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Systematic Review Article

The Role of Endoscopic Ultrasonography in the Diagnosis of Pediatric Pancreatitis: A Systematic Review

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ABSTRACT

Background:
There are various imaging modalities for diagnosing pancreatic diseases. Endoscopic ultrasonography (EUS) can safely diagnose chronic pancreatitis (CP) in pediatric patients and help manage its associated complications. Given that less information is available about the diagnostic role of EUS in children compared with adults, the present study aimed to investigate the diagnostic utility of EUS in pediatric pancreatic diseases.

Materials and Methods:
A comprehensive search was performed to identify relevant English-language studies published between 1.1.2005 and 1.1.2025. Two independent reviewers screened and selected studies involving pediatric patients (<18 years) who underwent EUS for pancreatic indications (Masoud Tahani , Alireza Aminisefat). The search was conducted across MEDLINE (via PubMed), EMBASE (via Ovid), the Cochrane Library, and the Trip Database. Keywords and MeSH terms used in the strategy included endosonography, pancreatitis, diagnosis, child, and infant.

Results:
151 studies were identified in the initial search. After analyzing their compliance with the required criteria, a final review of eight studies was conducted. This article presents the current findings on the potential role of EUS in the diagnosis of pediatric pancreatitis.

Conclusion:
The findings of this study indicated that EUS is an important and useful tool in the diagnosis of acute recurrent pancreatitis (ARP), CP, and common bile duct strictures (CBDs). In addition to diagnosing CP, it also plays an important role in classifying pediatric CP. However, further studies are needed to compare its diagnostic effect with that of endoscopic retrograde cholangiopancreatography.

Keywords: Endosonography, Pancreatitis, Child, Infants, Diagnosis

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INTRODUCTION

Children and adolescents are increasingly affected by pancreas-related diseases due to genetic mutations, autoimmune pancreatitis, congenital abnormalities of the pancreas, and other conditions. Acute recurrent pancreatitis (ARP) is defined as two separate episodes of acute pancreatitis (AP), while chronic pancreatitis (CP) is caused by ongoing inflammation of the pancreas (1). Despite the difference in age of onset, pediatric patients with CP exhibit overlaps with adults in terms of disease progression. To reduce the risk of future pancreatic exocrine insufficiency, diabetes, and pancreatic cancer, current diagnostic and therapeutic approaches for ARP and CP are of great importance (1,2). Clinical findings, biochemical tests, and imaging studies play a role in diagnosing pancreatic diseases. Interventional endoscopic procedures, including endoscopic retrograde cholangiopancreatography (ERCP) and endoscopic ultrasonography (EUS), are essential for the diagnosis and management of many pancreatic diseases in the adult population. However, over the past decade, pediatric interventional endoscopic procedures have become increasingly available, such that invasive surgical procedures are now being replaced by safer and less invasive endoscopic interventions (2).

There are various imaging modalities for diagnosing pancreatic diseases. A recent meta-analysis evaluating and comparing EUS, ERCP, Magnetic Resonance Cholangiopancreatography (MRCP), computed tomography (CT), and transabdominal US in the diagnosis of CP showed that EUS and ERCP had a more effective and better role in the diagnosis of CP (3). EUS and ERCP can be safely used to diagnose CP in pediatric patients and help manage its associated complications. EUS uses a flexible endoscope coupled with ultrasound to obtain high-quality endosonographic images. It provides transluminal ultrasound images of the pancreatic parenchyma and its ductal structure, as well as other intra-abdominal structures (4). Today, EUS is an integral part of the diagnosis and management of patients with acute and chronic pancreatitis. Additionally, in patients with acute biliary pancreatitis and a moderate probability of bile duct stones, EUS helps confirm the presence of CBD stones, thereby playing an effective role in preventing unnecessary ERCP (5). As the incidence of pancreatitis in children is increasing, EUS is used to evaluate potential causes for ARP, identify changes associated with CP, and examine the structure of the pancreatic ducts, which are often overlooked in non-invasive imaging (6). The utility of EUS stems from its capacity to demonstrate subtle changes in pancreatic parenchyma and ductal structures, and it has been compared with non-invasive cross-sectional imaging and ERCP in terms of accuracy in diagnosing CP (7, 8). The best-known classification for diagnosing CP by EUS in adults is the Rosemont criteria, which adjust the diagnostic threshold based on the patient's age and the indication for the procedure. This classification method is also used in children (3,4). However, studies have also shown that, due to the thin abdominal wall of neonates, EUS does not appear to have any advantage over conventional ultrasound, which is less invasive (9). Given that the diagnostic role of EUS in children has only recently been demonstrated and that less data is available regarding this method than in adults, the present study aimed to investigate the diagnostic role of EUS in pediatric pancreatic diseases, as well as the advantages and limitations of this method.

