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Predictors of Surgery and Gangrenous bowel in pediatric intussusception

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Abstract

Background: Intussusception is a surgical emergency and the leading cause of intestinal obstruction in children aged 3 months to 3 years. Delays in presentation, diagnosis, or treatment may result in intestinal necrosis, necessitating bowel resection.

Aim: To explore clinical presentations in children with intussusception requiring surgery or bowel resection and evaluate predictors of intestinal necrosis to facilitate timely management and improved outcomes.

Methods: A prospective study was conducted on 100 patients under 14 years of age diagnosed with intussusception at the Pediatric Surgery Department of Children Welfare Teaching Hospital, Baghdad, from October 2022 to November 2023. Diagnosis was confirmed via ultrasound (U/S). Data collection included medical history, physical examination, laboratory findings, U.S measurements of intussusception mass, and intraoperative findings (mass type, bowel status, and pathological lead points). Cases with alternative diagnoses (e.g., lymphoma, ovarian cyst, renal tumor) were excluded.

Results: Of the 100 patients, 46% underwent operative reduction, 24% required bowel resection, and gangrenous bowel was observed in 14%. Predictors for operative reduction included prolonged abdominal pain ($P=0.004$), bleeding per rectum ($P=0.004$), vomiting ($P=0.003$), bilious vomiting ($P=0.013$), tachycardia and tachypnea (both $p<0.001$), abdominal distension ($p<0.001$), red currant jelly stool ($p<0.001$), mass length on U/S ($p<0.001$), and hyponatremia ($P=0.014$). Predictors for gangrenous bowel included bleeding per rectum ($P=0.023$), prolonged vomiting ($P=0.045$), tachycardia, tachypnea, fever ($p<0.001$, <0.001 , 0.020), abdominal distension ($P=0.017$), and red currant jelly stool ($P=0.011$).

Conclusion: Prolonged symptoms, vital sign disturbances, and specific clinical findings predict the need for operative reduction and bowel resection, emphasizing the importance of timely diagnosis and intervention.

Keywords: Predictors, surgery, gangrenous, bowel, pediatric, intussusception

Introduction

Intussusception is the most common cause of bowel obstruction in infants and toddlers, characterized by the invagination of a proximal segment of the bowel (intussusceptum) into a distal segment (intussusciens) due to abnormal peristaltic activity^[1]. This condition primarily affects children between the ages of 3 months and 3 years and is considered a surgical emergency requiring timely diagnosis and treatment to prevent life-threatening complications such as bowel ischemia and necrosis^[2]. The historical recognition of intussusception dates back to the late 1600s in Europe when it was first described as a disease by Barbet and Peyer. However, John Hunter provided the first detailed clinical description in 1793^[3]. Early treatment methods, including pneumatic reduction with hand bellows, date as far back as Hippocratic times but were largely unsuccessful until the late 19th century. Hirschsprung's introduction of hydrostatic reduction in 1876 significantly decreased mortality rates associated with intussusception^[4]. Further advancements in diagnostic imaging, such as bismuth enemas reported by Ladd in 1913 and the use of ultrasonography (US) introduced by Burke and Clarke in 1977, have revolutionized the approach to diagnosis and management of intussusception^[5]. Globally, the incidence of intussusception is approximately 1 to 4 cases per 2000 infants and children, predominantly affecting healthy, well-nourished male infants^[6]. The peak incidence occurs between 4 and 9 months of age, and the condition is rare in neonates or children older than three years^[7].

