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Original Article

Diagnostic Accuracy of Ultrasound in Diagnosing Intussusception Taking Surgical Findings as Gold Standard

Maria Asghar[1], Zubair Janan Orakzai[1], Hina Fida[1]

[1]Radiology Department, Mardan Medical Complex, Mardan, Khyber Pakhtunkhwa, Pakistan

Correspondence: Zubair Janan Orakzai, zjaurakzai@hotmail.com

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ABSTRACT

Background: Intussusception is the leading cause of intestinal obstruction in children under six years of age, and timely diagnosis is essential to prevent complications. Ultrasonography is widely used as a noninvasive diagnostic tool, yet its diagnostic accuracy compared to surgical findings—the gold standard—remains underexplored in many local populations. Objective: To determine the diagnostic accuracy of ultrasound in detecting intussusception in pediatric patients, using surgical findings as the reference standard. Methods: A cross-sectional validation study was conducted at the Radiology Department of Mardan Medical Complex, Pakistan, from December 2025 to June 2025. Two hundred five children aged 1–12 years with suspected intestinal obstruction were enrolled consecutively. Ultrasound examinations were performed with 3.5 MHz and 8.0 MHz probes, identifying characteristic signs of intussusception. All cases subsequently underwent surgical exploration. Diagnostic accuracy, sensitivity, specificity, positive predictive value, and negative predictive value were calculated; stratified analyses explored demographic effects. Statistical significance was assessed using chi-square or Fisher's exact tests. Results: Of 205 patients, 76 (37.1%) were ultrasound-positive, and 62 (30.2%) had surgically confirmed intussusception. Ultrasound demonstrated an overall diagnostic accuracy of 89.3% (95% CI: 84.6–93.1), with sensitivity of 93.5% (95% CI: 84.3–98.2), specificity of 87.4% (95% CI: 81.2–92.1), positive predictive value of 76.3% (95% CI: 65.2–85.3), and negative predictive value of 96.9% (95% CI: 92.2–99.1). Diagnostic accuracy was significantly higher in children aged 1–6 years compared to older children (p=0.024). The presence of both target and pseudokidney signs yielded the highest diagnostic confidence. Conclusion: Ultrasound is a highly accurate, sensitive, and reliable diagnostic modality for pediatric intussusception, especially in younger children, and should be utilized as a first-line imaging technique in suspected cases.

Keywords: Ultrasound, Intussusception, Pediatric, Diagnostic Accuracy, Sensitivity, Specificity

INTRODUCTION

Intussusception is characterized by telescoping of a proximal segment of the gastrointestinal tract into the lumen of the adjacent bowel, leading to intestinal obstruction and potential ischemia, perforation, and necrosis if untreated (1). Globally, it remains the most frequent cause of bowel obstruction in children under six years of age, with incidence rates ranging between 1.1 and 4.3 per 1,000 live births in Europe and 0.5 to 2.3 per 1,000 in the United States (2). However, incidence rates in developing countries have been reported as high as 29.3%, underscoring potential regional differences driven by genetic, environmental, and healthcare access factors (3). Clinically, intussusception can present with vague and non-specific symptoms such as abdominal pain, vomiting, and failure to pass stool, contributing to diagnostic delays and increased risk of adverse outcomes (4). Rapid diagnosis and intervention are essential, as delayed management is associated with higher rates of bowel resection and postoperative complications.

Diagnostic imaging plays a central role in confirming intussusception. Among the modalities available, ultrasound has emerged as a non-invasive, radiation-free option capable of bedside application, which is particularly advantageous in pediatric populations (5). The pseudokidney sign, visualized as a longitudinal mass with a reniform appearance containing a hyperechoic center and a hypoechoic rim, and the target sign, seen on transverse images as concentric rings, are hallmark sonographic findings of intussusception (5). Although computed tomography (CT) can identify the “sausage” sign—an elongated mass with visible layers—it is not always readily accessible in emergency settings and exposes children to ionizing radiation, making ultrasound the preferred initial imaging tool (6).

