Int J Physiol Pathophysiol Pharmacol 2025;17(4):148-157
www.ijppp.org /ISSN:1944-8171/IJPPP0165227

Original Article

Using ultrasonographic features in pediatric Crohn's disease activity index severity

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Received April 10, 2025; Accepted June 22, 2025; Epub August 25, 2025; Published August 30, 2025

Abstract: Background: The diagnosis and follow-up of Crohn's disease (CD) often require invasive instrumental examinations, which carry a high risk of iatrogenic injury. This study aimed to determine the frequency of ultrasound features in each stage of the Pediatric Crohn's Disease Activity Index (PCDAI). Methods: This cross-sectional study included 22 pediatric patients with Crohn's disease. Disease activity was assessed using the PCDAI. The state of CD activity was categorized into four groups: remission (PCDAI scores less than 10), mild (PCDAI scores of 10-27.5), moderate (PCDAI scores of 30-37.5), and severe (PCDAI scores > 40). Clinical data collected included the thickness of the ascending colon loop, the thickness of the ileal loop, the number of lymph nodes, the short-axis diameter of lymph nodes (mm), spleen span, presence of free fluid, fistulas, liver echogenicity, vascularity around the loops, lumen narrowing, terminal ileum compression, mesenteric fat hypertrophy, intestinal wall and mesenteric fat echogenicity, and Superior Mesenteric Artery indices. These data were documented for analysis. Results: As disease activity progressed from mild to severe, intestinal wall echogenicity, fat echogenicity, mesenteric fat, vascularity, and lumen narrowing significantly increased ($P < 0.05$). The mean ileal loop thickness also significantly increased ($P = 0.005$), rising from 2.12 ± 0.58 in mild cases to 4.49 ± 1.43 in severe cases. However, the mean ascending colon loop thickness, the number of lymph nodes, the short-axis diameter of lymph nodes, and spleen span were not statistically significant ($P > 0.05$). Changes in the superior mesenteric artery indices across the different PCDAI phases were also not statistically significant ($P > 0.05$). Conclusions: Ultrasound is a convenient and reproducible tool for monitoring CD activity in pediatrics. This study demonstrated significant findings, including the increase in intestinal wall echogenicity, fat echogenicity, mesenteric fat hypertrophy, vascularity, and lumen narrowing as the disease activity progressed from mild to severe. Particularly, the mean ileal loop thickness showed a significant increase in the severe phase compared to the mild phase.

Keywords: Inflammatory bowel disease, pediatrics, ultrasonography, color Doppler

Introduction

Inflammatory Bowel Disease (IBD), which includes ulcerative colitis (UC), Crohn's disease (CD), and indeterminate colitis (IC), is characterized by chronic inflammation of the intestines [1]. Only 4% of pediatric IBD cases are diagnosed in children under the age of 5, while 25-30% of CD and 20% of UC cases are diagnosed in children under 20 [2]. Early diagnosis of IBD in pediatric patients is crucial, as delays can impact growth, sexual maturation, and lead to acute complications [3]. Due to the nonspecific nature of the symptoms, 25% of children with Crohn's disease experience symptoms for more than a year before being diagnosed [4]. The diagnosis and follow-up of Crohn's disease often require invasive instrumental examinations, which carry a high risk of iatrogenic injury [5]. Selecting the most appropriate imaging modality for assessing gastrointestinal disease in pediatric patients can be challenging. Imaging in pediatric IBD must balance diagnostic accuracy with the need to minimize exposure to ionizing radiation. Additionally, patient comfort and the non-invasiveness of the imaging technique must be considered [2]. Pediatric patients face a higher cancer risk per unit of radiation dose compared to adults, due to their smaller body size and higher cellular

https://doi.org/10.62347/RIGM1803

proliferation rate [1]. Transabdominal ultrasound is increasingly used to evaluate Crohn's disease (CD) in pediatric patients [4]. Although ultrasound is readily available and cost-effective, experience in diagnosing pediatric bowel disease with this modality is limited. Ultrasound allows for direct visualization of the bowel wall, and skilled operators can reliably detect mesenteric masses such as lymph nodes, phlegmon, abscesses, or matted bowel loops, as well as the phenomenon of creeping fat [5]. The terminal ileum is affected in 90% of Crohn's disease cases, but the disease may also involve other small bowel areas, including the colon [2]. Despite the large intestine being long and tortuous, ultrasound can still provide a complete assessment [6, 7]. The sensitivity of ultrasonography in detecting the location of Crohn's disease ranges from 74% to 96%, with specificity between 80% and 100% [5].

