Ultrasound Role in Assessment of Bowel Diseases in Pediatrics

Medhat M. Refaat, Ahmed E. Shalaan, Doaa A. Mokhtar

Department of Radiodiagnosis, Benha faculty of medicine, Benha University, Egypt.

Correspondence to: Doaa A. Mokhtar, Department of Radiodiagnosis, Benha faculty of medicine, Benha University, Egypt.

Email:

doaaafifiy2020@gmail.com

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Abstract

Background: Bowel diseases are relatively common in the pediatric age group that sometimes causes growth retardation due to malnutrition and vitamin deficiency. In addition to many bowel-related emergency situations which may cause serious complications in many cases. The main aim of this study was to determine the ability of ultrasonography to diagnose and follow up different cases of bowel diseases, either chronic or acute emergency conditions that may necessitate immediate surgical or medical intervention. **Methods**: sixty patients ranging between (Preterm up to 14 years) of age were examined in the Radiology department of Benha children hospital (BENCH) using linear transducer high frequency (12-15 MHz) probe. **Results**: Through the scheduled study period, forty (60) patients were examined by conventional ultrasound linear transducer. Seventeen (27) of them were female patients and twenty-nine (33) were males, with age ranging from preterm to fourteen years (neonate up to 2 months (19) , post neonate up to 1 years(15) and children from 1 years to 14 years (26). Validity of US in prediction of different bowel diseases in pediatric as sensitivity of US is 85, specificity is 100 and accuracy is 88.3. **Conclusion**: Ultrasound was proven to have a major role in different bowel diseases diagnosis in children; especially that it is considered a safe procedure that does not cause non-ionizing radiation exposure. Also, it helps rapid diagnosis without the need for prolonged special preparations.

Keywords: Ultrasound; bowel diseases; pediatrics

Introduction

For many years, traditional radiological techniques played a crucial role in the diagnosis of bowel diseases. In the last decades, the introduction of, and

improvements in, non-invasive cross-sectional imaging techniques including ultrasound (US), computed tomography (CT), positron-emission tomography (PET) and magnetic resonance imaging (MRI), have changed the diagnostic approach to the GI tract (1).

Bowel ultrasound is cheap, relatively quick, allows dynamic evaluation of the bowel, has no radiation burden, is well tolerated by patients and allows repeat imaging (2).

Some of the advantages of ultrasound when imaging children, such as the lack of ionizing radiation and the relatively short length of the exam obviating sedation, are obvious. This article outlines the diagnostic considerations within the different pediatric age groups, and considers the ways in which ultrasound can facilitate diagnosis, the cases in which ultrasound is limited in its ability to make a diagnosis, and the ways in which ultrasound can monitor the efficacy of treatment. As it would be beyond the scope of this article to consider each entity in detail, there is a focus on several diseases relatively unique to children. (3)

Targeted ultrasound has been well established for the evaluation of bowel pathology in children for intussusceptions, appendicitis, and hypertrophic pyloric stenosis for more than a decade. Although CT and fluoroscopic studies remain the gold standard investigations, both carry a significant radiation dose and so magnetic resonance imaging (MRI) and ultrasonography (US) are increasingly used as the first line investigation: especially when imaging patients with inflammatory bowel disease, where subsequent repeat imaging to monitor disease activity is useful, but the cumulative radiation dose from CT and fluoroscopic examinations is a concern (2).Alternatively, ultrasonography enables dynamic evaluation of the bowel and can be employed in the acute setting; however the diagnostic accuracy of the findings is operator dependent (4).

Main purpose of study to describe indications and techniques for bowel US for any dowel diseases, describe and illustrate their imaging appearance

Patients and method

This is an observational descriptive study aiming to emphasize the role of ultrasound examination of the bowel in pediatric age group.

Inclusion criteria :

- Pediatric age group (up to 14 years old).
- Suspected or already diagnosed patients with bowel diseases.
- Vitally stable cases.

Exclusion criteria :

- Adult patients.
- Non-complaint patients.
- Complicated unfit patients.

Throughout the study period (one year), sixty patients ranging between (Preterm up to 14 years) of age were examined in the Radiology department of Benha children hospital (BENCH) using linear transducer high frequency (12-15 MHz) probe.

