ORIGINAL ARTICLE

DIAGNOSTIC ROLE OF ULTRASONOGRAPHY FOR INTUSSUSCEPTION IN CHILDREN

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Background: Intussusception is a common cause of bowel obstruction in children, and early diagnosis is crucial to prevent complications. Ultrasonography is widely used to diagnose intussusception, but its validity parameters in children have not been well-established. The objective of this study is to determine the validity parameters of ultrasonography in diagnosing intussusception in children, taking surgical findings as the gold standard. **Methods:** This cross-sectional validation study was conducted at the diagnostic radiology and surgery departments of Ayub Teaching Hospital, Abbottabad. This study duration spans from September 2022 to December 2023, and 127children of both sex with ages in the range of 3 months to 12 years suspected to have intussusception on ultrasound as per operational definition were included, and patients managed conservatively were excluded. Ultrasound scan was performed with Toshiba Xario-100 machine using high frequency 8.5 MHz probe. All data, including patients' demographics were recorded on a proforma. Data analysis was conducted using SPSS version 25. **Results:** The mean age of patients was 6.50±3.38 years. The diagnostic accuracy of ultrasonography was 85.83%, with sensitivity of 82.93%, specificity of 91.11%, positive predictive value (PPV) of 94.44%, and negative predictive value (NPV) of 74.55%. **Conclusion:** The use of ultrasonography as a first-line diagnostic tool for intussusception in children can help in early diagnosis and prompt management of the condition, which can significantly reduce the risk of complications.

Keywords: Intussusception; Pediatric Intussusception; Ultrasonography; Diagnostic Accuracy; Surgery; Gold Standard

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INTRODUCTION

Intussusception, characterized by the telescoping of one segment of the bowel into an adjacent segment, poses a significant clinical challenge, particularly in pediatric populations.[1] This phenomenon primarily involves the small bowel, with instances in the large bowel being relatively rare. In the pediatric age group, intussusception stands as the second most common cause of acute abdomen, following appendectomy.[2] The incidence of intussusception is estimated to be 1.5 per 1000 live births in Pakistan and the associated mortality in Pakistan is reported to range from 3.8–5.6%.[3] The urgency in diagnosis and management stems from the potential progression to ischemic necrosis, bowel perforation, and peritonitis, each harboring elevated morbidity and mortality.[4,5] Historically recognized through symptomatic presentations leading to small bowel obstruction, the contemporary era of abdominal CT scans has unveiled a growing number of asymptomatic and transient intussusceptions.[5] The diagnostic landscape for intussusception includes abdominal radiography, ultrasound, and CT scans, each modality offering varying levels of sensitivity and specificity.[5,6]

The demographic variation in intussusception, more prevalent in children, necessitates a nuanced understanding of its etiology. Viral infections, particularly implicated in pediatric cases, have gained prominence contributing to an increased incidence of intussusception in children.[7–9] This surge in prevalence not only impacts the diagnostic accuracy of modalities but also underscores the urgency of investigating the local population to tailor diagnostic approaches and mitigate delays in diagnosis.[10] While intussusception is not immediately life-threatening, its potential complications, such as bowel ischemia and perforation, necessitate prompt treatment.[1,5] Ultrasound, particularly point-of-care ultrasound (POCUS), has emerged as a valuable tool in diagnosing ileocolic intussusception, allowing for bedside evaluations and potentially circumventing delays associated with radiology-performed ultrasound.[5,6]

The clinical presentation of intussusception, especially in infants, manifests as a triad of symptoms—vomiting, colicky abdominal pain, and passage of bloody stools.[5,6] Physical examination reveals distinctive signs, including a sausage-shaped mass in the right

hypochondrium and emptiness in the right lower quadrant.[4] Imaging studies, including radiography, ultrasound, and contrast enema, contribute to the diagnostic process, with ultrasound demonstrating high sensitivity and specificity in pediatric cases.[11] Management strategies for intussusception encompass non-operative reduction through therapeutic enemas and, if necessary, surgical reduction. Pneumatic enemas with air insufflation have become a preferred non-operative approach, boasting a low risk of major complications.[1,5] In cases where surgical intervention is warranted, laparoscopy has become an integral part of the surgical armamentarium, offering a less invasive alternative for both diagnosis and treatment.[1,12]

Discrepancies in diagnostic accuracy have been observed between local and international data, potentially attributed to the operator-dependent nature of ultrasound. However, research has emphasized ultrasound as the modality of choice for diagnosing ileocolic intussusception in children, aligning with the best available evidence.[13] As the prevalence of intussusception rises, especially in the context of the ongoing COVID-19 pandemic, there is an imperative need to conduct local studies to reconcile conflicting data and assess the effectiveness of ultrasound in diagnosing intussusception in this evolving landscape. Through this study, we aim to bridge the gap between international and local data, providing insights into the effectiveness of ultrasound in diagnosing intussusception in the contemporary healthcare landscape.

