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Diagnostic Accuracy of Sonographic Findings of Intestinal Intussusception in Paediatric Population with Surgical Outcomes as Gold Standard

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ABSTRACT

Background: Intestinal intussusception in children is an emergent condition requiring early diagnosis and management to prevent complications. While initially less invasive and more cost-effective ultrasound is commonly utilized for detection, the sensitivity of ultrasound for diagnosis of intussusception in relation to surgical exploration is an area that needs further study. **Objective:** To determine the diagnostic accuracy of sonographic findings in identifying intestinal intussusception in the pediatric population, with surgical outcomes serving as the gold standard for comparison. **Study Design:** This is a cross-sectional validation study conducted at the Department of Diagnostic Radiology, Ali Fatima Hospital, Lahore. **Duration and Place of Study:** The study was conducted from August 2024 to February 2025. **Methodology:** The study included 216 pediatric patients under 12 years of age, presenting with clinical symptoms indicative of intussusception, including colicky abdominal pain, vomiting, and red jelly-like stools. Ultrasound was performed using a Philips EPIQ 7G machine, and the results were compared with surgical outcomes. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated to determine the diagnostic accuracy of ultrasound. **Results:** The study found that ultrasound had a sensitivity of 82.5%, specificity of 50%, diagnostic accuracy of 73%, PPV of 80.1%, and NPV of 53%. Stratified analysis showed variability based on age, gender, and symptom duration. Ultrasound demonstrated higher sensitivity in patients older than 6 years (100%), while specificity decreased to 0%. **Conclusion:** Ultrasound is a moderately effective diagnostic tool for intussusception in pediatric patients.

INTRODUCTION

Intestinal intussusception is a serious medical condition in children in which one piece of intestine pushes into another and obstructs the intestine.[1] Intussusception occurs predominantly in infants and toddlers aged 3 months to 3 years.[2] Intussusception in the majority is of unknown cause although it can be provoked by a viral disease or abnormal growths in the intestine like polyps.[3] The onset is acute in the majority and can be with severe pain in the abdomen, vomiting, bloody diarrhea, and an abdominal mass that can be palpated.[4] Intussusception can result in ischemia, necrosis, and rupture of the involved intestine if left untreated; thus, it should be identified and treated early to reduce morbidity and mortality in children.[5]

It is important to make an accurate diagnosis of intussusception in children in order to treat it effectively. Conventionally, intussusception has been diagnosed on clinical grounds and on radiological examinations. But clinical presentation can be non-specific in nature, and hence, imaging is essential to arrive at a final diagnosis.

Intussusception can be definitively diagnosed with surgical exploration as it gives a direct visual of the involved bowel.[6] Nevertheless, non-invasive modalities such as ultrasound are assuming greater roles in pediatric practice.[7] Various medical equipment like the abdominal X-ray, contrast enema, and ultrasound allow clinicians to visualize the bowels telescoping into one another, establish a final diagnosis, and differentiate intussusception from other conditions with similar presentations such as gastrointestinal anomalies.[8]

Ultrasonography is an optimal imaging modality in pediatric intussusception because it is non-invasive, quickly made available, and radiation-free.[9] It is especially valuable in pediatric cases since ionizing radiation exposure must be avoided in this population.[9] The modality is exceedingly effective in delivering an accurate diagnosis because it has shown to be highly sensitive and specific in studies to detect intussusception.[10] The ultrasound findings in pediatric intussusception are highly specific and are an important key to the diagnosis of the illness. The classical ultrasound pattern of intussusception

is the "target sign," with concentric rings of different echogenicities formed by the mucosa, muscularis, and submucosa of the intestine.[11] Free fluid in the area surrounding the intussuscepted mass can be identified and represents impending intestinal ischemia and the subject of emergent intervention.[11] Ultrasound accuracy in diagnosing intussusception is also documented by its high sensitivity and high specificity in studies to detect intussusception such that it is an effective modality in pediatric emergency care that can both diagnose and exclude the process.[12]

