Review

Endoscopic Ultrasound

OPEN

EUS in pediatric patients

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Abstract

EUS has become an essential tool in pediatric gastroenterology for high-resolution imaging of the gastrointestinal tract and surrounding organs. This review describes the clinical applications and outcomes of EUS in diagnosing and managing pediatric gastrointestinal, pancreatic, biliary, and intestinal diseases. EUS is particularly useful in abdominal diseases, offering an accurate and high-resolution imaging method without radiation exposure. Despite its proven efficacy in children, EUS remains underutilized due to technical challenges and limited pediatric-specific expertise. Thus, the study highlights the importance of increasing the availability and training for pediatric EUS to enhance diagnostic precision and therapeutic options in children.

Key words: EUS; Pediatric; Diagnosis; Treatment

Introduction

EUS provides high-resolution imaging for the evaluation of diseases of the gastrointestinal (GI) wall and adjacent organs such as pancreas, bile duct and many others.[1,2] It is also possible to perform fine-needle aspiration (FNA) or biopsy (FNB) and treatment procedures.[3–7] Although the indications for endosonographic diagnosis are well known in adults, EUS techniques are still underutilized in children, whereas other valid diagnostic modalities such as ultrasound (US), computed tomography, magnetic resonance imaging (MRI), or magnetic resonance cholangiopancreatography (MRCP) are more preferred.[8,9] Thus, the aim of this review paper was to discuss the present studies of EUS in pediatrics, which demonstrate the role and clinical impact of EUS.

Echoendoscopes

Conventional linear echoendoscopes have an outer diameter of 14 mm and a channel diameter of 3.7 mm. Further developments resulted in slim linear echoendoscopes with 11-mm outer diameter and 2.8-mm working channel, which is comparable to the dimensions of a standard gastroscope. From the age of 3 years or 15-kg body weight, standard radial and linear echoendoscopes can be used. Newborns can be easily investigated with help of an endobronchial EUS probe.[10] Particular attention should be given during esophageal intubation in order to avoid cervical esophageal perforation due to the rigid part at the tip of the echoendoscopes.

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Clinical applications of EUS in pediatrics

Upper GI diseases

The classic indications for EUS in esophagogastroduodenal diseases include staging of tumors and the evaluation of subepithelial tumors. Cancers in the upper GI tract are extremely rare in childhood. Gastric lymphoma or GI stromal tumors (GISTs) occur infrequently in children.[11] GISTs are usually located in the stomach and occur more frequently in girls and typically in teenage years. EUS-guided sampling can provide the diagnosis and molecular subtyping.[12]

Often lesions seen in the esophagus, stomach, or duodenum at endoscopy can be identified endosonographically as indentation from nearby organs, duplication cysts, bronchogenic cysts, pancreatic rests, or sometimes subepithelial tumors. EUS allows the detailed characterization of subepithelial lesions in relation to size, delineation, echogenicity, vascularization, and position within the layers of the GI wall and enables EUS-guided FNA or FNB for molecular, cytological, or histological diagnosis.[13]

Granular cell tumors, leiomyoma, neuroendocrine tumors, and GISTs have been reported also in children and were characterized using EUS [Figure 1].[14–19]

Pancreatic rest is heterotopic pancreatic tissue, most often found in the submucosal layer of the antrum at the greater curve. Often, it presents as a subepithelial lesion with a central orifice at endoscopy. Most patients are asymptomatic, but it can also cause abdominal pain.[20]

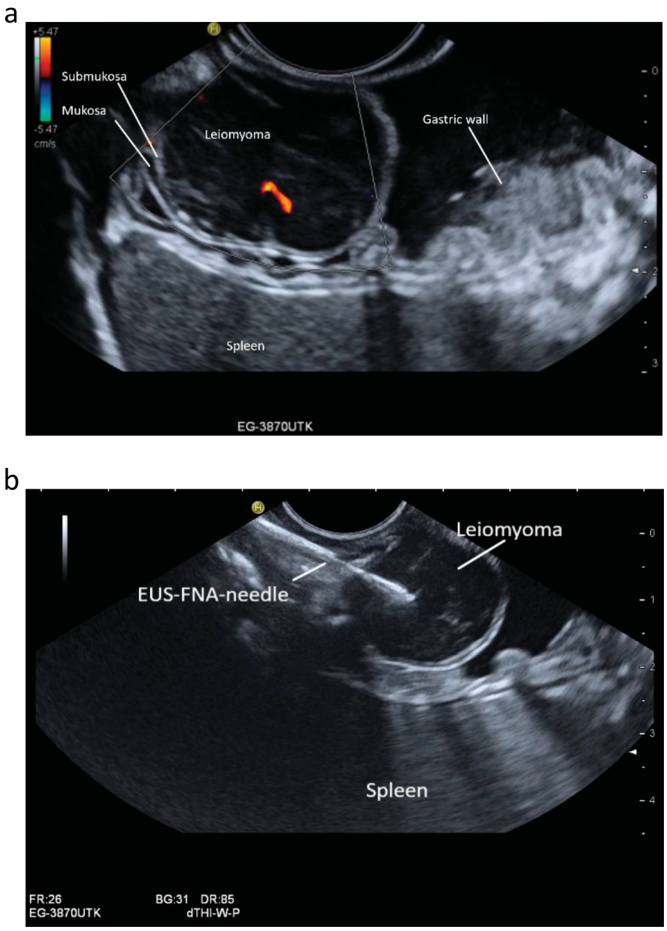

Figure 1. Subcardiac leiomyoma in a 15-year-old girl. Esophagogastroduodenoscopy was performed due to unspecific abdominal pain. A subcardiac impression was found. Endosonography showed a very hypoechoic round lesion of 20 × 14 mm covered by mucosa and submucosa. Color Doppler imaging shows a single macrovessel (A). Histological confirmation was performed by EUS-FNA. With a 22-gauge FNA needle, it was possible to obtain minute histological cores (B).

