Chapter 19
ERCP in Pediatric Populations

Mayssan Muftah, Christopher Fritzen, and Field F. Willingham

Case Presentations

Case 1

A 9-year-old male without significant past medical history presented to the emergency department with persistent and worsening epigastric abdominal pain. He reported decreased appetite and non-bloody, non-bilious emesis approximately 24 hours after falling off his bike onto the handle bars. The review of systems was notable for abdominal pain radiating to his back. The physical exam revealed epigastric tenderness, guarding, and bruising to his right mid-abdomen. Laboratory testing revealed

M. Muftah
Department of Medicine, Emory University School of Medicine, Atlanta, GA, USA

C. Fritzen
Gastroenterology, Hepatology and Nutrition, Children's Healthcare of Atlanta, Emory University School of Medicine, Atlanta, GA, USA

F. F. Willingham (✉)
Department of Gastroenterology, Children's Healthcare of Atlanta, Emory University School of Medicine, Atlanta, GA, USA

Division of Digestive Diseases, Emory University School of Medicine, Atlanta, GA, USA
e-mail: field.willingham@emory.edu

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an elevated lipase (9173 U/L) and amylase (197 U/L). Computed tomography (CT) scanning of the abdomen and pelvis with contrast revealed an abnormal hypo-density throughout the body of the pancreas consistent with a pancreatic body laceration and contusion with peri-pancreatic fluid. He was admitted to the pediatric surgical service and was initially managed conservatively with bowel rest. His lipase and amylase were initially down-trending, and his abdominal pain improved while NPO. However, upon advance to a low-fat diet, he developed acute, sharp, epigastric abdominal pain, nausea, and non-bloody, non-bilious vomiting with recurrent elevation in the serum lipase (9085 U/L) and amylase (345 U/L). Right upper quadrant ultrasound revealed a more defined peripancreatic fluid collection. Bowel rest was resumed, total parenteral nutrition (TPN) was initiated, and he was referred for ERCP.

Case 2

A 14-year-old female with a past medical history of chronic pancreatitis, nonalcoholic fatty liver disease (NAFLD), obesity, elevated liver enzymes, vomiting, functional abdominal pain, and laparoscopic cholecystectomy presented to the emergency department with worsening abdominal pain for 2 days. She had been previously managed with ERCP with a nasopancreatic drain 4 years prior for acute pancreatitis. Her lipase was elevated (4210 U/L) at presentation. She was referred for evaluation for ERCP.

Introduction

Endoscopic retrograde cholangiopancreatography (ERCP) is an advanced endoscopic procedure that allows for diagnostic evaluation and management of pancreaticobiliary disorders. Relative to adults, there is less data on ERCP in pediatric populations. Table 19.1 includes all studies on pediatric ERCP between the years of 2004 and 2017. Notably, there has been an increase in the number of pediatric ERCPs performed and an overall rise in therapeutic procedures

Table 19.1 Indications for pediatric endoscopic retrograde cholangiopancreatography

Biliary
Choledocolithiasis
Biliary stricture, usually secondary to primary sclerosing cholangitis or following liver transplantation
Intra- or extrahepatic ductal dilation
Management of other etiologies of biliary obstruction
Biliary leaks following blunt abdominal trauma, cholecystectomy, or liver transplantation
Neonatal cholestasis
Preoperative evaluation of choledochal cyst and pancreaticobiliary maljunction
Evaluation of the biliary tract when less invasive diagnostic modalities are equivocal or suspected to have a false negative
Pancreatic
Gallstone pancreatitis
Chronic pancreatitis
Acute or recurrent pancreatitis of unclear etiology
Pancreatic pseudocyst drainage
Pancreatic leaks following blunt abdominal trauma
Pancreas divisum
Annular pancreas
Evaluation of the pancreas when less invasive diagnostic modalities are equivocal or suspected to have a false negative

(69% increase between 2000 and 2009) with a decline in diagnostic procedures (43% decrease) felt to be due to more widespread use of MRI and endoscopic ultrasonography [1]. There has also been an increased incidence in pancreatitis and biliary disease in pediatric populations [1]. While the need for ERCP in pediatric populations is increasingly recog-

nized, there are no guidelines for ERCP in children, and the translation of adult practices to the pediatric population has been based largely on the clinical experience of providers. The overall technical and clinical success rates appear to parallel those seen in adults without an increase in the adverse event rate [2, 3]. This chapter aims at discussing the indications, success rates, procedural considerations, and complications associated with ERCP in pediatric populations.

