Endoscopic Advancements in Pediatric Pancreatitis

Michelle Saad and David S. Vitale

1 Division of Gastroenterology, Hepatology and Nutrition, Cincinnati Children’s Hospital Medical Center, Cincinnati, OH, United States; 2 Department of Pediatrics, University of Cincinnati College of Medicine, Cincinnati, OH, United States

Keywords: endoscopy, interventional endoscopy, EUS, ERCP, pancreatitis, pediatric

INTRODUCTION

Acute pancreatitis (AP) in children occurs with an estimated annual incidence of 3–13/100,000 (1, 2). While some children may have a single episode, others may develop acute recurrent pancreatitis (ARP) or chronic pancreatitis (CP). Children with pancreatic disease can have impacted quality of life due to chronic pain, frequent hospitalizations, and/or nutritional deficiencies. Supportive management is typically indicated for patients with acute pancreatitis, while in some circumstances endoscopic diagnostic evaluation and/or therapy are required. Endoscopy can also be beneficial in patients with ARP or CP (3).

Historically, interventional endoscopy procedures which can benefit patients with pancreatitis, such as endoscopic retrograde cholangiopancreatography (ERCP) and endoscopic ultrasonography (EUS), have been performed by adult gastroenterologists with advanced endoscopic training. Adult physicians certainly have adequate training to perform the procedures, but they often lack formal training in caring for pediatric patients or pediatric pancreatitis. Many are employed in facilities that care exclusively for adult patients and either travel to pediatric institutions to perform procedures in an unfamiliar setting or perform procedures for pediatric patients in adult facilities. This approach, when executed well, can be very successful and provide excellent patient care. However, issues can arise utilizing this model due to limited physician availability, timeliness of care and procedures, and challenges in communication amongst pediatric providers, adult proceduralists and families. In an ideal setting, children should be treated at a center with dedicated pediatric nursing staff, anesthesia, behavioral and child life specialists, and pediatric surgical and intensive care expertise if needed (4).

Over the last 10–15 years, pediatric gastroenterologists have increasingly pursued training in interventional endoscopy. Pediatric ERCP, EUS, and other advanced endoscopic procedures are now performed safely and effectively in specialized centers by pediatric providers worldwide (5–7). New training opportunities for pediatric gastroenterologists in interventional endoscopy continue to arise (8). In conjunction with advancements in interventional endoscopy, the field of pediatric pancreatology continues to evolve through increased recognition of AP and CP and collaborative approaches to research (9–11). It is increasingly important that providers managing children with pancreatitis are aware of the indications for endoscopic evaluations and interventions for pancreatitis, the benefits and risks involved, and when endoscopic therapy is no longer warranted (3).

ENDOSCOPIC ULTRASOUND

Endoscopic ultrasonography allows for highly detailed transgastric and transduodenal sonographic images of the pancreas and peripancreatic anatomy through an echoendoscope and can be safely and effectively performed in children (3, 6, 12, 13). EUS has been established in adults since the 1980s and is sensitive for evaluating changes in the pancreas that reflect CP, including specific...
parenchymal and ductal changes. While traditional cross-sectional imaging often reflects late irreversible changes to the pancreas, EUS can allow the detection of early changes or minimal change CP before irreversible changes occur (14). EUS has been shown to outperform cross-sectional imaging [magnetic resonance imaging (MRI) and computed tomography (CT)] for the detection of CP with a sensitivity of 81% and specificity of 90% (15). To maximize the success of interventions aimed at slowing or stopping disease progression and ameliorating the deleterious downstream effects of pancreatic insufficiency, techniques to identify the early stages of chronic pancreatic disease are imperative.

In adult patients, Rosemont or conventional criteria are used to assess CP parenchymal or ductal changes (14, 16–18). These guidelines are utilized but not accepted universally in adults, with poor reliability amongst different observers (17). These established criteria can be utilized as a guide in assessing the pediatric pancreas via EUS, however results in pediatric patients must be interpreted with caution as there is no data to validate its use in children (14, 16, 19).

