Understanding Risk Factors and Avoiding Complications with Endoscopic Retrograde Cholangiopancreatography

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Complications and technical failures of endoscopic retrograde cholangiopancreatography (ERCP) cause significant morbidity and, occasionally, mortality. An understanding of patient- and procedure-related risks is important for decision making with regard to whether or how ERCP should be performed. Instances in which ERCP is the least clearly indicated are often the most likely to cause complications. Patient-related risk factors include suspected sphincter of Oddi (SO) dysfunction, female sex, normal serum bilirubin, or previous history of post-ERCP pancreatitis, with multiple risk factors conferring especially high risk. Technique-related risk factors include difficult cannulation, pancreatic contrast injection, balloon sphincter dilation, and precut sphincterotomy performed by endoscopists of varied experience. Pancreatic stents may reduce the risk of pancreatitis in a number of settings including SO dysfunction. Hemorrhage and perforation are rare and can be avoided with endoscopic technique and attention to the patient's coagulation status. Cholangitis is avoidable with adequate biliary drainage. Because success rates are higher and complication rates lower for endoscopists performing large volumes of ERCP, ERCP should be concentrated as much as possible among endoscopists with adequate experience. Patients with a high risk for complications may be best served by referral to an advanced center.

Introduction

Endoscopic retrograde cholangiopancreatography (ERCP), alone or with associated biliary and pancreatic sphincterotomy and instrumentation, can cause a variety of short-term complications including pancreatitis, hemorrhage, perforation, infection, cardiopulmonary complications, and others [1••,2•,3–9,10••,11,12•,13–20]. These complications range from minor, with 1 or 2 extra days of hospitalization and full recovery, to severe and devastating, with permanent disability or death. In addition to short-term complications, potential long-term sequelae of sphincterotomy and stents include recurrent stone formation, sphincter restenosis, cholecystitis, and ductal strictures [21–31].

Definitions of Complications and Other Negative Outcomes

In 1991, Cotton *et al.* [1••] introduced a standardized set of consensus definitions for complications of sphincterotomy. According to these guidelines, severity is graded primarily on number of hospital days and intervention required to treat the complication. This classification has allowed uniform assessment of outcomes of ERCP and sphincterotomy in various settings. Beyond immediate complications, a wider spectrum of negative (as well as positive) outcomes, including technical failures, ineffectiveness of the procedure in resolving the presenting complaint, long-term sequelae, costs, extended hospitalization, and patient (dis)satisfaction have been described [32–34].

Variations in Complication Rates

Reported complication rates vary widely, even between prospective studies. Reasons for such variation include 1) the definitions used (changing the threshold of amylase required to define pancreatitis changes the observed incidence); 2) thoroughness of detection (prospective studies detect significantly more events than retrospective studies) [5]; 3) patient-related factors (case mix often varies widely between centers); and 4) procedural variables (complications may relate to differences in endoscopic expertise, use of preventive techniques, and extent or intent of therapy performed).

Understanding the Risk Factor Analyses

Many early studies of ERCP complications attempted to identify risk factors through univariate analysis using one or more variables, with potentially misleading results because of inability to sort out confounding variables [6,7,9]. Most recent studies have used multivariate analy-

Table 1. Risk factors for overall complications of ERCP in multivariate analyses

Definite*	Maybe†	No‡
Suspected sphincter of Oddi dysfunction	Young age	Comorbid illness burden
Cirrhosis	Pancreatic contrast injection	Small common bile duct diameter
Difficult cannulation	Failed biliary drainage	Female sex
Precut sphincterotomy		Billroth II
Percutaneous biliary access		Periampullary diverticulum
Lower ERCP case volume		

*Significant by multivariate analysis in most studies.
†Significant by univariate analysis only in most studies.
‡Not significant by multivariate analysis in any study.

