

The role of plain radiography in assessing intussusception with vascular compromise in children

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Abstract

Introduction: The diagnostic value of colour Doppler sonography for the detection of blood flow in intussusception is questionable. The purpose of this study was to evaluate plain radiography in the assessment of vascular compromise in children with intussusception.

Material and methods: The hospital notes of 1,119 paediatric cases of intussusception who presented between January 2007 and February 2008 were retrospectively analysed. Informed consent was given by the parents before the air enema and this study was approved by the hospital ethics committee. Overall, the plain abdominal X-rays of 190 cases were assessed independently by two experienced radiologists, and disagreements were settled by discussion. Symptom profiles, operative notes and pathological records were compared to plain radiography. SAS V8.1 was used for the analysis.

Results: Of the 190 patients, 30 cases had vascular compromise on plain films, as shown by the "coffee-bean" sign or "banana" sign. There was a paucity of gas in 36 cases, a quadrant-specific gas pattern in 51 cases, and the film showed a mass in 73 cases. Statistical analysis that compared signs on plain radiography signs and symptom onset showed a significant difference. Ninety-five cases were irreducible by air enema and required surgical intervention. The location of these intussusceptions were ileo-ileal-colic ($n = 44$), ileo-colic ($n = 25$), ileo-ileal ($n = 14$), ileo-caecal ($n = 10$), and ileo-colic-colic ($n = 2$). Eleven cases had intestinal necrosis and underwent resection of the necrotic bowel.

Conclusions: The signs of intussusception on plain radiography were significant during the clinical assessment of children with secondary ischaemic bowel. The radiological findings were shown to have a high concordance with pathology in the assessment of intussusception.

Key words: paediatric, intussusception, plain radiography, vascular compromise.

Introduction

Intussusception is a common emergency in children, especially in children aged less than 1 year [1]. As the intussusceptum is propagated distally along the intestine, it draws the mesenteric vessels with it. Thus, it often causes venous congestion and bowel-wall edema. With the consequent progression of the obstruction, the arterial blood supply may be compromised, resulting in intestinal ischaemia. If the intussusception is not treated correctly, or treatment is delayed, then intestinal infarction, perforation and secondary peritonitis may occur [2]. Therefore, appropriate and prompt diagnosis and treatment are vital for a successful outcome.

Ultrasonography is currently the gold standard modality for the diagnosis of intussusception. However, the diagnostic value of colour Doppler sonography for the detection of blood flow in the intestinal tract in such cases is questionable [3]. To our knowledge, there are few reports that have assessed vascular compromise in the bowel of children with intussusception. Furthermore, there are no relevant reports of the effect on plain radiography in the assessment of intussusception and any associated vascular compromise in children. This study retrospectively analysed a series of paediatric cases of intussusception, including a comparison between the surgical and pathological findings with those of plain abdominal radiography, in order to evaluate the value of plain radiography in the diagnostic assessment of intussusception with vascular compromise.

Material and methods

Case material

The study was approved by the Institutional Review Board of our hospital. The hospital records and radiographs of 1,119 patients with intussusception who presented to our hospital between January 2007 and February 2008 were retrospectively analysed. Informed consent was signed by the guardians of each child before air enema was performed and the study was approved by the hospital ethics committee.

Each case in this study had undergone abdominal plain radiography and ultrasound examinations, and their diagnosis was verified by the air enema. The gold standard diagnostic criteria include combined clinical and imaging materials, which are then standardized with the use of major and minor criteria [4]. Cases that could not be reduced by air enema in this study underwent surgery, and

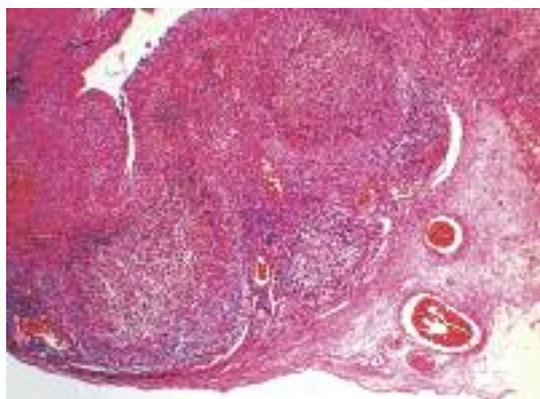


Figure 1. Intestinal mucosa, submucosal haemorrhage and necrosis of the intestinal mucosa can be seen associated with a significant increase in lymphoid tissue

patients were followed up after discharge in clinic. Cases were classified by the site and pathological cause of the intussusception.