Ultrasound sensitivity for detecting irregular bowel features similar to those observed on cross-sectional imaging, such as mural thickening, strictures, creeping fat, and hyperemia, can be as high as 87% [4]. In pediatric Crohn's disease (CD) patients, determining a therapeutic approach and predicting prognosis requires assessing disease activity with proper stratification. Several indices, such as the Pediatric Crohn's Disease Activity Index (PCDAI), are used to evaluate CD activity [4]. However, due to the complexity and subjectivity of the PCDAI, as well as the inconvenience of procedures like endoscopy and colonoscopy, and the limited availability and high cost of magnetic resonance enterography, ultrasound has become a widely accepted non-invasive imaging technique for assessing pediatric CD activity in a straightforward and semi-quantitative manner [6]. Ultrasound is particularly useful as it avoids ionization, sedation, anesthesia, or antiperistaltic medications. Additionally, it can effectively track treatment progress in pediatric CD patients by evaluating both mural and extramural findings. Color Doppler ultrasound can help identify bowel wall hyperemia and distinguish between chronic and active disease. Doppler tests may also assess a patient's response to treatment [6].

To our knowledge, there is limited data regarding ultrasound's usefulness in evaluating CD activity at each stage. Therefore, this study aimed to determine the frequency of ultrasound features in each PCDAI.

Methods

Study design

The present study is a cross-sectional study performed from March 2019 to April 2021 in Imam Hosein Hospital, affiliated with Isfahan University of medical science, Isfahan, Iran. The study protocol was reviewed and approved by the ethics committee of Isfahan University of Medical Sciences (IR.MUI.MED.REC.1399.097). Based on the formula for estimating the sample size and 90% reliability equal to 1.96 and 0.84 for the test power, and the effects size of 0.62 S, 35 patients were calculated for sample size.

$$N = \frac{(Z_{1-\alpha/2})^2 * P(1-P)}{d^2}$$

Z = 1.96 (corresponding to a 95% confidence level); P = 0.5 (estimated percentage of faculty members with sleep disorders); d = 0.09.

However, using the census method, we included 20 patients as the study population were restricted.

Inclusion and exclusion criteria

The inclusion criteria were age < 18 years, having documented CD based on standard criteria, and signing the informed consent by the parents or a legal guardian. Standard criteria for the diagnosis included: 1. Radiologic studies, endoscopy, and resected specimens showing: Discontinuous or segmental lesions, cobblestone appearance, longitudinal ulcers, and transmural inflammation. 2. Biopsy findings and resected specimens showing: Noncaseating granulomas. 3. Clinical evaluation showing: Fissures, fistulas, and perianal disorders.

Clinical parameters for CD activity

The PCDAI score was measured using the number of nine variables after experienced gastroenterologists adjusted each weighting factor [8, 9]. According to PCDAI, for all 22 patients, disease activity was calculated. The PCDAI is calculated using several criteria with specific scoring ranges. Abdominal pain is scored from

0 (none) to 10 (severe, frequent). Stool frequency is scored from 0 (normal) to 7 (greater than 6 stools/day or nocturnal diarrhea). General well-being is scored from 0 (excellent) to 10 (very poor). Weight change is scored from 0 (weight gain or stable) to 5 (weight loss 1-9%) to 10 (weight loss > 10%). Extra-intestinal manifestations like fever or arthritis are scored from 0 (none) to 10 (severe). Laboratory markers include hematocrit (0 to 5), ESR (0 to 5), and albumin (0 to 5). The total score ranges from 0 to 100, with higher scores indicating more active disease. Hematocrit, ESR, and albumin were included as laboratory components of the PCDAI to reflect anemia, systemic inflammation, and nutritional status, respectively-factors commonly altered in active Crohn's disease. These markers contribute objective data to the overall assessment of disease activity and have been validated in prior studies as part of the PCDAI scoring system [9].