Table 2. Risk factors for post-ERCP pancreatitis in multivariate analyses

Definite*	Maybe†	No‡
Suspected sphincter of Oddi dysfunction	Female sex	Small common bile duct diameter
Young age	Acinarization	Sphincter of Oddi manometry
Normal bilirubin	Absence of common bile duct stone	Biliary sphincterotomy
History of post-ERCP pancreatitis	Lower ERCP case volume	
Difficult cannulation		
Pancreatic duct injection		
Pancreatic sphincterotomy		
Precut sphincterotomy		
Balloon dilation of biliary sphincter		

*Significant by multivariate analysis in most studies.
†Significant by univariate analysis only in most studies.
‡Not significant by multivariate analysis in any study.

sis as a tool to identify and quantify the effect of multiple potentially confounding risk factors. However, even these studies have important limitations, because failure to evaluate important variables may make surrogate markers appear to be independent predictors of an outcome. In many studies, sample size is insufficient to allow examination of a broad range of key variables without overfitting, especially with relatively rare outcomes such as ERCP complications [35].

Overall Complications of ERCP and Sphincterotomy

Most prospective series report an overall short-term complication rate for ERCP and sphincterotomy of about 5% to 10% [2•,3–9,10••,11,12•,13–20]. Summaries of multivariate analyses of risk factors for overall and individual complications of ERCP and sphincterotomy are shown in Tables 1, 2, and 3. The three largest studies (over 1000 patients each) evaluated ERCP in a variety of practice settings [2•,10••,15]. The remaining studies are small (less than 500 patients) and limited to a single center [9,11,18,19]. Rates of overall and individual complications vary widely. In a major American study of biliary sphincterotomy, a particularly high rate of complications for sphincter of Oddi (SO) dysfunction was reported (21.7%, primarily pancreatitis, with 3.7% severe), along with a very low complication rate for bile duct stone extraction in tandem with laparoscopic cholecystectomy (under 5% complication rate with none severe) (Fig. 1) [10••].

Risk factors for overall complications

Although the studies are heterogeneous, several patterns emerge. Indication of suspected SO dysfunction is a significant risk factor whenever examined. In addition, technical difficulties, likely linked to the skill or experience of the endoscopist, are significant risk factors (including difficult cannulation, use of precut sphincterotomy to gain bile duct entry, failure to achieve biliary drainage, and use of simultaneous or subsequent percutaneous biliary drainage for otherwise failed cannulation). In turn, the ERCP case volume of the endoscopists or centers, when examined, is always significant either by univariate or multivariate analysis. Finally, although death from ERCP is rare (less than 0.5%), it is most often related to cardiopulmonary complications, highlighting the need for the endoscopist to attend to safety issues during sedation and monitoring of the patient (Table 1) [36]. In contrast, older age or increased number of coexisting medical conditions (younger age generally increased risk in univariate or multivariate analysis), smaller bile duct diameter in contrast to previous observation, and anatomic variants such as periampullary diverticulum or Billroth II gastrectomy are not risk factors, although the latter increases the technical difficulty for the endoscopist [5,6].

Table 3. Risk factors for hemorrhage after endoscopic sphincterotomy in multivariate analyses

Definite*	Maybe†	No‡
Coagulopathy	Cirrhosis	Aspirin or nonsteroidal anti-inflammatory drugs
Anticoagulation <3 days after sphincterotomy	Dilated common bile duct	Ampullary tumor
Cholangitis prior to ERCP	Periampullary diverticulum	Longer sphincterotomy
Bleeding during sphincterotomy	Precut sphincterotomy	Extension of prior sphincterotomy
Lower ERCP case volume		

*Significant by multivariate analysis in most studies.
†Significant by univariate analysis only in most studies.
‡Not significant by multivariate analysis in any study.