In a study by Dadlani et al.,[13] 143 patients with suspected intussusception were evaluated using ultrasonography, with 117 (81.8%) ultimately confirmed to have the condition during surgery, while 26 (18%) were found not to have intussusception upon surgical exploration. The diagnostic performance of ultrasonography in detecting intussusception was assessed, showing a sensitivity of 80.7% (95% CI: 73.5 to 86.3), specificity of 52.7% (95% CI: 39.79 to 65.31), positive predictive value of 81.8% (95% CI: 74.7 to 87.3), negative predictive value of 50.9% (95% CI: 38.3 to 63.4), and overall accuracy of 73% (95% CI: 66.46 to 78.68). In a separate study by Gul et al.,[14] which included 109 male patients (56.8%) and 83 female patients (43.2%), with a mean age of 4.3 ± 2.3 years, ultrasound and surgical findings were compared. Intussusception was correctly identified in 26 patients i.e. 14.4% (true positives) and excluded in 154 patients (true negatives). The ultrasound demonstrated an overall sensitivity of 83.9%, specificity of 95.7%, and diagnostic accuracy of 93.7%.[14]

This research is significant in assessing the accuracy of sonographic findings in the detection of intestinal intussusception in the pediatric patient. Accurate and timely diagnosis is important in order to prevent unnecessary surgery and to institute timely intervention with a potential diminishment in complications. Because ultrasound is a non-invasive modality with universal accessibility, its effectiveness in diagnosing intussusception will refine clinical practice, improve patient outcomes, and lower costs by lessening the amount of other procedures or imaging modality required.

METHODOLOGY

This cross-sectional study was conducted at the Department of Diagnostic Radiology, Ali Fatima Hospital, Lahore, from August 2024 to February 2025. The sample size of 216 was calculated using the WHO sample size calculator, keeping a sensitivity of 83.9%[14] and 52.7%[13] specificity of ultrasound in diagnosing intussusception, 95% confidence level, and 13% absolute precision and expected prevalence of 14.4%.[14]

Inclusion criteria consisted of male and female children under 12 years of age, presenting with the classic clinical triad of intussusception—colicky abdominal pain, vomiting, and red jelly-like stools for the past five hours. Only those who had failed barium enema reduction and were scheduled for surgical intervention were included. The exclusion criteria involved children whose excessive crying caused a gaseous abdomen, hindering proper

visualization during ultrasound. In such cases, low-dose CT abdomen was recommended for confirmation.

Informed consent was obtained from the parents or legal guardians before proceeding. Demographic data, including names, ages, genders, and symptom duration, were recorded. Each patient underwent ultrasound using the Philips EPIQ 7G machine with 3.5 MHz and 8.0 MHz probes, and the images were assessed by an experienced consultant radiologist based on specific sonographic features indicative of intussusception. These features included the target sign (concentric alternating bands with varying echogenicity), pseudokidney sign (longitudinal appearance of the intussuscepted bowel segment), crescent in a doughnut sign (a variation of the target sign), free fluid (suggesting poor reproducibility), and absent blood flow (indicating ischemia and necrosis). These criteria were used to determine whether the ultrasound result suggested intussusception.

Following ultrasound assessment, all patients underwent surgical treatment by a team of two consultant surgeons with over five years of experience. Surgical findings were used to confirm the presence or absence of intussusception, with diagnosis based on visual identification of bowel telescoping, palpation of a "sausage-shaped" mass, and observation of bowel obstruction signs such as distention and compromised blood flow in the affected bowel.

The diagnostic accuracy was evaluated by comparing ultrasound findings to surgical outcomes. Sensitivity, specificity, positive predictive value, and negative predictive value were calculated using a 2x2 contingency table. Continuous variables such as age and symptom duration were analyzed using mean and standard deviation, while categorical variables, including gender and diagnostic outcomes from ultrasound and surgery, were presented as frequencies and percentages. Stratification was performed based on age and gender to assess the impact of these factors on diagnostic accuracy. Data analysis was performed using SPSS version 27.