Indications

ERCP is performed for pancreaticobiliary indications. In children, it is more commonly utilized in early adolescents, with a mean age range of 7–13.9 years old [2, 4–14], without a gender predominance [3]. In adults, the American Society of Gastrointestinal Endoscopy (ASGE) has clear guidelines regarding use of ERCP for diagnostic and therapeutic purposes. Although there is considerable overlap between children and adults, the distribution of indications is different in pediatrics, and while malignant indications are common in adults, they are rare in pediatric cohorts.

Table 19.2 lists indications for ERCP in children. Similar to adults, the most common indications are biliary obstruction and pancreatitis, reported at rates of 11.3–63.9% and 4–60.9%, respectively [4–6, 8, 10, 11, 14, 16, 17]. Children ages 0–6 have an equal distribution of biliary and pancreatic indications, those ages 7–12 have a predominance of pancreatic indications, and those 13 and older have a predominance of biliary indications [7]. This discussion will focus on indications unique to pediatric populations.

Traumatic Injuries

Pancreatic injury following blunt abdominal trauma is estimated at about 0.6%. In children, the most common mechanism is from motor vehicle accidents (55.8%). Other common

Table 19.2 Consensus classification of post-ERCP pancreatitis [15]

Requires the presence of all three of the following:

- Clinical pancreatitis
- Amylase >3 times the upper limit of normal more than 24 hours following ERCP
- Admission to the hospital following procedure or extension of hospital stay by 2–3 days in those with planned admission

Can be categorized further as mild, moderate, or severe based off duration of hospital stay, associated complications, or need for intervention

Mild	*Moderate*	*Severe*
Hospital stay lasting up to 3 days	Hospital stay lasting 4–10 days	Requires *one* of the following: • Hospital stay lasting more than 10 days • Development of hemorrhagic pancreatitis, phlegmon, pseudocyst, or infection • Need for percutaneous drainage of surgery

etiologies include bicycle accidents (19.7%), strikes to the abdomen (14.1%), and falls (8.8%) [18]. Injury to the pancreas occurs when the pancreas is compressed by anterior blunt force against the vertebral bodies posteriorly resulting in pancreatic contusion, laceration, or transection [19]. The patient presentation may include abdominal pain, fever, leukocytosis, and elevation in the serum amylase and lipase. The diagnosis may be evaluated with abdominal imaging. Ultrasound is often favored in children and may demonstrate abdominal free fluid; however it is often unable to image the pancreas due to overlying bowel gas. Contrast-enhanced CT may demonstrate the pancreatic injury and the presence of peripancreatic fluid collections and/or walled off necrosis. MRI with magnetic resonance cholangiopancreatography (MRCP) may be more involved, especially for young children due to the need for breath holding and length of time required

to obtain imaging. For these reasons, sometimes general anesthesia is required to obtain MRI/MRCP in children. However, it is the best noninvasive modality for imaging the pancreatic and biliary ductal anatomy and can help discriminate between solid and liquid peripancreatic collections. ERCP is primarily indicated for therapeutic indications and is the most sensitive test for ductal anatomy and leaks.

Although rare, traumatic injuries are associated with high morbidity (26.5%) and mortality (5.3%) [18]. Pancreatic head injuries are more morbid than tail injuries due to associated damage to the inferior vena cava, portal vein, and superior mesenteric vein. Those with ductal injury have an increased risk of death within 48 hours, as leakage of pancreatic contents can lead to rapid decompensation and multiorgan failure. They also have a risk of major complications, including fistulas and abscess formation [19].

In the setting of ductal injury, the management has been traditionally operative. A recent review reported the use of ERCP for these injuries in 2.8% of patients [18]. Newer research for pancreatic duct disruption and pancreatic transection suggests a role for ERCP in the management of these conditions and may enable children with traumatic injuries to avoid major abdominal surgery and the postoperative complications of pancreatectomy.