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While idiopathic intussusception accounts for most cases in younger children and is often associated with hypertrophied lymphoid tissue following viral infections, older children are more likely to present with a pathologic lead point such as a Meckel's diverticulum, polyp, or tumor^[8]. Seasonal variation in incidence correlates with viral illnesses, particularly respiratory or gastrointestinal infections, with most cases reported during the spring and summer months^[9]. Familial clusters of intussusception have also been documented, suggesting a possible viral rather than genetic etiology^[10]. The pathophysiology of intussusception involves telescoping of the bowel, which carries its mesentery into the distal segment, leading to compression of mesenteric vessels. This results in venous congestion, ischemia, and, if untreated, bowel necrosis. The classic clinical presentation includes intermittent cramping abdominal pain, vomiting, and "currant jelly" stools caused by mucosal sloughing and venous stasis, although this triad is seen in less than 25% of cases^[1, 6]. Late-stage disease is associated with signs of bowel obstruction, peritonitis, or sepsis, underscoring the urgency of prompt intervention^[6]. Ultrasonography has become the diagnostic modality of choice, with characteristic findings such as the "target" or "doughnut" sign in the transverse plane and the "pseudokidney" sign on longitudinal sections^[11]. In select cases, computed tomography (CT) or magnetic resonance imaging (MRI) may provide additional information, particularly when a pathological lead point is suspected^[12]. Management strategies for intussusception include non-operative approaches such as pneumatic or hydrostatic reduction under imaging guidance and surgical intervention for cases unresponsive to these methods or complicated by bowel perforation or necrosis. Operative techniques may involve laparoscopic or open reduction, with bowel resection and anastomosis required in cases of ischemic or necrotic bowel^[1, 6]. The study aims to understand the clinical manifestations of children with intussusception who need surgery or intestinal resection. To assess predictors, risk factors, and determinants of intestinal necrosis that requires colon resection to quickly determine patient prognosis.

Methods

This prospective cross-sectional study was conducted at the Pediatric Surgery Department of Children Welfare Teaching Hospital, Baghdad Medical City, Iraq, from October 2022 to November 2023. It included 100 patients under 14 years of age diagnosed with intussusception based on history, physical examination, and ultrasonography (U/S). Children with intra-operative findings other than intussusception, such as

lymphoma, ovarian cyst, renal tumor, or appendicitis, were excluded. Data collection included patient demographics (age, gender), clinical presentation (duration of abdominal pain or screaming attacks, vomiting type and duration, and bleeding per rectum), clinical examination (vital signs, abdominal and rectal findings), laboratory tests (Hb, WBC count, platelet count, RBS, serum sodium, chloride, and potassium levels), and imaging findings (length of intussusception mass on U/S). Initial management involved intravenous fluids, antibiotics, and gastric decompression with an NG tube. Hydrostatic reduction with normal saline was attempted under U/S guidance, with up to four trials spaced 30 minutes to two hours apart based on clinical status. If unsuccessful or contraindicated due to unstable vital signs, acute abdomen, palpable rectal mass, or pneumoperitoneum, operative reduction was performed. During surgery, the type of intussusception (ileo-colic, ileo-ileal, ileo-colic, appendico-cecal, or ileo-ileocolic), bowel status (healthy or gangrenous), and presence of a lead point were documented. Patients with unstable vital signs or delayed recovery from anesthesia were admitted to the pediatric intensive care unit. Statistical analysis was conducted using SPSS software version 25. Descriptive statistics were presented as mean, standard deviation, frequency, and percentage. Continuous data were analyzed with the Student t-test, and categorical variables with the Chi-square test. A p-value of less than 0.05 was considered statistically significant.

Results

The majority of patients (63%) were ≤ 3 years old, with a predominance of males over females (62% vs. 38%). Screaming episodes lasted 24-48 hours in 62% of patients and > 48 hours in 21%. In 35% of patients, rectum bleeding prolonged >24 hours in 12 (34.29%). Three-fourths of patients vomited, and 53.33% vomited for more than 12 hours. The vomiting was bilious in 41.33% of patients. Mean pulse and respiratory rates were 111.72 ± 26.28 beats/min and 31.71 ± 14.57 breaths/min, respectively. The mean temperature of 37.38 ± 0.9 °C was over normal limits in numerous cases. Abdominal examination showed soft consistency in 75% of patients and distension in 20%. Digital rectal examination showed faeces and red currant jelly stool in 53% and 35% of individuals. The mean pathologic mass length (US finding) was 4.1 ± 2.51 cm. The bowel was gangrenous in 14 (30.43%) individuals. Intussusception was resected in 24 individuals (52.17%). 31 patients (67.39%) had no lead point. However, 19.57% and 6.52% of patients had Meckels and cecal mass as lead points. As in Table 1.