The state of CD activity was subdivided into four groups: remission of disease (PCDAI scores less than 10), mild (PCDAI scores of 10-27.5), moderate (PCDAI scores of 30-37.5), and severe (PCDAI scores > 40). Based on the components of the PCDAI score, the scoring system is designed such that there is a jump from 27.5 to 30 and from 37.5 to 40, meaning there are no scores between these values. Therefore, scores between 27.5 and 30 do not exist within the scale, and the classification shifts directly from mild to moderate at these thresholds [9, 10]. The assessed PCDAI scores were those closest to the examination dates in the US. The mean interval between the PCDAI and the ultrasound examination date was 11 days (range, 10-21 days).

Ultrasound

Since 4 hours of fasting helps to reduce bowel movements and better evaluation of the intestines, patients were advised to refer to the radiology department after 4 hours of fasting for ultrasound evaluation. Patients were tested in the ultrasound ward on an HDI 3000 (Advanced Technology Laboratories, Bothell, WA) with a 7-MHz linear transducer. Without being aware of the outcomes of the laboratory tests or the patient's medical history, one of two registered diagnostic sonographers and one of the authors conducted each session. Gray-scale, color, and power Doppler sonography were performed on all four quadrants of the abdomen, and the patient reported any regions of discomfort or tenderness throughout each examination. Each patient's follow-up examination inspected the same locations (or bowel segments). Images were collected in both the longitudinal and transverse directions. The duration of the studies ranged from 5 to 15 minutes. Images were digitally enlarged. Sensitivity was enhanced, and color gain was adjusted to optimize vessel visibility (70-80%) and was kept constant for each patient's follow-up scans. Color persistence was set to medium, and the bandpass filter was set to the lowest value. The repetition frequency of the pulses was set at 1000 MHz. We utilized a scale for both measurements identical to that used by Ruesset and colleagues in their color Doppler investigations of Inflammatory Bowel Disease in Children and Young Adults to examine each bowel segment with both color and power Doppler sonography [11].

Data gathering

For each visit, clinical data were collected and documented, including the thickness of the ascending colon loop (mm), the thickness of the ileal loop (mm), the number of lymph nodes, the short axis diameter of lymph nodes (mm), spleen span (mm), presence of free fluid, fistula, liver echogenicity (due to hepatobiliary manifestations of IBD), vascularity around the loops, lumen narrowing, terminal ileum compressibility, mesenteric fat hypertrophy, and intestinal wall and mesenteric fat echogenicity.

The Superior Mesenteric Artery (SMA) was then evaluated using color Doppler. For assessing the SMA, the sample volume was positioned 2 cm from the beginning of the artery, taken at an angle of 45-60 degrees, and should be less than half the lumen diameter. Peak Systolic Velocity, Resistance Index, and End Diastolic Volume were all recorded and analyzed.

Statistical analysis

Statistical analysis was performed in Statistical Package for the Social Sciences (SPSS) version 26 for Windows (IBM Inc., Armonk, NY). The Kolmogorov-Smirnov test confirmed the normal distribution of the data. Categorical data were compared using Fisher's exact test, and

Table 1. General information of the study population

Variable		Mean ± standard deviation/Number (percent)
Age		11.86 ± 3.01
Gender (boy)		13 (59.1%)
Race (Caucasian)		22 (100%)
Duration of disease (year)		3.61 ± 2.25
Crohn activity index	Mild	4 (18.2%)
	Moderate	4 (18.2%)
	Severe	8 (36.4%)
	Remission	6 (27.3%)
Ultrasound indices	Thickness of ileal loop (mm)	3.35 ± 1.58
	Thickness of colon loop (mm)	3.27 ± 1.57
	Short axis diameter of lymph nodes (mm)	6.93 ± 2.05
	Lumen narrowing	11 (50%)
	Spleen span (mm)	97.55 ± 14.23
	Terminal ileum compression	13 (59.1%)

one-way analysis of variance (ANOVA) was used for continuous parameters. A post hoc test was also used to identify differences between each pair of groups. An alpha error of 0.05 was set as the critical point of significance.

Results

General information

The overall 22 patient's PCDAI score was obtained. The mean age was 11.86 ± 3.01 years and 59.1% were boys. The mean duration of disease was 3.61 ± 2.25 years. Of them, 6 (27.3%) were in the remission phase, 4 (18.2%) were in the mild phase, 4 (18.2%) were in the moderate phase, and 8 (36.3%) were in the severe phase. Further information of the study population is showin in **Table 1**.