Endoscopic ultrasonography can also be used in patients with idiopathic ARP or CP, investigating for ductal or anatomic abnormalities not fully delineated by magnetic resonance cholangiopancreatography (MRCP), or even biliary microlithiasis. EUS identifies an etiology in up to 75% of patients with idiopathic ARP (20). More recent innovations in EUS diagnostic imaging include the use of real-time shear wave elastography. EUS elastography allows an indirect assessment of tissue rigidity and may predict pancreatic fibrosis or pancreatic exocrine insufficiency (21, 22). Contrast-enhanced EUS consists of EUS imaging while gas-filled microbubbles are injected into peripheral veins, highlighting vascular lesions within the pancreas and helping distinguish various pancreatic lesions. In benign pancreatitis, contrast-enhanced EUS can identify necrotizing foci of AP at an early stage and may be useful in differentiating focal autoimmune pancreatitis from pancreatic cancer (23, 24).

Autoimmune pancreatitis (AIP) presents a challenging diagnostic dilemma, with convoluted adult diagnostic criteria which include response to therapy (25). Pediatric guidelines from the International Study Group of Pediatric Pancreatitis: In Search for a Cure (INSPIRE) suggest “tissue diagnosis should ideally be obtained prior to initiating therapy,” with EUS guided biopsies favored when available (26). Diagnostic sensitivity for EUS guided fine needle biopsy (FNB) is quite low in adults (27). Pediatric patients typically present with type 2, rather than type 1 AIP and there is a paucity of data in children (26, 28). A recent meta-analysis showed the pooled diagnostic yield for histology criteria in AIP to be 55.8% for FNA and 87.2% for FNB despite similar rates of histologic tissue procurement (29). In our practice, cases of suspected autoimmune pancreatitis with classic, diffuse imaging findings are often treated empirically after discussing risks/benefits with the family. Cases that are less clear benefit from extensive discussions with families regarding the typical modest yield of EUS-FNB, along with the risks and benefits of empiric therapy vs. biopsy.

Interventional EUS is a rapidly progressing field utilizing echo endoscopes to perform therapeutic interventions and should be performed at high volume, experienced centers. The predominant use of interventional EUS in pediatric patients is in symptomatic pancreatic walled off necrosis and pseudocysts. EUS-guided transgastric or transduodenal cyst-enterostomy drainage procedures are preferred approaches with superior success rates and risk profiles, decreased length of stay and lower treatment cost as compared to surgical approach (3, 30, 31). Metal and plastic stents have been used in children successfully, along with lumen apposing metal stents (13, 32–34). EUS guided celiac plexus blockade in patients with CP and debilitating pain has been used successfully in adult and pediatric patients (6, 35–37). Pediatric patients with conventional or post-surgical anatomy with dilation of the pancreatic duct but the inability to cannulate the duct via ERCP are candidates for pancreatic duct rendezvous via EUS (38).

The risk of adverse events in EUS includes bleeding, bacteremia and perforation. FNA or FNB of the pancreatic parenchyma can cause pancreatitis. Diagnostic EUS presents risk rates similar to upper endoscopy, while interventional EUS presents higher risks of infection, bleeding and perforation. The failure rate for complex procedures, such as pancreatic rendezvous, can approach 30% (6, 39, 40).

**ENDOSCOPIC PANCREATIC FUNCTION TESTING**

Exocrine pancreatic insufficiency (EPI) can occur in patients with cystic fibrosis and other congenital diseases, and CP. Indirect EPI testing is available, but only detects severe EPI. Direct pancreatic function testing with endoscopic pancreatic function testing (ePFT) during conventional esophagogastrroduodenoscopy has emerged as a viable test in children. The North American Society of Pediatric Gastroenterology, Hepatology and Nutrition (NASPGHAN) recently published a position paper outlining a proposed standardized ePFT protocol in children. After aspiration of gastric and duodenal contents, cholecystokinin or secretin are administered and 3 duodenal aspirates are collected at 5-min intervals and sent for laboratory analysis of pancreas enzyme activity. EUS with secretin stimulation (sEUS) has been utilized to assess for structural changes reflective of minimal change chronic pancreatitis (MCCP), and can impact the likelihood of CP following, and predict progression of MCCP to overt CP in patients with abdominal pain thought to be pancreatic in origin with non-diagnostic cross-sectional imaging (41, 42). A multicenter research collaboration is needed to further refine and validate the proposed methods (43).