Table 1: Demographic characteristics, Clinical characteristics and u/s findings, Intraoperative findings of patients

Variables	Frequency	Percentage
Age, years		
≤ 3	63	63%
> 3	37	37%
Gender		
Male	62	62%
Female	38	38%
Screaming attack duration, hr		
< 24	17	17%
24-48	62	62%
> 48	21	21%
Bleeding per rectum		
No	65	65%
Yes	35	35%
Bleeding duration, hr		
≤ 24	23	68.57%

>24	12	34.29%
Vomiting		
No	25	25%
Yes	75	75%
Vomiting duration, hr		
≤12	35	46.67%
>12	40	53.33%
Bilious vomiting		
No	44	58.67%
Yes	31	41.33%
Pulse rate, beat/min	111.72±26.28	80-188
Respiratory rate, breaths/min	31.71±14.57	17-78
Temperature, °C	37.38±0.9	36.0-39.2
Abdominal examination	75	75%
Soft Distended	20	20%
Palpable mass	5	5%
DRE	52	52%
Stool staining	35	35%
Red currant jelly stool	12	12%
Empty rectum	1	1%
Mass	1	1%
Length of mass (US), cm	4.1±2.51	1.3-10
Bowel status		
Healthy	32	69.57%
Gangrenous	14	30.43%
Resection		
Done	24	52.17%
Not done	22	47.83%
Lead point		
None	31	67.39%
Meckels	9	19.57%
Cecal mass	3	6.52%
Others	3	6.52%

Included patients varied greatly. The mean Hb concentration was 10.78±1.42 g/dl (range: 4.4-13 g/dl). Mean WBC and platelet counts were 12.4±5.53×10⁹/L and 418.3±182.1×10⁹/L, respectively. Random blood glucose levels were increased in

several individuals, averaging 93.69±20.76 mg/dl. Electrolytes showed mean concentrations of 135.8±5.23 mEq/L Na, 102.13±5.82 mEq/L Cl, and 4.2±1.12 mmol/L K as in Table 2.

Table 2: Lab investigations at presentation

Variables	Mean ± SD	Range
Hb, g/dl	10.78±1.42	4.4-13.0
Total WBC×10 ⁹ /L	12.4±5.53	2.3-31.0
Platelets×10 ⁹ /L	418.3±182.1	39-1270
Random blood glucose, mg/dl	93.69±20.76	51-195
Na, mEq/L	135.8±5.23	113-151
Cl, mEq/L	102.13±5.82	80-115
K, mmol/L	4.2±1.12	2.9-6.2

Neither age nor gender of the patient had a significant impact on the operative or non-operative reduction of intussusception. Nine clinical characteristics strongly predicted surgical decrease. Screaming attacks lasting > 48 hrs were more common in surgical than hydrostatic reduction (32.61% vs. 11.1%), particularly significant. Compared to hydrostatic reduction (22.22% and 62.96%), surgical (50% and 89.13%) had higher bleeding per rectum and vomiting. Although length does not affect vomiting, bilious vomiting was 48.78% in surgical reduction and 32.35% in hydrostatic reduction, a significant difference. Operative reduction resulted in significantly greater

PR and RR (121.65±32.75 beats/min and 38.0±18.67 breaths/min) compared to hydrostatic reduction (103.26±14.87 beats/min and 26.35±6.07 breaths/min). Operative reduction indicated 41.3% distended abdomen and 10.87% palpable mass, compared to 1.85% and 0% with hydrostatic reduction, with significant differences. Operative reduction indicated 60.87% red currant jelly stool and 21.74% empty rectum, compared to 12.96% and 3.7% in hydrostatic reduction, with significant differences. Operative reduction resulted in a significantly greater mean mass length (5.71±2.76 cm) compared to hydrostatic reduction (2.72±1.07 cm) as in Table 3.