Ultrasound information

The sonographic features of each PCDAI phase are described in **Table 2**. As the disease activity progressed from mild to severe, intestinal wall echogenicity, fat echogenicity, mesenteric fat hypertrophy, vascularity, and lumen narrowing significantly increased ($P < 0.05$). In this case, there was no difference between mild and recovery and mild and moderate ($P > 0.05$), but the difference was mainly observed between the severe and other stages. The mean ileal loop thickness was significantly greater in the severe phase (4.49 ± 1.43 mm) than in the mild phase (2.12 ± 0.58 mm) (**Table 3**; $P = 0.005$). Using post hoc test, it was showed that thickness of ileal loop was signifincalty higher in moderate and severe groups compared to recovery and mild groups ($P = 0.002$). No other significant differences were observed ($P > 0.05$).

Further details

The mean ascending colon loop thickness (3.27 ± 1.57 mm), number of lymph nodes (5.68 ± 3.56), short axis diameter of lymph nodes (6.93 ± 2.05), and spleen span (97.55 ± 14.23) were not statically significant ($P > 0.05$). **Figure 1** shows the prominent lymph node in an active phase.

The mesenteric artery indices changes over the different PCDAI phases were not statistically significant ($P > 0.05$). **Figure 2** shows the increased focal vascularity using color doppler ultrasound. **Table 4** shows pediatric Crohn activity index and mesenteric arteries indices. Using post hoc test, we observed no significant differences between the groups ($P > 0.05$). **Figure 3** shows the end diastolic velocity of patients stratified based on the disease severity groups.

Discussion

The main findings of this study demonstrated that as disease activity progressed from mild to severe, the frequency of certain ultrasound features-such as increased intestinal wall

Table 2. Pediatric Crohn's activity index and qualitative sonographic results

Sonographic findings	Recovery	Mild	Moderate	Severe	Total	*p-value*
Intestinal wall echogenicity	Increased 1 (16.7) Normal 5 (83.3)	Increased 0 (0) Normal 4 (100)	Increased 2 (50) Normal 2 (50)	Increased 6 (75) Normal 2 (25)	Increased 9 (40.9) Normal 13 (59.1)	0.009
Fat echogenicity	Increased 1 (16.7) Normal 5 (83.3)	Increased 0 (0) Normal 4 (100)	Increased 2 (50) Normal 2 (50)	Increased 5 (62.5) Normal 3 (37.5)	Increased 8 (36.4) Normal 14 (63.6)	0.036
Mesenteric fat	Hypertrophed 1 (16.7) Normal 5 (83.3)	Hypertrophed 0 (0) Normal 4 (100)	Hypertrophed 2 (50) Normal 2 (50)	Hypertrophed 5 (62.5) Normal 3 (37.5)	Hypertrophed 8 (36.4) Normal 14 (63.6)	0.036
Free fluid	Positive 1 (16.7) Negative 5 (83.3)	Positive 0 (0) Negative 4 (100)	Positive 0 (0) Negative 4 (100)	Positive 2 (25) Negative 6 (75)	Positive 3 (13.6) Negative 19 (86.4)	0.56
Hypervascularity	Positive 1 (16.7) Negative 5 (83.3)	Positive 0 (0) Negative 4 (100)	Positive 0 (0) Negative 4 (100)	Positive 6 (75) Negative 2 (25)	Positive 7 (31.8) Negative 15 (68.2)	0.009
Lumen narrowing	Positive 1 (16.7) Negative 5 (83.3)	Positive 0 (0) Negative 4 (100)	Positive 4 (100) Negative 0 (0)	Positive 6 (75) Negative 2 (25)	Positive 11 (50) Negative 11 (50)	0.006
Fistula	Positive 0 (0) Negative 6 (100)	Positive 0 (0) Negative 4 (100)	Positive 0 (0) Negative 4 (100)	Positive 1 (12.5) Negative 7 (87.5)	Yes 1 (4.5) Negative 21 (95.5)	0.26
Liver echogenicity	Normal 5 (83.3) Increased 0 (0) Heterogenic 1 (16.7) Decreased 0 (0)	Normal 3 (75) Incresded 1 (25) Heterogenic 0 (0) Decresed 0 (0)	Normal 4 (100) Decreased 0 (0) Heterogenic 0 (0) Decreased 0 (0)	Normal 8 (100) Decreased 0 (0) Heterogenic 0 (0) Decreased 0 (0)	Normal 20 (91) Decreased 1 (4.5) Heterogenic 1 (4.5) Decreased 0 (0)	0.18
Terminal ileum	Compressed 1 (16.7) Normal 5 (83.3)	Compressed 4 (100) Normal 0 (0)	Compressed 3 (75) Normal 1 (25)	Compressed 5 (62.5) Normal 3 (37.5)	Compressed 13 (59.1) Normal 9 (40.9)	0.21