RESULTS

The demographic data from Table-I revealed that the average age of the patients was 2.8 ± 1.5 years, with a symptom duration of 11.3 ± 3.6 hours. Of the 216 patients, 137 (63.4%) were male, and 79 (36.6%) were female.

Table I

Patient Demographics

Demographics		Mean ± SD / n (%)
Age (years)		2.796±1.51
Duration of Symptoms (hours)		11.282±3.61
Gender	Male	137 (63.4%)
	Female	79 (36.6%)

Table-II summarized the overall ultrasound and surgical results for diagnosing intestinal intussusception, showing that 158 (73.1%) patients tested positive for both ultrasound and surgery, while 58 (26.9%) tested negative.

Table II

Overall results of Ultrasound and Surgery in diagnosis of Intestinal Intussusception

Intestinal Intussusception	Ultrasound	Surgery
Positive	158(73.1%)	154(71.3%)

Negative	58(26.9%)	62(28.7%)
Total	**216 (100%)**	**216 (100%)**

In the comparison between ultrasound and surgery results presented in Table-III, there were 127 true positives (TP), 31 false positives (FP), 27 false negatives (FN), and 31 true negatives (TN), with a statistically significant chi-square value of 23.72 and a p-value of 0.000. This highlights the accuracy of the ultrasound in detecting intestinal intussusception.

Table III
Comparison of Ultrasound versus Surgery in diagnosis of Intestinal Intussusception

Ultrasound	Surgery		Total
	Positive	**Negative**	
Positive	127 (TP)	31 (FP)	158
Negative	27 (FN)	31 (TN)	58
Total	154	62	216

Chi square = 23.72
P value = 0.000
Key:
TP = True positive
FP = False positive
FN = False negative
TN = True negative

As shown in Table-IV, the diagnostic performance of ultrasound revealed a sensitivity of 82.5%, specificity of 50%, diagnostic accuracy of 73%, positive predictive value (PPV) of 80.1%, and a negative predictive value (NPV) of 53%.

TableIV
Sensitivity, Specificity, Diagnostic Accuracy, PPV and NPV of ultrasound in diagnosis of Intestinal Intussusception

Diagnostic Parameter	Result
Sensitivity	82.5%
Specificity	50%
Diagnostic Accuracy	73%
PPV	80.1%
NPV	53%