Table 3: Association of demographic characteristics, clinical characteristics and u/s findings with the reduction type

Variables	Operative reduction (N=46)	Hydrostatic reduction (N=54)	P-Value
Age, years			
≤3	29(63.04%)	34(62.96%)	0.993
>3	17(36.96%)	20(37.04%)	
Gender			
Male	33(71.74%)	29(53.7%)	0.064
Female	13(28.26%)	25(46.3%)	
Screaming attack duration, hr			
<24	3(6.52%)	14(25.93%)	0.004
24-48	28(60.87%)	34(62.96%)	
>48	15(32.61%)	6(11.11%)	
Bleeding per rectum			
No	23(50%)	42(77.78%)	0.004
Yes	23(50%)	12(22.22%)	
Bleeding duration, hr			
≤24	13(56.52%)	10(83.33%)	0.113
>24	10(43.48%)	2(16.67%)	
Vomiting			
No	5(10.87%)	20(37.04%)	0.003
Yes	41(89.13%)	34(62.96%)	
Vomiting duration, hr			
≤12	16(39.02%)	19(55.88%)	0.145
>12	25(60.98%)	15(44.12%)	
Bilious vomiting			
No	21(51.22%)	23(67.65%)	0.013
Yes	20(48.78%)	11(32.35%)	
Pulse rate, beat/min			
Mean ± SD	121.65±32.75	103.26±14.87	<0.001
Range	80-188	80-130	
Respiratory rate, breaths/min			
Mean ± SD	38.0±18.67	26.35±6.07	<0.001
Range	18-78	17-44	
Temperature, °C			
Mean ± SD	37.36±0.93	37.39±0.86	0.896
Range	36-39.2	36-39	
Abdominal exam			
Soft Distended	22(47.83%)	53(98.15%)	<0.001
Palpable mass	19(41.3%)	1(1.85%)	
	5(10.87%)	0(0%)	
DRE	8(17.39%)	44(81.48%)	<0.001
Stool	28(60.87%)	7(12.96%)	
Red currant jelly stool	10(21.74%)	2(3.7%)	
Empty rectum	0(0%)	1(1.85%)	
Mass			
Length of mass (US), cm			
Mean ± SD	5.71±2.76	2.72±1.07	<0.001
Range	2.0-10.0	1.3-7.0	

The only significant association among lab investigation was the serum concentration of Na, which was slightly lower in operative reduction (134.39±6.09 mEq/L) than hydrostatic reduction (136.94±4.0 mEq/L) as shown in in Table 4.

Table 4: Association of laboratory findings with the reduction type

Variables	Operative reduction (N=46)	Hydrostatic reduction (N=54)	P-Value
Hb, g/dl	10.57±1.64	10.96±1.16	0.163
Mean ± SD Range	4.4-13	7.2-13	
RBS, mg/dl	97.76±19.1	90.54±21.65	0.082
Mean ± SD Range	51-154	54-195	
Total WBC×10 ⁹ /L	12.56±6.11	12.15±5.04	0.709
Mean ± SD Range	2.3-29	4.0-31.0	
Platelets×10 ⁹ /L	424.8±236.7	410.2±118.1	0.691
Mean ± SD Range	144-787	39-1270	
Na, mEq/L	134.39±6.09	136.94±4.0	0.014
Mean ± SD Range	113-151	130-147	
Cl, mEq/L	101.52±7.07	102.66±4.46	0.331
Mean ± SD Range	80-115	92-112	
K, mmol/L	4.23±0.66	4.3±0.58	0.606
Mean ± SD Range	3.1-6.2	2.9-5.7	

Neither age nor gender of the patient had a significant impact on the occurrence of gangrenous bowel in intussusception (Table 5).