**ENDOSCOPIC RETROGRADE CHOLANGIOPANCREATOGRAPHY**

Acute recurrent pancreatitis and CP are some of the most frequent indications for pediatric ERCP, which is feasible in children of all ages and sizes (3, 7, 44, 45). Historically diagnostic ERCP had been utilized, however, with the advent
of high quality MRCP and EUS, the vast majority of pediatric patients undergo ERCP for therapeutic indications (7). ERCP is used sparingly for diagnostic purposes, however in cases of suspected pancreatic ductal anatomic abnormalities, such as pancreas divisum, anomalous pancreaticobiliary junction or choledochocele it remains the gold standard (3, 46, 47). Diagnoses of abnormal pancreaticobiliary ductal anatomy can be confirmed and sometimes treated within the same procedure.

Endoscopic retrograde cholangiopancreatography allows numerous therapeutic modalities for ARP and CP in symptomatic patients. Pancreatic duct strictures are managed with catheter or balloon dilation, followed by serial pancreatic duct (PD) stent placements for up to 12 months with close observation (48). Calculi in the PD can also be removed using an extraction balloon during ERCP or for larger refractory stones through extracorporeal shockwave lithotripsy or pancreatoscopy (49). Other anatomical abnormalities such as pancreas divisum associated with ARP or CP can be addressed through a minor papillotomy and/or dorsal pancreatic duct stent placement (50–52).

Pediatric patients with AP may benefit from ERCP as well. ERCP with stent placement may be necessary for AIP with associated pancreatic or bile duct strictures/obstruction. Therapeutic intervention through biliary sphincterotomy and stone extraction is performed if AP is due to biliary etiology, specifically gallstone pancreatitis with suspected persistent bile duct obstruction (53, 54).

Technically successful ERCP may not always alleviate patients’ symptoms in the setting of pancreatic disease. Moreover, ERCP is associated with certain risks, including post ERCP pancreatitis (PEP), bleeding, infection, and perforation (5). PEP occurs in up to 12% of children undergoing ERCP and is more likely to occur in patients needing pancreatic sphincterotomy, PD cannulation, PD injection, or prophylactic stent placement (55, 56). Pre-emptive use of IV ketorolac or ibuprofen in children has been performed at the time of ERCP to decrease the rates of PEP, albeit published results have not reached statistical significance (55, 57).

**SURGICAL MANAGEMENT**

Patients who do not respond to endoscopic therapy and have progressive, debilitating pancreatitis, may require surgical intervention. Traditional surgical drainage procedures such as lateral pancreaticojejunostomy (Puestow), or other surgical drainage variants (Frey or Beger), pancreatic tail resection, or pancreaticoduodenectomy (Whipple) have fallen out of favor in children with ARP and CP, especially in those with genetic risk factors. Endoscopic procedures can improve drainage in cases of pancreatic duct strictures amenable to stenting, usually attempted for up to a year before surgical intervention (48).

Children debilitated by their disease, with chronic pain, frequent hospitalizations, and failure of maximized medical and endoscopic therapy can be considered for total pancreatectomy with islet auto-transplantation (TPIAT) after an extensive evaluation. Total pancreatectomy offers the advantage of pain relief but leads to diabetes. The risk of diabetes is offset by the islet auto-transplantation intraoperatively, with childrens’ glycemic outcomes ranging from insulin-independent to diabetic, with contributing factors such as the timing of surgery from the onset of symptoms, body mass index, pancreas mass, and fibrosis (58). Pancreatic enzyme replacement therapy is also needed post-operatively as patients have acquired exocrine pancreatic insufficiency.

**PEDIATRIC INTERVENTIONAL ENDOSCOPY: THE FUTURE**

While the field of pediatric interventional endoscopy has evolved, many care gaps exist and there are tremendous opportunities for growth and research (3, 45). Awareness of available pediatric diagnostic and interventional procedures will need to continue to increase. Unique research opportunities arise in pediatric pancreatitis, with the ability to study the progression and entire spectrum of disease by following patients from a first episode of AP to CP. EUS findings along the spectrum of disease, including objective findings of shear wave elastography, could lead to the development of a pediatric EUS CP criteria (59).

Endoscopic retrograde cholangiopancreatography and EUS are frequently used to diagnose and treat autoimmune pancreatitis and pancreas divisum, but supporting literature is sparse. Individualized decisions regarding endotherapy related to specific genetic mutations needs further research and randomized studies are needed to further assess PEP prophylaxis.