Pancreatitis

Reported rates of pancreatitis after ERCP and sphincterotomy range from less than 1% to 40%, but rates of 5% or more are typical [2•,3–9,10••,11,12•,13–20]. In the consensus classification, post-ERCP pancreatitis is defined as a clinical syndrome consistent with pancreatitis (*ie*, new or worsened abdominal pain) with an amylase level at least three times normal more than 24 hours after the procedure and requiring more than one night of hospitalization [1••]. The potential mechanisms of injury to the pancreas during ERCP and endoscopic sphincterotomy are mechanical, chemical, hydrostatic, enzymatic, microbiologic, and thermal. Multivariate analyses have attempted to identify the clinical patient- and procedure-related factors independently associated with pancreatitis [2•,10••,12•,14–16,18].

Patient-related risk factors for post-ERCP pancreatitis

The risk of post-ERCP pancreatitis is determined at least as much by the characteristics of the patient as by endoscopic techniques or maneuvers (Table 2). Risk factors found to be significant in one or more major studies include younger age, suspected SO dysfunction, history of previous post-ERCP pancreatitis, and absence of elevated serum bilirubin [2•,10••,12•,14–16,18]. Women appear to have increased risk [12•], but it is difficult to sort out the contribution of SO dysfunction, a condition that almost exclusively occurs in women. Patients with multiple risk factors have dramatically enhanced risk [12•,37].

SO dysfunction, most often suspected in women with abdominal pain after cholecystectomy [38–40], poses a formidable risk for pancreatitis after any kind of ERCP whether diagnostic, manometric, or therapeutic, of 10% to 30% [2•,3–9,10••,11,12•,13–20]. The reason for heightened susceptibility in these patients remains unknown. Contrary to widely held opinion that SO manometry is the culprit [1••,41,42], recent multivariate analyses show that empiric biliary sphincterotomy or even diagnostic ERCP has a similarly high risk in these patients [10••,12•,15,16]. In many centers, manometry was always performed in patients with suspected SO dysfunction, making it impossible to separate the risk of the manometry from that of the patient. Use of aspirating instead of conventional perfusion catheters appears to have reduced the risk of manometry to the background risk of cannulation with any other ERCP accessory [43]. Absence of a stone in patients with suspected choledocholithiasis was found to be the most potent single risk factor for post-ERCP pancreatitis in a prior study in which the diagnosis of SO dysfunction was not considered [16]. All of these observations point out the danger of using diagnostic ERCP to look for bile duct stones in women with recurrent post-cholecystectomy pain, because the probability of finding stones in such patients is low and the risk of causing pancreatitis is high.

History of previous post-ERCP pancreatitis was found to be a potent risk factor in one study (odds ratio=5.4) and warrants special caution [12•]. However, advanced chronic pancreatitis confers some immunity against post-ERCP pancreatitis, perhaps because of atrophy and decreased enzymatic activity [12•]. Pancreas divisum is probably a risk factor only if minor papilla cannulation is attempted [12•].

Technique-related risk factors for post-ERCP pancreatitis

The risk of pancreatitis has been correlated with an increasing number of pancreatic duct contrast injections [10••,12•,44,45]; however, pancreatitis occurred in one study after 2.5% of ERCP procedures in which there was no pancreatic duct contrast injection at all [12•], and two studies have shown that papillary trauma induced by difficult cannulation has a negative effect independent of the number of pancreatic duct contrast injections [10••,12•]. Acinarization of the pancreas, although undesirable, is probably less important than generally thought and is not an independent risk factor [2•,10••,12•,15].

