

Role Of Sonography In Diagnosis Of Acute Abdomen In Various Pathologies And Assessment With Shear Wave Elastography In Patients With Acute Appendicitis In Pediatric Age Group In A Tertiary Care Centre

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ABSTRACT

Acute abdominal pain is a prevalent clinical presentation in the pediatric population and accounts for a substantial number of emergency department visits. Diagnosing the exact cause can be complex due to the overlapping symptoms among various pathologies. Acute appendicitis is one of the leading causes of surgical intervention in children, and early diagnosis is crucial to prevent complications such as perforation, abscess formation, and peritonitis. To overcome these limitations, shear wave elastography (SWE) has emerged as a promising adjunct. SWE is a quantitative imaging technique that assesses tissue stiffness by measuring the speed of mechanically generated shear waves. Inflamed tissues typically exhibit increased stiffness compared to their normal counterparts. In the context of appendicitis, this difference can be captured using SWE, potentially providing a more definitive diagnosis.

The purpose of this study was to assess the diagnostic utility of combining conventional grayscale ultrasonography with SWE in evaluating acute appendicitis in pediatric patients. Furthermore, we aimed to explore the feasibility of incorporating SWE as a routine part of abdominal sonography protocols in children presenting with acute abdominal symptoms.

Keyword: Acute abdominal pain, SWE, sonography, surgical intervention

1. INTRODUCTION

Acute abdominal pain is a prevalent clinical presentation in the pediatric population and accounts for a substantial number of emergency department visits. Diagnosing the exact cause can be complex due to the overlapping symptoms among various pathologies. Acute appendicitis is one of the leading causes of surgical intervention in children, and early diagnosis is crucial to prevent complications such as perforation, abscess formation, and peritonitis [1].

Ultrasound (USG) remains the first-line imaging modality in evaluating pediatric abdominal pain due to its safety, real-time imaging, absence of ionizing radiation, and relatively low cost [2]. However, ultrasonography is limited by its operator dependency, patient body habitus, bowel gas, and in certain cases, an unvisualized appendix. This can lead to diagnostic delays or the need for further imaging such as computed tomography (CT), which raises concerns about radiation exposure in children [3].

To overcome these limitations, shear wave elastography (SWE) has emerged as a promising adjunct. SWE is a quantitative imaging technique that assesses tissue stiffness by measuring the speed of mechanically generated shear waves. Inflamed tissues typically exhibit increased stiffness compared to their normal counterparts. In the context of appendicitis, this difference can be captured using SWE, potentially providing a more definitive diagnosis [4,5].

The purpose of this study was to assess the diagnostic utility of combining conventional grayscale ultrasonography with SWE in evaluating acute appendicitis in pediatric patients. Furthermore, we aimed to explore the feasibility of incorporating SWE as a routine part of abdominal sonography protocols in children presenting with acute abdominal symptoms.

2. MATERIALS AND METHODS

This prospective, cross-sectional study was conducted at the Department of Radiology, Shri Sathya Sai Medical College and Research Institute, over a period of 18 months. Ethical clearance was obtained from the institutional review board, and informed consent was collected from parents or guardians of all enrolled participants.

Study Population: Children aged 1 to 14 years presenting with symptoms of acute abdominal pain to the emergency department or pediatric outpatient clinics were considered for inclusion. Exclusion criteria included children with prior abdominal surgery, known chronic abdominal pathology (e.g., Crohn's disease), or hemodynamic instability that precluded imaging [6,7].

Imaging Protocol: Initial grayscale ultrasonography was performed on all patients using the Mindray DC-80 ultrasound system. A high-frequency linear transducer (5–12 MHz) was employed for detailed evaluation of the right lower quadrant (RLQ), aiming to visualize the appendix and assess secondary signs of appendicitis. Findings were recorded for appendiceal diameter, compressibility, echogenicity, and periappendiceal changes [8].