Table 5: Association of demographic characteristics with gangrenous bowel

Variables	Healthy bowel (N=32)	Gangrenous bowel (N=14)	p-value
Age, years			
≤3	22(68.75%)	7(50%)	0.225
>3	10(31.25%)	7(50%)	
Gender			
Male	23(71.88%)	10(71.43%)	0.975
Female	9(28.13%)	4(28.57%)	

Gangrenous bowel had 78.57% per rectum bleeding compared to 37.5% in healthy intestine-a significant difference. Gangrenous patients were more likely than healthy intestinal patients to vomit for more than 12 hours (86.62 vs. 50%). Patients with gangrenous bowel had significantly higher mean PR, RR, and temperature (148.71 ± 29.59 beats/min, 54.14 ± 17.6 breaths/min,

37.84 ± 0.95 °C) compared to those with healthy bowel (109.81 ± 26.73 beats/min, 30.94 ± 14.38 breaths/min, 37.16 ± 0.86 °C, respectively). Gangrenous bowel patients had 71.43% and 92.86% distended abdomen with red currant jelly stool, compared to 28.13% and 46.87% in healthy bowel patients, with significant differences. As in Table 6.

Table 6: Association of clinical characteristic and u/s finding with gangrenous bowel

Variables	Healthy bowel (N=32)	Gangrenous bowel (N=14)	P-Value
Screaming attack duration, hr			
<24	3(9.37%)	0(0%)	0.168
24-48	21(65.63%)	7(50%)	
>48	8(25%)	7(50%)	
Bleeding per rectum	20(62.5%)	3(21.43%)	0.023
No Yes	12(37.5%)	11(78.57%)	
Bleeding duration, hr			
≤24	9(75%)	4(36.36%)	0.100
>24	3(25%)	7(63.64%)	
Vomiting			
No	4(12.5%)	1(7.14%)	0.591
Yes	28(87.5%)	13(92.86%)	
Vomiting duration, hr			
≤12	14(50%)	2(15.38%)	0.045
>12	14(50%)	11(84.62%)	
Bilious vomiting			
No	16(57.14%)	3(27.27%)	0.216
Yes	12(42.86%)	8(72.73%)	
Pulse rate, beat/min	109.81 ± 26.73	148.71 ± 29.59	<0.001
Mean ± SD Range	80-180	100-188	
Respiratory rate, breaths/min	30.94 ± 14.38	54.14 ± 17.6	<0.001
Mean ± SD Range	18-78	25-70	
Temperature, °C	37.16 ± 0.86	37.84 ± 0.95	0.020
Mean ± SD Range	36-39.2	36.4-39.1	
Abdominal exam	18(56.25%)	4(28.57%)	0.017
Soft	9(28.13%)	10(71.43%)	
Distended Palpable mass	5(15.63%)	0(0%)	0.011
DRE	7(21.88%)	1(7.14%)	
Stool staining	15(46.87%)	13(92.86%)	0.011
Red currant jelly stool Empty rectum	10(21.25%)	0(0%)	
Length of mass (US), cm	5.12 ± 2.5	6.12 ± 3.33	0.504
Mean ± SD Range	2.0-10	2.0-10	

None of laboratory findings had a significant association with gangrenous bowel. Although the mean PLT count was markedly higher in patients with gangrenous bowel ($519.3\pm 330.4\times 10^9/L$) than those with healthy bowel ($383.5\pm 172.6\times 10^9/L$), the

difference was not significant. Neither the type of intussusception mass, nor the type of lead point had a significant association with gangrenous bowel as in (Table 7).

Table 7: Association of laboratory findings with gangrenous bowel

Variables	Healthy bowel (N=32)	Gangrenous bowel (N=14)	P-Value
Hb, g/dl	10.7 ± 1.46	10.28 ± 2.03	0.437
Mean ± SD Range	7.8-13.0	4.4-13.0	
RBS, mg/dl	97.88 ± 17.94	97.5 ± 22.24	0.952
Mean ± SD Range	70-154	51-124	
Total WBC $\times 10^9/L$	13.51 ± 6.49	10.4 ± 4.67	0.113
Mean ± SD Range	6-29	2.3-18	
Platelets $\times 10^9/L$	383.5 ± 172.6	519.3 ± 330.4	0.073