Overall, the risk of pancreatitis is similar for diagnostic and therapeutic ERCP [12•,15]. Performance of biliary sphincterotomy does not appear to add significant independent risk of pancreatitis to ERCP [12•,15], a finding that is contrary to widely held opinion [1••]. This points not to the safety of sphincterotomy, but rather to the risk of diagnostic ERCP. Pancreatic sphincterotomy was found to be a significant risk factor for pancreatitis in the only large multivariate study in which it was evaluated, although the risk of severe pancreatitis was very small (less than 1%), perhaps because

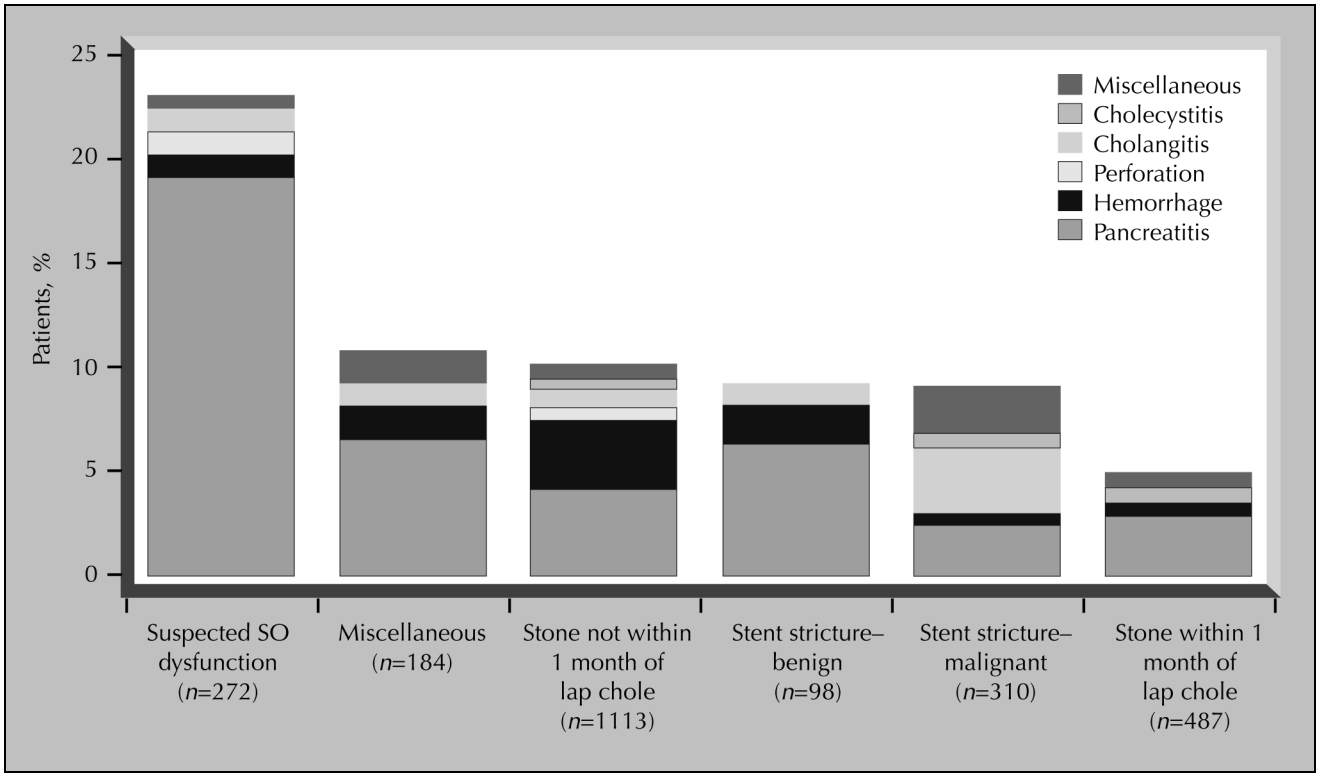

Figure 1. Complications of 2347 biliary sphincterotomies by indication. Lap chole—laparoscopic cholecystectomy. (*Data from* Freeman *et al*. [10••].)

nearly all of these patients had a stent placed for pancreatic drainage [12•].