Biliary tract injuries are rare but can occur in children following blunt abdominal trauma via motor vehicle accidents, bicycle accidents, or strikes to the abdomen. These can range from minor injuries to complete ductal transections and are estimated to occur at a rate of 0.09% [19, 20]. Patients may have a delayed presentation and can present with fever, abdominal pain, hyperbilirubinemia, or the presence of a biloma. A hepatobiliary iminodiacetic acid (HIDA) scan may confirm a biliary leak. ERCP is often the best approach to biliary leaks. Biliary sphincterotomy and stent placement can provide for physiologic flow of bile and allow for healing of the biliary injury. Bilomas may in some cases require percutaneous drainage. Stenting across duct transections and strictures has reduced the number of children requiring laparotomy and hepaticojejunostomy [20].

Multiple studies highlight the use of ERCP in managing blunt abdominal injuries. A retrospective review evaluated nine patients that underwent ERCP following blunt abdominal trauma. Seven had pancreatic injuries and two had hepatic duct injuries. Four patients were successfully treated with stents (44.4%), one was stented but required distal pancreatectomy for persistent leak, and four were managed with laparotomy following diagnostic evaluation [21]. An additional retrospective review of 22 pediatric trauma centers found that ERCP altered management or improved outcomes in 50% of patients with blunt pancreatic injury [22]. Another retrospective review evaluated 11 patients with traumatic bile leaks. All patients were diagnosed with a HIDA scan and were successfully treated with combinations of percutaneous drainage and ERCP with stenting and/or sphincterotomy [23]. A retrospective review evaluated patients with biliary tract injuries following blunt abdominal trauma. Five patients were identified, and 60% were successfully treated with ERCP and stenting. The remaining patients required laparotomy [20]. Lastly, a retrospective study demonstrated successful treatment of posttraumatic and postoperative biliary leaks with ERCP and stenting in 85.7% of patients [24].

Neonatal Cholestasis and Biliary Atresia

Neonatal cholestasis, defined as a direct hyperbilirubinemia >1 mg/dL, occurs in about 1 in 2,500 full-term infants [25, 26]. It can have intra- or extrahepatic causes and warrants further investigation. Biliary atresia is the most common extrahepatic disorder, occurring at a rate of 1 in 12,000 live births in the United States [26]. There is a female predominance and increased incidence among non-white infants [27]. Biliary atresia typically presents 2–6 weeks following birth with jaundice and acholic stools, consistent with an extrahepatic ductal obstruction disrupting the flow of bile [25]. Initial evaluation may involve ultrasound and hepatobiliary scintigraphy. MRCP,

while sensitive (99%), has poor specificity (36%) and may not be able to confirm the diagnosis. The gold standard for the diagnosis is intraoperative cholangiogram and biopsy [26]. ERCP is emerging as a less invasive diagnostic tool with higher specificity (estimated at 73–94%) than MRCP [26, 28, 29] and may spare a laparotomy and biopsy in up to 12–20% of neonates [12, 29]. Multiple studies have demonstrated that ERCP can be safe in infants with a low risk of complication [12, 28, 30]. Management of biliary atresia may necessitate liver transplantation, although a Kasai portoenterostomy may be an alternative, particularly as a bridge to transplant [31].

Choledochal Cysts and Pancreaticobiliary Maljunction

Choledochal cysts are rare congenital cystic dilations of the biliary tract. They are more common in Asians and have a female predominance. They may present in 1 in 13,000 individuals in Japan and 1 in 100,000–150,000 individuals in Western countries. Choledochal cysts may be associated with an anomalous pancreaticobiliary junction (APBJ), a congenital malformation in which the pancreatic and bile ducts join outside the duodenal wall, in approximately 30–70% of cases [32]. It can also be associated with concurrent biliary atresia [32].

Approximately 80% of patients are diagnosed within the first decade of life. Patients usually present with abdominal pain, jaundice, or a right upper quadrant mass. They may experience complications such as pancreatitis and cholangitis. Patients may be initially identified due to common bile duct dilatation concerning for choledocholithiasis or other ductal obstruction. ERCP is the gold standard for diagnosis and is also indicated in type 3 choledochal cysts (choledochoceles) in which a biliary sphincterotomy may be therapeutic. MRCP is often performed in lieu of ERCP and has a high sensitivity (70–100%) and specificity (90–100%) for the diagnosis. However, MRI does not have a therapeutic role and can miss small choledochoceles and more subtle abnormalities [32]. ERCP may also provide for bet-

