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Bowel Obstruction in Children; Ultrasound or Abdominal X-ray?

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Abstract

Background: Early diagnosis of intestinal obstruction is critical for preventing subsequent complications. In this study, we compare the accuracy of plain abdominal X-ray and ultrasound imaging among children with intestinal obstruction, in terms of the diagnosis of obstruction and its underlying causes.

Methods: This analytical cross-sectional study was performed at Akbar Children's Hospital of Mashhad, Iran, in 2019-2021. Children with clinical manifestations of bowel obstruction underwent abdominal ultrasound examination and plain abdominal X-ray imaging, and the diagnostic findings were compared with the final definite diagnosis. Radiologic signs of obstruction were bubble signs in obstructions until the jejunum, and sausage-shaped air-filled bowel in obstructions of the rest of the bowel. The ultrasound signs were fluid-filled dilated loops, tubular or sausage-shaped dilated bowels, parallel valvulae conniventes (stack of coins), the to-and-fro motion, and the cause of the obstruction.

Results: Overall, 60 children with a mean age of 3.05 ± 0.87 years were studied. Post-operative adhesion was the most common cause of obstruction (28%). Plain radiography revealed a normal pattern in 15% of cases, bubble sign and/or decreased abdominal gas pattern in 15% of patients (high-level obstruction), and sausage-shaped pattern of low-level obstruction in 70% of cases, with 72% accuracy. The sonographic signs of bowel obstruction were seen in all patients, with 96.6% accuracy. The cause of obstruction could be determined in 91% of patients, with 91.6% accuracy.

Conclusion: Plain abdominal X-ray had a normal pattern in 15% of bowel obstructions while sonography revealed all obstructions with 91.6% accuracy. Therefore, ultrasound imaging can be used as the preferred imaging modality to diagnose gastrointestinal tract obstructions.

Key Words: Abdominal imaging techniques, abdominal ultrasonography, Abdominal x ray, bowel obstruction, bubble sign, Intestinal obstruction, Pediatrics, Sausage-shaped pattern, Ultrasound.

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1- INTRODUCTION

Intestinal obstruction is a common emergency condition among patients admitted for pediatric surgery, accounting for 15% of acute abdominal pathologies in children. The causes of intestinal obstruction differ according to age, sex, geographical area, nutrition, and genetics. Some of the most frequent causes include inguinal hernia, intussusception, adhesion, bowel atresia, Hirschsprung's disease, complicated appendicitis, meconium ileus, complicated Meckel's diverticulum, duodenal hematoma, intestinal duplication, closed loop obstruction, etc. (1, 2). Early diagnosis is essential to prevent subsequent complications and reduce the morbidity and mortality caused by an intestinal obstruction (2). For example, as opposed to adults who can tolerate hernias for years, hernia in children can lead to strangulation and eventually necrosis of the hernia (1, 3).

Accurate diagnosis and recognition of the underlying etiology of obstruction is challenging, particularly in children (3, 4). Imaging advances have revolutionarily changed the diagnosis and management of bowel obstruction over the past two decades (5). Due to the growing use of advanced abdominal imaging techniques in recent years, most of the cases with obstruction can be diagnosed and treated by non-surgical or laparoscopic methods (6, 7). The introduction of non-surgical treatments such as reduction of intussusception, hydrostatic treatment of meconium ileus and meconium plaque syndrome, and conservative treatment of Adhesions increase the importance of accurately diagnosing the etiology of obstruction (11, 12).

Imaging is the first step in the para-clinical diagnosis of bowel obstruction. Abdominal radiography has been reported as a suitable imaging method for early diagnosis of this condition considering its accessibility, applicability, and low cost. However, it has a low sensitivity in the diagnosis of the underlying etiology for intestinal obstructions (8). Ultrasonographic examination also faces limitations since it cannot provide sufficient information in the presence of gas in the bowel lumen. However, the application of abdominal ultrasonography has significantly increased the rate of timely diagnosis (7).