Another indication of EUS is the characterization of stenoses and strictures in the GI tract.

The mini probe EUS proved to be helpful in the differential diagnosis of congenital esophageal and duodenal stenoses. Tracheobronchial remnants, fibromuscular hypertrophy, and pancreas annulare were described.[21–23]

A case of gastric duplication cyst also highlighted the key role of the EUS. In this report, EUS characterized the cause of the bulging mass in the stomach, and an anechoic oval lesion with well-defined margins originating from the submucosal layer was found.[24] In addition, EUS allowed the diagnosis and treatment. The aspiration of the internal liquid relieved the acute symptoms of the patient, showing the importance and utility of this procedure.

Eosinophilic esophagitis is a chronic immune-mediated progressive disease, which often can be controlled by food elimination diet in children.[25,26] Despite earlier enthusiasm, endoscopic assessment of the esophageal wall thickness in children has proved to be not helpful in the diagnosis of eosinophilic esophagitis.[27]

Pancreatic disease

Pancreaticobiliary issues are the most common indications for endosonography in children in many studies.[28–32] The incidence of acute pancreatitis in childhood has been rising.[9] Endoscopic methods, including EUS and endoscopic retrograde cholangiopancreatography (ERCP), are useful tools to diagnose and manage pancreatitis, even in small children, where cross-sectional imaging is not sufficient to diagnose or characterize the disease.[25,33,34] In addition, EUS is reported to be the most sensitive and highly specific diagnostic tool for choledocholithiasis and microlithiasis, which are responsible for at least half of all cases of acute pancreatitis.[35–38]
In the study by Demirbaş et al., EUS was found to be a useful and safe procedure in pediatric patients with pancreatitis, and there was no false-negative EUS result.[9]

Because of noninvasiveness and lack of radiation, transabdominal US and MRI are the first-line imaging modalities in the diagnosis and follow-up of recurrent or chronic pancreatitis in childhood.[9] In the study by Demirbaş et al., parenchymal and ductal pathologies were observed in EUS procedures in the patients with recurrent pancreatitis who had normal results in US and MRCP.[9] EUS allows for a highly accurate assessment of pancreatic parenchymal and ductal changes and disease severity. There is increasing evidence to support the role and clinical impact of EUS, particularly to avoid unnecessary ERCP.[39]

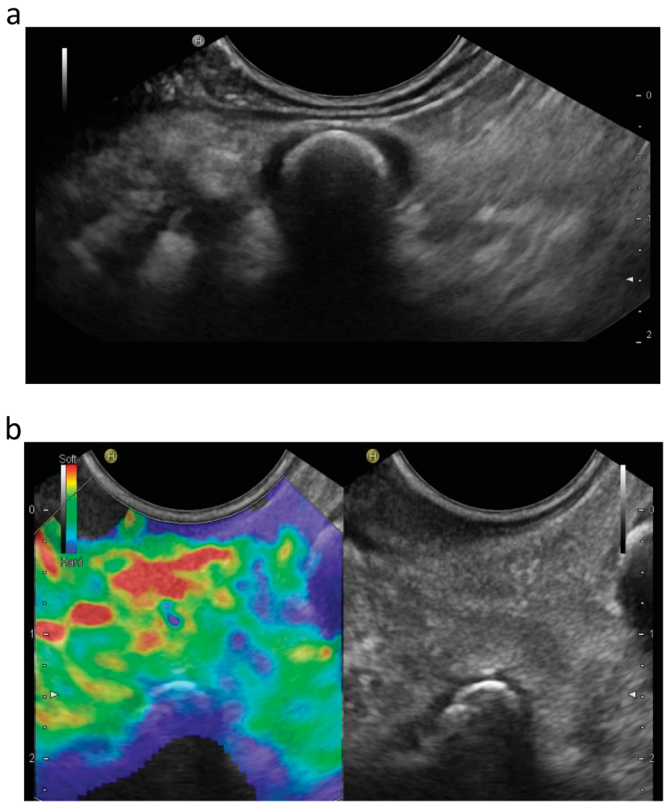

Figure 2. A 10-year-old boy with abdominal pain and finally the diagnosis of hereditary pancreatitis. The discrepancy between the large pancreatic duct with lumen-filling pancreatic calculi and the still soft pancreatic parenchyma (red-green) should be noted.