SWE was performed only in cases where the appendix was clearly visualized. The elastography mode was activated, and multiple region-of-interest (ROI) measurements were taken over the anterior wall of the appendix, avoiding intraluminal contents and surrounding inflamed fat. The mean stiffness value was recorded in kilopascals (kPa) from three consistent measurements [9].

Diagnostic Reference Standard: Final diagnosis of appendicitis or other etiologies was established through surgical confirmation (where applicable), serial clinical examination, laboratory parameters (WBC count, CRP), and patient outcome during hospital stay [10].

Statistical Analysis: Descriptive statistics were used to summarize demographic and clinical characteristics. Mean SWE values were compared between inflamed and non-inflamed appendices using unpaired t-tests. A p-value <0.05 was considered statistically significant. Data analysis was performed using SPSS Version 23.0.

3. RESULTS

A total of 67 children were enrolled during the study period. The mean age was 6.2 ± 3.1 years, with 47 males (70%) and 20 females (30%).

Clinical Diagnoses Based on Final Outcome:

Appendicitis: 21 cases (31%)

Mesenteric lymphadenitis: 8 cases (12%)

Intussusception: 4 cases (6%)

Urinary tract infections: 6 cases (9%)

Functional pain or nonspecific abdominal pain: 15 cases (22%)

Other/uncertain diagnoses: remainder

Appendix visualization was successful in 45 patients (67%). SWE was thus performed in these cases.

SWE Findings:

Inflamed appendices (n=21): Mean stiffness 14.22 ± 0.87 kPa

Non-inflamed appendices (n=24): Mean stiffness 7.25 ± 0.85 kPa

The difference in elasticity values was statistically significant ($p = 0.03$), indicating that SWE effectively distinguished between inflamed and normal appendices.

4. DISCUSSION

The present study demonstrates that the integration of shear wave elastography (SWE) into routine grayscale ultrasonography significantly enhances the diagnostic performance in pediatric acute appendicitis. Among children with visualized appendices, SWE provided a quantifiable distinction between inflamed and non-inflamed tissue, with a statistically significant difference in mean stiffness values.

Ultrasound remains the cornerstone of first-line imaging in pediatric patients with abdominal pain due to its non-invasive

nature and absence of ionizing radiation. However, limitations such as operator dependency, bowel gas, and poor acoustic windows often hinder its reliability, especially when the appendix is not clearly visualized (11,12). SWE addresses this limitation by offering objective metrics—stiffness values in kilopascals—that correlate with tissue inflammation (13).

In our study, appendicitis was the most common cause of acute abdomen (31%), followed by mesenteric lymphadenitis and intussusception. SWE was feasible in 67% of patients, comparable to visualization rates reported in prior literature (14,15). The mean SWE stiffness value of inflamed appendices (14.22 ± 0.87 kPa) was significantly higher than that of non-inflamed appendices (7.25 ± 0.85 kPa), aligning with findings from previous studies that reported similar elasticity thresholds for inflammatory pathology (16,17).

The role of elastography in differentiating soft tissue conditions has been increasingly validated across multiple domains including liver fibrosis, thyroid nodules, and breast lesions (18–20). However, its role in appendiceal evaluation—particularly in children—has only recently garnered attention. Our findings support that SWE not only enhances diagnostic confidence but also contributes to standardizing assessments that were previously more subjective. The technique's reproducibility and real-time capability make it ideal for pediatric practice, where patient cooperation and exposure time must be minimized (21).

Furthermore, SWE may be particularly useful in equivocal cases where clinical presentation overlaps with other causes of right lower quadrant pain such as mesenteric adenitis, Meckel's diverticulum, or even gynecologic pathology in adolescent females (22). In these scenarios, quantitative stiffness values can serve as a tiebreaker, reducing both unnecessary surgeries and imaging delays (23).

Despite promising results, our study also underscores certain limitations. The inability to visualize the appendix in approximately one-third of patients restricted SWE utility. This aligns with global experience where visualization rates in pediatric USG for appendicitis vary between 60–80% (24). Additionally, since elastography relies on proper ROI placement, technical expertise and standardization are paramount to ensure consistent measurements. Inter-operator variability, patient movement, and variations in transducer pressure can influence readings. Although SWE is less operator-dependent than strain elastography, experience still plays a critical role in image acquisition and interpretation (25).