ter preoperative planning, particularly in cases where cross-sectional imaging is equivocal for the diagnosis. A retrospective review found that preoperative ERCP was successful in 99% of 92 patients with choledochal cysts. ERCP clearly identified pancreaticobiliary maljunction (PBM) in 79% of patients and delineated the pancreatic duct in 94% of patients [30]. PBM is another condition that may benefit from preoperative evaluation with ERCP [33]. This condition, particularly the non-cystic sub-type, does not typically cause symptoms in patients. However, diagnosis and excision are important due to the risk of malignant transformation to cholangiocarcinoma or gallbladder cancer [34]. For many choledochal cysts, the management involves surgical excision, particularly in those with high risk for malignant transformation. Some patients may require liver transplantation, and choledochoceles may be managed with ERCP alone [32].

Pancreas Divisum

Pancreas divisum is the most common anatomical variant of the pancreas in the general population, occurring at a rate of 5–10% [35]. It is a congenital abnormality in which a short duct of Wirsung drains the minor, ventral portion of the pancreas through the major papilla and the duct of Santorini drains the major, dorsal portion of the pancreas through the minor papilla. It occurs when the dorsal and ventral pancreatic buds fail to fuse during the seventh week of embryonic development [36]. Most patients remain asymptomatic; however, approximately 5% can present with chronic or recurrent pancreaticobiliary-type pain, idiopathic recurrent acute pancreatitis, and/or chronic pancreatitis due to inability to drain pancreatic secretions [36]. The diagnosis may be confirmed by MRCP; however, MRI has a sensitivity of 60–73.3% compared to ERCP [37–39]. When indicated, ERCP is the gold standard for establishing the diagnosis of a ductal abnormality. Endoscopic ultrasound may also be used with a reported sensitivity of 50–86.7% [37, 40].

Management is either endoscopic or surgical with a goal of improving pancreatic drainage through the minor papilla. The most common endoscopic therapy involves a papillotomy at the minor papilla with pancreatic duct stent placement. Other therapies include balloon dilation of the minor papilla, stone extraction, and botulinum toxin injection at the minor papilla [36]. Endoscopic therapy has a reported clinical success rate of 62.3–69.4%. It is associated with a higher risk of re-intervention; however it is much less invasive than surgical interventions which may involve a sphincteroplasty, pancreatic head resection, or Whipple procedure [35, 41]. More recently, the role of divisum in pancreatitis has been called into question, and large prospective studies in adults are being developed to define the role for interventions directed at minor papilla therapy. Overall, the clinical decision making should weigh the risks, benefits, and patient characteristics.

Complications Post Liver Transplant

Following liver transplantation, patients may develop biliary complications at a rate of 12–50%, most common of which are biliary strictures and biliary leaks occurring at the anastomotic site. These are more common in those who have a duct to duct anastomosis [42, 43]. Patients can present with abdominal pain or abnormal liver enzymes, and the work-up may involve evaluation and treatment with ERCP. ERCP has proven to be safe in the management of biliary complications following transplant in children [44, 45]. Biliary strictures can be treated via ERCP with sphincterotomy, balloon dilation, and stenting. A retrospective review evaluated children with liver transplant undergoing ERCP for abdominal pain, elevated liver enzymes, and known biliary strictures. Seventy-seven percent of these patients underwent therapeutic interventions. The overall complication rate was 2.9%, similar to that in adults and in children who have not had liver transplantation [44].

Procedural Considerations

The ASGE addresses specific procedural considerations when performing endoscopy in children [46]. General anesthesia is typically employed when performing ERCP in children; however, some studies suggest that monitored anesthesia care with propofol was equivalent to general anesthesia in regard to safety and technical success [5]. Children may be at greater risk of hypoventilation in the prone or supine position and airway obstruction due to higher airway compliance. Airway hyperreactivity can be exacerbated by recent upper respiratory infection. General anesthesia is generally favored, and at present we use general anesthesia for all patients undergoing ERCP. Contraindications to ERCP are relative and similar to those seen in adults and include neutropenia, coagulopathy, and unstable cardiopulmonary disease [46].