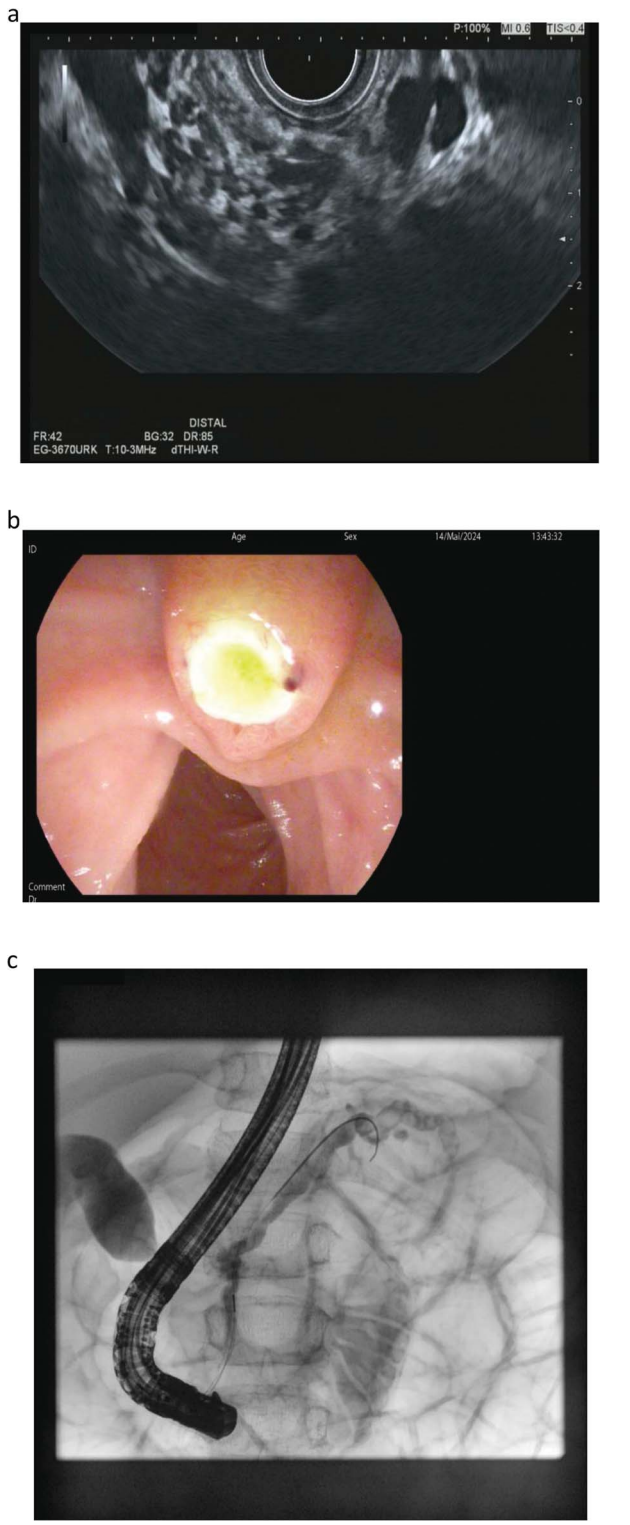

Figure 3. EUS and ERCP in an 8-year-old patient with abdominal pain and jaundice. Transcutaneous ultrasound revealed only an unexplained enlargement of the common bile duct resulting in the diagnosis chronic hereditary pancreatitis; (A) view of the pancreatic tail with a radial EUS scanner, the pancreatic tissue appears inhomogeneous with hyperechoic strains; (B) endoscopic view of the papilla, a pancreatic stone (white color) is impacted in the papilla; (C) ERCP image of the pancreatic duct, the pancreatic duct is enlarged with side branches visible; within the duct, the contrast agent shows indirect signs of stones and air bubbles.

Chronic pancreatitis is a rare disease in children. However, chronic hereditary pancreatitis was described as early as 3 years of age with major damage to the organ, such as calcifications or pancreatic stones.[40] Due to its high resolution in imaging of the pancreatic duct, EUS can be useful to discriminate between parenchymal calcifications and obstructive pancreatic duct stones to lead the way for therapeutic ERCP when needed but to avoid unnecessary and potential complicated ERCP procedures [Figures 2, 3]. ERCP can be used selectively to treat obstructing pancreatic duct stones. The complication rate of ERCP does not differ from ERCP procedures in adulthood.[41,42]

Autoimmune pancreatitis (AiP) is another rare condition in children. Unfortunately, AiP type 2 is more common and harder to diagnose than AiP type 1.[43,44] EUS can provide valuable information to lead

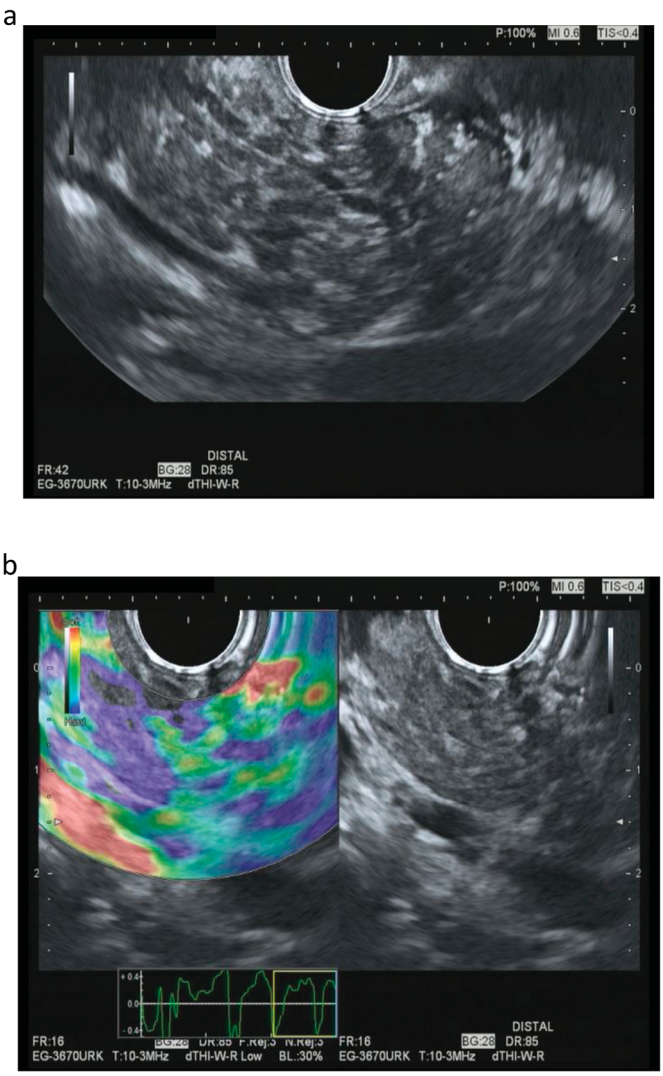

Figure 4. EUS of a 13-year-old child with chronic abdominal pain—resulting in the diagnosis autoimmune pancreatitis. (A) View of the pancreatic body with a radial scanner. The pancreatic tissue shows an inhomogeneous pattern with white strains and an enlarged pancreatic duct with a change of caliber. (B) Elastography of the pancreatic tail, the straining impression of the pancreatic tissue is not as pronounced; however, a blue coding in elastography is visible implicating harder tissue than the normal pancreas.