The need for standardized cut-off values for appendiceal stiffness remains an area for future research. While our study found 14.22 kPa to be a significant marker for inflammation, this may vary across different machines and elastography platforms. Collaborative multicenter studies are essential to establish consensus thresholds that can be universally adopted (26). Such initiatives could pave the way for protocol-based imaging in pediatric appendicitis, reducing the burden on emergency departments and surgical teams.

From a broader perspective, integration of SWE into pediatric abdominal USG protocols aligns with global trends in precision medicine. Quantitative imaging biomarkers like tissue stiffness are increasingly being used to guide management decisions (27). In resource-limited settings, where CT and MRI are not readily available, elastography-enhanced ultrasound offers a viable alternative that is both cost-effective and safe (28).

Additionally, SWE has the potential to aid in post-treatment monitoring. In cases of conservatively managed appendicitis, serial elastographic measurements could track resolution of inflammation, thereby reducing the need for follow-up CT or MRI (29). This opens new possibilities for SWE in non-operative pediatric care pathways.

In conclusion, our study contributes to the growing body of evidence supporting the clinical utility of SWE in pediatric abdominal imaging. While further studies are needed to address its limitations and refine its applications, SWE represents a valuable adjunct in the diagnostic armamentarium for pediatric appendicitis.

5. CONCLUSION

Shear wave elastography, when combined with grayscale ultrasound, offers a robust, non-invasive, and reproducible method to improve diagnostic accuracy in pediatric appendicitis. Its ability to objectively quantify tissue stiffness enables better discrimination of inflamed versus normal appendices. Incorporating SWE into routine pediatric abdominal imaging protocols has the potential to enhance early diagnosis, minimize radiation exposure, and support clinical decision-making in acute care settings.

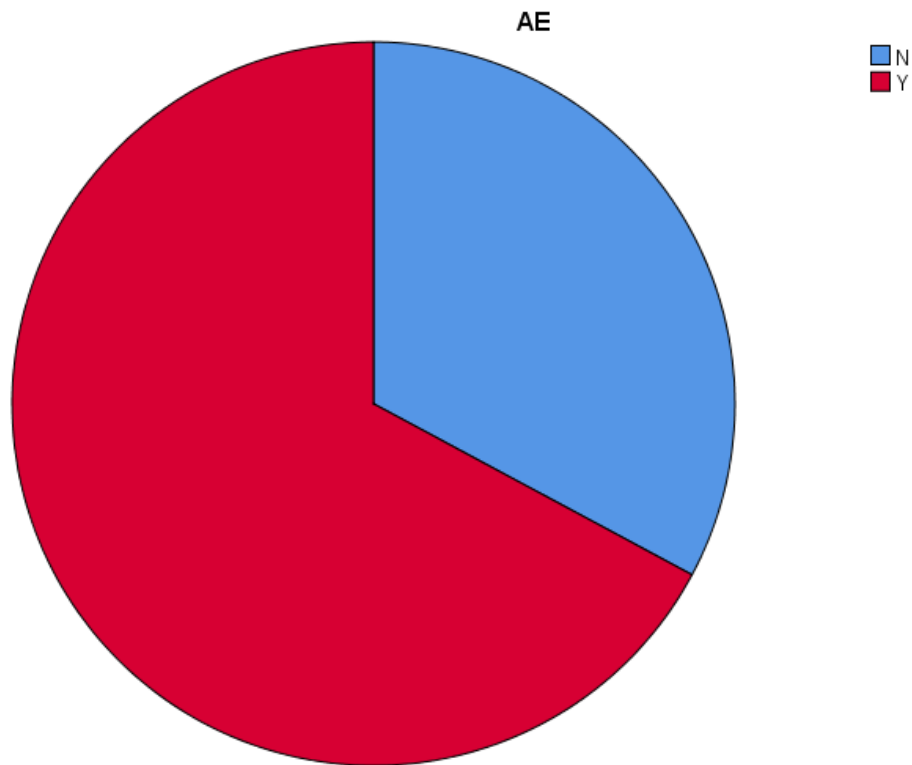
The future of pediatric imaging lies in combining safety, speed, and accuracy—qualities that SWE inherently possesses. As more clinicians and institutions adopt elastography into routine protocols, children presenting with acute abdominal pain will benefit from more precise diagnoses, faster treatment decisions, and improved outcomes.