Assessing abdominal plain radiography

All the abdominal plain films were retrospectively analysed by the PACS imaging workstation (Neusoft) with a monochromatic liquid crystal display (2 M, 0.270 mm pixels, 1600-1200 spatial resolution). A Philips digital radiographic system (115 KV, 2.0 MA) was used in plain radiography and the distance was 100 cm between the tube and the objective. All of the cases were exposed in the supine position.

The signs of intussusception on plain radiography were classified as follows: paucity of bowel gas, quadrant gas, mass or crescentic air pattern, coffee-bean sign or banana sign. All of the imaging was assessed by two experienced radiologists; all disputes were resolved by discussion. The onset of symptoms was also correlated with the radiographic signs, and confirmed with any surgical findings.

Statistical analysis

SAS V8.1 was used to analyse the data. The rate was analysed by the χ^2 test. The relationship between the signs found on plain radiography and the onset of symptoms was analysed by Spearman correlation coefficient analysis. The relationship between the pathological type and signs on plain radiography were analysed by the Cochran-Mantel-Haenszel (CMH) test. A *p*-value of less than 0.05 was considered to indicate a significant difference.

Results

Overall, the condition of the bowel was assessed by plain radiography in 190 randomly selected cases during the time period stated above, including 95 cases where air enema reduction successfully reduced the bowel, and 95 cases where this treatment was unsuccessful. These cases required further surgical intervention (60 males, 35 females (1.7 : 1); mean age: 1.1 years, age range 4 months – 11 years). Of the cases that could be reduced, 44 cases were ileo-ileal-colic, 25 cases were ileo-colic, 14 cases were ileo-ileal, 10 cases were ileo-caecal, and two cases were ileo-colic-colic. Eleven cases had intestinal necrosis and underwent resection of the necrotic section (Figure 1). Fifty cases developed symptoms within 24 h of presentation and 37 cases had symptoms for longer than 24 h. Seven cases had obvious lead points, including 4 cases of small bowel duplication cyst and 3 who had a Meckel's diverticulum.

There was a high degree of correlation between the findings on plain radiography and the nature of the pathology (κ score = 0.7128; row mean scores

difference = 11.5; $p < 0.05$). Of the 190 cases assessed by plain radiography, 30 cases of intussusception had vascular compromise, which was indicated by the coffee-bean or banana signs (Figure 2); additionally, 36 cases had paucity of bowel gas (Figure 3), 51 cases had a quadrant gas pattern (Figure 4), and 73 cases demonstrated a mass or crescent sign (Figure 5). There was also a positive correlation between signs on plain radiography and the timing of symptom onset ($R = 0.32833$, $p = 0.0080$, Tables I-IV).

Discussion

Plain radiography can be useful in the diagnosis of intussusception. As reported by Sargent *et al.* [5], abdominal X-rays alone correctly identified approximately 45% of intussusception. Plain radiography can also serve as the initial screening procedure [6, 7], which is principally used to identify other acute abdomen emergencies [8-10]. Certain signs can be seen in cases of intussusception, which most commonly include gas-filled bowel



Figure 2. Intussusception in a 4-month-old girl. She had developed symptoms approximately 40 h previously. The plain film demonstrates distended small bowel loops and the banana sign



Figure 3. Intussusception in a 2-year-old boy who underwent imaging 6 h after their presentation. The plain film indicates a paucity of bowel gas



Figure 4. Intussusception in a 5-month-old girl who developed symptoms approximately 10 h prior to presentation. The plain film indicates gas filled loops in the right lower quadrant of the abdomen



Figure 5. Intussusception in a 7-month-old boy who developed symptoms 30 h previously. The plain film indicates multiple distended small bowel loops associated with a mass