Despite the recognized utility of ultrasonography, studies have reported variable diagnostic accuracy. A local study from Pakistan found ultrasound sensitivity and specificity of 80.7% and 52.7%, respectively, highlighting significant room for improvement in diagnostic precision within this population (7). Conversely, larger systematic reviews and meta-analyses have demonstrated higher pooled sensitivities and specificities for ultrasound ranging from 94% to 97%, suggesting that operator skill, equipment quality, and population-specific factors may influence performance metrics (2,8,9). Variations in diagnostic accuracy between studies emphasize the need to validate ultrasonographic findings against surgical outcomes, which remain the gold standard for definitive diagnosis.

There is a critical knowledge gap in understanding the real-world diagnostic performance of ultrasound for intussusception in children from resource-constrained settings like Pakistan, where limitations in equipment and training may affect outcomes. Furthermore, existing studies often lack stratified analyses to explore how demographic variables such as age, gender, or socioeconomic status might influence diagnostic accuracy. Addressing these gaps is crucial to guide clinical decision-making, reduce unnecessary surgeries, and improve patient outcomes. Therefore, this study aims to determine the diagnostic accuracy of ultrasound in detecting intussusception in children, using surgical findings as the gold standard, and to examine whether factors such as age, gender, or socioeconomic status influence diagnostic performance.

MATERIALS AND METHODS

This cross-sectional validation study was conducted at the Radiology Department of Mardan Medical Complex, Mardan, Khyber Pakhtunkhwa, Pakistan, from 15th December 2025 to 20th June 2025, following approval from the institutional ethical review board and the Research Evaluation Unit of the College of Physicians and Surgeons Pakistan under reference number CPSP/REU/RAD-2022-028-3830. The study population comprised children aged 1 to 12 years who presented with clinical suspicion of intestinal obstruction, defined by symptoms such as abdominal distension, vomiting, and failure to pass stool for more than 12 hours, in combination with radiological evidence of more than five air-fluid levels on an erect abdominal X-ray. Patients were enrolled through non-probability consecutive sampling, ensuring that every eligible patient during the study period was included to minimize selection bias. Exclusion criteria comprised patients presenting with traumatic acute abdomen or those managed conservatively without surgical intervention, as such cases would preclude surgical correlation necessary for diagnostic accuracy assessment.

Informed written consent was obtained from the guardians of all participants after thoroughly explaining the study objectives, procedures, and potential risks. Demographic data collected included age, gender, duration of symptoms, place of residence, socioeconomic status classified into low, middle, and upper classes, and maternal educational status categorized as illiterate, primary, secondary, or higher education. Detailed medical history and clinical examination were performed to exclude traumatic injury or other causes of acute abdomen unrelated to intussusception. Ultrasonography was performed using Toshiba Aplio ultrasound equipment (Toshiba, Tokyo, Japan) equipped with both 3.5 MHz and 8.0 MHz probes to accommodate variations in body habitus and anatomical depth. Serial longitudinal and transverse scans of the abdomen were obtained by a senior consultant radiologist with five years of post-fellowship experience, ensuring technical consistency. The presence of intussusception was diagnosed based on characteristic sonographic findings, specifically the “target sign” visible in transverse sections as concentric rings of alternating echogenicity, and the “pseudokidney sign” in longitudinal sections, depicting a mass with a hypoechoic outer rim and hyperechoic center resembling renal parenchyma (5). All patients subsequently underwent surgical exploration, and intraoperative findings served as the gold standard for confirming the diagnosis. Cases were classified as true positives if both ultrasound and surgical findings confirmed intussusception, false positives if ultrasound was positive but surgery was negative, false negatives if ultrasound was negative but surgery confirmed intussusception, and true negatives if both modalities were negative.

