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Diagnostic Accuracy of Ultrasound for Small Bowel Obstruction in Paediatric Population Undergoing Laparotomy Keeping Surgical Findings as the Gold Standard

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ABSTRACT

Objective: To analyze the diagnostic accuracy of ultrasound in small bowel obstruction in the paediatric population and compare it with surgical findings.

Study Design: Cross-sectional study.

Place and Duration of Study: Radiology Department, Pakistan Institute of Medical Sciences, Islamabad Pakistan from Jun 2018 to Jun 2019.

Methodology: This study enrolled 84 paediatric small bowel obstruction cases who underwent exploratory laparotomy at the Pakistan institute of medical sciences from Jun 2018 to Jun 2019. The clinically suspected cases of small bowel obstruction were referred by paediatric surgery to the Radiology department, where an ultrasound abdomen was performed by a senior resident, exclusively targeting the bowel. The clinical, sonological, and per-operative findings were recorded on a proforma.

Results: The mean age in our study was 3.5±2.7 years. A male gender predominance was noted. The most consistent greyscale feature favouring bowel obstruction was dilated bowel loops, found among 98.7% (76 out of 77) of surgically confirmed cases of bowel obstruction. The sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of ultrasound were 98.7%, 71.4%, 97.4%, 83.4% and 94.6% respectively. The sonological cause of obstruction was readily demonstrated among 51 (67%) out of 76 true positive cases. The most common site of obstruction was the distal ileum, with intussusception being the leading cause found among 32% of true positive cases.

Conclusion: The overall diagnostic accuracy of ultrasound in revealing small bowel obstruction is high among the paediatric population.

Keywords: Intestinal obstruction, Intussusception, Small bowel, Ultrasound.

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INTRODUCTION

Intestinal obstruction is one of the few frequently encountered surgical emergencies, especially in the paediatric population, where it can be potentially life-threatening if prompt surgical intervention is not sought.[1] Acute intestinal obstruction occurs when the forward flow of intestinal contents gets interrupted by some mechanical cause. The real dilemma that surgeons and radiologists face when confronted with a possible small bowel obstruction is to confirm or exclude the pathology. Early recognition via clinical and imaging studies is crucial to management because once intestinal ischemia with subsequent bowel infarction or perforation ensues, morbidity and mortality of this condition rise several folds.[2,3] According to a study, intestinal obstruction is responsible for almost 20% of surgical admissions in cases of acute abdomen, among which 60% to 80% are attributable to small bowel obstruction.[4] In the adult population, adhesions and hernias are considered the two most common causes of intestinal obstruction.[5] However, when it comes to the pediatric population, intussusception is by far the commonest etiological factor recognized.[1,4,6] Other important causes in children include obstructed hernia, Meckel diverticulum, adhesions (post-op or tuberculous), worms' infestation, anomalous peritoneal bands and midgut volvulus.[7]

The diagnosis of intestinal obstruction relies upon the classic triad: A thorough clinical history, a detailed physical examination and imaging studies. A clinical diagnosis of intestinal obstruction is usually made in any child with non-passage of stool, abdominal distension, abdominal pain and vomiting,[8] that is further confirmed by clinical signs like empty rectum on digital rectal examination, visible palpable bowel loops, and non-audible or hyperactive bowel sounds.[2] Despite the advancement in the field of radiology, plain radiography of the abdomen remains the starting point of involvement of a radiologist in the workup of

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such cases.[6] The findings on plain X-ray erect abdomen are dilated bowel loops with multiple air-fluid levels.[7] This preliminary diagnosis is further supplemented by ultrasonography of the bowel, which is an invaluable, non-invasive imaging modality in the evaluation of intestinal obstruction, providing a real-time evaluation of the bowel without requiring any contrast media or sedation and addressing various fields of surgeon's interest like the site of obstruction, cause of obstruction, the viability of bowel, presence of any perforation.[6,8] Sonography is as sensitive but far more specific than plain-x rays in the diagnosis of bowel obstruction but has a sensitivity and specificity comparable to that of CT.[9] In a recent meta-analysis of imaging modalities to diagnose small bowel obstruction, it has been concluded that CT scans are associated with increased radiation exposure, delayed time to diagnosis, increased cost and requires a certain expertise level from the radiologist.[10] The presence of dilated bowel (>25 mm) had the highest specificity among the other criteria in diagnosing small intestinal obstruction, while decreased bowel peristalsis had the highest sensitivity (100%) among the other variables but a relatively low specificity.[3] The accuracy of ultrasound in diagnosing bowel obstruction has been established in the adult population at the national and international levels. The rationale of this study was to assess the accuracy of ultrasound exclusively in the paediatric age group where certain other limiting factors hinder correct sonological diagnosis of bowel obstruction.