Precut, or "access" sphincterotomy, used to gain access to the common bile duct, has been uniformly associated with a higher risk of pancreatitis in multicenter studies involving endoscopists with varied experience [2•,10••,12•,46,47], leading some experts to discourage its use [48]. In contrast, many series from tertiary referral centers have found complication rates for precut sphincterotomy to be no different than those for standard sphincterotomy, suggesting that the risk of precut sphincterotomy is highly dependent on the operator [49–56]. Greater use of pancreatic stents may explain the smaller number of complications with precut sphincterotomy performed at advanced centers [49,56,57••,58–61].

Most multicenter studies have failed to show a significant independent correlation between ERCP case volume and pancreatitis [2•,10••,12•]. It is possible that none of the participating endoscopists in these studies reached the threshold volume of ERCP procedures above which pancreatitis rates would diminish (perhaps 300–500/year). However, most American endoscopists average less than two ERCPs per week [12•], and the pancreatitis rates from the highest volume tertiary referral centers in the United States are often relatively higher than those in private practice [10••,12•]. All of these observations suggest that case mix is at least as important as expertise in determining risk of post-ERCP pancreatitis.

Cumulative effect of multiple risk factors on post-ERCP pancreatitis

The risk of post-ERCP pancreatitis escalates in patients with multiple risk factors [12•]. The interactive effect of multiple risk factors is reflected in the profile of patients developing severe post-ERCP pancreatitis. In two different studies, nearly all of the patients who developed severe pancreatitis were young to middle-aged women and had recurrent abdominal pain, normal serum bilirubin levels, and no biliary obstructive pathology. These factors are consistent with the syndrome of possible SO dysfunction, whether or not it was suspected by the endoscopist [12•,37]. Nearly half of the procedures performed on these patients were purely diagnostic. Few if any of them had much probability of harboring obstructive biliary pathology or of benefiting from conventional therapeutic ERCP such as empiric biliary sphincterotomy.

Specific techniques to reduce risk of post-ERCP pancreatitis

Pancreatic stent placement can reduce the risk of post-ERCP pancreatitis and is widely performed at many advanced centers for this purpose (Fig. 2). Specific situations in which placement of a pancreatic stent has been shown to reduce risk include biliary sphincterotomy for SO dysfunction [57••], pancreatic sphincterotomy [58,59], precut sphincterotomy [56,60,61], and balloon dilation of the biliary sphincter [62]. Pancreatic stenting for other high-risk situations was equivocally beneficial in one study, perhaps because the stents were placed later in the

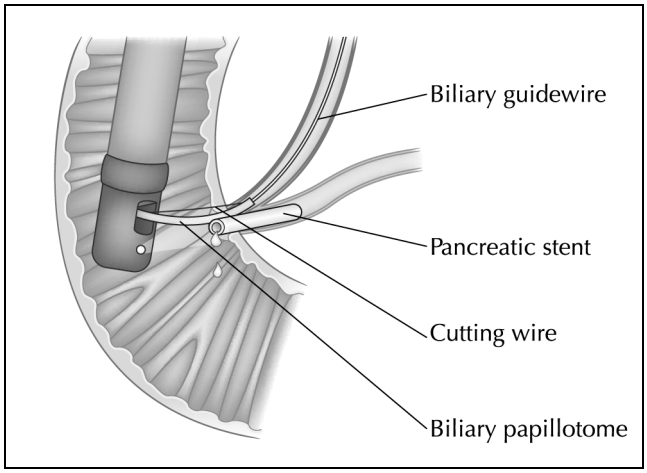

Figure 2. Pancreatic stent placement to reduce the risk of post-ERCP pancreatitis.