into the right diagnostic or therapeutic direction. Like in adults, AiP shows a stiff tissue all over the pancreas in elastography.[45] General blue coding gives a hint for presence of AiP in children, independent of the appearance of the pancreatic tissue [Figures 4 and 5]. EUS also provides the opportunity of tissue sampling for immunohistological diagnosis with no difference of complications compared with the procedure in adults.[46,47] One of the barriers is to perform EUS-guided biopsy from the child's pancreas for immunohistological confirmation by an experienced EUS examiner. In addition, according to experts, there is limited expertise in interpretation of pediatric pancreatic histopathology.[48]

Children are susceptible to pancreatic injury from blunt abdominal trauma,[49] for example, from bicycle or tricycle handlebars. Insufficiently developed abdominal muscles are considered to be a possible factor. Acute pancreatitis, peripancreatic fluid collections after a corresponding trauma history, should always be a reason for further diagnostics. Progressive fluid collections may indicate a pancreatic duct rupture. US, contrast-enhanced US (CEUS), MRI, computed tomography, and endosonography are available for diagnosis. In addition to MRI, US is particularly suitable for assessing pancreatic duct continuity.

Solid pancreatic masses can present focal pancreatitis or AiP but also—although rarely—tumors such as solid pseudopapillary tumors, pancreatoblastoma, neuroendocrine tumors, or, even rarer, lymphoma, adenocarcinoma, sarcoma, or metastasis.[50,51]

The relative frequency of the various pancreatic tumor entities differs from those in adults.

In the first decade of life, pancreatoblastomas, acinar cell carcinomas, and pancreatic neuroendocrine tumors are the most common pancreatic tumors. In the second decade of life, solid pseudopapillary neoplasms, pancreatic neuroendocrine tumors, and acinar cell carcinomas are the most frequent pancreatic neoplasia.[52] Cystic

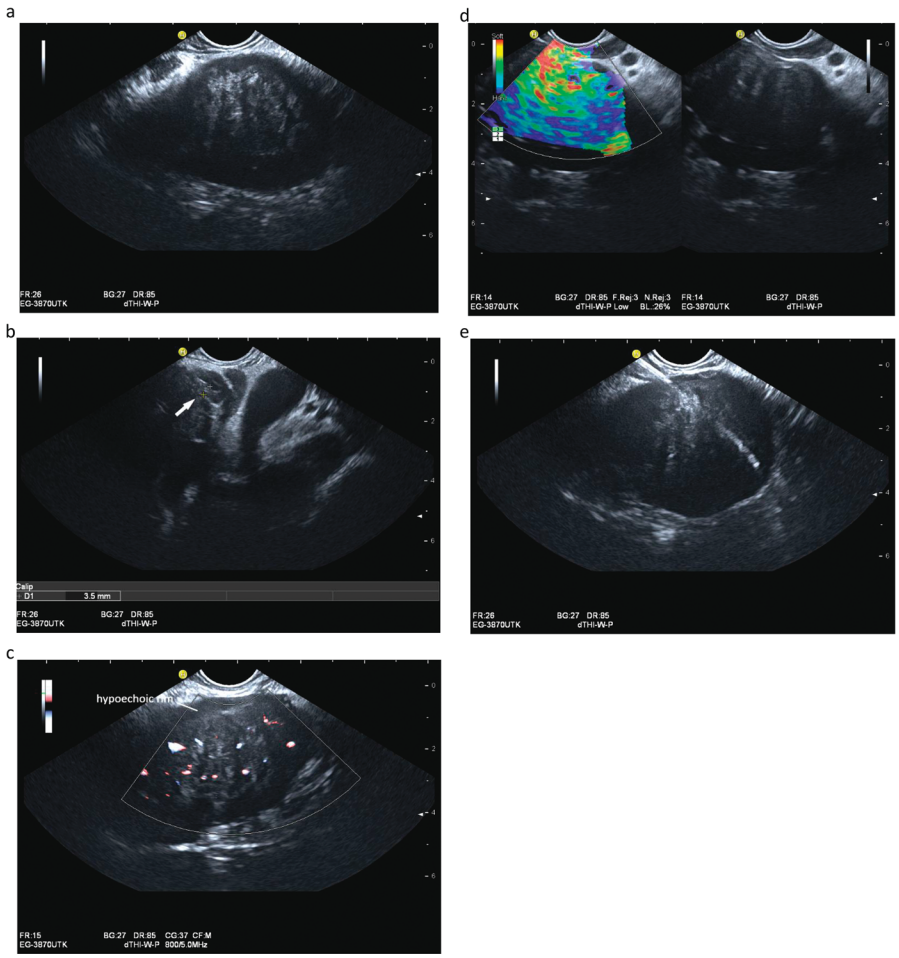

Figure 5. Autoimmune pancreatitis. A 17-year-old boy, no alcohol abuse, no known chronic inflammatory bowel disease. Acute upper abdominal pain. Lipasemia, GGT 2-fold elevated, immunoglobulin G4 normal. Enlarged hypoechoic pancreatic parenchyma with hyperechoic parts, otherwise not recognizable parenchymal structure, hypoechoic rim, pancreatic duct cannot be delineated (A). The wall of the common bile duct is thickened, no evidence of choledocholithiasis (B). Power Doppler imaging shows macrovessels in the parenchyma (C). The parenchyma is stiffer on strain elastography (D). Suspicion of autoimmune pancreatitis in the EUS and the MRI (not shown here). EUS-guided sampling was performed with a 22-gauge needle (E). The mini histology described exocrine pancreas, no tumor cells. The diagnosis of autoimmune pancreatitis could not be confirmed from the material. In the case of persistent pain and lipasemia, trial therapy with prednisolone was started for 3 weeks. This improved the patient's condition and the imaging findings. Cortisone therapy was carried out for 6 months.