Table 3. Pediatric Crohn activity index and quantitative sonographic results

Pediatric Crohn's activity index	recovery	mild	moderate	severe	*p*-value
Thickness of ascending colon (mm)	3.48 ± 1.65	2.45 ± 0.97	3 ± 1.78	3.66 ± 1.75	0.64
No. of lymph nodes	5.92 ± 1.6	5.47 ± 1.38	8.32 ± 0.96	7.41 ± 2.53	0.14
Short axis diameter of lymph nodes (mm)	5 ± 3.35	2.75 ± 2.22	8.25 ± 4.99	6.38 ± 2.77	0.17
Thickness of ileal loop (mm)	2.2 ± 1.49	2.12 ± 0.58	4.07 ± 0.15*	4.49 ± 1.43*	0.005
Spleen span (mm)	105.83 ± 17.45	86 ± 9.76	96 ± 3.92	97.88 ± 14.38	0.19

*Showing significantly higher compared to recovery and mild group based on post hoc test.

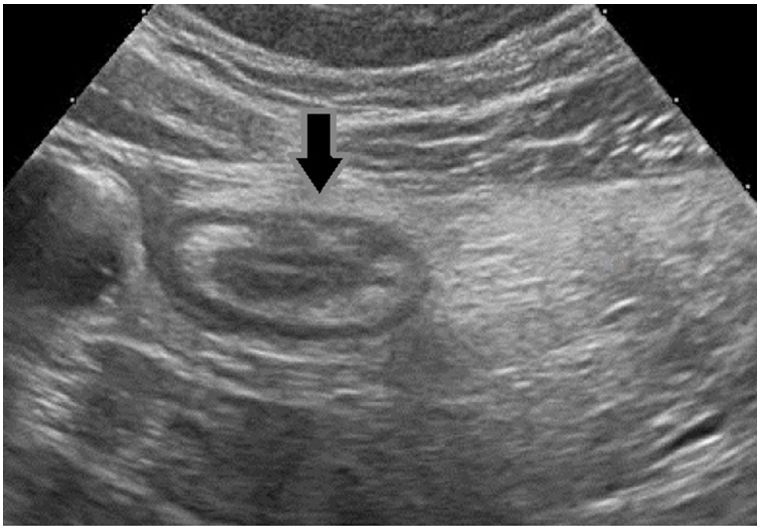

Figure 1. Prominent lymph node in an active phase.

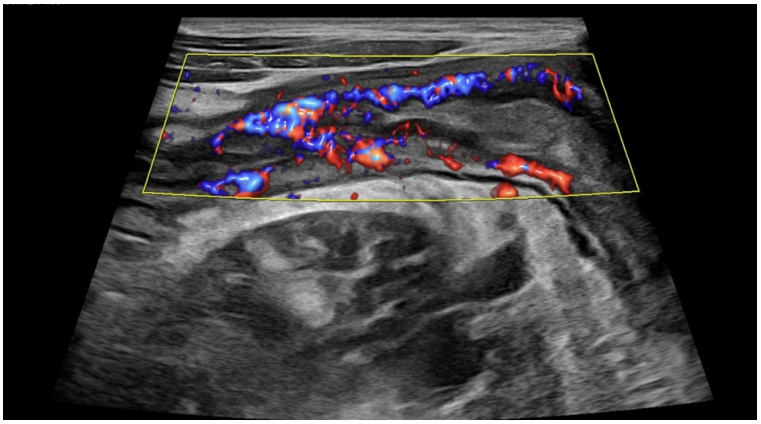

Figure 2. Increased focal vascularity shown in color doppler ultrasound.

echogenicity, fat echogenicity, mesenteric fat hypertrophy, hypervascularity, and lumen narrowing-significantly increased. Additionally, the mean ileal loop thickness increased significantly from the mild to the severe phase.

