CRC) risk is significantly increased in patients with co-existing IBD and PSC. A meta-analysis of 11 studies concluded that patients with UC-PSC were at increased risk of developing CRC compared to patients with UC alone (OR: 4.09; 95%CI 2.89–5.76) (124). A recent large population-based study in the Netherlands found a 9-fold increased risk of developing CRC in PSC-UC patients, compared to the age- and gender-matched population (SIR, 8.6; 95% CI: 3.5–17.7), and a 10-fold increased risk, compared to UC controls (ratio of SIRs: 9.8; 95% CI: 1.9–96.6) (95).

Most dysplasia is visible at colonoscopy (135, 136). On the other hand, invisible dysplastic lesions can also be diagnosed by random biopsies during surveillance. According to the IBD-Dysplasia Morphology Study Group (137), dysplasia is subdivided in low grade (LGD) and high grade dysplasia (HGD). According to the recent ECCO guidelines, a visible lesion with dysplasia should be completely resected endoscopically irrespective of the grade of dysplasia or the localisation relative to the inflamed mucosal areas (127). Subsequently, the surrounding mucosa (around the visible lesion) should be examined (with chromo-endoscopy-guided targeted biopsies or random biopsies if chromo-endoscopy not available). If endoscopic resection is incomplete or impossible, or if dysplasia is detected in the surrounding mucosa, total proctocolectomy is recommended. In the case of
invisible lesions with LGD, urgent repeat chromoendoscopy should be performed, to eventually identify a well-circumscribed lesion and/or perform additional random biopsies. If the presence of LGD is confirmed, there is no clear consensus regarding management; proctocolectomy or surveillance could be recommended. Actually, two studies revealed a significant 5-year progression rate (33%-54%) of LGD to HGD (138, 139), whereas others showed low progression rates (140, 141). Finally, in the case of invisible lesions with HGD or adenocarcinoma, total procto-colectomy is indicated.

References