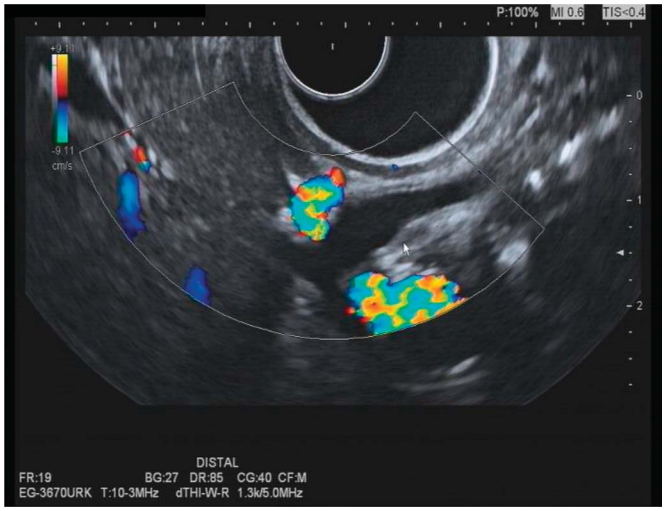

Figure 6. EUS of a 14-year-old child with ulcerative colitis and elevated liver enzymes—resulting in the diagnosis primary sclerosing cholangitis; (A) view with a radial scanner and color Doppler mode; the bile duct is displayed close to the liver hilum; the bile duct shows a focal enlargement, and a nodular thickening of the bile duct is marked with an arrow.

(peripancreatic) lesions might be caused by pseudocysts after pancreatitis or present lymphangioma.[53] EUS-guided sampling may guide in the differentiation.[46]

Biliary diseases

The prevalence of childhood gallbladder diseases has increased significantly over the last 20 years.[54] In a population-based cross-sectional study of 510,816 patients aged 10 to 19 years, 0.15% had gallstones.[55] Obesity was an important risk factor. Other risk factors include hemolysis, long-term parenteral nutrition, congenital anomalies of the biliary system, and mutations of certain genes including cystic fibrosis.

It is difficult to diagnose or exclude microlithiasis (gallstones smaller than 3 mm) in patients with biliary colic symptoms by transabdominal US.[56] In the diagnosis of diseases such as microlithiasis, gallbladder sludge, and choledocholithiasis, EUS has shown between 95% and 100% accuracy.[57] A systematic review comparing EUS with MRCP found similar overall diagnostic performance, whereas another systematic review that included 8 randomized trials demonstrated slightly higher overall accuracy for EUS as compared with MRCP (93% *vs*. 90%) for detecting choledocholithiasis.[58] EUS may prevent unnecessary cholecystectomy or ERCP in children with no evidence of microlithiasis.[59] Scheers et al. reported that ERCP was prevented in 13 of 17 children due to the findings in EUS.[60]

Liver diseases

Autoimmune liver diseases might be an indication for EUS in children due to differential diagnostic difficulties to microlithiasis. Although autoimmune hepatitis is very seldom with approximately 1/100,000 children,[61] EUS gives a hint due to lymph node enlargement in the liver hilum as a sign for an autoimmune or acute inflammatory disease of the liver. Thickening of the common bile duct, noted on EUS, might indicate primary sclerosing cholangitis[62] or IgG4-related cholangiopathy. The use of EUS in children with ulcerative colitis with the question of common bile duct stones has been recorded in studies[28] [Figures 6, 7].

Recently, EUS-guided liver biopsy has emerged as alternative to percutaneous biopsy for pediatric patients with unclear hepatopathy.[63] In a retrospective comparison, EUS-guided liver biopsy was superior in number of complete portal triads and intact specimen length to the percutaneous biopsy in 56 children.[64] The authors considered EUS-guided liver parenchyma biopsy to be indicated in obese children or those at increased risk of bleeding.

Enlarged perihepatic lymph nodes are a typical sign of inflammatory liver disease in pediatric patients[65–67] including autoimmune hepatitis.[68] US can be used for follow-up[69] [Figure 8].

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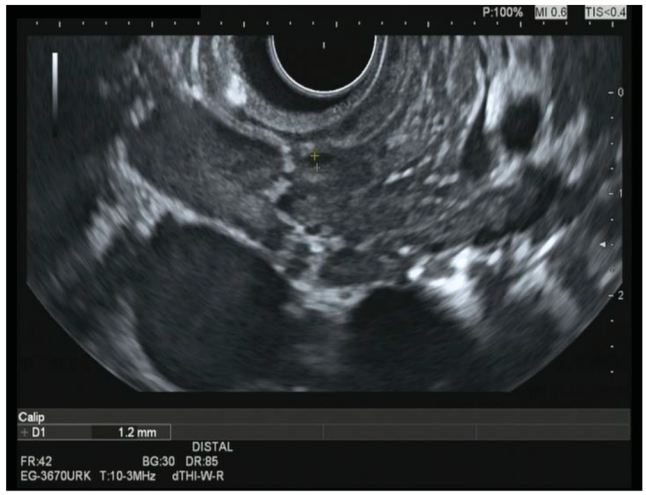

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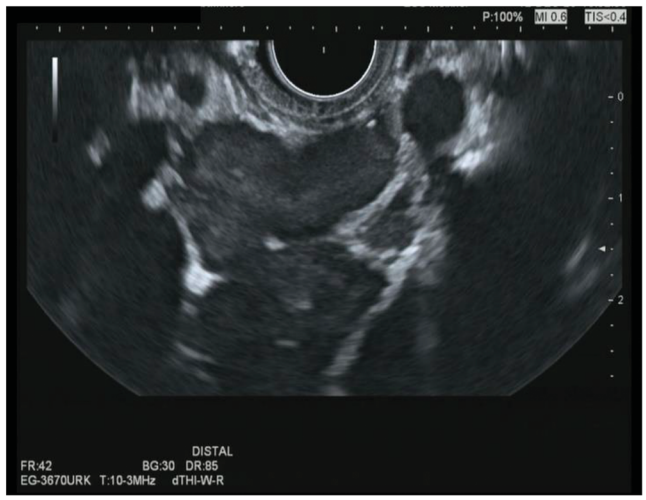

Figure 7. EUS of an 11-year-old child with elevated liver enzymes—resulting in the diagnosis autoimmune hepatitis; (A) view of the pancreatic head, the pancreas parenchyma on the right side of the picture appears normal, the common bile duct is marked in the 6-o'clock position with 1.2 mm. On the left side of the bile duct, an enlarged lymph node is visible; (B) view of the liver hilum, 3 enlarged lymph nodes with a size up to 2 × 1 cm are visible.