Although new techniques such as Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) have provided good diagnostic accuracy, ultrasonography and abdominal radiography are still considered the first steps in the diagnosis of bowel obstruction (9, 10). Therefore, in the present study, we aimed to evaluate the accuracy of plain abdominal X-ray and ultrasonography to diagnose intestinal obstruction and detect its underlying causes in children.

2- MATERIALS AND METHODS

2-1. Design and Participants

This prospective cross-sectional study was performed in the radiology and surgery departments of Akbar Children's Hospital of Mashhad, Iran, from 2019 to 2021. Sixty children aged 2 days to 14 years, referred to the radiology department with clinical manifestations of bowel obstruction, were enrolled in the study. Patients with intussusception, esophageal atresia, inguinal hernia, and imperforate anus were excluded, given the different course of diagnosis required for these conditions. Cases with incomplete documentation of medical records were also excluded from the study. Ultimately, 48 subjects underwent abdominal plain X-ray imaging.

2-2. Procedure

The X-ray images were assessed by an expert radiologist for the presence of the following views/signs: honeycomb pattern, decreased abdominal gas, and gasless abdomen, presence of gas in the rectum,

longitudinal or sausage-shaped dilated bowel loops, and bubble-shaped loops.

Complete abdominal sonography was done using 5-12 MHz multi-frequency probes (Voluson E6, Samsung WS80, and Esaote Class C ultrasound machine). The targeted ultrasound examination of bowels was performed by an expert pediatric radiologist focusing on the cause and level of obstruction. Graded compression sonography started from the collapsed loops toward the distended bowel to determine the location and cause of the obstruction. The ultrasound scans were done assessing for the presence of the following views/signs: fluid-filled dilated loops, collapsed loops, the transition point between the dilated proximal and collapsed distal loops, tubular or sausage-shaped dilatation of bowels, valvulae conniventes (stack of coins view), to-and-fro motion of the bowel contents, and the cause of the obstruction at the transition point (**Fig. 1**). Other nonspecific ultrasound signs are peritoneal free fluid, bowel wall thickening, and intra-mural gas.

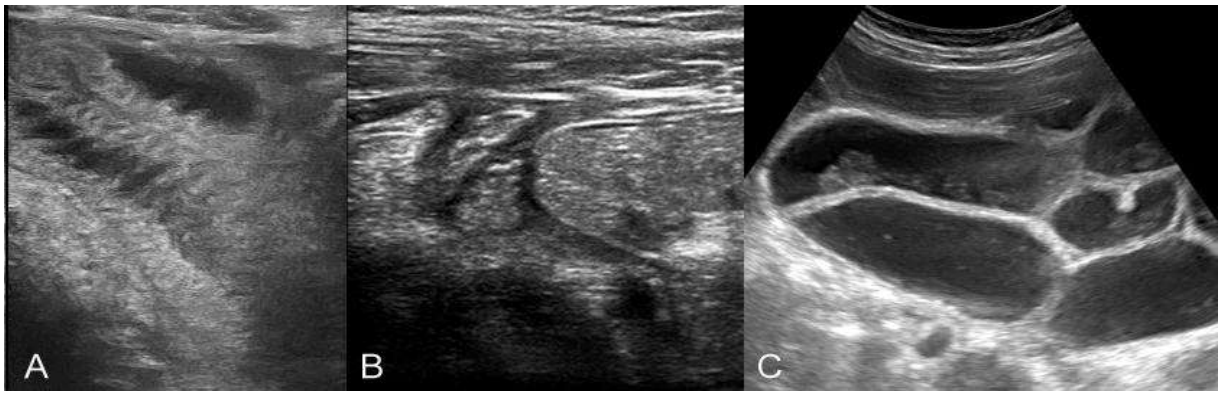

Fig. 1: The sonographic sign of bowel obstruction: A) Visibility of valvulae conniventes as a stack of coin. B) Transit point of obstruction as dilatation and collapse of affected loop due to adhesion. C) Fluid-filled and sausage-shaped dilatation of loops.