Using the high-resolution linear transducer, Gray-scale and color Doppler imaging in the sagittal and transverse planes along the entire length of the bowel were performed, starting with the terminal ileum and ileocecal valve in the right lower quadrant and continuing along the colon into the left lower quadrant.

Using the same technique, the jejunal loops in the left upper quadrant and ileal loops in the mid and lower abdomen were evaluated. The jejunum is characterized by its normal folds as opposed to the ileum. Subsequently, it is customary to have the patient drink water and image the stomach and duodenum with the patient in a decubitus position. In this manner, gastric and duodenal wall abnormalities can be depicted easily.

To complete the examination, using the 5–8 MHz transducer, the mesentery was evaluated for fluid collections, abscesses, or dilated loops of bowel. The Doppler portion of the examination is performed with a low wall filter and the lowest pulse repetition frequency to prevent aliasing. This systematic approach provided both anatomic and functional information, which was a direct benefit of ultrasound over modalities such as CT.

Patients with inflammatory bowel diseases coming for follow up or with exacerbated symptoms were examined. Those coming for follow up were examined and compared with the CT enterography and pathology data acquired from colonic/ileal loops through lower endoscopy.

Other patients coming with miscellaneous bowel related complaints e.g. Absolute constipation, abdominal distension, hernia or suspected appendicitis were also examined with the same protocol and diagnoses were

suggested. The cases then were followed up and diagnoses were surgically confirmed.

Statistical analysis:

Data were statistically described in terms of frequencies and percentages. Comparison between the different modalities was done using McNemar test. Agreement was done using kappa statistic. Accuracy was represented using the terms sensitivity, specificity, +ve predictive value, -ve predictive value, and overall accuracy. *p* values less than 0.05 was considered statistically significant. All statistical calculations were done using computer program IBM SPSS (Statistical Package for the Social Science; IBM Corp, Armonk, NY, USA) release 22 for Microsoft Windows.

Results

Through the scheduled study period, forty (60) patients were examined by conventional ultrasound linear transducer. Seventeen (27) of them were female patients and twenty-nine (33) were males, with age ranging from preterm to fourteen years (neonate up to 2 months (19) , post neonate up to 1 years(15) and children from 1 years to 14 years (26).

During the period of our study we divided the pathologies examined into 3 main groups, congenital (malrotation, volvulus, atresia, mesenteric cyst), inflammatory (appendicitis, NEC, inflammatory bowel disease) and other miscellaneous cases (IHPS, intussusception, familial adenomatous polyposis)

Distribution of the studied group according to clinical picture and suspected diagnosis, (table 1)

Distribution of the studied group according to clinical picture, (table 2).

There is significance difference between age groups regarding vomiting , abdominal pain , fever ,delayed passage of meconium and abdominal distention as P value <0.05. (Figure 1).

Table 3 show different positive US findings in differentiating bowel diseases in pediatric in forty (67%) cases that diagnosed by US and the other twenty cases (33%) are negative US findings mostly normal study or gas distention obscuring examination. Correlation between US diagnosis &confirmed diagnosis, (table 4)

Validity of US in prediction of different bowel diseases in pediatric as sensitivity of US is 85, specificity is 100 and accuracy is 88.3, (table 5).

Table (1) Distribution of the studied group according to clinical picture and suspected diagnosis

Suspected diagnosis	Clinical picture						Total
	Vomiting	Abdominal colic	fever	Bleeding per rectum	Delayed passage of meconium	Abdominal distension	
	+	+	+	+	+	+	
Appendicitis	6	8	6	0	0	0	8
Intussusception	3	4	0	5	0	5	7
IHPS	8	0	0	0	0	0	8
Inflammatory bowel disease	4	6	6	3	0	0	10
Atresia	5	0	0	0	7	0	7
Malrotation/ volvulus	7	0	0	2	2	4	8
NEC	3	0	0	0	0	3	4
mesenteric cyst	1	0	0	0	0	1	3
FAP	0	2	0	2	0	0	5
Total							60

Table (2) Distribution of the studied group according to cl p.