procedure [63]. In patients with SO dysfunction undergoing biliary sphincterotomy, a randomized controlled trial showed a significantly reduced rate of pancreatitis (from 26% to 7%) if a pancreatic stent was placed [57••]. In one large series of patients with SO dysfunction, combined pancreatic and biliary therapy including a pancreatic stent was substantially safer than simple biliary sphincterotomy [64•]. Pancreatic stents may reduce the otherwise high risk of precut sphincterotomy. In three studies from advanced centers, precut sphincterotomy without pancreatic stenting resulted in pancreatitis in 14% to 20% of patients, compared with 2% to7% if the stent was placed prior to precutting and left in place for a few days [56,60,61,65]. Pancreatic stents may protect against precut-induced pancreatitis, whereas the advanced skill of the endoscopist alone does not. One limitation of pancreatic stenting is that many endoscopists are not familiar with the technique and lack the necessary inventory of specialized small-caliber stents required to fit the ductal anatomy of each patient. Once placed, pancreatic stents have the potential to cause pancreatic ductal injury or perforation and must be removed as early as possible, within a few days to weeks, from otherwise normal ducts [66,67].

Balloon dilation of the biliary sphincter has been introduced as an alternative to sphincterotomy for the extraction of bile duct stones [27,28]. Although two randomized trials from overseas showed complications that were equivalent to or less than those for sphincterotomy [29,30], balloon dilation has been associated with a markedly increased risk of pancreatitis in the United States, resulting in two deaths in one study [12•,31].

Use of a papillotome for biliary cannulation has been prospectively compared with a standard catheter in two randomized trials [68,69]. Although both studies showed significantly greater success with the sphincterotome, no difference in rates of pancreatitis or other complications was reported. It stands to reason, however, that the most expeditious method of cannulation will likely be the safest.

Thermal injury is thought to play a causative role in pancreatitis after biliary sphincterotomy. Bipolar cautery, which is seldom used, was shown in one study to result in significantly lower rates of pancreatitis than conventional monopolar cautery (0% vs 6 %) [70]. A more recent study showed that pure-cutting current significantly reduced pancreatitis rates compared with the more conventional blended current (3% vs 11%) [71]. Automated current delivery systems such as the Erbe generator are used increasingly, but their effect on pancreatitis is unclear. Preliminary data suggest no difference in pancreatitis rates with an automated delivery system compared with conventional blended current [72].

Pharmacologic agents

Many pharmacologic agents have been investigated for their potential to reduce post-ERCP pancreatitis, but results have been mixed or negative. In a meta-analysis of randomized controlled trials, only gabexate (a protease inhibitor) and somatostatin were found to be effective [73]. Both agents require continuous infusion, and neither is available in the United States, limiting their practicality. Interleukin-10 has shown promise in some preliminary trials and is currently undergoing further investigation [74]. Agents shown not to be effective include octreotide, corticosteroids, allopurinol, platelet-activating factor inhibitors, and nonionic contrast [75,76].

Prevention of post-ERCP pancreatitis

The single most important way to avoid post-ERCP pancreatitis is to avoid performing ERCP for marginal indications, especially in patients at higher risk of complications. Paradoxically, the risk is often higher and the potential benefit of therapy lower than for patients with obstructive jaundice. ERCP should be avoided when the probability of finding stones or other obstructive pathology is low and other methods are available (*eg*, abnormal liver chemistries prior to laparoscopic cholecystectomy) or if the risk–benefit ratio of conventional diagnostic or biliary therapeutic ERCP is excessive (*eg*, suspected SO dysfunction). Alternative imaging techniques such as intraoperative laparoscopic cholangiography, magnetic resonance cholangiopancreatography (MRCP), and endoscopic ultrasound are safer for excluding obstructive biliary pathology [77]. Patients who have negative results with these alternative techniques but are still suspected of having a pancreatic or biliary cause for recurrent symptoms are best served by referral to a tertiary ERCP center with capabilities for advanced diagnostic techniques (including SO manometry), effective therapy (including pancreatic therapeutics), and prevention of complications (placement of pancreatic stents).