After the radiological assessment of bowel obstruction, the patients underwent appropriate medical or surgical procedures such as contrast study, observation, or surgical treatment. Then, they were followed until a final definite diagnosis was made for them. The results of the paraclinical tests were compared with the final postoperative diagnosis.

Data analysis was performed using Statistical Package for the Social Sciences (SPSS; version 16.0 for Windows; IBM Statistics, Chicago, IL, United States). All statistical tests were performed considering $P < 0.05$ as statistically significant.

3- RESULTS

In the current study, 60 cases with bowel obstruction were studied. The subjects had a mean age of 3.05 ± 0.87 years (2 days to 14 years). **Table 1** shows the causes and frequency of bowel obstruction in the participants. Post-operative adhesion with 17 cases (28%) was the most common cause of obstruction in the present study, followed by intestinal atresia (n=10, 16.6%).

3-1. Radiography

Plain radiography revealed a normal pattern (usually honey comb) in 7 cases (15%), while 7 (15%) had the bubble sign and/or decreased abdominal gas with high-

level obstructions (**Table 2**). A Sausage-shaped pattern of low-level obstructions was seen in 34 cases (70 %). Overall, 85% of our patients had abnormal radiographic findings to diagnose obstruction. Among those 7 (15%) patients with normal abdominal gas pattern, partial obstructions due to adhesion and HPS were the corresponding etiologies for obstruction.

Table-1: The frequency of different causes of bowel obstruction among the subjects

Final diagnosis	N (%)	Mean age (month)
Post-operative Adhesion	18 (30)	84
Bowel atresia	10 (17)	<1
Meconium ileus	5 (8)	<1
hirschsprung's disease	3 (5)	2
Appendicular phlegmon	3 (5)	50
Meckel's diverticulum	3 (5)	6
Duodenum web	2 (3)	1
HPS	2 (3)	<1
Annular pancreas	1(1.7)	<1
Bezoar	1(1.7)	72
Immune deficiency	1(1.7)	120
Crohn	1(1.7)	96
Malrotation and Midgut volvulus	1(1.7)	<1
Duplication	1(1.7)	24
Small left colon syndrome	1(1.7)	<1
Typhlitis	1(1.7)	108
perforation	1(1.7)	72
Stricture (post NEC)	1(1.7)	1
Pseudo-obstruction	4 (7)	48
Total	60 (100)	36

HPS: Hypertrophic Pyloric Stenosis. NEC: Necrotizing Enterocolitis

Table-2: Diagnostic findings in the plain radiography of patients

Final diagnosis	Radiographic Diagnosis (N., Percent)	Radiographic pattern (N., Percent)	Normal rectal Gas (N., Percent)
Adhesion, HPS	Normal (7, 15%)	Honeycomb (7, 15%)	4 (8%)
Up to proximal part of jejunum	High-level obstruction (7, 15%)	Bubble sign (7, 15%)	1 (2%)
From mid-jejunum to the anal canal	Low-level obstruction (34, 70%)	Sausage (34, 70%)	7 (14%)

HPS: Hypertrophic Pyloric Stenosis

Regarding rectal gas, plain radiography showed that 24 cases (52%) had no gas in the rectum, 11 cases (24%) had reduced gas, and 11 (24%) had normal gas pattern. Therefore, abnormal rectal gas as decreased or absent was observed in 35 patients (76%).

The bubble sign was found in the obstruction of the gastric outlet, duodenum, and the beginning of the jejunum, while the sausage-shaped pattern was seen in obstructions occurring in the rest of the jejunum, ileum, and colon. The radiographic signs were non-specific for diagnosing the cause of the obstruction.

3-2. Sonography

Table 3 shows the frequency of the cases diagnosed for each modality and the final diagnosis of the patients. Some or all of the sonographic patterns of obstruction, including fluid-filled dilatation of loops, collapsed loops, the transit point, tubular or sausage-shaped dilatation, to-and-fro motion of the bowel contents, and valvulae conniventes (stack of coins) were seen in all patients with 96.6% accuracy. The level and cause of obstruction (specific diagnostic sign for the cause of obstruction) were found in 85% of patients (51 out of 60) with 91.6% accuracy.