The volume of interventional endoscopic procedures in children is increasing, however it still does not approach adult volume. Strong collaboration amongst institutions and individual endoscopists remains vital to the advancement of the field. As the field evolves, questions remain regarding appropriate training avenues and the appropriate location and number of centers offering pediatric interventional endoscopic expertise.

**CONCLUSION**

Increased awareness of pancreatic disease in children has led to improved detection of AP, ARP, and CP in this population. Diagnostic and therapeutic options with EUS and ERCP are available and ideally should be performed at large tertiary centers with high patient volumes. The approach to each patient is individualized, and some may not need endoscopic diagnostic or therapeutic intervention. Surgical options such as TPIAT should be considered in patients with debilitating pain and affected quality of life who also need serial endoscopic therapy with no notable improvement in symptoms or frequency of inflammatory attacks. There are ample research opportunities to advance the fields of pediatric interventional endoscopy and pancreatology as they continue to evolve.

**AUTHOR CONTRIBUTIONS**

MS and DV contributed to the conceptualization, drafting of the manuscript, and editing of the final manuscript. Both authors contributed to the article and approved the submitted version.
REFERENCES

1. Rebours V, Bourtin-Ruault MC, Schnee M, Ferec C, Le Marechal C, Hentic O, et al. The natural history of hereditary pancreatitis: a national series. Gut. (2009) 58:97–103. doi: 10.1136/gut.2008.149179

2. Mortinville VD, Barmanda MM, Lowe ME. Increasing incidence of acute pancreatitis at an American pediatric tertiary care center: is greater awareness among physicians responsible? Pancreas. (2010) 39:5–8. doi: 10.1097/MPA.0b013e3181bac47

3. Liu QY, Gugg R, Troendle DM, Bittin S, Patel N, Vitale DS, et al. The roles of endoscopic ultrasound and endoscopic retrograde cholangiopancreatography in the evaluation and treatment of chronic pancreatitis in children: a position paper from the North American society for pediatric gastroenterology, hepatology, and nutrition pancreas committee. J Pediatr Gastroenterol Nutr. (2020) 70:681–93. doi: 10.1097/MPG.0000000000002664

4. Troendle DM, Barth BA. ERCP can be safely and effectively performed by a pediatric gastroenterologist for cholelithioblastiasis in a pediatric facility. J Pediatr Gastroenterol Nutr. (2013) 57:655–8. doi: 10.1097/MGP.0b013e31828f5594

5. Troendle DM, Barth BA. Pediatric considerations in endoscopic retrograde cholangiopancreatography. Gastrointest Endosc Clin N Am. (2016) 26:119–36. doi: 10.1016/j.gi.2015.08.004

6. Barakat MT, Cagil Y, Gugg R. Landscape of pediatric endoscopic ultrasound in a United States tertiary care medical center. J Pediatr Gastroenterol Nutr. (2022) 61:311–9. doi: 10.1097/MPG.0000000000003403

7. Barakat MT, Cholankeril G, Gugg R, Berquist WE. Nationwide evolution of pediatric ERCP indications, utilization and re-admissions over time. J Pediatr. (2020) 232:159–65.e1. doi: 10.1016/j.jpeds.2020.11.019

8. Foundation N. NASPGHAN Foundation Advanced Fellowship In Pediatric Endoscopy. (2020). Available online at: https://naspghan.org/wp-content/uploads/2020/02/AdvancedEndoscopy2020_2720.pdf (accessed April 14, 2022).

9. Uc A, Hussain SZ. Pancreatitis in children. Gastroenterology. (2019) 156:1969–78. doi: 10.1053/j.gastro.2018.12.043

10. Sellers ZM, MacIsaac D, Yu H, Dehghan M, Zhang KY, Bensen R, et al. Nationwide trends in acute and chronic pancreatitis among privately insured children and non-elderly adults in the United States, 2007–2014. Gastroenterology. (2018) 155:649–78.e1. doi: 10.1053/j.gastro.2018.04.013

11. Schwarzenberg SJ, Bellin M, Husain SZ, Ahuja M, Barth R, Davis H, et al. Pediatric chronic pancreatitis is associated with genetic risk factors and substantial disease burden. J Pediatr. (2015) 166:890–6.e1. doi: 10.1016/j.jpeds.2014.11.019

