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Original Article

Role of clinical and CT findings in the identification of adult small-bowel intussusception requiring surgical intervention

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Abstract

Background: In adults, intussusception has been considered traditionally to have an underlying aetiology. The aim of this study was to determine CT and clinical features of small-bowel intussusceptions that required surgical intervention.

Methods: Adult patients were identified in whom small-bowel intussusceptions were noted on CT images. The appearance, number, type (enteroenteric *versus* enterocolic), length and maximum short-axis diameter of intussusceptions, and presence of bowel obstruction (short-axis diameter of proximal small bowel greater than 3 cm) were analysed. The outcome was defined as surgical (complicated) or self-limiting (uncomplicated). Associations between complicated and uncomplicated intussusceptions and patient characteristics were investigated.

Results: Among 75 patients (56 male) with a mean age of 45 years, 103 intussusceptions were identified, of which 98 (95 per cent) were enteroenteric and 5 (5 per cent) enterocolic. Only 12 of 103 intussusceptions (12 per cent) in 12 of 75 (16 per cent) patients required surgical therapy and were considered to be complicated, with half of these having a neoplastic lead point. Length ($P < 0.001$), diameter ($P < 0.001$) and type ($P = 0.002$) of intussusception as well as presence of vessels ($P = 0.023$) within an intussusception on a CT scan, clinical symptoms ($P = 0.007$) and signs of bowel obstruction ($P < 0.001$) were associated with a surgical outcome.

Conclusion: Clinical symptoms, signs of bowel obstruction, type and length of intussusception, and a visible tumour within an intussusception on CT scan were critical signs of complicated intussusception, requiring surgical intervention.

Introduction

Intussusception involves telescoping of a proximal segment of the bowel (the intussusceptum) into an adjacent distal segment (the intussuscipiens). Adult intussusception accounts for approximately 5–16 per cent of all intussusceptions and 1 per cent of small-bowel obstructions[1,2]. In contrast to children, where intussusception is idiopathic in up to 90 per cent of patients, adult intussusception was considered traditionally to have an identifiable aetiology[1–3], based on surgical series where the diagnosis of intussusception was made intraoperatively. More recent studies, in which intussusception was diagnosed by computed tomography (CT), suggest that small-bowel intussusceptions in adults are mostly self-limiting, without an underlying aetiology[4–7].

The aim of the current study was to evaluate if clinical or CT findings can be used to distinguish between self-limiting adult small bowel intussusceptions and those requiring surgery .

Methods

This study was approved by the local ethics committee (reference 15–104-0170) of University Hospital Regensburg, a tertiary referral centre. A free-text search for the key word 'intussusception' was performed on all CT imaging reports from 1 March 2003 to 15 October 2017. The evaluated CT examinations were performed for various medical departments (for example visceral surgery, gastrointestinal medicine, oncology) involving both in- and out-patients. Studies were reviewed for the presence of an intussusception that was determined as bowel-within-bowel appearance and noted on at least two axial or coronal sections. Patients were included in the study if they were at least 18 years of age at the date of CT acquisition. One of the authors reviewed all the medical records and documented patient demographics, indication for CT scanning and clinical features, especially symptoms indicative of obstruction due to intussusception (abrupt-onset abdominal pain, nausea, vomiting, abdominal distention). Known

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diagnoses of underlying gastrointestinal disease or malignancy were noted along with the need for surgery and patient outcome.

CT technique

During the study period, different CT scanners were used (Somatom® Sensation 16 and Somatom® Definition Flash Dual Source; Siemens, Erlangen, Germany). For image analysis, axial and coronal planes with a slice thickness of 3.0 mm were reconstructed. All CT data sets were stored digitally in the Picture Archiving and Communication System.

Image analysis and definitions

CT images were evaluated by two radiologists with consensus reading. The variables examined were: appearance of intussusception (especially if mesenteric vessels ('vessel inclusion') or mesenteric fat ('fat inclusion'), or both, were drawn into the intussusception (*Fig. 1*)), type and number of intussusceptions (enteroenteric if the intussuscipiens and intussusceptum were part of the small bowel, enterocolic if the intussusceptum was part of the small bowel and the intussuscipiens was part of the colon (*Fig. 2*)), maximum short-axis diameter and intussusception length (maximum short-axis diameter was measured as the largest distance between the outer aspects of the intussusception perpendicular to the long axis of the bowel (*Fig. 3*), length of the intussusception was defined as the length of the long axis of the intussusceptum within the intussuscipiens (*Fig. 3b*)), and bowel obstruction (considered to be present if the small bowel proximal to the intussusception had a short-axis diameter greater than 3 cm (*Fig. 4*)).