In regard to equipment, most pediatric procedures can be performed using an adult duodenoscope. The pediatric duodenoscope is limiting due to a diminutive 2 mm working channel [46], which severely limits the passage of devices and/or stents through the working channel as well as the ability to suction. The adult duodenoscope is recommended in any child over 2 years of age [5, 8, 46]. For children between 1 and 2 years of age, it may still be reasonable to use the adult duodenoscope if the child is larger and weighs more than 10 kg. In children less than 1 year of age, a pediatric duodenoscope may be required [46].

Pediatric ERCP has been compared to ASGE grade-matched adult controls on procedural parameters and clinical outcomes. In this study, all procedures were done for therapeutic indications with adult duodenoscopes by adult gastroenterologists. No difference was found between the two groups in regard to technical success, clinical success, or complication rates. There was also no difference in procedural duration, length of hospital stay, or the number of procedures performed on each patient. There was an increased use of general anesthesia in pediatric patients, and post-procedural

admission rates were higher. Overall outcomes were equivalent between the two groups [6].

There is debate on whether adult or pediatric gastroenterologists should be performing ERCP in children. To date, most procedures are performed by high-volume adult-trained endoscopists. Previously, ERCP was exclusively performed by adult-trained endoscopists due to the technical skill and procedural proficiency needed to ensure adequate success rates and reduce the risk of adverse events [47, 48]. A pragmatic consideration is that there are no clear pathways for therapeutic pediatric advanced endoscopy fellowship training. In rare cases, pediatric gastroenterologists may pursue advanced endoscopic training in adult-based fellowships. In terms of competency, the ASGE recommends at least 200 ERCPs at a minimum [49]; however, a 2015 meta-analysis suggested that this may not be sufficient [50]. A meta-analysis evaluating rates of adverse events in pediatric ERCPs attempted to assess for differences related to the type of endoscopist performing the procedure; however, the data that currently exists is too heterogeneous to draw meaningful conclusions [3]. A 2010 retrospective review found that high-volume centers have lower rates of post-ERCP pancreatitis, despite performing ERCP on higher-risk patients, compared to low-volume centers [48]. Another retrospective review suggests an ongoing case volume of at least 50 cases a year is associated with higher success rates and lower complication rates [51].

Outcomes and Complications

The overall complication rate in children undergoing ERCP is reported at 6% [3]. This parallels that seen in the adult population [46, 52]. The most common complication is post-ERCP pancreatitis, estimated to occur at a rate of 2.8–9.2%, in line with reported rates in adults at 3–10% [52]. Other complications include bleeding, estimated at a rate of 0.8%, and infection, estimated at 0.6% [3].

Post-ERCP Pancreatitis

A consensus definition of post-ERCP pancreatitis (PEP) has been frequently used since 1991 (Table 19.3) [15]. This definition is used to report rates of PEP in most studies. There are concerns that this definition overestimates the rates of PEP because many patients have abdominal pain prior to the procedure and many patients have expected hyperamylasemia following instrumentation of the pancreatic duct [52]. There are limited data on procedural and patient characteristics associated with an increased risk of PEP in children including pancreatic duct injection, pancreatic sphincterotomy, pancreatic duct stricture dilation, and prophylactic pancreatic stenting [16, 53, 56]. In adults, prophylactic pancreatic duct stenting has been repeatedly shown to reduce the risk of PEP [52]. However, a retrospective multivariate analysis evaluating 432 pediatric ERCPs showed that pancreatic sphincterotomy and pancreatic duct injection were associated with an increased risk of PEP in children. There was no identifiable association between PEP risk and age, female gender, or prior episodes of PEP as has been found in adult cohorts. Chronic pancreatitis was found to be a protective factor [56].

Given that PEP is the most common adverse event following ERCP, many studies have been performed to evaluate prophylactic interventions to reduce the risk of PEP. In a large blinded sham-controlled trial, rectal indomethacin has been shown to be protective against PEP in adults – reducing the overall incidence and severity of PEP [52]. A single dose of 100 mg rectal indomethacin is used at the time of the procedure. There have been limited data on the use of rectal indomethacin in the pediatric population. One trial examined the rates of PEP in children who received a dose of rectal indomethacin compared to those that did not. In this study, the rate of PEP was not different between the groups. There was no increase in bleeding or renal injury in the group receiving indomethacin. The study was not powered to examine an impact on the PEP rate; however, the authors recommend the use of indomethacin for prophylaxis in pediatric

Table 19.3 Studies on pediatric ERCP (2004–2017)