12. Lakhole A, Liu QY. Role of endoscopic ultrasound in pediatric disease. Gastrointest Endosc Clin N Am. (2016) 26:137–53. doi: 10.1016/j.gi.2015.08.001

13. Nabi Z, Lakhitkia S, Basha J, Chavan R, Ramchandani M, Gupta R, et al. Endoscopic ultrasound-guided drainage of walled-off necrosis in children with fully covered self-expanding metal stents. J Pediatr Gastroenterol Nutr. (2017) 64:592–7. doi: 10.1097/MGP.0000000000001491

14. Catalano MF, Sahai A, Levy M, Romagnuolo J, Wiersema M, Saad and Vitale Endoscopic Advancements in Pediatric Pancreatitis

15. Guss A, Pomeroy JM. The role of endothet in recurrent acute pancreatitis. Gastrointest Endosc Clin N Am. (2018) 28:455–76. doi: 10.1016/j.gi.2018.05.001

16. Iglesias-Garcia J, Larino-Noia J, Domínguez-Munoz JE. New imaging techniques: endoscopic ultrasound-guided elastography. Gastrointest Endosc Clin N Am. (2017) 27:551–67. doi: 10.1016/j.gi.2017.06.015

17. Dominguez-Muñoz JE, Iglesias-García J, Castellinha Alvarinho M, Luaces Regueira M, Lariño-Noia J. EUS elastography to predict pancreatic exocrine insufficiency in patients with chronic pancreatitis. Gastrointest Endosc. (2015) 81:136–42. doi: 10.1016/j.gie.2014.06.040

18. Ripolles T, Martinez MJ, Lopez E, Castello I, Delgado F. Contrast-enhanced ultrasound in the staging of acute pancreatitis. Eur Radiol. (2010) 20:2518–23. doi: 10.1007/s00330-010-1824-5

19. Cho MK, Moon SH, Song TJ, Kim RE, Oh DW, Park DH, et al. Contrast-enhanced endoscopic ultrasound for differentially diagnosing autoimmune pancreatitis and pancreatic cancer. Gut Liver. (2018) 12:591–6. doi: 10.5009/gnl17391

20. Silveiratava G, Chari ST, Frulloni L, Kamisawa T, Kawa S, Mino-Kenudson M, et al. International consensus diagnostic criteria for autoimmune pancreatitis: guidelines of the international association of pancreatology. Pancreas. (2011) 40:352–8. doi: 10.1097/MPA.0b013e3182142612

21. Scheers I, Palermo JJ, Freedman S, Wilschanski M, Shah U, Abu-El-Hajia M, et al. Recommendations for diagnosis and management of autoimmune pancreatitis in childhood: consensus from INSPPIRE. J Pediatr Gastroenterol Nutr. (2018) 67:232–6. doi: 10.1097/MPG.0000000000002028

22. de Pretis N, Criniò SF, Frulloni L. The role of EUS-guided FNA and FNB in autoimmune pancreatitis. Diagnostics. (2021) 11:8–10. doi: 10.3390/diagnostics11091653

23. Scheers I, Palermo JJ, Freedman S, Wilschanski M, Shah U, Abu-El-Hajia M, et al. Autoimmune pancreatitis in children: characteristic features, diagnosis, and management. Am J Gastroenterol. (2017) 112:1604–11. doi: 10.1038/ajg.2017.85

24. Yoon SB, Moon SH, Song TJ, Kim JH, Kim MH. Endoscopic ultrasound-guided fine needle aspiration vs. biopsy for diagnosis of autoimmune pancreatitis: systematic review and comparative meta-analysis. Dig Endosc. (2021) 33:1024–33. doi: 10.1111/den.13866

25. Lerch MM, Stier A, Wahnschaffe U, Mayerle J. Pancreatic pseudocysts: observation, endoscopic drainage, or resection? Disch Arztebl Int. (2009) 106:614–1. doi: 10.3328/arztebl.2009.0614

26. Farias GFA, Bernardo WM, De Moura DTH, Guedes HG, Brunaldi VO, Visconti TAC, et al. Endoscopic vs. surgical treatment for pancreatitis: systematic review and meta-analysis. Medicine. (2019) 98:e14255. doi: 10.1097/MD.0000000000014255