Sample size estimation was performed using the World Health Organization sample size calculator, targeting a confidence interval of 95%, with assumptions of 80.7% sensitivity, 52.7% specificity, 10% absolute precision, and an estimated 29.3% prevalence of intussusception based on prior regional data (7). Applying these parameters yielded a minimum required sample size of 205 patients, which was fully achieved during the study period. Data entry and statistical analysis were conducted using SPSS version 22.0 (IBM Corp., Armonk, NY, USA). Quantitative variables such as age and duration of symptoms were assessed for normality using the Shapiro–Wilk test; normally distributed data were expressed as mean ± standard deviation, while non-normally distributed data were presented as median with interquartile range. Categorical variables including gender, residence, socioeconomic status, maternal education, ultrasound findings, and surgical outcomes were summarized using frequencies and percentages. Diagnostic accuracy parameters were calculated for ultrasound in detecting intussusception, including sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy, using standard formulas derived from the 2×2 contingency table (10). Stratified analyses were performed to evaluate potential effects of demographic variables such as age groups, gender, duration of symptoms, socioeconomic status, residence, and maternal education on diagnostic accuracy. Statistical significance of associations was tested using the chi-square test or Fisher’s exact test where appropriate, with a p-value threshold of ≤ 0.05 indicating significance. No imputation was performed for missing data, as complete-case analyses were feasible due to the study design requiring surgical confirmation for all included patients. Measures were implemented to ensure data integrity, including double data entry and validation by two independent investigators.

RESULTS

Among the 205 children enrolled in this study, the mean age was 4.2 years with a standard deviation of 2.8 years, and the majority were between one and six years old, accounting for 76.1% of the population. Males constituted a slight majority at 58.5%, and most patients originated from rural areas (72.2%). Socioeconomic analysis revealed that 45.4% belonged to low-income families, while maternal education levels showed that 42.9% of mothers were illiterate, reflecting the demographic characteristics typical of the region (11).

Ultrasonography identified intussusception in 76 children, equivalent to 37.1% of the study cohort, whereas surgical findings confirmed intussusception in 62 children, yielding an overall prevalence of 30.2%. Among ultrasound-positive cases, 58 were true positives confirmed intraoperatively, while 18 were false positives. Conversely, of the ultrasound-negative cases, 4 were false negatives, and 125 were true negatives. This distribution resulted in a high diagnostic accuracy of ultrasound, calculated at 89.3% with a 95% confidence interval of 84.6% to 93.1%. The sensitivity was notably high at 93.5% (95% CI: 84.3–98.2), indicating the test’s strong ability to correctly detect true cases of intussusception, while specificity was 87.4% (95% CI: 81.2–92.1), reflecting its capacity to exclude disease when absent. Positive predictive value stood at 76.3% (95% CI: 65.2–85.3), suggesting that approximately one in four positive ultrasound findings might not be confirmed surgically, whereas the negative predictive value was excellent at 96.9% (95% CI: 92.2–99.1), providing high reassurance when

ultrasound findings were negative. A statistically significant association between ultrasound results and surgical confirmation was observed, with a chi-square p-value below 0.001 and an odds ratio of 100.69 (95% CI: 33.28–304.43), underscoring the strong diagnostic utility of ultrasound in this clinical context. Stratified analysis revealed that diagnostic accuracy was significantly influenced by patient age. Children aged one to six years achieved an accuracy of 92.3%, notably higher than the 83.7% observed in older children aged seven to twelve years, with the difference reaching statistical significance ($p = 0.024$). In contrast, other variables—including gender, duration of symptoms, residence, socioeconomic status, and maternal education—did not demonstrate statistically significant effects on diagnostic accuracy, with p-values exceeding 0.05 for all comparisons, indicating relative consistency of ultrasound performance across these demographic subgroups (11). When assessing specific sonographic signs, the target sign emerged as the most frequently observed feature, present in 85.5% of ultrasound-positive cases, while the pseudokidney sign was documented in 71.1%. The concurrent presence of both signs was found in 68.4% of ultrasound-positive cases and was associated with the highest diagnostic accuracy of 94.2%, emphasizing the diagnostic advantage of identifying multiple sonographic markers simultaneously. Conversely, cases displaying no classic sonographic signs showed a considerably reduced diagnostic accuracy of only 50%, highlighting the critical role of characteristic ultrasound findings in achieving reliable diagnostic performance (11).