MATERIALS AND METHODS

A systematic search of the literature was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline. The following search technique was used between January 2005 and January 2025 to find the eligible studies. Two separate researchers (MT, AA) searched for pertinent papers published between January 2005 and January 2025.

The Cochrane Library databases, Ovid, and Trip, were searched for English-language publications in MEDLINE, Excerpta Medica dataBASE (EMBASE), and MEDLINE via PubMed. For literature saturation (Masoud Tahani), the list of included references or relevant reviews was examined. The Health Sciences Librarian website was used to develop unique search techniques focused on systematic review searches using MESH terms and open-ended terms, as per PRESS criteria.

Eligibility criteria

The addition of cross-sectional, cohort, and case-control with the Availability of full text were the articles that met the criteria for the systematic review. Non-random sample size, duplicate studies, lack of relevance to the issue, and inadequate data were among the exclusion criteria. Two researchers carried out each of the stages mentioned above separately to prevent bias in the study. Finally, the consistency of the third researcher's findings was checked.

Study selection and data extraction

All relevant publications were initially collected, and then a list of abstracts was created. The full text of the articles was made available to the researchers after the journal and author details were kept anonymous. Two researchers independently reviewed each publication, and if the article was rejected, the reason was stated. In case of disagreement

between the two researchers, a third researcher evaluated the article.

Quality of included studies

It includes the following six parameters: sample size, mean age, male/female, main indication, main endosonographic findings, and EUS criteria. A general overview of the study (first author, country, and year of publication) and study details (sampling method, data collection method, the proportion of females versus males, number of participants, mean age, and the general population) were extracted (Table 1).

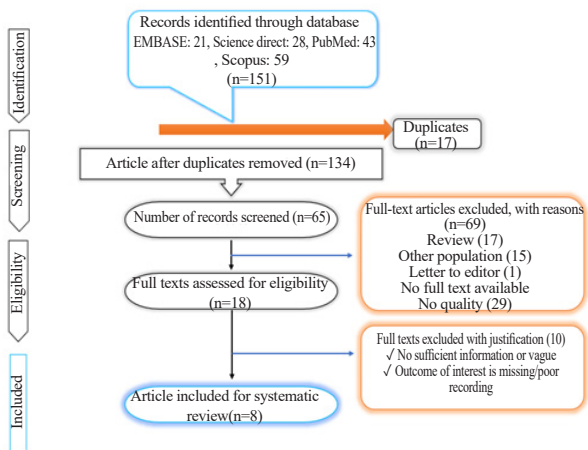

Figure 1. PRISMA flow diagram.

RESULTS

In the present study, eight studies were evaluated, and a final review was conducted(Fig 1). A total of 306 children under 18 years of age with pancreas-related disorders participated in this evaluation. The most common indications for EUS in children were suspected biliary obstruction and CBDs, recurrent/chronic pancreatitis or suspected pancreatitis, and solid pancreatic mass, respectively. One of the most common indications for EUS in children is CP. In the study by Scheers and colleagues (10), 17 patients suspected of CP underwent EUS, 10 of whom were diagnosed with CP, 6 with pancreatic pseudocyst, and one with Main Pancreatic Duct (MPD) stone. Also, Tan Attila and others (11) reported that out of a total of 10 patients with an initial diagnosis of suspected CP, only four patients met the criteria for CP. Less than 50% of patients with an initial suspicion of CP based on laboratory findings and clinical examinations met the diagnostic criteria for CP on EUS.