Table-V, which presents a stratified analysis by age, gender, and duration of symptoms, indicates that for patients aged 1-6 years, the sensitivity was 82%, specificity 53%, diagnostic accuracy (DA) 74%, PPV 82%, and NPV 53%. In contrast, for patients older than 6 years, sensitivity increased to 100%, while specificity dropped to 0%. This resulted in a diagnostic accuracy of 57%, PPV of 57%, and NPV of 0%. Regarding gender, males showed a sensitivity of 74%, specificity of 63%, diagnostic accuracy of 70%, PPV of 78%, and NPV of 57%. Females had a higher sensitivity of 94%, but their specificity was 0%, leading to a diagnostic accuracy of 78%, PPV of 83%, and NPV of 0%. In terms of duration of symptoms, patients with symptoms lasting 10 days or fewer had a sensitivity of 74%, specificity of 29%, DA of 59%, PPV of 68%, and NPV of 34%. In contrast, for patients with symptoms lasting longer than 10 days, sensitivity rose to 90%, specificity increased to 78%, DA reached 87%, PPV was 92%, and NPV was 72%.
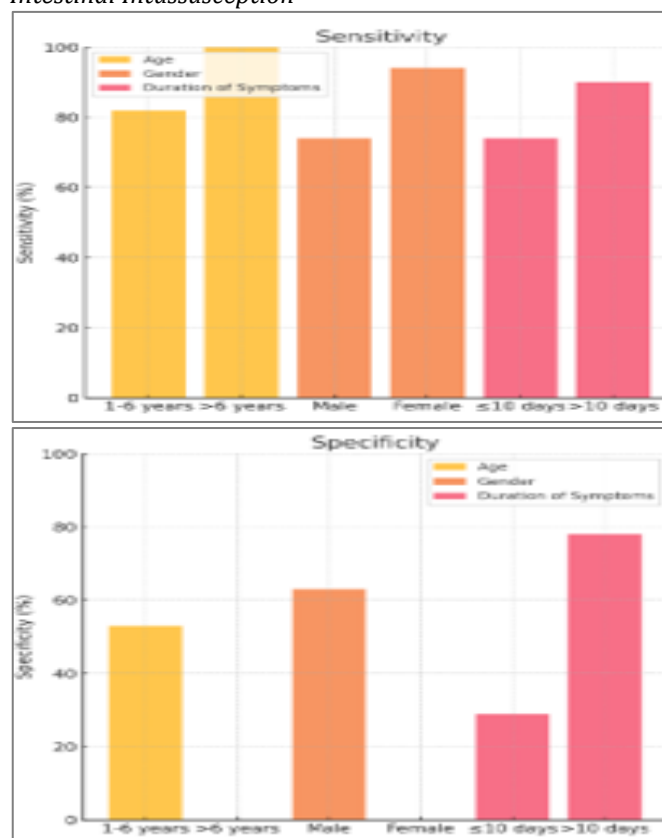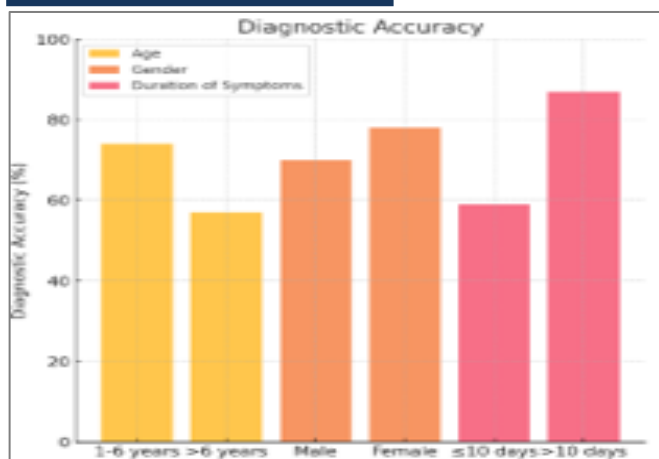
Table V
Stratified analysis of Sensitivity, Specificity, Diagnostic Accuracy, PPV and NPV of ultrasound in diagnosis of Intestinal Intussusception with age, gender and duration of symptoms

Variables	Groups	Diagnostic Parameter	Result
Age (years)	1-6	Sen	82%
		Spec	53%
		DA	74%
		PPV	82%
		NPV	53%
	>6	Sen	100%
		Spec	0%
		DA	57%
		PPV	57%
		NPV	0%
Gender	Male	Sen	74%
		Spec	63%
		DA	70%
		PPV	78%
		NPV	57%
	Female	Sen	94%
		Spec	0%
		DA	78%
		PPV	83%
		NPV	0%
Duration of symptoms (days)	≤10	Sen	74%
		Spec	29%
		DA	59%
		PPV	68%
		NPV	34%
	>10	Sen	90%
		Spec	78%
		DA	87%
		PPV	92%
		NPV	72%

Graph I
Stratified analysis of Sensitivity, Specificity, Diagnostic Accuracy, PPV and NPV of ultrasound in diagnosis of Intestinal Intussusception

DISCUSSION

The results of this research demonstrate ultrasound as a moderate-level effective diagnostic tool in intestinal intussusception, with sensitivity, specificity, and diagnostic accuracy varying in groups of patients by age, gender, and symptom duration.