Year[a]	Focus of study	Number of procedures	Age[b]	Technical success rate[c] (%)	Complication rate[d] (%)
2004 [2]	Compared technical success and complication rates between ERCP in pediatric and matched adult cohorts	163	9.3 years	97.5	3.4
2005 [14]	Diagnostic and therapeutic yields of ERCP in children	48	10 years	97	6
2005 [13]	Indications, findings, therapies, safety, and success rates	329	12.3 years	97.9	9.7
2009 [12]	Indications, findings, therapies, safety, and success rates	99	7 years	71	4
2009 [29]	Diagnostic accuracy of ERCP in neonates with cholestasis compared to intraoperative cholangiogram	140	60 days	93	3.6
2009 [53]	Post-ERCP pancreatitis (excluded patients with chronic pancreatitis)	276	11 years		2.5
2010 [11]	Indications, findings, therapies, safety, and success rates	245	8 years	98.4	18.4
2010 [28]	Diagnostic efficacy of ERCP in evaluating neonates with cholestasis	104	7 weeks	91.3	1.0
2011 [10]	Indications, therapies, safety, and success rates	231	11.4 years		4.76
2012 [54]	Evaluation of neonatal cholestasis	27	55 days		0

Table 19.3 (continued)

Year[a]	Focus of study	Number of procedures	Age[b]	Technical success rate[c] (%)	Complication rate[d] (%)
2013 [7]	Compared indications, findings, therapies, and safety of ERCP between age groups in the pediatric population	289	11.5 years	90.7	5.9
2013 [17]	Indications, safety, success rates	429	14.9 years	95.2	7.7
2013 [55]	Safety and success rates of pediatric ERCP by pediatric gastroenterologists for choledocholithiasis	154	15.2 years	98	5
2013 [9]	Efficacy and safety of pediatric ERCP performed by adult gastroenterologists	70	12 years	97.1	7.1
2014 [23]	Traumatic bile leaks	11	11 years	100	18
2014 [1]	Pediatric ERCP trends in the United States	22,153	18 years (median)		
2014 [30]	ERCP in small children with pancreaticobiliary disorders, including choledochal cyst and biliary atresia	235	2 years	96	9.4
2015 [21]	Role in blunt abdominal trauma	9	7.8 years		55.6
2015 [56]	Factors associated with post-ERCP pancreatitis	432	12.7 years (median)		10.9
2015 [57]	Pancreaticobiliary maljunction	63			
2015 [45]	Post-transplant biliary complications	17	12 years	94	29.4
2015 [4]	Indications, therapies, and safety	75	13.9 years (median)	94.7	9.7

(continued)

Table 19.3 (continued)

Year[a]	Focus of study	Number of procedures	Age[b]	Technical success rate[c] (%)	Complication rate[d] (%)
2015 [16]	Indications, type of sedation, therapies, and safety	425	13.6 years	95	16.6
2016 [8]	Outcomes of pediatric ERCP by adult gastroenterologists using adult duodenoscopes	65	13 years	93.8	12.3
2016 [5]	Clinical outcomes of therapeutic ERCP	144	13.3 years	93.1	4.9
2016 [6]	Compared outcomes of ERCP in children compared to ASGE grade-matched adult controls	107	12.8 years	91	4.7
2016 [58]	Blunt pancreatic trauma	25	8.5 years		
2016 [3]	Systematic review of complication rates	3566			6
2017 [59]	Biliary complications following liver transplantation	25	10.7 years (at time of transplant)		
2017 [60]	Outcomes of sphincterotomy	198	8.7 years	98.9	14.1 (early); 6.1 (long-term)
2017 [61]	Efficacy and safety of rectal indomethacin for post-ERCP pancreatitis	119	13 years	95.8	4.2
2017 [62]	Demographics, indications, therapies, safety, and success rates	215	14 years	97	10

Table 19.3 (continued)

Year[a]	Focus of study	Number of procedures	Age[b]	Technical success rate[c] (%)	Complication rate[d] (%)
2017 [63]	Therapeutic ERCP for recurrent acute pancreatitis or chronic pancreatitis	117	11.9 years		
2017 [24]	Bile duct injuries	46	10 years	85.7	4.3
2017 [64]	MRCP vs. ERCP in evaluating chronic pancreatitis	48	12.1 years	85.4	
2017 [22]	Pediatric pancreatic trauma	28	11 years	86	16
2017 [65]	Indications, safety, and success rates	54	7.6 years	90.7	9.3