6. TABLES AND FIGURES

Appendix visibility: Shear wave velocity was collected in 45 children out of 67

. Table 1: Appendix Visibility for Shear Wave Elastography Among Study Participants

		Frequency	Percent
Valid	N	22	32.8
	Y	45	67.2
	Total	67	100.0

**Fig 1 : Appendix Visibility for Shear Wave Elastography (SWE)****6. Tables and Figures****Table 1: Feasibility of Shear Wave Velocity Assessment of Appendix Across Clinical Diagnoses**

	Number of children in whom Shear Wave Velocity assessment of Appendix was performed	
	Yes	No
Acute Appendicitis	21	0
Intussusception	1	3
Mesentric LN	7	4
UTI	2	5
Subacute Intestinal Obstruction	0	3

Undescended Testis	2	3
Ovarian Torsion	1	0
Normal	11	4

Table 2: Comparison of Gray-Scale Ultrasonography and Shear Wave Elastography in Children With and Without Appendicitis

	Appendicitis (n= 21)	No appendicitis (n= 19)
Gray-scale ultrasonography		
Diameter (≥ 6 mm)	21	0
Echogenicity of periappendiceal fat	21	0
Thickening of appendiceal wall	21	0
Appendicolith	18	0
Diameter (≥ 6 mm), echogenicity of periappendiceal fat, thickening of appendiceal wall (all)	21	0
Shear wave elastography		
Elastic modulus scale (kPa)	14.224	7.250
	.8694	.8470

Table 3: Comparison of Tissue Stiffness (Elastic Modulus in kPa) Between Inflamed and Non-Inflamed Appendices

Tissue stiffness (Elastic modulus(kPa))					
Appendicitis	N	Mean	Std. Deviation	Lower Limit	Upper Limit
Non -Inflamed	19	7.250	.8470	5.556	8.944
Inflamed	21	14.224	.8694	12.485	15.962
Total	45	10.504	3.6191		
Student Unpaired t test p= 0.03					