27. Brimhall H, Han S, Tatman PD, Clark TJ, Wani S, Brauer E, et al. Increased incidence of pseudoaneurysm bleeding with lumen-apposing metal stents compared to double-pigtail plastic stents in patients with peripancreatic fluid collections. Clin Gastroenterol Hepatol. (2018) 16:1521–8. doi: 10.1016/j.cgh.2018.02.021

28. Trindade AJ, Inamdar S, Button S. Pediatric application of a lumen-apposing metal stent for transgastric pancreatic abscess drainage and subsequent necrosectomy. Endoscopy. (2016) 48 Suppl 1:E204–5. doi: 10.1055/s-0042-108573

29. Gieter MJ, Balmadrid BL. Pediatric application of the lumen-apposing metal stent for transgastric pancreatic abscess drainage and subsequent necrosectomy. Endoscopy. (2016) 48:1848–9. doi: 10.1055/s-0042-1085829

30. Moutinho-Ribeiro P, Costa-Moreira P, Caldeira A, Leite S, Marques S, Moreira T, et al. Endoscopic ultrasound-guided celiac plexus interventions. GE Port J Gastroenterol. (2020) 28:32–8. doi: 10.1159/000508529

31. Guss A, Schmidt C, Sherman S, Ciccia D, Ilkenny S, Lehman G. Endoscopic ultrasound-guided celiac plexus block for managing abdominal pain associated with chronic pancreatitis: a prospective single center experience. Am J Gastroenterol. (2001) 96:409–16. doi: 10.1111/j.1572-0241.2001.03551.x
37. Membrillo-Romero A, Rascon-Martinez DM. [Celiac block in pediatric patients using endoscopic ultrasound for management of severe pain due to chronic pancreatitis. Review of the technique in 2 cases]. Cir Cir. (2017) 85:264–8. doi: 10.1016/j.circir.2017.05.006

38. Yoshimura Y, Yamashita S, Sato M, Iwano K, Kurita A, Hata D. The first successful rendezvous procedure for pancreatic duct drainage in a pediatric case with obstructive pancreatitis. Pancreas. (2021) 50:e37–9. doi: 10.1097/MPA.0000000000001775

39. Early DS, Acosta RD, Chandrasekharra V, Chathadi KV, Decker GA, Evans JA, et al. Adverse events associated with EUS and EUS with FNA. Gastrointest Endosc. (2013) 77:839–43. doi: 10.1016/j.gie.2013.02.018

40. Saumoy M, Kahele M. Safety and complications of interventional endoscopic ultrasound. Clin Endosc. (2018) 51:235–8. doi: 10.5946/ce.2017.081

41. DeWitt JM, Al-Haddad MA, Easler JJ, Sherman S, Slaven J, Gardner TB, et al. Pancreatic function testing and dynamic pancreatic duct evaluation for the diagnosis of exocrine pancreatic insufficiency and chronic pancreatitis. Gastrointest Endosc. (2021) 93:444–53. doi: 10.1016/j.gie.2020.06.029

42. Monachese M, Lee PJ, Harris K, Jang S, Bhatt A, Chahal P, et al. EUS and secretin endoscopic pancreatic function test predict evolution to overt structural changes of chronic pancreatitis in patients with non-diagnostic baseline imaging. Endosc Ultrasound. (2021) 10:116–23. doi: 10.4103/2390-9027.313801

43. Patel N, Sellers ZM, Grover A, Liu QY, Maqbool A, Morinville VD, et al. Endoscopic pancreatic function testing (ePFT) in children: a position paper from the NASPGHAN pancreas committee. J Pediatr Gastroenterol Nutr. (2021) 72:144–50. doi: 10.1097/MPG.0000000000002931

44. Pant C, Sfera TJ, Barth BA, Deshpande A, Minocha A, Qureshi WA, et al. Trends in endoscopic retrograde cholangiopancreatography in children within the United States, 2000–2009. J Pediatr Gastroenterol Nutr. (2014) 59:57–60. doi: 10.1097/MPG.0000000000000333

45. Vitale DS, Lin TK. Trends in pediatric endoscopic retrograde cholangiopancreatography and interventional endoscopy. J Pediatr. (2021) 232:10–2. doi: 10.1016/j.jpeds.2020.12.078