Several researchers have found a strong correlation between intestinal wall thickness and Crohn's disease [6]. A meta-analysis revealed that diagnosing Crohn's disease with a bowel wall thickness greater than 3 mm had a sensitivity of 88% and specificity of 93%, while a thickness greater than 4 mm had a sensitivity of 75% and specificity of 97% [12, 13]. There is also a statistically significant association between maximum wall thickness and disease activity [14]. Our study aligns with these findings, as we observed that the mean ileal loop thickness significantly increased in the severe phase (4.49 ± 1.43 mm) compared to the mild phase (2.12 ± 0.58 mm). This supports the idea that measuring bowel wall thickness can serve as an effective indicator of disease severity in Crohn's disease patients.

Our study did not find any significant changes in large bowel thickness across different PCDAI classes; however, ileal loop thickness showed significant variation. Examining the small intestine in IBD remains more challenging than assessing the colon. A study on the sonographic evaluation of inflammatory bowel disease found that terminal ileum thickness greater than 2.5 mm predicts moderate to severe inflammation. This finding aligns with our results, as the mean ileal loop thickness in the moderate and severe phases exceeded 2.5 mm, while in the mild and remission phases, it was less than 2.5 mm. This suggests that sonographic measurement of ileal loop thickness can serve as a

Table 4. Pediatric Crohn activity index and mesenteric arteries indices

Pediatric crohn's activity index	recovery	mild	moderate	severe	*p*-value
Peak systolic velocity	122.83 ± 96.16	69.75 ± 13.72	212 ± 166.47	172.38 ± 71.21	0.18
Resistive index	0.83 ± 0.05	0.79 ± 0.07	0.81 ± 0.07	0.83 ± 0.05	0.63
End diastolic velocity	21.85 ± 20.46	15 ± 7.07	41.25 ± 43.32	28.41 ± 16.06	0.43

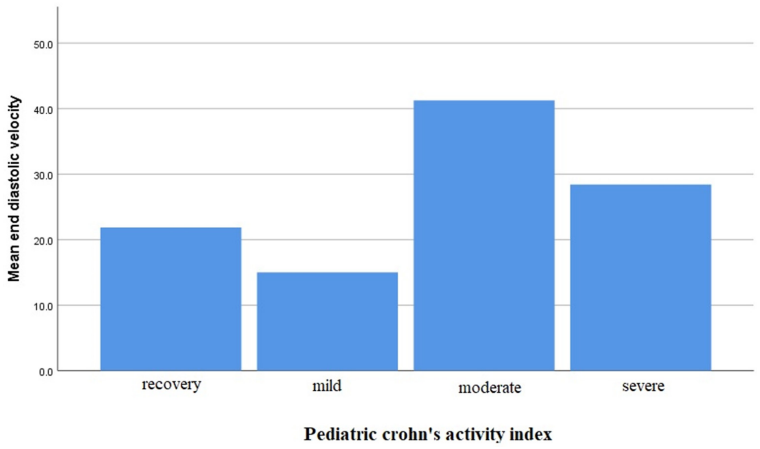

Figure 3. End diastolic velocity among the study groups based in disease severity.

practical and non-invasive method to assess and monitor disease activity in pediatric Crohn's disease patients.

In Crohn's disease, regional lymphadenopathy is typical. There are often more and larger mesenteric lymph nodes in the right lower quadrant that are close to and drain aberrant segments of the colon [15]. Recent studies on this topic have revealed that regional lymphadenopathy weakly correlates with active Crohn's disease [16, 17]. Similar results were observed in this study, where the size and number of lymph nodes did not show significant differences in each phase of PCDAI. This indicates that while lymphadenopathy is a common feature in Crohn's disease, its presence alone may not be a reliable indicator of disease activity. Thus, relying solely on lymph node size and number might lead to inaccurate assessments of disease progression or remission in clinical practice.

Doppler ultrasonography has been introduced as a method for measuring the flow of the superior and inferior mesenteric arteries in individuals with Crohn's disease [18, 19]. However, subsequent research found no statistically significant differences in mesenteric artery Doppler exams between patients with active and inactive Crohn's disease [16, 20, 21]. Similarly, this study did not find any significant differences in superior mesenteric artery measurements across PCDAI phases. This aligns with current understanding that mesenteric artery blood flow, as measured by Doppler ultrasonography, may not significantly fluctuate with disease activity in Crohn's disease. Therefore, Doppler ultrasound of mesenteric arteries may not be a sensitive tool for assessing disease activity, and clinicians should consider other ultrasound features when evaluating Crohn's disease progression.