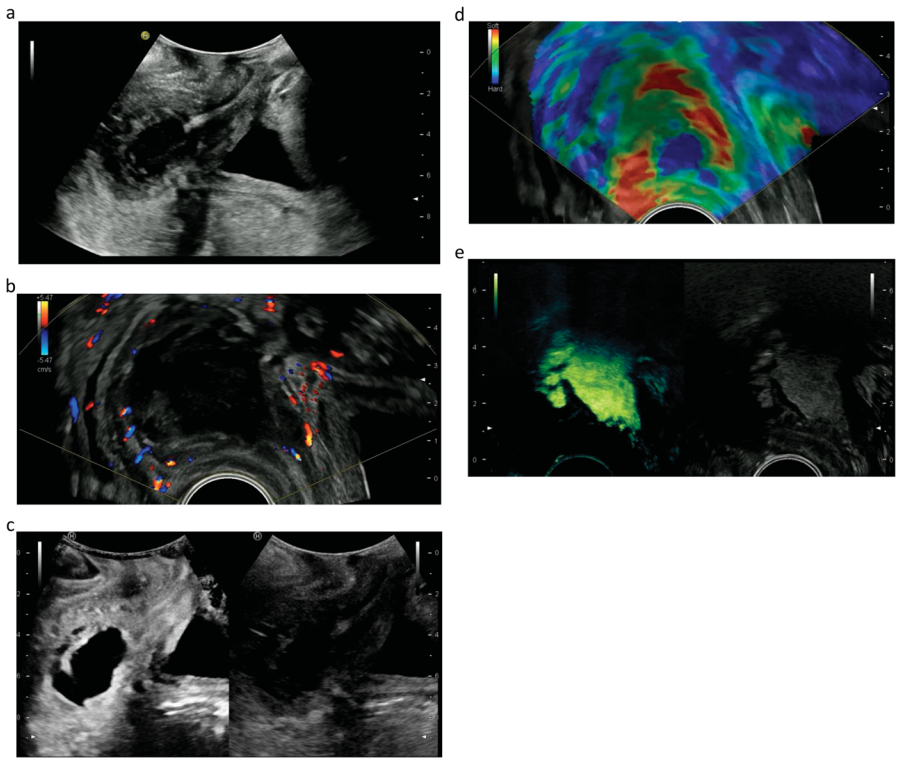

Figure 8. A 6-year-old boy with bicycle accident and rectal pain and fever. Endorectal ultrasound-guided puncture and drainage. B-mode ultrasound with unclear finding (A), color Doppler imaging indicating abscess or necrosis (B), contrast-enhanced ultrasound clearly delineating the abscess for needle guidance (C), strain elastography delineating the softer central parts (D), and intracavitary contrast-enhanced ultrasound excluding communication to other cavities (E).

Varia, splenic, adrenal, and vascular diseases

Diseases of the spleen are rarely an indication for EUS in adults. Splenic tumors are rare and can usually be well differentiated using CEUS and MRI. EUS-guided sampling of unclear splenic tumors is recommended if the lesion is localized close to the splenic hilus. Other indications are splenic hilar processes (pancreatic tail tumors, complications of acute pancreatitis). Small splenic artery pseudoaneurysms can be diagnosed by endosonography. EUS of the spleen plays only a minor role in the pediatric patient population. Only one case of EUS-FNA of a splenic hilar mass with an inconclusive biopsy result has been recorded.[29]

The adrenal glands in children can be seen very well on US. Visualization of the left adrenal gland in endosonography is usually possible without problems.[70] Access to the right adrenal gland from the transduodenal side is more difficult, but possible.[71] In the pediatric EUS studies, there are no data on the examination of the adrenal glands, but some of the authors examine the adrenal gland as part of the standard protocol in children.

In children, 3 different tumors develop in the adrenal gland: neuroblastic tumors, pheochromocytomas, and adrenocortical tumors.[72–75] Other tumors of the adrenal gland (adrenal adenomas, carcinomas, pheochromocytomas) are extremely rare in children. The purpose of imaging is to describe the extent of the tumor and its relationship to the surrounding anatomical structures and vessels. Neuroblastoma is the most common malignant extracranial tumor in children, with a preference for early childhood. It arises from the neuroblasts of the sympathetic nervous system; around 75% of neuroblastomas are found in the retroperitoneum (50% of which originate from the adrenal glands). A tumor biopsy[76] should not be performed due to the possible spread of tumor cells.

Rectal diseases

Perianal fistulas and abscesses in children are not uncommon and are reported in 0.5% to 4.3% of cases, predominantly affecting male children.[77] A congenital anomaly of the crypts of Morgani is considered to be the underlying cause. However, other causes such as underlying congenital anorectal malformations with vestibular and perineal fistulas, Crohn disease, surgical complications, and immunodeficiencies (leukemia, HIV, other immunodeficiencies, neutropenia, and chemotherapy) must be ruled out. The most common indications for rectal EUS in children were suspected anal Crohn disease, fecal incontinence, and encopresis,[28] but also mucosal and submuscular lesions and pelvic masses.