The sensitivity of ultrasound overall was 82.5%, suggesting it identifies most cases of intussusception correctly. The specificity was lower at 50%, suggesting ultrasound tends to produce a large number of false positives. This might be due to the presentation of other conditions of the gastrointestinal system, whose presentation mimics that of intussusception. The diagnostic accuracy of 73% is quite good, but there is definitely room for improvement in separating true positives from true negatives, a function partly of operator expertise as well as variability of the patient.

Stratified analysis revealed maximum sensitivity in children older than the age of 6 years (100%), suggesting ultrasound might be extremely effective in older children, perhaps due to more clear-cut radiological as well as clinical findings in this age group. Specificity dropped to 0% in this age group, most likely due to overdiagnosis, with instances of non-intussusception wrongly diagnosed as positive. In younger children (1-6 years of age), sensitivity was reduced (82%), but specificity was better (53%), suggesting ultrasound might be more effective in ruling out false positives in this age group.

Gender-based evaluation showed a higher sensitivity in women (94%) compared with men (74%). This can be explained by anatomical or physiological reasons by which intussusception is more readily identified in women. The specificity in women, however, was lower (0%), indicating a larger proportion of false positives in this subgroup.

Finally, the symptom duration was a highly predictive criterion, with a sensitivity of 74% in cases of up to 10 days, yet higher sensitivity, at 90%, in cases with more than 10 days of symptoms. This would suggest more symptomatic cases for a longer duration are more easily picked up by ultrasound given the higher stage of severity and characteristic presentation in these cases. Specificity was also higher in cases of a longer symptom period (78%), demonstrating ultrasound's higher reliability in identifying true positives in these cases.

Dadlani et al. [15] evaluated the effectiveness of ultrasound in diagnosing intussusception in 200 children aged under 12 years, with a mean age of 6.7 ± 2.8 years. The study found that ultrasound detected intussusception in 143 cases (81.8%) and failed to detect the condition in 57 cases. The sensitivity was 80.2%, specificity was 90.0%, and the overall diagnostic accuracy was 85.5%. These results are similar to our study in terms of ultrasound's ability to detect intussusception with moderate sensitivity and high specificity, although our specificity was lower (50%) and diagnostic accuracy was also somewhat lower (73%) compared to Dadlani et al. This could be attributed to differences in sample size, geographical factors, or clinical setting.

Ashraf et al.[16] studied 54 patients with an age range that spanned from 3 months to 12 years, whose mean age was not specified. Intussusception was confirmed by ultrasound in 41 (75.9%) children, while 13 (4.1%) remained undetected. The sensitivity was 81.6%, specificity was 80%, with an accuracy rate for diagnosis at 81.5%. The positive predictive value was 97.6%, with negative predictive value (NPV) at 30.8%. The author's conclusion was that ultrasound is a sensitive, accurate test with high positive predictive value and specificity for diagnosing intussusception.

Ali et al.[17] examined 127 patients with an age range from 3 months to 12 years with a mean age of 6.5 ± 3.4 years. Ultrasound's sensitivity rate was 82.93%, specificity rate was 91.11%, PPV rate was 94.44%, and NPV rate was 74.55%. The accuracy rate was 85.83%. The researchers emphasized that early diagnosis is attainable with an efficient modality such as ultrasound, facilitating early intervention and prevention of complications.

Asmast et al. [18] studied 170 children with an age group from 4 months to 12 years with an average age of 3.56 ± 3.29 years. The study concluded that there was a sensitivity of 85.05%, specificity of 90.48%, PPV of 78.08%, and an NPV of 93.81%, with an overall accuracy rate of 87.06%. The study concluded that early diagnosis and early management of intussusception is feasible by employing an ultrasound as a compulsory diagnostic aid, thus improving outcomes in patients.