MATERIAL AND METHODS

This study was presented at the First National Medical Research Conference at Ayub Medical Teaching Institution (AMTI) Abbottabad, and had won first prize in the category of oral presentations. This cross-sectional validation study was conducted at the departments of diagnostic radiology and pediatric surgery at AMTI Abbottabad. The study duration spanned from September 2022 to December 2023, and the calculated sample size was 127, determined based on expected sensitivity (80.7%), specificity (89.9%), expected prevalence of intussusception in patients presenting with the symptom's triad (72.5%), desired precision (10%), and a confidence interval of 95%.[14] The sampling technique employed was non-probability consecutive sampling. Inclusion criteria encompassed children of both sexes aged 3 months to 12 years, presenting with a symptoms triad of colicky abdominal pain, vomiting, and a palpable abdominal mass, with or without red currant jelly stools-the symptoms trifecta to raise suspicion of intussusception, with parental written informed consent taken prior to enrolling them in the study. Exclusion criteria include patients whose intussusception is managed conservatively. Intussusception on ultrasound was defined operationally as children exhibiting the doughnut sign or pseudo kidney sign on abdominal ultrasound. Intussusception on per-operative naked eye examination was operationally defined as children with proximal gut loop invagination into the distal gut loop observed during laparotomy.

Data collection involves a self-developed questionnaire, approved by the hospital's ethical review committee. Parents or guardians of eligible patients were counseled, and written informed consent was obtained. Detailed demographic and socio-demographic data, along with medical history, are collected. Ultrasound scans, performed with 3.5 MHz and 8.0 MHz probes, involve serial longitudinal and transverse images to label intussusception based on the operational definition. For patients requiring surgical intervention, operative findings are noted during laparotomy.

All data, including demographic details, were recorded in a proforma, and consistency was ensured by conducting all the required diagnostic workup was done within the hospital, using the same machine and review by the same radiology consultant having post fellowship experience of more than five years. Data analysis was conducted using SPSS version 25. Numerical variables (age, duration of abdominal pain, weight) were presented as mean±SD, while categorical variables (gender) was expressed as frequency and percentage. Validity parameters were calculated from the 2x2 table comparing ultrasound diagnosis and per-operative diagnosis, presented as percentages. Data was stratified for age, gender, duration of abdominal pain, and weight, with post-stratification appropriate statistical tests applied, considering a *p*-value of ≤0.05 as statistically significant.

RESULTS

Table 1 summarizes demographic and clinical characteristics of our study cohort. Gender distribution shows male predominance 82 (64.4%). Patients aged 1 to 12 years were included with 64 (50.4%) between age group of 7–12 years. Most participants reported for the ultrasound to establish their diagnosis with pain durations of 1–2 hours (69.3%). Ultrasound detected intussusception in 72 (56.7%) patients while the rest were reported to have other possible etiologies for the pain. Per-operatively, intussusception was diagnosed in 82 (64.65%) cases. Mean values with standard deviations were calculated for age (6.50±3.38 years), weight (21.78±7.26 kg), and pain duration (1.97±0.81 hours).

Table 2 displays the operative diagnosis in relation to gender, age groups, pain duration, and weight categories. No significant difference was found on fisher's exact test in operative diagnosis based on categories of any of the above mentioned parameters as shown by *p*-values >0.05.

Table 3 presents mean and standard deviation (SD) values for age, pain duration, and weight in relation to operative diagnosis. No significant difference was

found on independent samples t-test in the mean values for any of the parameters in relation to the operative diagnosis as shown by *p*-values >0.05.

Table 4 illustrates the relationship between operative diagnosis and ultrasound diagnosis. Among cases where ultrasound diagnosis was negative 55 (43.3%), 41 (91.1%) were true negative, while 14 (17.1%) were false negative. In contrast, among cases with a positive ultrasound diagnosis 72 (56.7%), 4 (8.9%) were false positive, while 68 (82.9%) were true positive. Overall, significant association was found between operative and ultrasound diagnoses ($p<0.001$).