In infancy, perineal fistulas and abscesses are usually a self-limiting process. Otherwise, treatment in children is both conservative and surgical.[77,78] The course and classification of the fistula are important in imaging, as the treatment may depend on this. Perineal US,[79] pelvic MRI,[80,81] and transrectal EUS[78,81,82] are established imaging procedures. Transrectal EUS also offers the possibility of guided sampling and obtaining material to examine for pathogens and antibiotic resistance.

Table 1

Prevalence of EUS indications in pediatric patients.

Study	No. of procedures/ age/time interval	Pancreaticobiliary	Upper GIT	Lower GIT	EUS-guided sampling	Therapeutic EUS drainage	Clinical impact
Bjerring et al., 2008[87] Single center	18 children/median age 12 yr, range 0.5–15 yr/1992–2006	14/18 (77.8%)	Mediastinal tumor 1/18 (5.6%) Stomach 3/18 (16.7%)	Not performed	Not performed	Not performed	78%
Cohen et al., 2008[57]	32 children/median age 12.5 y; range 1.5–18 yr/1999–2005	19/32 (59%)	Esophagus 8/42 (25%) Stomach 2/42 (6.5%) Duodenal 1 (3%)	Rectum 2/42 (6.5%)	7/32 (21.9%)	Not performed	44%
Attila et al., 2009[88] Two tertiary referral centers	38 children; 40 procedures; median age 13.5 yr/2001–2008	25/40 (62.5%)	Mediastinal masses/lymph nodes 5/40 (12.5%) Esophageal 1/40 (2.5%) Gastric 6/40 (15%)	Perirectal fluid collection 1/40 (2.5%)	12/40 (30%)	Celiac axis block 2/40 (5%)	No information
Al-Rashdan et al., 2010[89] Single center	56 children; 58 procedures/median age 16 yr, range 4–18 yr/2000–2008	41/58 (70.7%)	8/58 (13.8%)	4/58 (6.9%) Unexplained rectal pain/bleeding Suspected perianal fistulas/fecal incontinence	15/58 (25.9%)	5/58 (8.6%) Celiac plexus blocks; EUS-guided pancreatogram	86%
Mahajan et al., 2016[31] Single center	121 children, 125 procedures/ 15.2 ± 2.9 yr/range 3–18 yr/2006–2014	114/125 (91.4%)	Mediastinum 5/125 (4%) Stomach 2/125 (1.6%)	Not performed	7/125 (5.6%)	PFC 2/125 (1.6%) Cystogastrostomy	35.5% (high proportion, lack of follow-up monitoring
Gordon et al., 2016[90] Single center	43 children; 51 procedures/median age 14.5 yr/range 4–18 yr/2005–2012	Biliary 11/51 (21.5%) Pancreatic 19/51 (37.3%) Abdominal pain 8/51 (16%)	Mediastinal/esophageal 1/51 (2%) Gastric 6/51 (3.8%)	Rectal bleeding 1/51 (2%)	13/51 (25.5%)	PFC 4/51 (7.8%) cystogastrostomy Celiac plexus blockade 1/51 (2%)	New diagnosis 79%, prompted further intervention 47%
Fugazza et al., 2017[28] Single center	40 children, 47 procedures/15.1 ± 4.7 yr/range 3–18 y/2010–2016 (2.17% of all EUS)	28/47 (59.5%)	Stomach 2/47 (4.3%) Duodenum 2/47 (4.3%)	Suspected anal Crohn disease; fecal incontinence; encopresis 15/47 (31.9%)	3/47 (6.4%)	PPFC 1/47 (2.1%); cystogastrostomy	87.2%
Altonbary et al., 2020[91] Single center	13 children, median age 15.6 yr/range 6–18 yr/2016–2020 (1.7% of all EUS)/	6/13 (46.1%)	Mediastinal 2/13 (15.4%), perigastric 2/13 (15.4%), abdominal lymphadenopathy 1/13 (7.7%), tracheal 1/13 (7.7%)	Rectal GIST 1/13 (7.1%)	7/13 (53.8%)	Not performed	77%

(*continued*)

Table 1 (continued).

Study	No. of procedures/ age/time interval	Pancreaticobiliary	Upper GIT	Lower GIT	EUS-guided sampling	Therapeutic EUS drainage	Clinical impact
Piester and Liu, 2021[32] Two tertiary referral centers	72 children, 98 procedures/ 10.7 ± 4.5 yr/range 3–18 yr/2017–2020	Pancreatic (n = 54/98; 55.1%), Biliary (n = 34/98; 34.7%)	Esophageal 5/98 5.1% Small bowel lesion 1/98 1.0%	Not performed	15/98 (15.30%)	PPFC 9/98 (9.2%) cystogastrostomy	Changed management in 17.3%
Dalal et al., 2022[92] Single center study	85 children; 92 procedures/ 12.1 ± 3.9 yr/2018–2020	Abdominal pain 45/92 52.9% Biliary 20/92 (21.7%) Pancreatic 16/92 (17.4%)	Mediastinal 9/92 (9.8%) Esophageal 2/92 (2.2%) Gastric 3/92 (3.3%) Abdominal lymph nodes 3/92 (3.3%)	Not performed	Not performed	5/92 (5.9%) PPFC: cystogastrostomy; EUS-guided rendezvous for failed ERCP	81.2%
Ragab et al., 2022[29] Four tertiary centers	29 children/median age 9 yr range 2.5–15 yr/ 2017–2020	Pancreatic 19/29 (65.5%) Biliary 1/29 (3.4%)	Mediastinal 1/29 (3.4%) Esophageal 1 (3.4%) Duodenal 2 (6.9%) Splenic hilum 1 (3.4%)	Rectal 1/29 (3.4%) Pelvic 3 (13.7%)	11/29 (37.9%)	PPFC 5/29 (17.2%) Cystogastrostomy	Diagnosis in 87.5%

Advantages and limitations of diagnostic EUS in pediatrics

EUS allows the highest-resolution imaging of organ structures in real time. In addition, without radiation exposure, highly sensitive detection rates, and very low rates of adverse events, diagnostic EUS is quite safe, also in children. Even though young children can easily be investigated by noninvasive transcutaneous US because of the slim body structure, especially the diagnosis of aforementioned diseases depends on high-resolution US, and this is not always achievable from the outside.