[a]Studies listed in chronological order
[b]Listed as mean age unless otherwise stated
[c]Technical success rate was typically defined as successful cannulation of the bile duct; however definitions were either omitted or varied between studies
[d]Complications were defined differently between studies, particularly that there was no consistency on whether hyperamylasemia alone was considered a complication

patients undergoing ERCP [61]. There have been many studies in adults investigating the utility of prophylactic pancreatic stenting [66], intravenous hydration [67], and cannulation techniques [68, 69] in preventing PEP. However, there are no prospective studies evaluating the efficacy of these interventions in children.

Outcome of Cases

Case 1

Due to the persistent inability to tolerate oral intake, an MRCP was performed which confirmed the formation of a peripancreatic fluid collection at the site of the laceration, measuring 2.9 × 2.6 × 3.4 cm, which was in communication with the pancreatic duct (PD). He was then transported to a quaternary children's hospital for ERCP. Pancreatogram

revealed a PD stricture in the region of the neck and a PD leak with extravasation of contrast (Fig. 19.1b). A sphincterotomy was performed, and stent was placed bridging the stricture and the region of the ductal disruption. He returned to the floor with near complete resolution of his symptoms. A regular diet was advanced the following day, and he was discharged home in stable health that evening.

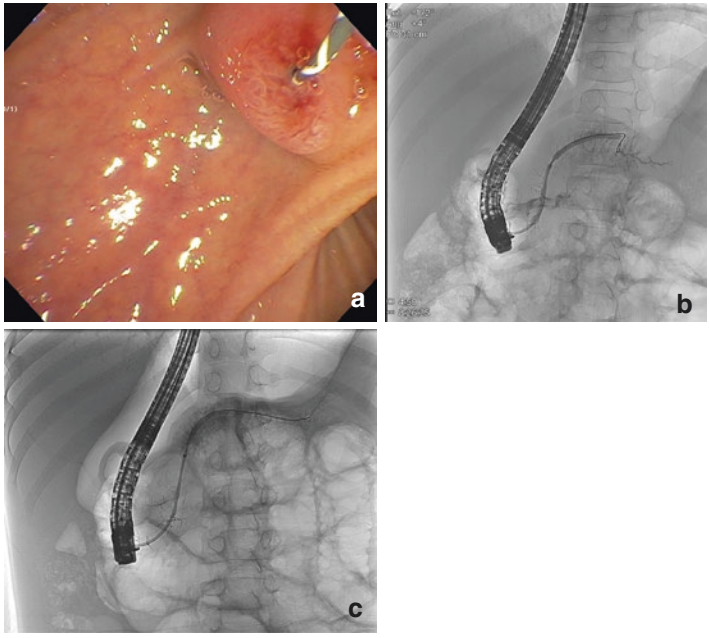

Figure 19.1 (**a**) Endoscopic image of the duodenoscope in the second portion of the duodenum. A wire has been inserted into the pancreatic duct to traverse the ductal disruption. (**b**) Fluoroscopic image showing the duodenoscope in the second portion of the duodenum. A wire has been advanced across the ductal disruption to the tail of the pancreas. In the central portion and overlying the spine, there is contrast extravasation confirming a transection and pancreatic duct leak. (**c**) The final fluoroscopic image on follow-up ERCP. The stent has been removed and a wire has been passed to the tail of the pancreas. The pancreatic duct leak and injury have resolved

Following discharge, he continued to thrive. He returned for repeat outpatient ERCP approximately 1 month later which showed minimal dilatation of the main PD (3 mm), improved PD stricture in the body region, and improved leak in the body/tail region. The stent was upsized again bridging the leak, and he was discharged home. A repeat right upper quadrant abdominal ultrasound was repeated 3 weeks later which showed complete resolution. His final ERCP was performed the next day, confirming resolution of the stricture and leak, and no new stents were placed at that time (Fig. 19.1c).