Aqeel et al. [19] conducted research on 125 children under the age of 6 years with an average age of 1.75 years. Ultrasound had a sensitivity rate of 91.95%, specificity rate of 78.95%, PPV rate of 90.91%, NPV rate of 81.08%, and an overall accuracy rate of 88%. The study justified the use of ultrasound as a first-line diagnosis given that it is non-invasive with high diagnostic efficiency.

Rahmani et al. [20] performed a systematic review and meta-analysis, including 37 studies. The pooled sensitivity and specificity of ultrasound for diagnosing intussusception were 96% and 97%, respectively. The positive likelihood ratio (PLR) was 24.57, and the negative likelihood ratio (NLR) was 0.05, indicating excellent diagnostic performance. The area under the hierarchical summary receiver operating characteristic (HSROC) curve was 0.989. The study found that point-of-care ultrasound (POCUS) performed by emergency physicians (EPs) had diagnostic accuracy similar to that of radiologist-

performed ultrasound (RADUS), supporting its use in emergency departments.

Nazir et al. [21] studied 225 children aged 4 months to 12 years, with ultrasound detecting intussusception in 186 cases (82.7%). The sensitivity of ultrasound was found to be 99%, specificity was 100%, PPV was 100%, and NPV was 97%, with a diagnostic accuracy of 99%. The study concluded that ultrasound is a highly effective, non-invasive diagnostic tool for intussusception with exceptional sensitivity and specificity.

For the age group of 1-6 years, sensitivity was 82%, specificity was 53%, DA was 74%, PPV was 82%, and NPV was 53%. On the other hand, for above the age of 6 years, sensitivity was 100% while specificity was decreased to 0%, resulting in a diagnostic accuracy of 57%, PPV of 57%, and NPV of 0%. These are in agreement with Dadlani et al. [15] and Asmat et al. [18] in whom ultrasound performance was affected by age. Regarding gender, males showed a sensitivity of 74%, a specificity of 63%, DA of 70%, PPV of 78%, and NPV of 57%, while females showed a higher sensitivity of 94%, but specificity was 0%, resulting in a diagnostic accuracy of 78%, a PPV of 83%, and NPV of 0%. These are consistent with Aqeel et al. [19] in whom gender difference in sensitivity was observed while specificity was also observed. For symptom duration, for up to 10 days, sensitivity was 74%, specificity was 29%, DA was 59%, PPV was 68%, and NPV was 34%. For more than 10 days, sensitivity was 90%, specificity was 78%, DA was 87%, PPV was 92%, but NPV was 72%. These are consistent with Dadlani et al. [15] and Rahmani et al. [20] in whom symptom duration was a significant criterion for improving diagnostic performance.

These variations in sensitivity, specificity, and accuracy in research can be attributed to a discrepancy in sample size, patient demographics, operator competence, and clinical settings. Despite the inconsistencies,

ultrasound is a valuable tool for diagnostic use, especially in the urgent setting, with a sound trade-off of accuracy, speed, and tolerance by the patient.

There are several limitations in this research. The study was a single-centre study, which limits the generalizability of the results in other settings with different populations or health organizations. The sample size, while adequate, could be larger in size in order further to increase the statistical power of the results. The study employed a single imaging modality (ultrasound) but not a blend of imaging modalities, e.g., barium enema or CT, with potentially complementary information. Finally, operator skill would also affect the sensitivity and specificity of ultrasound, as the skill of radiologists who use it may not be the same. Future multi-centre studies with larger numbers of subjects involving a larger range of diagnostic tools would help validate our results.

CONCLUSION

Our study has shown ultrasound to be a safe, effective diagnostic tool in pediatric populations for detecting intussusception. Unlike a degree of divergence in diagnostic accuracy between groups, ultrasound is a cost-effective, non-invasive, readily accessible early detection technique. The results are consistent with its utility in everyday practice, in the emergency setting, where early diagnosis has the most impact as a preventative for complications. However, further studies in larger, multi-centre populations are needed in a bid to prove these results, as well as to see if further improvements in diagnostic performance can be made.

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