Mean ± SD Range	39-841	46-1270	
Na, mEq/L	135±6.63	133.1±4.58	0.337
Mean ± SD Range	113-151	125-139	
Cl, mEq/L	101.9±7.38	100.62±6.5	0.577
Mean ± SD Range	80-115	89-109	
K, mmol/L	4.32±0.58	4.04±0.81	0.198
Mean ± SD Range	3.2-5.2	3.1-6.2	
Type of intussusception mass	21(67.74%)	9(64.29%)	0.919
Ileo-colic Ileo-ileal	6(19.35%)	3(21.43%)	
Ileo-colicolic	4(12.9%)	2(14.29%)	
Appendicocecal	1(3.23%)	0(0%)	
Lead point			0.483
None	21(65.62%)	10(71.43%)	
Meckels	6(19.35%)	3(21.43%)	
Cecal mass	2(6.45%)	1(7.14%)	
Others	3(9.37%)	0(0%)	

Discussion

Intussusception remains a surgical emergency where delayed presentation, diagnosis, or treatment often necessitates bowel resection due to loss of intestinal viability [13]. This study analyzed 100 pediatric patients presenting with intussusception, 46% of whom required operative reduction, with bowel resection performed in 24%, including 14% with gangrenous bowel and 10% due to pathological lead points. These findings demonstrate a lower resection rate compared to studies from developing countries, such as Nigeria (43.6%-70.4%) and Nepal (89.3%) [14, 15]. This may reflect differences in healthcare access and early management. Age and gender were not significant predictors of bowel resection, consistent with studies by Yao *et al.* [16], Ezomike *et al.* [17], and Nasir *et al.* [18]. However, Yao *et al.* found females at higher risk due to prolonged symptom duration, while Huang *et al.* reported a male predisposition [19]. Symptom duration was critical, as prolonged abdominal pain was significantly associated with operative reduction ($P=0.004$), although not with bowel gangrene ($P=0.168$). Late presentation was linked to lethargy and silent symptoms, as reported by Wu *et al.* [20]. Similar findings have shown late presentations beyond 24 hours correlate with increased bowel resection rates [21, 22]. Bleeding per rectum, often a late symptom, significantly predicted operative reduction ($P=0.004$) and bowel resection ($P=0.023$). This aligns with studies by Ajao *et al.* [23] and Nasir *et al.* [24]. Vomiting, particularly bilious, indicated late presentation and increased likelihood of operative reduction ($P=0.003$, $P=0.013$), similar to findings by Wu *et al.* [20]. Longer symptom duration further increased bowel resection risk, corroborating studies by Nasir *et al.* [18] and Ogundoyin *et al.* [21]. Vital sign abnormalities (tachycardia, tachypnea, and fever) were strongly associated with bowel resection ($p<0.001$, <0.001 , 0.02), reflecting late-stage disease with volume depletion, inflammation, and sepsis [20]. Abdominal distension, a sign of proximal obstruction, significantly predicted surgical management and bowel resection, consistent with findings by Khorana *et al.* [24]. Diagnostic ultrasound findings, specifically mass length, were significantly different between non-operative and operative groups ($p<0.001$), though not predictive of gangrenous bowel ($P=0.678$), consistent with Juliansyah *et al.* [25]. Laboratory findings, including platelet count and anemia, were not significantly associated with bowel resection in this study, though prior research noted associations in specific contexts [18, 26]. Electrolyte disturbances were largely non-significant, except hyponatremia, which predicted operative reduction ($P=0.014$). This contrasts with Wu *et al.* [20], where both hyponatremia and hypochloremia were risk factors for surgery and resection. Early fluid replacement by paramedics in

this population likely mitigated electrolyte imbalances. Intraoperatively, ileo-colic intussusception was the most common type (65.21%), followed by ileo-ileal and ileo-colic forms. These results align with prior studies [18, 20]. Pathological lead points, seen in 15% of cases, were predominantly Meckel's diverticulum, consistent with Wong *et al.* [13] and Nasir *et al.* [18]. However, lead points did not predict gangrenous bowel, contrasting with Wu *et al.* [20], where they were significantly associated with bowel resection ($p<0.001$).

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