In the study by Singh and colleagues (12), a total of 32 children with a primary diagnosis of ARP underwent EUS. Of these, 10 children were diagnosed with CP (≥ 4 features), 10 children with mild CP (3 features), and 10 patients were also reported as normal. In these patients, MRCP reported a diagnosis of CP in only three patients out of a total of 32 patients. The differences between normal EUS and CP in patients with a primary diagnosis of ARP include a lower age of symptom onset (mean 9 years versus 12 years) and a longer duration of illness in patients with CP. In the study by Téllez-Ávila and co-workers (13), 22 patients with an initial diagnosis of ARP and two patients with suspected CP underwent EUS. The final report indicated that 12 children met the criteria for a diagnosis of CP.

Kadyada and others (14) also examined 18 children with Idiopathic Acute Pancreatitis (IAP) and 27 children with ARP by EUS and showed that abnormal findings were observed in 33.3% of patients with IAP and 40.7% of patients with ARP on EUS. Changes related to CP were found in about one-third of ARP, while patients with IAP had no evidence in favor of CP. Consistent with the above findings, Fuji and colleagues (15) also showed that EUS was able to diagnose IAP in six patients with suspected IAP successfully. However, EUS was unable to diagnose it in one patient with IAP.

Table 1. Summary of included studies (Editor: Please define all abbreviations used in the table below it.)

	Sample size	Age (y), mean (range)	Male/ Female	Country	Years	Main indication	Main endosonographic findings	EUS criteria	Quality
Attila et al (11)	38	13.5 (1-18)	22/16	USA	2009	RP/CP or pancreatitis (26.3%)	CP(18.4%) pancreatitis(7.9%)	Cambridge classification	Good
Fujii et al (15)	9	13.6 (9-18)	4/5	USA	2013	AIP(66.7%)	AIP(77.8%)	Cambridge classification	Moderate
Scheers et al (10)	48	12 (2-17)	20/28	Belgium	2015	CP(35.4%) Choledocholithiasis (35.4%)	CP(20.8%) Pseudocyst(12.5%) Choledocholithiasis(8.3%)	Cambridge classification	Good

Table 1. Summary of included studies (Editor: Please define all abbreviations used in the table below it.)

	Sample size	Age (y), mean (range)	Male/ Female	Country	Years	Main indication	Main endosonographic findings	EUS criteria	Quality
Fugazza et al (16)	40	15.1 ± 4.7 (3-18)	22/18	Italy	2017	Suspected CBDs(20%) Acute biliary pancreatitis (17.5%) RP/CP(10%) Suspected anal Crohn's Disease(30%)	Gallstones and CBDs(32.5%) CP(10%)	Cambridge classification	Moderate
Singh SK et al (12)	32	14 (8-18)	22/10	India	2018	ARP(100%)	CP (≥ 4 features) (31%)	Cambridge classification	Good
Téllez-Ávila et al (13)	54	16 (9 - 17)	22/32	Mexico	2019	RAP(54%) Choledocholithiasis (9.3%) CP(3.7%)	microlithiasis(25.9%) CP(25.5%) pancreatic tumors(11.1%)	Rosemont criteria	Moderate
Kadyada et al (14)	44	9.1 ± 2.6 (1-18)	26/18	India	2019	ARP(60%) IAP(40%)	CP(3.7%) Pancreatic divisum(4.4%)	Rosemont criteria	Good
Demirbaş et al (17)	41	12.2 ±4.2 (1-18)	16/25	Turkey	2021	biliary colic(51.2%) RP(29.2%) cholecystitis/ cholangitis in 5 (12.2%) AP(7.4%)	biliary colic(51.2%) CP(17.1%)	Cambridge classification	Good

Evidence has shown that EUS has high sensitivity and specificity in diagnosing CBDs and choledocholithiasis, and is comparable to ERCP in this regard. In the study by Scheers and others (10), 17 patients suspected of having choledocholithiasis underwent EUS, and the diagnosis was confirmed in four patients, while 13 patients had normal findings. Also, in the study by Demirbaş and colleagues (17), 21 patients with biliary colic underwent EUS, all of whom had gallstones. Fugazza et al. (16) also reported that out of a total of 11 patients with suspected CBDs, eight patients had gallstones on EUS, and three patients were reported to be normal.