METHODOLOGY

This cross-sectional validation study was carried out in the Radiology department of Pakistan Institute of Medical Sciences in collaboration with the Paediatric Surgery Department from June 2018 to June 2019. The approval from the Institutional Ethical Review Board (ERC/IERB NO) was taken with ERC/IERB number of F.1-1/2015/ERB/SZAMBU/612. The sample size was calculated by keeping a sensitivity of 97.7% and specificity of 92.7%, and a confidence interval of 95%.[11]

Inclusion Criteria: Paediatric patients from 1 month to 13 years of age who underwent laparotomy due to strong clinical suspicion of bowel obstruction were included in the study.

Exclusion Criteria: Patients with duodenal and jejunal atresia, pseudo-obstruction or post diarrheal distension, chronic constipation history, trauma, and conservatively managed patients were excluded from the study.

Ultrasound examination of the bowel was performed by senior Radiology residents using a high-frequency linear probe (7.5MHz and 10MHz). Informed consent was obtained from all selected cases. The patients were examined in a supine position with-out any special preparation. Interference from gas shadows was avoided by oblique and coronal planes. The small bowel loops were scanned in a general sweep from the epigastrium across the mid abdomen down to the pelvis. Gentle but adequate graded compression was applied to displace gas and bowel contents.

Excessive cry of children, inability to take the optimum position for the scan and restlessness on probe placement were the limiting factors during the scan. The sonographic findings were interpreted based on pre-determined criteria and were documented on a set proforma. Sonologically positive cases included dilated small bowel loops (25mm or above) with an altered pattern of peristalsis (usually absent, to and fro or sluggish) and possible visualization of cause-specific findings like target signs of intussusception, intestinal worms etc. Intergut loop free fluid and bowel wall oedema were additional complementary findings frequently noted. All these patients were returned to paediatric surgery, and the surgeon deci-ded on optimum management upon compiling clinical and imaging findings. As already mentioned, only those cases who underwent laparotomy were included in the study, so the final diagnosis was made on surgical exploration, and the outcome was recorded.

Statistical Package for Social Sciences (SPSS) version 22.0 was used for the data analysis. The record was analyzed to determine the mean age of presentation, gender distribution, cause occurrence, specificity and sensitivity of ultrasound based on the per-operative finding.

RESULTS

The study enrolled 84 candidates who were clinically labelled cases of small bowel obstruction and underwent ultrasound examination followed by exploratory laparotomy. There were 50 males and 35 females. The mean age was 3.5±2.7 years. Sonologically, 78 patients out of this total number of 84 were labelled to have a small bowel obstruction, and on surgical exploration, 76 were confirmed to have an intestinal obstruction (true positive), while two cases were false positive on exploration. Similarly, six patients were sonologically labelled to have no bowel obstruction, which was surgically explored based on surgeons' strong clinical suspicion. Among them, five

were surgically confirmed as negative for obstruction, while only one case came out to be surgically positive. The 2x2 table was used to calculate sensitivity, specificity, and positive and negative predictive values (Table-I).

Table-I: Distribution of Small Bowel Obstruction On Ultrasound and Laparotomy(n=84)

	Positive on Surgical Exploration n (%)	Negative on Surgical Exploration n (%)
Sonologically Positive	76 (90.6)	2 (2.5)
Sonologically Negative	1 (1.2)	5 (5.7)

*Sensitivity= TP/(TP+FN)= 76/(76+1)*100=98.7%, Specificity= TN/(TN+FP)= 5/(5+2)*100=71.4%, Positive Predictive Value= TP/ (TP+FP)*100= 76/(76+2)= 97.4% , Negative Predictive Value= TN/(TN+FN)*100=5/(5+1)= 83.4%, Diagnostic Accuracy=(TP+TN)/ All patients*100 = (76+5)/84 =96.4%*

The sensitivity, specificity, positive predictive value and negative predictive value of ultrasound in the diagnosis of bowel obstruction were 98.7%, 71.4%, 97.4% and 83.4%, respectively.

The various cases of mechanical small bowel obstruction were shown in Table-II. The most common cause of small bowel obstruction was intussusception, found among 24 out of 76 true positive cases (32%), while adhesions were second to this, found among 15 out of 76 true positives (20%). The third common cause was intestinal worms in 11 out of 76 true positive cases (14 percent). Meckel diverticulum with the associated band, bezoars (phytobezoar or trichobezoar), hernia and congenital anomalous bands were next commonly found underlying etiologies. Various surgical interventions, including laparotomy with resection anastomosis, Meckel diverticulum resection, division of adhesions or obstructing bands, were done depending upon the cause of obstruction.