Keeping the disadvantages of a semi-invasive procedure, the necessary sedation, the fasting period before the investigation, and a small but possible perforation risk in mind, in well-chosen patients, EUS provides highly valuable information. In addition, EUS-guided sampling provides cytological and histological diagnosis in a pediatric population with high sensitivity (>90%) and safety.[29,83,84] The most comprehensive study in this regard, by Nabi et al., reports on EUS-guided sampling in 67 children. The most common indications were solid pancreatic lesions (43.3%) and mediastinal or abdominal lymphadenopathy (44.7%). Less common were cystic pancreatic lesions (7.5%), subepithelial lesions (3%), and retroperitoneal masses (1.5%). EUS-FNA and EUS-FNB allowed a histopathologic diagnosis in 88.1% of the children.[84]

Adverse events such as throat pain, self-limiting bleeding, abdominal pain, or fever are infrequent.[84]

However, EUS is performed even less frequently than ERCP in pediatrics and is performed only at a subset of pediatric institutions.[85] The lack of EUS training in pediatrics is a key factor-limiting adoption of this technique.

In the systematic review by Bizzarri et al., the effectiveness of EUS was reported from 36% to 100% in the management of pediatric patients examined for several indications including EUS-guided sampling and therapeutic interventions.[86] The frequency of EUS questions in children regarding the upper and lower GI tract and the pancreaticobiliary system and the frequency of EUS-guided sampling and therapeutic indications are summarized in Table 1. The most important indications for EUS in children are listed in Table 2.

Therapeutic EUS

Therapeutic EUS-guided procedures are reported as cases or case series in the literature[60,93] and more specifically, for example, EUS-guided pancreatic fluid/pseudocyst drainage in children[94–99] and EUS-guided celiac neurolysis/block.[100]

Gastric variceal (GV) bleeding is among the most morbid sequelae of portal hypertension, with mortality ranging from 30% to 50%.[101] Pediatric data focused on endoscopic approaches to management are limited. Achieving hemostasis in the setting of upper GI bleeding because of gastric varices can prove challenging for management by any modality. There are no well-established guidelines for the management of GV bleeding.[56] Treatment options for acute GV bleeding are varied and include medical, surgical, endoscopic, and endovascular approaches.[101,102]

Barakat et al. described the first pediatric case series of EUS-guided coil placement within feeding vessels as monotherapy for management of GV bleeding, with primary hemostasis achieved in all patients successfully.[101] The results confirmed the feasibility and efficacy of EUS-guided coil placement as monotherapy for GV bleeding

Table 2

EUS indications in pediatric patients.

Pancreatic indications	Rectal and pelvic indications
Upper abdominal pain of suspected pancreatobiliary origin	Suspected Crohn disease with perineal abscess and fistulas
Recurrent/acute pancreatitis	Suspected perianal fistulas
Acute pancreatitis of biliary origin	Unexplained rectal pain/bleeding
Pancreatic masses (solid, cystic)	fecal incontinence
Recurrent hypoglycemia	Pelvic masses
suspected annular pancreas	Mucosal/submucosal lesions
Ampullary mass	Pelvic masses
Pancreatic divisum	Thrombosed hemorrhoids
Biliary indications	**EUS-guided sampling**
Common bile duct stones	Solid pancreatic tumors
Choledochal cyst	Cystic pancreatic lesions
Common bile duct lesion	Suspected autoimmune pancreatitis
Mediastinal indications	Mediastinal lymph nodes/masses
Mediastinal lymph nodes and masses	Retroperitoneal, paragastric, pelvic masses
Esophageal indications	Abdominal lymph nodes
Mucosal and submucosal masses	Abscesses
Eosinophil esophagitis	**Therapeutic interventions**
Strictures/congenital stenosis	EUS-guided cystogastrostomy for PFC
Suspected duplication cyst	Celiac axis block
Gastric/duodenal indications	EUS-guided rendezvous for failed ERCP
Mucosal and submucosal masses	
Abdominal lymph nodes	
Paragastric/paraduodenal masses and abscesses	
Upper GI bleeding with portal hypertension without visible varices during gastroscopy	
Duodenal strictures/pancreas annulare	

in children, which may represent an alternative to current approaches for management of highly morbid GV bleeding.

Conclusion

Despite many challenges that remain, EUS imaging has attracted more and more attention because of its advantages such as low invasiveness, lack of radiation, and a similarity to endoscopic and sonographic procedures.[103] Based on this, EUS enables a detailed evaluation of the pancreatic parenchyma and the pancreatic duct, especially in pediatric patients with pancreatic masses, suspected AiP, or fluid collections.[46,49] EUS has a value in the diagnosis of autoimmune liver diseases as well as in cholelithiasis and other biliary diseases. EUS-FNA and EUS-FNB enable tissue acquisition for cytological, histological, microbiological and molecular diagnosis.

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None.

Conflicts of Interest

Siyu Sun is the editor-in-chief of the journal, and Christoph F. Dietrich is a coeditor-in-chief. Christian Jenssen and Michael Hocke are editorial board members. This article was subject to the journal's standard procedures, with peer review handled independently of the editors and their research groups. The authors declare that they have no financial conflict of interest with regard to the content of this report.

Author Contributions

Christoph F. Dietrich did the conceptualization. Methodology, formal analysis, writing—review and editing, and monitoring were done by all authors. Christoph F. Dietrich performed the creation of the original draft. All authors have read and agreed to the published version of the manuscript.

Ethical Approval

Not applicable.

Informed Consent

Not applicable.

Data Availability Statement

No additional data.

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