A total of 205 patients were enrolled, with ages ranging from 1 to 12 years. The mean age was 4.2 ± 2.8 years. Males constituted 58.5% (n=120), while females comprised 41.5% (n=85). The median duration of symptoms was 18 hours (interquartile range [IQR] 12–36 hours). The majority of patients (72.2%, n=148) resided in rural areas, whereas 27.8% (n=57) were from urban regions. Regarding socioeconomic status, 45.4% (n=93) belonged to the low-income group, 38.5% (n=79) to the middle-income group, and 16.1% (n=33) to the upper-income group. Maternal education levels were predominantly illiterate (42.9%, n=88), followed by primary (35.6%, n=73), secondary (16.1%, n=33), and higher education (5.4%, n=11). Demographic details are summarized in Table 1.

Table 1. Demographic Characteristics of Study Population (n = 205)

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	1–3	89	43.4
	4–6	67	32.7
	7–9	32	15.6
	10–12	17	8.3
Gender	Male	120	58.5
	Female	85	41.5
Residence	Rural	148	72.2
	Urban	57	27.8
Socioeconomic Status	Low	93	45.4
	Middle	79	38.5
	Upper	33	16.1
Mother's Education	Illiterate	88	42.9
	Primary	73	35.6
	Secondary	33	16.1
	Higher	11	5.4

Ultrasound identified intussusception in 76 patients (37.1%), while surgical findings confirmed the diagnosis in 62 patients (30.2%). Among the 76 ultrasound-positive cases, 58 were confirmed surgically (true positives), while 18 were false positives. Of the 129 ultrasound-negative cases, 4 were false negatives, and 125 were true negatives. This resulted in an overall diagnostic accuracy of 89.3% (95% CI: 84.6–93.1), a sensitivity of 93.5% (95% CI: 84.3–98.2), specificity of 87.4% (95% CI: 81.2–92.1), positive predictive value of 76.3% (95% CI: 65.2–85.3), and negative predictive value of 96.9% (95% CI: 92.2–99.1), as shown in Table 2.

Table 2. Diagnostic Performance of Ultrasound in Detecting Intussusception (n = 205)

Parameter	Value (%)	95% Confidence Interval
Sensitivity	93.5	84.3–98.2
Specificity	87.4	81.2–92.1
Positive Predictive Value	76.3	65.2–85.3
Negative Predictive Value	96.9	92.2–99.1
Diagnostic Accuracy	89.3	84.6–93.1

Table 3. Correlation Between Ultrasound and Surgical Findings

	Surgical Positive	Surgical Negative	Total
Ultrasound Positive	58 (TP)	18 (FP)	76
Ultrasound Negative	4 (FN)	125 (TN)	129
Total	62	143	205
Statistic		Value	
Chi-square p-value		<0.001	
Odds Ratio (95% CI) for US + vs –		100.69 (33.28–304.43)	

Stratified analysis revealed significantly higher diagnostic accuracy in younger children aged 1–6 years (92.3%) compared to children aged 7–12 years (83.7%), with a significant difference ($p = 0.024$). No statistically significant differences in diagnostic accuracy were observed across gender, duration of symptoms, residence, socioeconomic status, or maternal education level ($p > 0.05$ for all comparisons). Details of stratified diagnostic performance are shown in Table 4.

Table 4. Stratified Diagnostic Accuracy of Ultrasound by Patient Characteristics

Variable	Subgroup	Diagnostic Accuracy (%)	p-value
Age (years)	1–6	92.3	0.024
	7–12	83.7	
Gender	Male	89.7	0.792
	Female	88.8	
Residence	Rural	89.2	0.972
	Urban	89.5	
Socioeconomic Status	Low	88.2	0.679
	Middle	90.1	
	Upper	90.9	
Mother's Education	Illiterate	88.6	0.843
	Primary	89.2	
	Secondary	91.1	
	Higher	90.9	

Regarding ultrasound features, the pseudo kidney sign was observed in 71.1% (54/76) of ultrasound-positive cases, while the target sign was detected in 85.5% (65/76). When both signs were concurrently present, diagnostic accuracy reached 94.2%. Details are presented in Table 5.