Case 2

Prior to proceeding with ERCP, an MRCP was performed which revealed an accessory pancreatic duct with a peripancreatic fluid collection near the head (Fig. 19.2a). There were edema and inflammatory changes surrounding the pancreas compatible with pancreatitis. The common bile duct (CBD) was dilated to 10 mm with no obstructing stones. Based on these findings, she was admitted to the pediatric gastroenterology service and underwent ERCP. The ERCP was remarkable for pancreatic duct (PD) dilation to 5 mm, with a prominent duct of Santorini and a santorinicele at the insertion. There was a frank pancreatic duct leak with free contrast extravasation at the insertion of the duct of Santorini in the region of the santorinicele (Fig. 19.2b). There was biliary ductal dilatation to 12 mm with no contrast extravasation on the cholangiography. A pancreatic duct stent was placed into the ventral PD via the major papilla, and a biliary stent was placed into the CBD; however, she remained symptomatic. The minor papilla was not patent. ERCP was repeated, and a thin stent was placed via the major papilla in an antegrade manner back into the duct of Santorini and to the region of the leak in the santorinicele, and a new stent was placed via the major papilla to the tail (Fig. 19.2c, d). She returned to the floor, and her symptoms improved almost immediately. She was discharged home in stable health. She has returned to school and remains asymptomatic tolerating a regular diet. Repeat ERCP with stent exchange has demonstrated a slowly resolving leak.

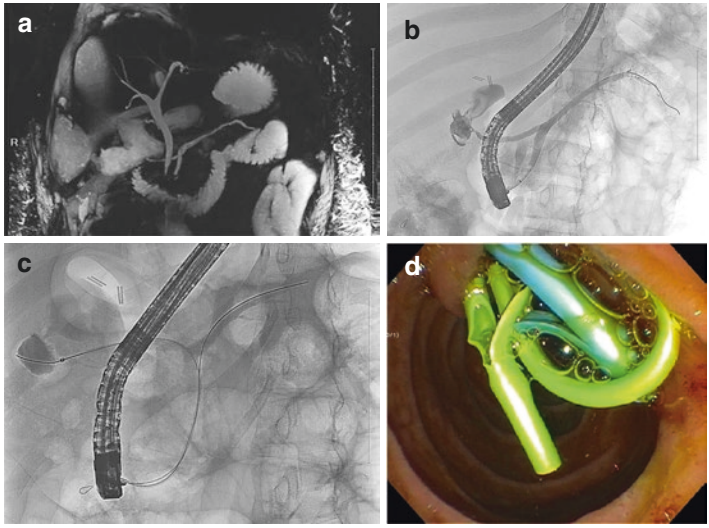

FIGURE 19.2 (**a**) MRCP revealing the pancreatic and biliary ductal anatomy. The duct of Wirsung terminates at the major papilla with the bile duct. There is a prominent duct of Santorini. There is a fluid collection and pancreatic duct leak at the insertion of the duct of Santorini on the duodenum. (**b**) Fluoroscopic image showing the duodenoscope in position. A wire and catheter have been passed to the tail of the pancreas. There is a prominent duct of Santorini and a frank pancreatic duct leak with free contrast extravasation at the insertion of the duct of Santorini on the duodenum. (**c**) Fluoroscopic image showing the duodenoscope in position. Two wires have been passed. One wire inserts at the major papilla and passed back in a partially antegrade manner into the duct of Santorini, while the second passes in a completely retrograde manner in the ventral duct to the tail of the pancreas. Stents were placed over both wires, resulting in resolution of symptoms, tolerance of an oral diet, and discharge home. (**d**) Final endoscopic image showing both pancreatic duct stents and a biliary stent in position

Conclusions

The numbers of ERCPs performed in children have been increasing, and the procedure has shown to be safe and efficacious for a growing number of indications in pediatric populations. ERCP may be critically indicated in children and may

result in dramatic benefit with certain clinical presentations. There is a major role for pancreatic injuries, some pancreatitis presentations, biliary strictures, and obstructions such as stones. As the procedure becomes more widely adopted, larger prospective studies may further refine the roles the procedure plays in younger cohorts of patients.

Pearls and Pitfalls

- ERCP can be performed safely in children, with similar success and complication rates as in adult populations.
- Indications such as traumatic pancreaticobiliary leaks and congenital abnormalities may be more frequent in pediatric cohorts.
- An adult duodenoscope is typically used in children over the age of 2 years.
- The most common complication is post-ERCP pancreatitis, for which rectal indomethacin can be used safely for prophylaxis.

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Disclosures

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