The validity parameters calculated from the table 4 showed sensitivity (82.9%), specificity (91.1%), NPV (74.5%), PPV (94.4%) and diagnostic accuracy of 85.8%.

Table-1: Demographic and Clinical Characteristics

Characteristics		N (%)
Gender	Female	45 (35.4%)
	Male	82 (64.4%)
Age Groups	1 to 6 years	63 (49.6%)
	7 to 12 years	(50.4%)
Duration of pain	> 2 hours	39 (30.7%)
	1-2 hours	88 (69.3%)
Weight	> 25 kg	45 (35.4%)
	≤ 25 kg	82 (64.6%)
Ultrasound Diagnosis	Negative	55 (43.3%)
	Positive	72 (56.7%)
Per-operative Diagnosis	No	45 (35.4%)
	Yes	82 (64.65)
Parameters	Mean	Standard Deviation (SD)
Age in years	6.50	3.38
Weight in Kg	21.78	7.26
Pain Duration in hours	1.97	0.81

Table-2: Operative Diagnosis in Relation to Gender, Age Groups, Pain Duration, and Weight Categories

		Operative Diagnosis		*p*-value
		No	Yes	
Gender	Female	18 (40.0%)	27 (32.9%)	0.425
	Male	27 (60.0%)	55 (67.1%)	
Age groups	1-6 years	24 (53.3%)	39 (47.6%)	0.534
	7-12 years	21 (46.7%)	43 (67.2%)	
Pain duration	>2 hours	13 (28.9%)	26 (31.7%)	0.742
	1-2 hours	32 (71.1%)	56 (68.3%)	
Weight	> 25 Kg	12 (26.7%)	33 (40.2%)	0.126
	13-25 Kg	33 (73.3%)	49 (59.8%)	

Table-3: Mean and Standard Deviation Values for Age, Pain Duration, and Weight in Relation to Operative Diagnosis

	Operative Diagnosis	Mean	SD	*p*-value
Age	Yes (n = 82)	6.74	3.41	0.283
	No (n = 45)	6.07	3.33	
Pain Duration	Yes (n = 82)	1.96	.823	0.924
	No (n = 45)	1.98	.783	
Weight	Yes (n = 82)	22.45	7.56	0.143
	No (n = 45)	20.55	6.58	

Table-4: Relationship Between Operative Diagnosis and Ultrasound Diagnosis

Ultrasound diagnosis	Operative Diagnosis		Total	*p*-value
	No	Yes		
Negative	41 (91.1%)	14 (17.1%)	55 (43.3%)	<0.001
Positive	4 (8.9%)	68 (82.9%)	72 (56.7%)	
Total	45 (35.4%)	82 (64.6%)	127 (100%)	

DISCUSSION

Intussusception stands out as one of the leading causes of intestinal obstruction in infants, presenting a significant clinical challenge. Its classic triad of symptoms—abdominal colic, bile-stained vomiting, and red jelly stools—typically signal bowel obstruction. Remarkably, this trio of symptoms

exhibits a high positive predictive value of 93%, underscoring its diagnostic significance.[5,11,13] Notably, the inclusion of rectal bleeding elevates this predictive value to an impressive 100%. Left untreated, intussusception can precipitate severe complications, including intestinal necrosis, necessitating bowel resection, and, tragically, leading to fatalities.[1,4] The etiology of intussusception often remains idiopathic, with approximately 90% of cases lacking a discernible cause. However, certain pathologic lead points, such as intestinal lymphoma, Meckel's diverticulum, and solid bowel lesions, are implicated in a minority of cases.[1,5] Epidemiologically, incidences vary globally, with rates ranging from 0.3 to 2.7 per 1,000 live births in regions like Europe, North America, and Australia.[11] Notably, some developing nations report higher incidence rates, amplifying the burden of this condition and exacerbating healthcare challenges.[14]

Abdominal ultrasonography emerges as a pivotal screening tool, particularly for cases with atypical clinical presentations.[5,15] This imaging modality not only facilitates rapid and confident diagnosis but also offers the advantages of cost-effectiveness, reduced radiation exposure, and diminished patient and parental anxiety. Studies have demonstrated remarkable accuracy in the hands of skilled practitioners, with sensitivity ranging from 98–100% and specificity from 88–100%.[16,17] Furthermore, ultrasonography aids in identifying alternative diagnoses, assessing reducibility, detecting lead point masses, and discerning small bowel involvement.[5,11] In resource-constrained settings, ultrasonography assumes paramount importance as the primary imaging modality for early diagnosis and management decision-making.[11] Notably, the length of intussusception exceeding 3.5 cm often necessitates surgical intervention, especially if blood flow within the intussusception is compromised which can easily be assessed by ultrasonography.[18]