Table-II: Causes of Intestinal Obstruction (on surgical Exploration) (n=76)

Cause of Obstruction	n (%)
Intussusception	24 (31.6)
Worms infestation	15 (19.7)
Adhesions (post-op, tuberculous)	11 (14.5)
Obstructed hernia (Umbilical, Inguinal)	7 (9.2)
Meckel diverticulum with band	5 (6.6)
Bezoars	5 (6.6)
Anomalous bands (Congenital)	5 (6.6)
Midgut volvulus	1 (1.3)
Enteric duplication Cyst	1 (1.3)
Ileal atresia	1 (1.3)
Foreign body	1 (1.3)

DISCUSSION

Small bowel obstruction is a common surgical emergency in all ages with a rising incidence in developing countries, especially among the pediatric population.[12,13] Small bowel obstruction is considered a dynamic pathology, making ultrasound a more accurate diagnostic tool.[14] In 2017 Gottileb *et al.* conducted a meta-analysis of 11 studies of 1178 patients taking into account the role of ultrasound in small bowel obstruction.[10] In this systematic review, ultrasound was 92.4 % sensitive and 96.6% specific for detecting small bowel obstruction. This study highlights that ultrasound can lead to early identification of bowel obstruction cases that need emergent intervention and hence can minimize associated morbidity and mortality. This meta-analysis predominantly included the adult population, while our study population was exclu-sively pediatric, with a comparable ultrasound sensitivity of 97.8% but a relatively lower specificity of 72%. In our study, we had two false positive cases, among which one sonologically misdiagnosed case of a nine-year-old child who had borderline bowel dilatation with poor peristalsis was later confirmed to be a case of tuberculous enterocolitis. The second false positive case was that of a five years old child with Hirschsprung disease. The only false negative case in our study was a case of phytobezoar in the distal ileum per-operatively. The possible explanation for this false negative sonological finding could be an operator-dependent variation in diagnosis or an early scan with less well-established sonological signs of obstruction at the time of the scan. True negative cases in our study were five with variable surgical findings. Two of them were with pseudo appendicular mass. The most important sonographic feature is dilated gut loops, and diagnosis cannot be established solely based on ineffective peristalsis.[5,15]

The importance of ultrasound lies not only in detecting the small bowel obstruction but also has a high likelihood of answering the cause of it in a significant number of cases.[16] The most common site of obstruction was the distal ileum, as confirmed surgically. In a national paper by Halepota *et al.* published in 2018, the ileum remained the commonest site of obstruction among children.[4] Our study demonstrated sonological cause in 51 out of 76 true positive cases, including intussusception, worms, obstructed hernia, and enteric duplication cyst. While sonologically occult true positive cases were 25 and causes included adhesions, Meckel diverticulum with the meso-diverticular band, congenital bands, bezoars and foreign

body. In 2015 Hazra *et al*. published a paper suggesting intussusception as the leading cause of pediatric small bowel obstruction.[1] A review of world literature has further supplemented the data on intussusception as the commonest cause of bowel obstruction.[4 6,17] However, the second common cause remains variable in different works of literature, i-e., Meckel diverticulum was second to intussusception in a study conducted in Nepal Tertiary care hospital by Hazra *et al*.[1] and ascariasis in another international study by Ooko *et al*.[13] In our cases, adhesions were the second commonest cause found. Among the cases of intussusception, 24/76, the commonest underlying aetiology was enlarged mesenteric lymph nodes, while the commonest type recognized on surgical exploration was ileocolic/ileocecocolic. Compared to the previous studies, worms' infestation, ascariasis, remained the third leading cause of SBO, found among 11/76 no of cases which was quite high compared to the previous studies.[16,17,18] Abdominal Tuberculosis was confirmed in three of our cases, with the affected cases showing adhesions obstructing the small bowel loops.

One other aspect of the role of ultrasound in SBO was to address the complications like intestinal gangrene evident as edematous bowel loop with reduced mural vascularity and perforation, which in some cases was evident as complex abdominopelvic ascites and the presence of faecal contents within peritoneal cavity.[19,20]

CONCLUSION

The overall diagnostic accuracy of ultrasound in revealing small bowel obstruction is high in expert hands. It can precisely determine the presence of pathology in most cases, thus limiting the need for alternative imaging approaches like CT. In addition, it can minimize the cost of surgical care by avoiding unnecessary operative interventions.

Conflict of Interest: None.

Author's Contribution

RL: Article writing, data collection and analysis, AIM: Supervision, data interpretation, BL: Data collection, statistical analysis, AS: Data Collection, article writing, RR: Statistical analysis, SA: Data collection.

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