Intussusceptions were also classified according to underlying aetiology as: 'neoplastic' if a tumour was visible within an intussusception; 'non-neoplastic/non-idiopathic' if another pathological alteration adjacent to an intussusception was noted (for example inflammatory changes); or 'idiopathic'.

Intussusceptions were then classified by outcome as: 'uncomplicated' if the intussusception did not require surgical intervention and had resolved on follow-up imaging and/or if clinical follow-up was uneventful; or 'complicated' if the intussusception required surgery for reduction or resection of bowel.

Decision for surgical *versus* conservative management was based on clinical evaluation supported by CT features (elevated blood lactate concentration, signs of bowel ischaemia on CT imaging, acute abdomen in combination with bowel obstruction, suspected neoplasm on CT).

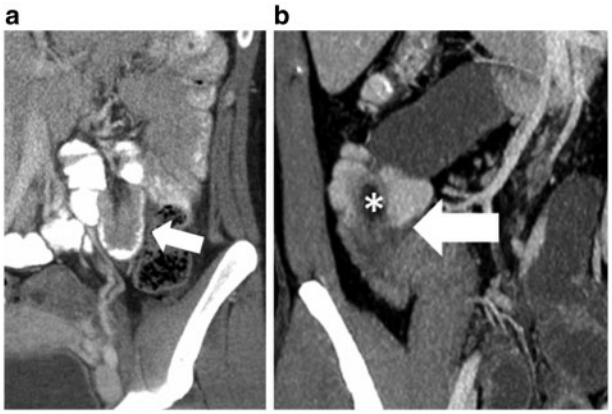

Fig. 2 CT scans

a Coronal reconstruction of an abdominal staging CT scan during portal venous phase in a patient with Hodgkin's disease showing enteroenteric intussusception (arrow). **b** Coronal reconstruction of an abdominal CT scan during portal venous phase performed for an acute abdomen. The CT scan shows enterocolic intussusception (arrow), which was treated by surgery and revealed an endoluminal lipoma (*) and ischaemic enteritis.

Statistical analysis

Statistical analysis was performed using the software package SPSS® (version 25; SPSS Inc, Chicago, Illinois, USA) and SAS® (version 9.4, SAS Institute Inc., Cary, North Carolina, USA) using the procedure *proc genmod*. The level of significance was set at $P \leq 0.050$ for all tests. Data analyses were exploratory with no adjustments for multiple testing.

Descriptive analyses were performed using frequency, percentages and mean(s.d.). Owing to the small number of complicated intussusceptions, univariable analyses were conducted. To deal with patients with multiple intussusceptions, generalized linear models using an exchangeable working correlation structure were used to evaluate the impact of intussusception characteristics on developing complicated intussusceptions. Because distinct groups of patients with or without complicated intussusceptions existed, binary logistic regression models were

Fig. 1 Axial slice of an abdominal CT in a scan during portal venous phase in a patient with metastatic malignant melanoma

The image shows enterocolic intussusception (arrowhead) with mesenteric fat (small arrow) and mesenteric vessels (thick arrow) being drawn into the intussusception. Surgical treatment revealed intraluminal metastasis of malignant melanoma which was not seen on the CT scan.

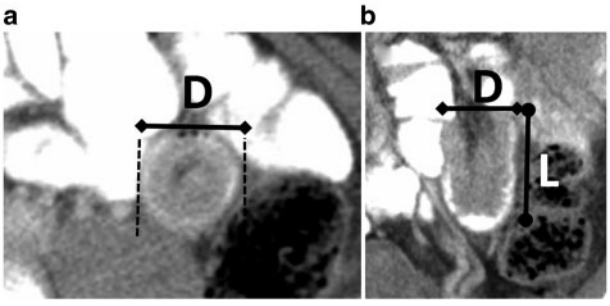

Fig. 3 CT scan illustrating maximum short-axis diameter and length of an intussusception

a Axial and **b** coronal reconstruction of an abdominal CT scan during portal venous phase showing enteroenteric intussusception. D is the maximum short-axis diameter of the intussusception. L is the length of the intussusception. (Same scan as *Fig. 2a*).