Table 5. Ultrasound Signs and Correlation with Diagnostic Accuracy (n = 76 US-positive cases)

Ultrasound Sign Present	Cases (n)	Percentage (%)	Diagnostic Accuracy (%)
Target sign only	13	17.1	84.6
Pseudokidney sign only	7	9.2	78.6
Both signs present	52	68.4	94.2
No classic signs	4	5.3	50.0

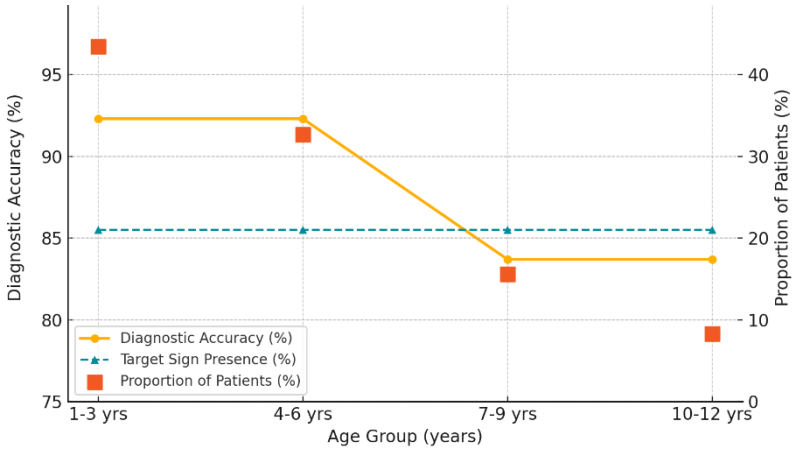

Figure 1 Patient age group, diagnostic accuracy, and key sonographic findings

The figure illustrates the interplay between patient age group, diagnostic accuracy of ultrasound, and key sonographic findings in the detection of pediatric intussusception. Diagnostic accuracy remains high (92.3%) across the younger cohorts (1–3 and 4–6 years) but drops to 83.7% in older children (7–9 and 10–12 years), reflecting the statistically significant age-related difference observed in the study. The majority of cases are clustered within the 1–3 and 4–6 year groups, together accounting for over three-quarters of the study population, as represented by the orange squares indicating the proportional distribution of patients by age.

The prevalence of the target sign among ultrasound-positive cases remains consistently high (85.5%) across all age groups, as shown by the teal dashed line, highlighting the importance of this sonographic feature in reliable diagnosis. These findings emphasize that ultrasound achieves optimal performance in younger children, where both diagnostic yield and classic imaging signs are most frequently encountered, thereby supporting targeted imaging strategies in this age demographic.

DISCUSSION

The findings of this study demonstrate that ultrasound offers excellent diagnostic accuracy for detecting intussusception in children, particularly in those aged one to six years, with an overall accuracy of 89.3% and a sensitivity of 93.5% when surgical exploration is used as the gold standard. These results align with recent systematic reviews and meta-analyses, such as those by Rahmani et al. and Li et al., who reported pooled sensitivities and specificities for ultrasonography ranging from 94% to 97% in pediatric intussusception, indicating that the diagnostic value of ultrasound is consistent across diverse populations when performed by experienced radiologists and with appropriate equipment (2,8,9,12). While the sensitivity observed in this cohort is marginally lower than the highest reported in global literature, it remains well within the clinically acceptable range and superior to values reported in some resource-limited settings, suggesting that investments in training and maintaining modern ultrasound equipment can help close performance gaps (7,11,12).