Table I. Comparison between onset of symptoms of intussusception and findings on plain radiography

Onset of symptoms [h]	Signs of plain radiography				Total
	Paucity of bowel gas	Quadrant gas-filled bowel loops	Distended bowel with a mass	Coffee-bean or banana sign	
~12	17	15	11	5	48
~24	12	21	25	8	66
~36	6	9	27	7	49
~48	1	6	10	10	27
Total	36	51	73	30	190

Spearman correlation coefficients: $R = 0.32833$, $p = 0.0080$, Cochran-Mantel-Haenszel statistics: non-zero correlation = 20.7, $p < 0.01$

Table II. Comparison between pathological type of intussusception and signs on plain radiography

Pathology type	Signs of plain radiography				Total
	Paucity of bowel gas	Quadrant gas-filled bowel loops	Distended bowel with a mass	Coffee-bean or banana sign	
Ileo-ileal	1	4	6	3	14
Ileo-caecal	1	7	1	1	10
Ileo-colic	1	12	6	6	25
Ileo-ileal-colic	1	13	12	18	44
Ileo-colic-colic	–	–	–	2	2
Total	4	36	25	30	95

Cochran-Mantel-Haenszel statistics: row mean scores differ = 11.4585, $p = 0.0219$

Table III. Comparison of clinical features between different age groups

Parameter	< 1 year old	> 1 year old	Total
Onset of symptoms [h]			
0~12	21	6	27
~24	26	5	31
~36	16	1	17
~60	18	2	20
Pathological type			
Ileo-ileal-colic	40	4	44
Ileo-colic	22	3	25
Ileo-caecal	9	1	10
Ileo-ileal	8	6	14
Ileo-colic-colic	2	0	2
Blood per rectum			
None	20	7	27
Slight	32	2	34
Moderate	18	3	21
Gross	11	1	12
Meckel's diverticulum	2	1	3
Duplication cyst	4	0	4
Necrosis and resection	10	1	11
Total	81	14	95

Table IV. Comparison of plain radiography and surgical findings that indicated intestinal obstruction with vascular compromise

Plain radiography findings (IOVC)	Surgical findings (IOVC)		Total
	+	–	
+	25	5	30
–	7	58	65
Total	32	63	95

Specificity = 0.78, sensitivity = 0.92, $\kappa = 0.7128$; 95% CI (0.5620, 0.8637) intestinal obstruction with vascular compromise (IOVC)

loops in a single quadrant and a paucity of bowel gas. In this situation, further examinations by ultrasound or air enema should be conducted [11-13]. When multiple distended small bowel loops are associated with a mass, then plain radiography has a high predictive value in making the diagnosis of intussusception [5, 8, 14].

If the symptoms have been present for a prolonged time, then it is more likely to involve intestinal obstruction and possible vascular compromise. In this instance, the coffee-bean or banana signs indicate vascular compromise; the bowel wall is thickened and perforation may occur.

Hypoxia and ischaemia of the bowel wall lead to low tonicity and intestinal distension. Therefore, the signs are more evident on plain radiography

than abdominal colour Doppler sonography, which has a questionable role in the assessment of the severity of the ischaemic insult to the bowel [3, 15]. This present study suggests that the coffee-bean or banana signs on plain radiography may be an alternative way of identifying intestinal obstruction with vascular compromise. The high degree of correlation shown between pathology and plain radiographic findings demonstrates the high sensitivity of radiography for assessing the severity of the intussusception. This is important, as vascular compromise leads to a higher irreducible rate during air enema and increased risks of associated complications [3, 14, 16, 17]. In these cases, surgical reduction may need to be performed more promptly to avoid bowel necrosis.

There were limitations to this study. Firstly, it was a retrospective study, and therefore a selection bias might have occurred. Additionally, we did not assess the children with the left lateral decubitus plain radiographic view, which might have omitted important clinical data in some children.

In conclusion, this study found that plain radiographic signs had a high concordance with the severity and site of intussusception in this series of paediatric patients. The signs on plain films were clearer than those on colour Doppler sonography, which may be important in the diagnosis of children who are developing vascular compromise of the bowel secondary to intussusception.

Acknowledgments

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