This study focused on evaluating the validity parameters of ultrasonography in diagnosing intussusception in children, using surgical findings as the gold standard. The findings from our comprehensive analysis reveal significant insights into the diagnostic accuracy of ultrasonography for intussusception in pediatric patients. The results underscore the pivotal role of abdominal ultrasonography as an indispensable diagnostic tool in pediatric intussusception cases. With an overall diagnostic accuracy of 85.8%, ultrasonography demonstrated high sensitivity (82.9%) and specificity (91.1%). The positive predictive value (PPV) was found to be 94.4%, while the negative predictive value (NPV) stood at 74.5%. These parameters collectively highlight the reliability and efficacy of ultrasonography in diagnosing intussusception, aiding in timely and accurate clinical decision-making.

Our findings align with global research trends and emphasizes the importance of ultrasonography in early detection and prompt management of intussusception in children. The non-invasive nature, cost-effectiveness, and rapidity of ultrasound make it an invaluable tool, particularly in resource-constrained settings. A study from Pakistan reported a diagnostic accuracy of 93.7%, with sensitivity and specificity figures of 80.7% and 52.7%, respectively.[14] Across diverse studies, diagnostic accuracy ranges from 81.5–87.06%, with sensitivity and specificity approximating 85.05–94% and 90.48–96%, respectively.[16,17,19,20] A systematic review and meta-analysis reported a pooled sensitivity and specificity of ultrasonography for diagnosis of intussusception to be 0.96 (95% CI: 0.95-0.97) and 0.97 (95% CI: 0.97–0.98), respectively [21]. These consistent findings underscore the reliability and efficacy of ultrasound in intussusception diagnosis, reinforcing its pivotal role in clinical practice. Moreover, ultrasonography's non-invasive nature, rapidity, and accuracy make it indispensable for timely intervention and optimal patient outcomes.[15,17,18] Despite variations in reported sensitivity and specificity levels, ultrasonography remains a cornerstone in diagnosing pediatric intussusception, offering a safe, efficient, and cost-effective approach.[5] Notably, its ability to detect transient intussusception and concomitant disorders further enhances its clinical utility, potentially obviating the need for contrast-based enemas and minimizing radiation exposure.[21]

While our findings support the widespread adoption of ultrasonography in pediatric intussusception cases, ongoing efforts should focus on operator proficiency, standardization of protocols, and continuous evaluation of diagnostic modalities to further enhance patient care outcomes.

Recommendations:

Ultrasonography should be used as a first-line diagnostic tool for intussusception in children. Continued research and collaborative efforts are warranted to optimize diagnostic strategies and ensure the best possible care for pediatric patients presenting with intussusception. Therefore, larger studies with greater sample size and good control of confounders should be done.

CONCLUSION

Abdominal ultrasonography emerges as a cornerstone in the diagnosis of pediatric intussusception, offering high accuracy, safety, efficiency and diagnostic accuracy of 85.83%. The use of ultrasonography as a first-line diagnostic tool for intussusception in children can help in early diagnosis and prompt

management of the condition, which can significantly contribute to improved patient care and outcomes, reinforcing its indispensable role in modern pediatric healthcare settings.

AUTHORS' CONTRIBUTION

AA, MF: Conceptualization, literature search, data collection, manuscript preparation, approval of final draft, accountability for the work. HJ, SB: Data collection and analysis, critical review, approval of the final form and accountability for the fork. UNK: Data collection, critical review, final approval.