For more than a decade, intestinal wall vascularity has been studied, with consistent findings showing a link between blood vessel density, as measured by power Doppler sonography, and the degree of local inflammation, as assessed by endoscopy or clinical and biochemical examination [22-24]. In our study, we observed a significant increase in vascularity as the disease progressed from mild to severe phases, supporting the notion that intestinal wall vascularity can serve as a reliable marker of disease activity. Increased blood vessel density, as detected on power Doppler sonography, corresponds with heightened inflammation and provides valuable insights into the patient's current disease state. Incorporating vascularity measurements into routine sonographic evaluations could improve the accuracy of disease monitoring and help guide therapeutic decision-making.

Additionally, the increased intestinal wall echogenicity observed in our study as disease severity progressed suggests a correlation between echogenicity and inflammatory activity. Higher echogenicity may reflect greater tissue inflam-

mation and fibrosis, which are common in advanced stages of Crohn's disease [21]. This finding underscores the potential utility of echogenicity as a supplementary sonographic parameter for assessing disease severity. Furthermore, the observed increase in mesenteric fat hypertrophy and fat echogenicity during severe disease phases highlights the role of mesenteric alterations in Crohn's disease pathology [22]. These changes in mesenteric fat contribute to the chronic inflammatory process and may serve as additional sonographic markers of disease activity.

Lumen narrowing, another significant finding in our study, further highlights the progression of Crohn's disease. As inflammation and fibrosis increase, the intestinal lumen narrows, leading to obstructive symptoms and complications [23]. This observation aligns with clinical experiences, where patients with severe Crohn's disease often present with obstructive symptoms that may necessitate surgical intervention [24]. Therefore, regular monitoring of lumen narrowing via ultrasound can facilitate early detection of potential complications, enabling timely medical or surgical intervention.

Our findings also underscore the importance of comprehensive sonographic evaluation in pediatric Crohn's disease patients. Given the challenges associated with invasive procedures like endoscopy, non-invasive imaging techniques such as ultrasound offer a valuable alternative for disease monitoring [25]. Ultrasound is not only patient-friendly but also provides real-time insights into disease activity and progression. Clinicians should consider integrating detailed sonographic assessments, including measurements of intestinal wall thickness, vascularity, echogenicity, and lumen narrowing, into routine clinical practice for managing pediatric Crohn's disease.

Our study contributes to the growing body of evidence supporting the use of ultrasound in assessing and monitoring Crohn's disease. The significant sonographic changes observed in various PCDAI phases, particularly in ileal loop thickness, vascularity, and mesenteric alterations, highlight the utility of ultrasound as a non-invasive, reliable tool for evaluating disease activity. Further research with larger cohorts is warranted to validate these findings and refine sonographic criteria for more accurate disease assessment. Nonetheless, our study underscores the potential of ultrasound in enhancing clinical management and improving outcomes for pediatric Crohn's disease patients.

Our study has several limitations. One primary shortcoming is the relatively small sample size of 22 patients, which may limit the generalizability of the findings. Additionally, the study was conducted at a single center, potentially introducing selection bias and affecting the applicability of the results to broader populations. The study also did not account for potential confounding factors such as variations in treatment regimens, disease duration, or the presence of extraintestinal manifestations, which could influence ultrasound findings. Furthermore, the lack of longitudinal follow-up restricts the ability to assess changes in ultrasound features over time and their correlation with long-term clinical outcomes. Future research should address these limitations by including larger, multicenter cohorts to enhance the generalizability and robustness of the findings. Longitudinal studies are needed to evaluate the progression of ultrasound features over time and their relationship with clinical outcomes and treatment responses.

Conclusions

Ultrasound is a convenient and reproducible tool for monitoring Crohn's disease activity in pediatrics. This study demonstrated significant findings, including the increase in intestinal wall echogenicity, fat echogenicity, mesenteric fat hypertrophy, vascularity, and lumen narrowing as the disease activity progressed from mild to severe. Particularly, the mean ileal loop thickness showed a significant increase in the severe phase compared to the mild phase. These results confirm the utility of ultrasound in effectively assessing and monitoring disease progression in pediatric Crohn's disease patients. While the mean ascending colon loop thickness, number of lymph nodes, short axis diameter of lymph nodes, and spleen span were not statistically significant, and the mesenteric artery indices did not show significant changes across different PCDAI phases, the significant findings underscore the value of ultrasound in clinical practice.

Disclosure of conflict of interest

None.

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