Clinical picture	**No (60)**	**%**
Vomiting	37	61.5
Pain	20	33.5
fever	12	20
Red stool	13	22
Delayed meconium	9	15
Abdominal distention	16	26.5

Table (3) Distribution of the studied group according to US findings

Diagnosis	**U/S**	**No (40)**	**%**
IHPS	Increased parameter of pylorus (thickness , length , diameter)	6	10
Malrotation	Inverted relation of SMA&SMV	4	7
Volvulus	Inverted relation of SMA&SMV with whirlpool sign	2	3
Atresia	Distended stomach & duodenum with collapsed bowel loops with us	5	8
Intussusception	Single Heterogeneous mass of alternating echogenicity (Target sign) with signs of bowel obstruction (distended bowel loops , minimal free fluid)	6	10
NEC	Diffuse bowel wall thickening with minimal intra peritoneal free fluid and portal venous gas	3	5
Colitis	Diffuse bowel wall thickening	5	8
Appendicitis	Minimal amount of free fluid collection with smudged mesenteric fat in right iliac fossa	2	3
	Increased diameter of incompressible appendix more than 6 mm	4	7
Mesenteric cyst	Intra-abdominal cystic lesion	2	3
Familial adenomatous polyposis	Multiple Heterogeneous mass of alternating echogenicity of the bowel loops without intestinal obstruction.	1	1
	Total	40	67%

Table (4) correlation between US diagnosis &confirmed diagnosis:

Suspected diagnosis	US findings				Confirmed diagnosis		Statistical test(FET)	P value
	+		-		+	-		
	N	%	N	%				
Appendicitis	5	71.4	2		7	1	0.08	**0.38**
intussusception	5	100	1		5	2	0.26	**0.29**
IHPS	6	100	2		6	2	3.56	**0.036**
Inflammatory bowel disease	5	62.5	5		8	2	0.63	**0.44**
Atresia	5	100	2		5	2	2.96	**o.o48**
Malrotation / volvulus	6	85.7	2		7	1	0.38	**0.25**
NEC	3	100	1		3	1	0.44	**0.25**
Mesenteric / duplication cyst	2	50	1		3	0	0.0	**1**
FAP	2	50	3		4	1	0.0	**1**
Total	40				48	12		

Table 5: Validity of US in prediction of different bowel diseases in pediatric

Confirmation U/S (**Suspected diagnosis**)	Positive (47)		Negative (13)		Statistical test (FET)	P value
	No	%	No	%		
Positive	40	83.3	0	0.0	29.47	<0.001**
Negative	8	16.7	12	100		
Sensitivity						85.1
Specificity						100
PPV						100
NPV						65.0
Accuracy						88.3

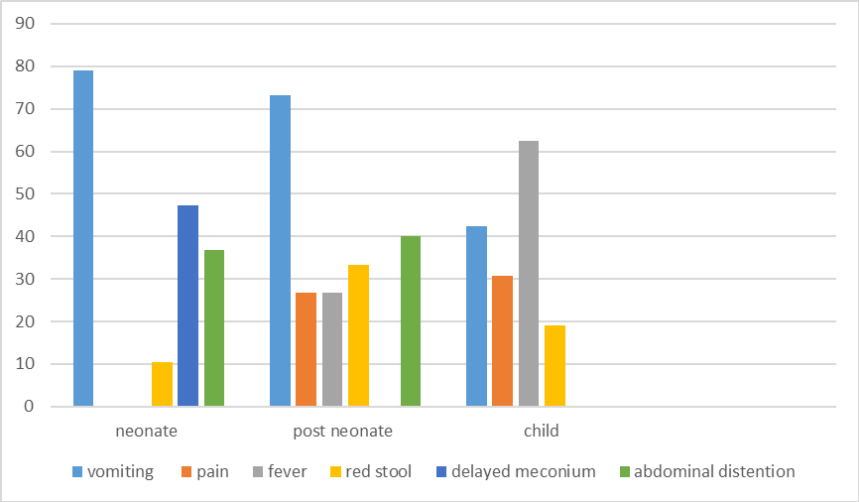

Figure 1: Distribution of the clinical picture according to different age groups

Discussion:

Ultrasonographic enables dynamic evaluation of the bowel and can be employed in acute settings. Our study included a spectrum of pediatric patients ranged between preterm to 13-year-old patients. Ultrasound examination of different bowel conditions revealed accurate diagnosis in many diseases e.g. CHPS, Appendicitis, intestinal obstruction and intussusception. It also was of great value in the follow up and diagnosis of active inflammatory bowel disease attacks, as will be discussed briefly in this discussion.