Hemorrhage

Bleeding is seen endoscopically in about 10% to 30% of patients undergoing sphincterotomy but in itself does not represent an adverse outcome [1••,10••,78,79]. Clinically significant hemorrhage, such as melena or hematemesis, with or without an associated fall in hemoglobin or requirement for a secondary intervention such as endoscopy or blood transfusion, is much less common [1••]. Clinical presentation is generally delayed from 1 to as many as 10 days after sphincterotomy [10••,78]. Hemorrhage is less common now than in early reports, occurring in about 1% to 2% of patients in recent prospective multicenter studies, with very few patients (less than 1/1000 sphincterotomies) requiring surgery or angiography to control bleeding [10••,78–80].

Risk factors for hemorrhage after sphincterotomy

For clinically significant hemorrhage (Table 3), risk factors include any degree of bleeding during the procedure, presence of coagulopathy or thrombocytopenia (including hemodialysis-associated coagulation disorders), initiation of anticoagulant therapy within 3 days after sphincterotomy, and relatively low case volume on the part of the endoscopist (performance of no more than one sphincterotomy per week), which may reflect less precise control of the incision or less effective endoscopic control of bleeding once it occurs [10••,20]. Factors that do not appear to raise the risk include use of aspirin or nonsteroidal anti-inflammatory drugs, making a longer incision, or enlarging a previous sphincterotomy [2•,10••].

Methods to prevent and treat hemorrhage

The risk factors described in the previous section suggest that bleeding can mostly be avoided by correction of any coagulopathies and withholding of anticoagulant medications for up to 3 days after sphincterotomy, but most of all by meticulous endoscopic technique. Two preliminary reports suggest that prophylactic injection of the sphincterotomy site with epinephrine for endoscopically observed bleeding [81], or even a sclerosing agent in patients with coagulopathy [82], may reduce the risk of hemorrhage. Newer cautery units like the Erbe appear to reduce the incidence of immediate bleeding but not delayed hemorrhage. Once hemorrhage occurs, either during sphincterotomy or later, it can almost always be controlled with endoscopic therapy via injection of epinephrine, bipolar coagulation, or clipping [83]. Rarely, angiography or surgery is required for refractory bleeding.

Perforation

Perforation may be retroperitoneal, caused by extension of a sphincterotomy incision beyond the intramural portion of the bile or pancreatic duct; intraperitoneal, as a result of perforation of the bowel wall by the endoscope; or occurring at any location due to extramural passage or migration of guidewires or stents. Perforation is reported in less than 1% of ERCP and sphincterotomy procedures [1••,2•,3–9,10••,11,12•,13–20]. Risk factors for sphincterotomy perforation have been difficult to quantify because of its rarity. If sphincterotomy perforation is suspected, drainage with a nasobiliary catheter or stent, nasogastric suction, and intravenous antibiotics may improve chances that nonsurgical management will be effective [84]. If CT scanning demonstrates a large and ongoing leak, or if the patient's clinical condition deteriorates, prompt surgical or percutaneous drainage is advisable. Bowel wall perforations are generally treated surgically, whereas guidewire or stent-related perforations can usually be treated endoscopically by providing adequate ductal drainage [84].

Cholangitis

Cholangitis (ascending bile duct infection) and cholecystitis (gallbladder infection) are potential complications or sequelae of ERCP and sphincterotomy [1••,10••]. Risk factors for cholangitis after ERCP and sphincterotomy consist primarily of failed or incomplete biliary drainage and use of combined percutaneous-endoscopic procedures [10••]. Other risk factors include jaundice, especially if it is caused by malignancy, prior cholangitis, and operator inexperience [2•,10••,13,15,17]. Several studies have shown that prophylactic antibiotics can reduce the rate of bacteremia, but few have shown a reduction in clinical sepsis following ERCP, and a meta-analysis concluded that there was no clinical benefit to routine administration of antibiotics [85].