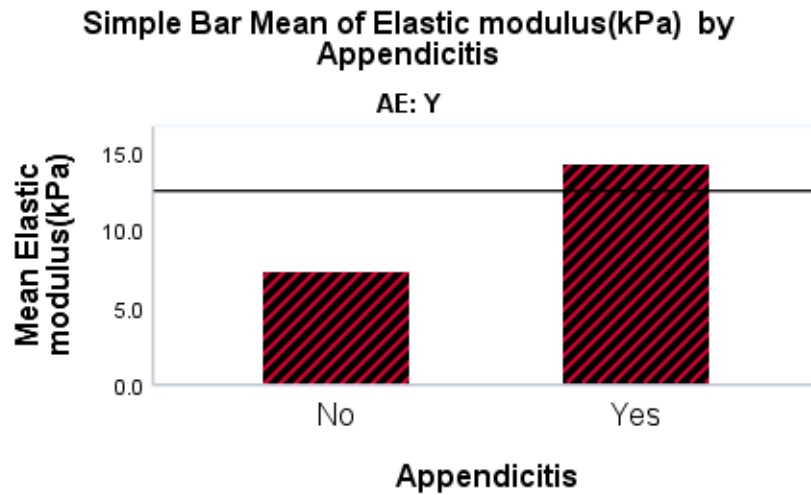


Fig 2: Mean Elastic Modulus (kPa) in Inflamed and Non-Inflamed Appendix

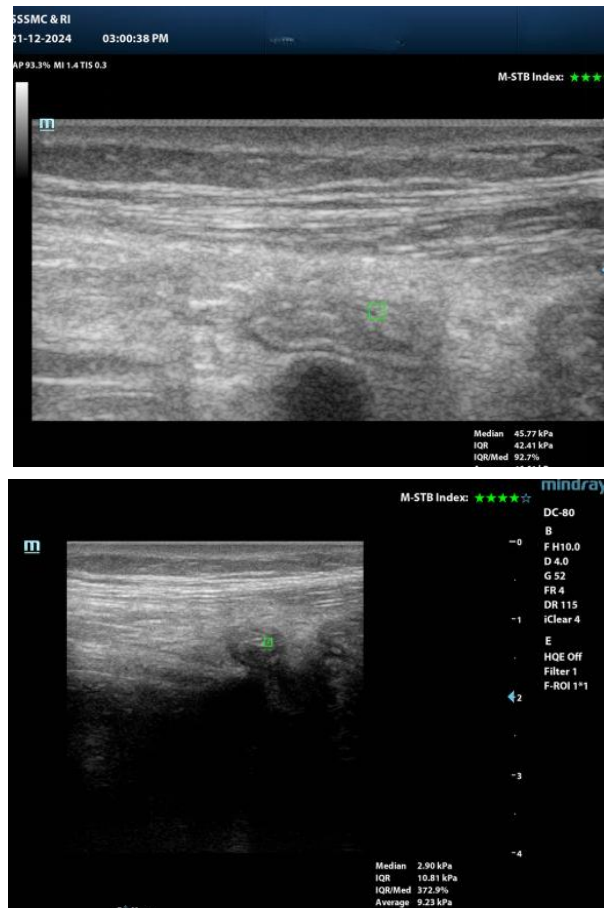


Fig 3 a: Gray-scale ultrasonography was 7.9 mm in diameter. The echogenicity of periappendiceal fat and the appendiceal wall thickening were also noted. Elastic modulus scales by shear wave elastography was more than 13.0 kilopascal (kPa)—Inflamed appendix

Fig 3 b: Gray-scale ultrasonography was 5.3 mm in diameter. Elastic modulus scales (mean Q-Box) by shear wave elastography was 2.5, (kPa)-Normal appendix

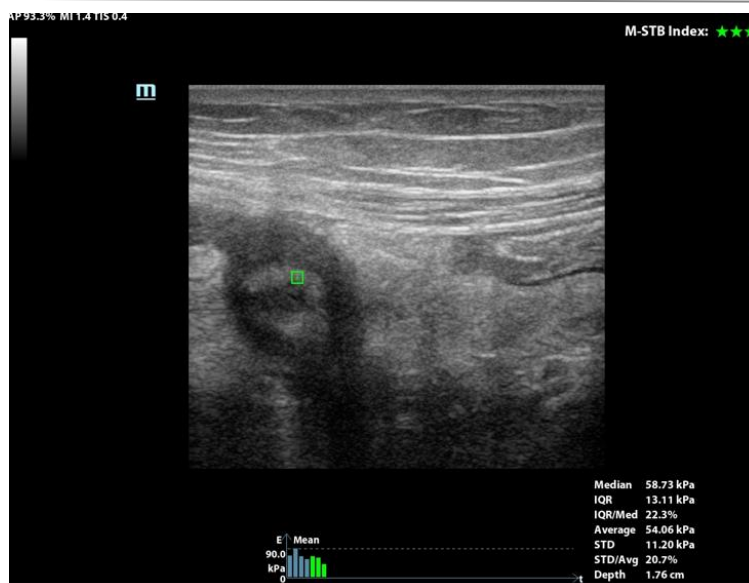


Fig 4 : Gray scale ultrasonography and shear wave elastography in a 8 years old female with appendicitis, with peri appendiceal fat stranding and wall thickening

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