Advantages concluded from our study included ultrasound examination being safe, well tolerated and allowing dynamic examination at the setting of complaint. While the major limitation was that it is mainly an operator dependent procedure, allowing reaching accurate diagnosis only with skillful hands. During analysis of the results obtained from this study, it showed that ultrasound examination of the bowel is comparable to the clinical data, Pathology results and CT enterography findings regarding diagnosis and estimating disease activity and severity in cases of inflammatory bowel disease in pediatric age group. Also, ultrasound showed high accuracy in diagnosing other diseases such as Intussusception, Hernia, CHPS, Appendicitis and bowel obstruction that were in all conditions confirmed surgically.

In cases of inflammatory bowel disease, Ultrasound examination of the bowel, diagnosis was reached after detecting increased bowel wall thickness, effacement of mesenteric fat and lymphadenopathy. The disease activity was diagnosed in cases with increased mesenteric vascularity, bowel loops dilatation, free fluid collection and lymphadenopathy. Accordingly, ultrasound was found to be of high accuracy in diagnosing the disease activity and almost as accurate as the pathology results regarding the detection of active inflammation. And when compared to CT enterography findings, it was found of better ability in detecting increased mesenteric vascularity, minimal amounts of free fluid and most importantly the exact bowel wall thickening.

While in conditions other than inflammatory bowel disease, ultrasound was found to obtain solid findings that gave sure diagnoses. Such as sonographic diagnosis of intussusception is accomplished by the identification of a “target” or “bull’s-eye” that represents the appearance of intussuscepted bowel in cross-section.

US guided hydrostatic reduction is a very simple, effective, economical and quick

method of managing intussusception. It has a high success rate especially when patients are carefully selected and associated acceptable complications both short and long term. Uncertainty in the US diagnosis of IHPS is placed upon measurements of the antropyloric channel. The measurements most often used include muscle thickness, length of the hypertrophied pyloric channel typically termed pyloric length, and pyloric diameter.

The diagnosis of appendicitis is made on ultrasound when the appendix is thickened (diameter >6mm) and non-compressible. A positive ultrasound scan in appendicitis should allow us to diagnose and treat earlier, leading to less in-hospital observation or negative explorations, shorter hospital stay, and better outcomes. Utrasonography has been introduced as an alternative method for the diagnosis of malrotation, with an emphasis on the relationship of the SMV and SMA and the so-called “whirlpool sign” in cases of volvulus. Studies have reported that sonographic findings of abnormal relative positions of the SMA and SMV have high sensitivity in diagnosing intestinal malrotation.

These findings were found consistent with previous studies (5), the role of ultrasound in diagnosis of small bowel diseases and found that Ultrasound examination of the small bowel was well tolerated by patients and was a useful skill for radiologists / sonographers both in the acute and chronic disease setting. Good sonographic technique, with optimization of machine settings, use of graded compression, allowed a detailed examination of the whole small bowel, with the advantages over CT & MR of cost, very high spatial resolution, and true real-time assessment.

In the pediatric population and early pregnancy, US evaluation of the small bowel was often the preferred option over other cross-sectional imaging modalities. Additional physiological information were also obtained using colour Doppler imaging, microbubble contrast agents and more recently quantitative information on the mechanical properties of the bowel wall

Our study results were also found in line with others, (6) where it was aimed to describe the indications and techniques for bowel ultrasound for inflammatory bowel disease and other common and uncommon entities and describe and illustrate their imaging appearances and concluded that Ultrasound is a useful tool for the evaluation of inflammatory bowel disease and many other bowel diseases, especially in the evaluation of

the bowel in children because of the need for alternative radiation-free imaging techniques continues to grow.

Similarly, the bowel wall thickness measured by ultrasound as a marker of Crohn's disease activity in children, was studied (7). They concluded that bowel wall thickness measured by ultrasound was related to clinical and histological assessment of disease activity and could represent an easy method for monitoring the intestinal inflammatory process in Crohn's disease. This is due to the need of non-invasive procedures for assessing disease activity in the follow-up of children with Crohn's disease.

Conclusion

Ultrasound was proven to have a major role in different bowel diseases diagnosis in children; especially that it is considered a safe procedure that does not cause non-ionizing radiation exposure. Also, it helps rapid diagnosis without the need for prolonged special preparations.

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