Long-term Sequelae

Long-term sequelae of biliary sphincterotomy include recurrent stone formation, possibly resulting form sphincterotomy stenosis, bacterobilia caused by duodenal-biliary reflux, or "sine-materia" cholangitis [21–23]. Recurrent stones and other biliary problems occur in 6% to 24% of patients undergoing long-term follow-up [21–23]. Recurrent pancreatitis, presumably caused by thermal injury to the pancreatic sphincter, has been reported after biliary sphincterotomy [86]. Restenosis of biliary and pancreatic sphincterotomy is a vexing problem in patients with SO dysfunction and pancreas divisum [26]. The long-term effects of pancreatic sphincterotomy, which is increasingly performed in patients with and without chronic pancreatitis, are largely unknown. Pancreatic stents have potential to cause permanent ductal injury with stenosis, especially if they are left in for prolonged periods in patients without advanced chronic pancreatitis [66,67].

Operator Experience and Complications

The effect of endoscopic expertise on outcome of ERCP appears to be substantial. ERCP case volume, defined variably as less than 50 annual sphincterotomies per endoscopist

[10••], less than 40 annual sphincterotomies per endoscopist [18], or center case volume of less than 200 ERCPs per year, was significantly associated with higher overall complications by univariate or multivariate analysis [2•]. Endoscopists who performed no more than one sphincterotomy per week had substantially higher rates of severe complications (2.3% vs 0.9%) [10••]. Lower case volume was significantly associated with higher rates of hemorrhage after sphincterotomy in two studies [2•,10••]. In contrast, lower ERCP case volume has not been consistently correlated with rates of post-ERCP pancreatitis, suggesting the importance of case mix in determining this complication [2•,10••,12•,18]. Type of center (university vs private) or participation of a trainee were not significant risk factors in two studies [10••,12•].

The available data probably underestimate the influence of operator experience on outcomes of ERCP, because high-volume endoscopists attempt higher-risk cases and also have higher success rates at duct access [2•,10••,12•]. The minimum volume of cases required to maintain proficiency is unknown, but probably over 100 cases per year are needed to sustain good outcomes for routine biliary therapy, and 200 to 250 cases per year for advanced pancreatic techniques. A minority of endoscopists in the United States achieve such volumes of ERCP [87]. The data suggest that outcomes will be optimal if fewer endoscopists perform more ERCP [88]. It is not feasible or palatable to suggest that all ERCP be performed at advanced centers. Rather, adequate training and ongoing case volume should be a prerequisite for performing ERCP in practice. Larger groups should concentrate all their ERCP to a few dedicated individuals rather than dilute the experience, and smaller groups who are unable to sustain adequate volumes should consider contracting their ERCP work out to more experienced individuals. Endoscopists who perform limited amounts of complex ERCP are best served by referral to a specialized center for most potentially complex cases including difficult biliary problems, suspected SO dysfunction, and pancreatic therapy. The key is for each endoscopist to find the optimal balance between risk and benefit for the individual patient and his or her own expertise and experience.

Conclusions

Complications and technical failures are adverse outcomes of ERCP that cause significant morbidity and occasionally mortality. The key to preventing complications is to understand patient and procedure-related risk factors. ERCP procedures that are least clearly indicated are often the ones most likely to cause complications. Post-ERCP pancreatitis risk is largely determined by patient-related risk factors including suspected SO dysfunction, female sex, normal serum bilirubin, or previous history of post-ERCP pancreatitis, with multiple risk factors conferring especially high risk. Technique-related risk factors include difficult cannulation, pancreatic contrast injection, balloon sphincter dilation, and precut sphincterotomy performed by endoscopists of varied experience. Pancreatic stents may substantially reduce the risk of pancreatitis in a number of settings including SO dysfunction. Hemorrhage and perforation are rare and can generally be avoided by attention to coagulation status and endoscopic technique. Cholangitis is usually related to incomplete drainage and is thus avoidable by achieving adequate biliary drainage. Because success rates are higher and complication rates lower for endoscopists performing large volumes of ERCP, ERCP should be concentrated as much as possible among endoscopists with adequate experience. Patients at high risk of complications, or with limited chance of benefit from conventional ERCP techniques, may be best served by referral to an advanced center.

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- •• Of major importance

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