46. Agarwal J, Nageshwar Reddy D, Talakdar R, Lakhtakia S, Ramchandani M, Tandan M, et al. ERCP in the management of pancreatic diseases in children. Gastrointest Endosc. (2014) 79:271–8. doi: 10.1016/j.gie.2013.07.060

47. Lin TK, Vitale DS, Abu-El-Haija M, Anton CG, Crotty E, Li Y, et al. Magnetic resonance cholangiopancreatography vs endoscopy retrograde cholangiopancreatography for detection of anatomic variants of the pancreatic duct in children. J Pediatr. (2022) 244:120–4. doi: 10.1016/j.jpeds.2022.01.008

48. Dumonceau JM, Delhaye M, Tringali A, Arvanitakis M, Sanchez-Yague A, Vayse T, et al. Endoscopic treatment of chronic pancreatitis: European society of gastrointestinal endoscopy (ESGE) guideline—updated August 2018. Endoscopy. (2019) 51:179–93. doi: 10.1055/a-0822-0832

49. Dumonceau JM, Delhaye M, Tringali A, Domínguez-Munoz JE, Poley JW, Arvanitaki M, et al. Endoscopic treatment of chronic pancreatitis: European society of gastrointestinal endoscopy (ESGE) clinical guideline. Endoscopy. (2012) 44:784–800. doi: 10.1055/s-0032-1309840

50. Lin TK, Pathak SJ, Hornung LN, Vitale DS, Nathan JD, Abu-El-Haija M. Clinical outcomes following therapeutic endoscopic retrograde cholangiopancreatography in children with pancreas divisum. J Pediatr Gastroenterol Nutr. (2021) 72:300–5. doi: 10.1097/MPG.0000000000002996

51. Lin TK, Abu-El-Haija M, Nathan JD, Palermo JP, Barth B, Bellin M, et al. Pancreas divisum in pediatric acute recurrent and chronic pancreatitis: report from INSPPIRE. J Clin Gastroenterol. (2019) 53:e232–8. doi: 10.1097/MCG.0000000000001063

52. Pan G, Yang K, Gong B, Deng Z. Analysis of the efficacy and safety of endoscopic retrograde cholangiopancreatography in children with symptomatic pancreas divisum. Front Pediatr. (2021) 9:761331. doi: 10.3389/fped.2021.761331

53. Buxbaum JL, Abbas Fehmi SM, Sultan S, Fishman DS, Qumseya BJ, Cortessi VK, et al. ASGE guideline on the role of endoscopy in the evaluation and management of choledocholithiasis. Gastrointest Endosc. (2019) 89:1075–105.e15. doi: 10.1016/j.gie.2018.10.001

54. Zakko L, Gardner TB. Endoscopic management of recurrent acute pancreatitis. Clin Gastroenterol Hepatol. (2017) 15:2167–70. doi: 10.1016/j.cgh.2019.04.069

55. Troendle DM, Gurram B, Huang R, Barth BA. IV ibuprofen for prevention of post-ERCP pancreatitis in children: a randomized placebo-controlled feasibility study. J Pediatr Gastroenterol Nutr. (2020) 70:121–6. doi: 10.1097/MPG.0000000000002524

56. Troendle DM, Abraham O, Huang R, Barth BA. Factors associated with post-ERCP pancreatitis and the effect of pancreatic duct stenting in a pediatric population. Gastrointest Endosc. (2015) 81:1408–16. doi: 10.1016/j.gie.2014.11.022

57. Mark JA, Kramer RE. Keterolac is safe and associated with lower rate of post-endoscopic retrograde cholangiopancreatography pancreatitis in children with pancreatic duct manipulation. J Pediatr Gastroenterol Nutr. (2021) 73:542–7. doi: 10.1097/MGP.0000000000003252

58. Balamurugan AN, Elder DA, Abu-El-Haija M, Nathan JD. Islet cell transplantation in children. Semin Pediatr Surg. (2020) 29:150925. doi: 10.1016/j.sempedsurg.2020.150925

59. Yamashita Y, Tanioka K, Wakiy T, Tamura T, Nuta J, Hatamaru K, et al. Utility of elastography with endoscopic ultrasonography shear-wave measurement for diagnosing chronic pancreatitis. Gut Liver. (2020) 14:659–64. doi: 10.5009/gnl19170

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Copyright © 2022 Saad and Vitale. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.