DISCUSSION

EUS is now used as an accessible and useful tool for the diagnosis of CP. Although most studies in this field are related to adults, these findings and diagnostic criteria are also applied to children. Normal pancreatic parenchyma has a fine reticular pattern on EUS, and MPD appears as a homogeneous linear echogenic structure without any prominence or visible side branches. In contrast, in CP, parenchymal fibrosis is characterized by a set of findings on EUS, including hyperechoic foci, hyperechoic strands, a lobular outer margin of the gland, lobularity, and parenchymal calcifications, which are consistent with specific histopathological findings. Also, changes in the duct include dilated MPD, intraductal calcification, side branch dilatation, ductal irregularity, and hyperechoic ductal margin (18). Early ductal changes visible on EUS are seen as mild irregularities in the MPD, dilation of the side branches, and hyperechoic margins of the MPD, which have high sensitivity. Still, due to age-related physiological changes in the pancreatic duct, there is a possibility of false positives (18). Although EUS can detect subtle changes in the pancreatic parenchyma as well as the pancreatic duct and is, therefore, an attractive and useful method for diagnosing CP, especially early CP, operator dependence may cause interobserver variability, which affects the overall accuracy of EUS in diagnosing early CP (19).

Many reported studies have compared EUS findings with pancreatic duct findings in ERCP and have shown that the overlap between EUS findings and pancreatic duct findings in ERCP is about 80%, which is a high and significant percentage (20). Wallace and others (21) also reported that EUS findings, such as hyperechoic foci, hyperechoic strands, lobularity, and hyperechoic ductal margins, were consistent with histological findings indicating parenchymal fibrosis, including focal fibrosis, bridging fibrosis, interlobular fibrosis, and periductal fibrosis. Pungpapong and others (22) compared the findings of

EUS and MRCP in the diagnosis of CP. The study's results showed almost identical specificity but higher sensitivity for EUS compared with MRCP. It was also demonstrated that the combination of EUS and MRCP significantly enhanced diagnostic accuracy, with a sensitivity of 98% when either EUS or MRCP was abnormal and a specificity of 100% when both were abnormal.

Therefore, the combination of EUS and MRCP may be considered as an alternative to ERCP in the diagnosis of CP. Considering the points mentioned above, it was found that EUS, in addition to its high sensitivity and accuracy in diagnosing CP, is also widely used today in classifying CP severity. The assessment of the diagnosis and classification of CP by EUS is based on two criteria, including the total number of EUS findings based on ERP findings (Cambridge classification) as the gold standard and the Rosemont classification (Table 2) (20).

In the classification based on the number of EUS findings, 2-4 findings will be considered mild, 5-6 findings will be considered moderate, and more than seven findings will be considered severe. It has been shown that EUS findings overlap with about 80% of ERCP diagnoses. Also, Irisawa and colleagues (23) showed in their evaluation that more than 80% of patients with borderline or higher changes in ERCP classification had 3 or more EUS findings, indicating the useful role of EUS in classifying the severity of CP. The debate about the number of features required to detect CP on EUS is varied, with most experts suggesting that changes of less than 2 should be considered normal.

Table 2. Types of CP diagnosis classification based on EUS findings

Rosemont classification		**Cambridge classification**	
EUS° findings	**Major criteria**	**ERP* findings**	
Parenchymal features		Quality study visualizing the whole gland without abnormal features	Normal
Hyperechoic foci with shadowing	Major A	Less than three abnormal branches	Equivocal
Lobularity with honeycombing	Major B	More than three abnormal branches	Mild
Lobularity without honeycombing	Minor	Abnormal main duct and branches	Moderate
Hyperechoic foci without shadowing	Minor	As above with one or more of: Large cavities (>10mm) Gross gland enlargement (>2×N) Intraductal filling defects or calculi Duct obstruction, stricture, or gross irregularity Contiguous organ invasion	Marked
Cysts	Minor		
Strands	Minor		
Ductal features			
MPD‡ calculi	Major A		
MPD contour	Minor		
Dilated side branches	Minor		
MPD dilation	Minor		
Hyperechoic MPD margin	Minor		