Table-3: Results of plain abdominal X-ray and abdominal ultrasound examination for the diagnosis of obstruction and its causes

Imaging modality	Signs	Final diagnosis of patients	
		Obstruction	Ileus
Plain abdominal X-ray	Presence of radiological signs of obstruction	33	1
	lack of radiological signs of obstruction	13	3
Ultrasound	Presence of ultrasound signs of obstruction	56	2
	lack of ultrasound signs of obstruction	0	2
	Ability of ultrasound to diagnose the cause of obstruction	51	0
	Inability of ultrasound to diagnose the cause of obstruction	5	4

A comparison of diagnostic indices between plain abdominal X-ray and sonography is shown in **Table 4**. As can be seen, sonography was more sensitive and specific than plain X-ray in the diagnosis of obstruction and was performed effectively in detecting the cause of obstruction.

Table-4: Comparison of sensitivity, specificity, and accuracy between plain abdominal X-ray and ultrasound imaging

Purpose	Plain abdominal X-ray			Ultrasound imaging		
	Sensitivity	Specificity	Accuracy	Sensitivity	Specificity	Accuracy
Presence of obstruction	71.7%	75%	72%	100%	50%	96.6%
Cause of obstruction	-	-	-	91%	100%	91.6%

4- DISCUSSION

Intestinal obstruction in children is one of the common conditions leading to abdominal surgery. This condition can arise in the first years of life as a complication of congenital malformations and can, in turn, cause life-threatening complications such as midgut volvulus or perforation. Therefore, early diagnosis followed by timely treatment of the complications and underlying causes is of vital importance (1, 2, 11).

Intestinal obstruction manifests a wide range of clinical signs and symptoms, ranging from an asymptomatic and silent development to severe volvulus leading to life-threatening consequences (3).Nevertheless, some conditions such as ileus might mimic intestinal obstruction by presenting similar signs and symptoms. Such conditions should be ruled out cautiously to render accurate diagnoses and prescribe further treatment (4). For the conditions such as intussusceptions and meconium ileus, non-surgical treatments are very effective (12, 13). On this basis, the main concern in patients presenting with signs and symptoms of intestinal obstruction is timely and accurate diagnosis using an appropriate imaging modality (5–7).

Today, imaging modalities such as abdominal radiography and ultrasonography play a significant role in the diagnosis of intestinal obstructions and selection of the best course of treatment (8). The present study aimed to determine the prevalence and etiology of intestinal obstruction in children and to compare the diagnostic value of ultrasonography and radiography in these patients.

In spite of being common underlying causes of intestinal obstruction, considering the difference in diagnostic or therapeutic approaches, intussusception, esophageal atresia, inguinal hernia, and imperforate anus were excluded from this study. Nikavar reported Hirschsprung's disease, invagination, and imperforate anus as the most common causes of intestinal obstruction with relatively equal prevalence (14). Ahmadi et al. stated anorectal malformations and intestinal atresia as the most common causes of obstruction (15). Apart from these excluded cases, we found tissue adhesion to be the leading underlying cause, which is in line with the results reported by Asefa (16). In ultrasound images, adhesion is identified as fixation of loops at the transition point by one or more hypoechoic bands due to fibrinous exudate, and/or by the echogenic band due to fixed omentum or mesentery. Change of diameter and inverted rectosigmoid ratio in the fluid-filled colon of infants can easily be seen in ultrasound images of patients with Hirschsprung’s disease. Sonographic signs of meconium ileus are hypoechoic tubular or beaded intraluminal inspissed meconium within the terminal ileum and floating air bubbles within the fluids in the proximal dilated loops (17) (**Fig. 2**).