REFERENCES

1. O'Connell PR, McCaskie AW, Sayers RD. Bailey & Love's short practice of surgery. In: The small intestine. Corlson GL, Epstein JC, editors. 28th ed. Boca Raton: CRC Press, Taylor & Francis Group: 2023; p.1306–17.
2. Kolar M, Pilkington M, Winthrop A, Theivendram A, Lajkosz K, Brogly SB. Diagnosis and treatment of childhood intussusception from 1997 to 2016: a population-based study. J Pediatr Surg 2020;55(8):1562–9.
3. Zaidi AK, Awasthi S, DeSilva HJ. Burden of infectious diseases in South Asia. BMJ 2004;328(7443):811–5.
4. Kelley-Quon LI, Arthur LG, Williams RF, Goldin AB, Peter SD, Beres AL, *et al*. Management of intussusception in children: a systematic review. J Pediatr Surg 2021;56(3):587–96.
5. Amini B, Niknejad MT, Chieng R. Intussusception. [Internet] [cited 2024 Mar 21]. Available from: https://doi.org/10.53347/rID-1526
6. Panzera F, Di Venere B, Rizzi M, Biscaglia A, Praticò CA, Nasti G, *et al*. Bowel intussusception in adult: prevalence, diagnostic tools and therapy. World J Methodol 2021;11(3):81.
7. Burnett E, Kabir F, Van Trang N, Rayamajhi A, Satter SM, Liu J, *et al*. Infectious etiologies of intussusception among children< 2 years old in 4 Asian countries. J Infect Dis 2020;221(9):1499–505.
8. Salman R, Sher AC, Sammer MB, Rodriguez JR, Shah SR, Seghers VJ. Ileocolic intussusception in pediatric SARS-CoV-2 patients: experience at a tertiary pediatric center. Pediatr Surg Int 2022;38(3):437–43.
9. Pradhan SK, Dash M, Ray RK, Mohakud NK, Das RR, Satpathy SK, *et al*. Childhood intussusception after introduction of indigenous rotavirus vaccine: hospital-based surveillance study from Odisha, India. Indian J Pediatr 2021;88(Suppl 1):112–7.
10. Shreffler J, Huecker MR. Diagnostic Testing Accuracy: Sensitivity, Specificity, Predictive Values and Likelihood Ratios. 2022. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024
11. Lin-Martore M, Kornblith AE, Kohn MA, Gottlieb M. Diagnostic accuracy of point-of-care ultrasound for intussusception in children presenting to the emergency department: A systematic review and meta-analysis. West J Emerg Med 2020;21(4):1008–16.
12. Li Y, Zhou Q, Liu C, Sun C, Sun H, Li X, *et al*. Epidemiology, clinical characteristics, and treatment of children with acute intussusception: a case series. BMC Pediatr 2023;23(1):143.
13. Álvarez-Bautista FE, Moctezuma-Velázquez P, Pimienta-Ibarra AS, Vergara-Fernández O, Salgado-Nesme N. Adult intussusception: still a challenging diagnosis for the surgeon. Rev Gastroenterol Méx (Engl Ed) 2022;88(4):315–21.
14. Dadlani A, Lal S, Shahani B, Ali M. Ultrasonography for the Diagnosis of Intussusception in Children: An Experience From Pakistan. Cureus 2020;12(8):e9656.
15. Rahmani E, Amani-Beni R, Hekmatnia Y, Fakhre Yaseri A, Ahadiat SA, Talebi Boroujeni P, *et al*. Diagnostic Accuracy of Ultrasonography for Detection of Intussusception in Children; a Systematic Review and Meta-Analysis. Arch Acad Emerg Med 2023;11(1):e24.
16. Ashraf S, Tazeen A, Nasreen M, Farooq SM, Iqbal MJ, Kamran M. Diagnostic Accuracy of Abdominal Ultrasound In Children With Suspected Intussusception Keeping Surgical Findings As Gold Standard. J Pharm Negat Results 2023;13:7080–7.
17. Burki SA, Arsalan MK, Amin P, Khursheed A, Naz S, Cheema KA. Diagnostic Accuracy of Ultrasonography in Pediatric Intussception Taking Surgical Findings as Gold Standard. Pak J Med Health Sci 2022;16(1):1159–62.
18. Munden MM, Bruzzi JF, Coley BD, Munden RF. Sonography of pediatric small-bowel intussusception: differentiating surgical from nonsurgical cases. Am J Roentgenol 2007;188(1):275–9.
19. Shuaib I. Diagnostic accuracy of ultrasound in diagnosis of intussusception in children considering surgical findings as gold standard. Pak J Radiol 2022;32(4):209–12.
20. Otero HJ, De Leon Benedetti LS, Applegate KE. Intussusception in Children: Diagnostic Imaging and Treatment. In: Evidence-Based Imaging in Pediatrics: Clinical Decision Support for Optimized Imaging in Pediatric Care. Springer: 2023; p.1–16.
21. Salazar JH, Li BU. Intussusception in children. UpToDate. Edited by Nagler J. [Internet]. (August 2023). [cited 2024 March 21]. Available from: https://www.uptodate.com/contents/intussusception-in-children

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