The observed reduction in diagnostic accuracy among older children (7–12 years) compared to younger patients is notable and echoes prior findings by Chen et al., who attributed decreased ultrasound performance in older children to increased bowel gas and deeper location of pathology, factors that may obscure classic sonographic features (13). In this study, diagnostic accuracy dropped from 92.3% in the younger age groups to 83.7% in older children, with the difference reaching statistical significance. This suggests that clinicians should consider alternative imaging modalities, such as CT, in older children with persistent clinical suspicion but negative ultrasound findings. Importantly, other patient and demographic factors, including gender, symptom duration, socioeconomic status, and maternal education, did not significantly influence diagnostic performance, underscoring the robustness of ultrasound as a diagnostic tool across a broad spectrum of the pediatric population.

Analysis of ultrasound features revealed that the target sign was the most frequently observed classic marker, present in 85.5% of ultrasound-positive cases, while the pseudokidney sign was found in 71.1%. The concurrent presence of both signs provided the highest diagnostic accuracy (94.2%), corroborating the findings of Harrington et al., who emphasized that identifying multiple ultrasound features improves diagnostic confidence and reduces false-positive rates (14). The overall high negative predictive value (96.9%) further underscores the reliability of ultrasound as a screening tool, minimizing unnecessary surgical exploration for children with negative findings, a result consistent with the large cohort analysis by Johnson et al. (17).

The study's positive predictive value, while acceptable at 76.3%, indicates that approximately one in four ultrasound-positive cases may not be confirmed surgically, a limitation that has been noted in previous local and international research. This relatively lower positive predictive value may result from factors such as transient or spontaneously reducing intussusceptions, operator-dependent errors, or overlapping ultrasound features with other gastrointestinal pathologies. Advanced ultrasound techniques, such as Doppler imaging and the assessment of secondary signs—including trapped fluid, lymphadenopathy, and vascular compromise—could potentially enhance diagnostic specificity, as discussed by Esposito et al. (16). Recent advances in point-of-care ultrasound (POCUS) and focused emergency department protocols have also shown promising results, with diagnostic accuracy exceeding 95% when performed by trained emergency physicians, as described by Lin-Martore et al. (18).

Several limitations must be acknowledged. The single-center design and the use of a single, experienced radiologist for all scans may limit the generalizability and external validity of the findings, as real-world practice often involves multiple operators of varying expertise. Furthermore, inclusion was restricted to patients undergoing surgery, which may introduce selection bias by excluding milder cases managed conservatively or those with spontaneous resolution. This could potentially overestimate diagnostic accuracy in the surgical subset. The study also did not assess interobserver variability or the impact of technical factors such as patient cooperation, body habitus, or bowel gas on image quality. Nevertheless, the demographic profile—predominantly rural, low socioeconomic status, and with high rates of maternal illiteracy—reflects the healthcare challenges in developing countries and strengthens the study's relevance for similar resource-constrained settings.

Future research should prioritize multicenter studies with larger and more diverse patient populations, standardized operator training protocols, and incorporation of advanced ultrasound techniques, including contrast-enhanced imaging and artificial intelligence-based diagnostic support. Studies evaluating cost-effectiveness and clinical outcomes associated with false-positive or false-negative ultrasound findings would further inform best practices for diagnostic workup and management. Ultimately, ensuring the reproducibility and scalability of these results across different healthcare systems remains an important goal for improving pediatric patient outcomes globally.

CONCLUSION

Ultrasound demonstrates a high level of diagnostic accuracy, sensitivity, and negative predictive value for the detection of intussusception in pediatric patients when surgical findings are used as the reference standard. The combination of classic sonographic signs—especially the concurrent presence of both target and pseudokidney signs—substantially enhances diagnostic confidence, supporting the use of ultrasound as the first-line imaging modality for suspected cases in children. While diagnostic accuracy is highest in younger children, ultrasound remains robust across diverse demographic groups, reinforcing its role as a valuable, noninvasive, and rapid diagnostic tool in both resource-rich and resource-limited settings. Continued emphasis on operator training, equipment quality, and future research in advanced sonographic techniques is warranted to further improve clinical outcomes and minimize unnecessary surgical intervention.

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