Jun et al. reviewed and compared radiography and Computed Tomography (CT) scan for the diagnosis of gastrointestinal obstruction. They found that although radiography is considered a cheaper and highly accessible first step, it should not be regarded as the sole diagnostic criteria due to its limitation to recognize the exact location and severity of the obstruction and the underlying pathology. The researchers concluded that CT scan is the preferred modality for the diagnosis of gastrointestinal obstructions (18). Similarly, our results showed that abdominal X-ray detected the obstructions in 71.7% of the patients with 72% accuracy, which was notably lower compared to ultrasonography and CT scans. The radiographic features of intestinal obstruction were sausage-shaped loops or bubble patterns with or without the presence of gas in the rectum. About

15% of our patients had normal radiographic findings (72% accuracy), while ultrasound could detect all obstructions with 96.6% accuracy and their underlying cause with 96.6% accuracy. These results show a higher accuracy of ultrasound than abdominal radiography in diagnosing bowel obstruction, and especially partial types. In addition, unlike plain abdominal X-rays, ultrasound scans were able to detect the cause of obstruction.

Fig. 2: The sonographic signs in some causes of bowel obstruction: A) duodenal web as septa in the transit point. B) Dilatation of duodenum with claw sign of pancreas in the annular pancreas case. C) Hypoechoic tubular intra-luminal inspissated meconium within the terminal ileum of the meconium ileus and the floating air bubbles within the fluids on the proximal dilated loops. D) Adhesion is presented as the fixation of loops by some of the enveloping hypoechoic bands in the transient point. E) Intraluminal echogenic mass in the bezoar case. F) Inverted rectosigmoid ratio in Hirschsprung's disease.

A study by Silva et al. reported that in patients with the clinical presentation of obstruction, the presence of gas in the intestinal lumen obscures the ultrasonographic view and might lead to lower sensitivity in the diagnosis of obstruction (19). In contrast, ultrasonography showed a more acceptable diagnostic value for intestinal obstruction in our study, as well as helping in the detection of the underlying causes of obstruction.

The increased use of ultrasonography in the initial assessment of intestinal obstruction is stated in some publications (9). In the study by Galeet al., abdominal ultrasonography had high sensitivity and acceptable availability and applicability in the diagnosis of intestinal obstruction (20). Their findings were in agreement with the results of Mwango et al. which introduced

ultrasonography as a reference modality in the diagnosis of intestinal obstruction due to its significant features, including high sensitivity, noninvasiveness, and non-ionizing nature (9).

Until now, ultrasound imaging has been presented as the first imaging modality in diagnosing abdominal pathologies, except for intestinal tract obstructions where its application is limited by the presence of gas in the bowels, while plain X-ray radiography has been recommended (10). Our results showed that ultrasound examination is an accurate diagnostic test in small bowel obstructions. If available, this modality can be the first step in the diagnosis of all abdominal pathologies including gastrointestinal tract obstructions. However, plain radiography and other X-ray modalities have a unique role, especially in the suspicion of obstruction complications such as perforation and in cases where the ultrasound findings are non-diagnostic. Graded compression sonography and starting the examination from the collapsed loops toward the distended bowel can contribute to better visualization of the location and detection of the cause of obstruction.

4-1. Limitations of the study

We recognize some limitations in this study. First, our sample size was small. Another limitation was our available sampling method and having the results only from one center. It is thus advisable to investigate more patients in future studies.

5- CONCLUSION

According to the results of plain abdominal x-ray, in this study, the bubble sign was found in the obstruction of the gastric outlet, duodenum, and the proximal of the jejunum. And the sausage-shaped pattern was seen in obstructions occurring in the rest of the jejunum, ileum, and colon. The partial obstructions may be missed on the abdominal radiography, while ultrasound could detect all obstructions with 96.6% accuracy and their underlying cause with 96.6% accuracy. If available, ultrasound imaging can be used as the first-line imaging modality in the diagnosis of bowel obstructions.

6- ETHICAL CONSIDERATIONS

The Ethics Committee of Mashhad University of Medical Sciences approved this study with the approval code of IR.MUMS.fm.REC.1396.282.

7- CONflICTS OF INTEREST

None.

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