Wiersema and others (24) showed in their study that the presence of ≥3 EUS features had a sensitivity of 100%, specificity of 79%, and accuracy of 85% compared with ERCP. In comparison, the number of ≥4 EUS features was reported to increase the specificity and accuracy to 85% and 88%, respectively, compared with pancreatic histology, which is used as the standard diagnostic method for CP. However, there is a lack of detailed and comprehensive information on this issue in the pediatric literature. Therefore, due to the higher specificity and histopathological correlation with CP, in most studies, ≥4 EUS features are considered for the diagnosis of CP in children. The Rosemont classification is also a diagnostic method for CP using EUS findings, which includes four

levels: consistent with CP, suggestive of CP, indeterminate for CP, and normal. This classification is used in both children and adults.

The incidence of pancreatitis in childhood is increasing. Reports indicate that EUS is one of the most sensitive and specific diagnostic tools for choledocholithiasis and microlithiasis, which are responsible for at least half of acute pancreatitis cases (25, 26). Studies have shown that stones that cause acute pancreatitis are between 1-3 mm, and since EUS plays a significant role in detecting stones with dimensions < 5 mm, it can be considered a useful and valuable tool in this field (21). Due to its high sensitivity in detecting gallstones, EUS can prevent unnecessary cholecystectomy or ERCP in children in more than 50% of cases (27). Scheers and others (10) also showed that in 13 of 17 children, ERCP was not performed because of EUS findings. EUS enabled the detection of small gallstones that were not visible on abdominal ultrasound or CT scans.

Fugazza and colleagues (16) also showed in their study that EUS was useful in preventing unnecessary ERCP and its associated risks in 16 patients (88.9%) with an initial diagnosis of CBDs. In this study, out of a total of 18 patients suspected of biliary stones or acute biliary pancreatitis, only two patients were reported to have CBDs on EUS. It is worth noting that all patients underwent ERCP simultaneously, and the results were consistent with the EUS findings.

Additionally, a systematic review comparing EUS with MRCP revealed that the overall accuracy of EUS was slightly higher than that of MRCP (93% vs. 90%) for the diagnosis of choledocholithiasis, and overall, they had similar diagnostic performance (28,29). These findings suggested that EUS is a powerful and useful tool in diagnosing CBDs in children and can replace ERCP and MRCP in this field.

Limitations and future research

Limitations of the present review include the potential for publication bias because the studies had a small sample size, and only published studies were included. In the diagnosis and classification of pancreatitis based on EUS findings, not all studies used a specific classification. Some researchers used the Cambridge classification as the gold standard, while others used the Rosemont classification, which made it difficult to compare the results of the studies. Also, in the classification based on the number of EUS findings, some studies used the presence of ≥3 EUS features to diagnose CP and compare it with the findings of ERCP or pancreatic histology, and some considered the final criterion for diagnosing CP based on the number of ≥4 EUS features to have better sensitivity and specificity. These differences have prevented proper comparisons. Since the studies conducted in the pediatric population were fewer than those in adults, more studies are needed in the future to examine the diagnostic findings of EUS in children and compare them with the results of ERCP or pancreatic histology.

CONCLUSION

The findings of the present study showed that EUS has a significant role in the diagnosis of various disorders related to the pancreas, especially CP, ARP, and CBDs in children. The high sensitivity and specificity of EUS in the initial diagnosis and assessment of CP severity have led to its use in classifying the severity of CP. Also, CBDs, which are responsible for many cases of pancreatitis in children, can be easily diagnosed using EUS. Therefore, EUS can replace ERCP and MRCP in many cases, thereby preventing their unnecessary performance. However, more studies are needed in this field to compare the results of EUS and ERCP in various pancreatic disorders in children.

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