Fig. 4 CT scan illustrating bowel obstruction

Coronal reconstruction of an abdominal CT scan during portal venous phase showing enterocolic intussusception (arrow). Small bowel proximal to the intussusception has a short-axis diameter (D) greater than 3 cm. (Same scan as *Fig. 2b*).

used to evaluate the impact of patient characteristics on developing complicated intussusceptions. Additionally, the predictive value of clinical condition, history of malignancy and signs of bowel obstruction based on patient numbers, as well as of length and diameter of intussusceptions based on numbers of intussusceptions were evaluated to detect complicated intussusceptions. For dichotomous variables, sensitivity, specificity, positive predictive values (PPVs) and negative predictive values (NPVs)were computed[8]. For the metric variables length and diameter of intussusceptions, receiver operating curves (ROC) with area under the curves (AUC) were computed[8]. The optimal threshold for distinguishing between complicated and uncomplicated intussusceptions was defined by the highest Youden index[9].

Results

CT examinations

Abdominal CT examination was acquired only in portal venous phase in 70 of 75 (93 per cent) patients and in both arterial and portal venous phase in four of 75 (5 per cent) patients. In one patient (1 per cent), CT was performed without intravenous contrast material owing to impaired renal function, but with both orally and rectally administered contrast medium. Non-ionic contrast agent (Ultravist® 370; Bayer-Schering AG, Berlin, Germany) was administered intravenously in 74 of 75 patients (99 per cent) by power injection of 70–140 ml at a flow-rate of 2–4 ml/s. Of those patients receiving intravenous contrast material, contrast medium was additionally administered both orally and rectally in 21 of 74 (28 per cent), only orally in 35 of 74 (47 per cent), and only rectally in one of 74 (1 per cent) patients. Seventeen of 74 (23 per cent) patients with intravenous contrast material did not receive oral and/or rectal contrast material.

Patient characteristics, main CT indications and intussusception characteristics

Some 75 adult patients with a total of 103 intussusceptions met the inclusion criteria. The patient characteristics, main CT indications and intussusception characteristics are presented in *Table 1*. Of these, 35 (47 per cent) patients had abdominal symptoms at the time of imaging. Abdominal pain was the most common complaint and was noted in 34 (45 per cent) patients followed by abdominal tenderness in 17 (23 per cent), vomiting in eight (11 per cent), constipation in six (8 per cent) and distension in three (4 per cent) patients. An abdominal tumour was not palpated in any patient.

Uncomplicated intussusceptions

Some 63 of 75 (84 per cent) patients with a total of 91 of 103 (88 per cent) intussusceptions (90 enteroenteric, 1 enterocolic) were considered uncomplicated as no surgical therapy of the intussusception had been considered necessary following clinical assessment. Of these 63 patients, 12 (19 per cent) subsequently underwent abdominal surgery within a mean(s.d.) of 4.4(6.9) days (range 0–20 days) after detection of an intussusception on CT scan. In six of these patients (50 per cent), surgery was performed for an 'acute abdomen' (including the single patient with enterocolic intussusception). In the remaining six patients, surgery was performed for other specific reasons (appendicitis, intra-abdominal haematoma, intra-abdominal abscess, liver transplantation, exclusion of neuroendocrine malignancy and Whipple resection). The intussusceptions detected by CT were not verified by surgery in any of these 12 patients. The remaining 51 of 63 (81 per cent) patients had an uneventful clinical follow-up and unremarkable follow-up imaging in 34 of 51 (67 per cent) patients using CT, MRI or abdominal ultrasound.

Complicated intussusceptions

Twelve of 103 (12 per cent) intussusceptions (8 enteroenteric, 4 enterocolic) in 12 of 75 (16 per cent) patients required surgical therapy. All patients with complicated intussusceptions had only a single intussusception. Surgery was performed on the same day as the CT scan (mean(s.d.) 0(0.5) days, range 0–1 day). The intussuscepted bowel segment was resected in 10 of 12 patients and reduced in two of 12 patients. A neoplasm was responsible for six of 12 intussusceptions (4 enteroenteric, 2 enterocolic). In four of these patients, the surgically confirmed tumour within the intussusception was detected on the prior CT scan. In the other six patients, one had an enteroenteric intussusception associated with appendicitis and peritonitis, while the remaining five patients were considered as idiopathic because no underlying reason could be verified.

Predictors of complicated intussusceptions

In patients with complicated intussusceptions, a single intussusception was detected within one CT scan. In 63 patients with uncomplicated intussusceptions, 46 (73 per cent) had a single one intussusception, and 17 (27 per cent) had more than one intussusception detected within one CT scan (*Table 1*).

Patient level

Age , sex, history of malignancy, history of metastatic disease and status after abdominal surgery did not predict complicated intussusceptions (*Table 2*). Complicated intussusceptions were more likely in patients with clinical symptoms ($P = 0.007$) and with signs of bowel obstruction ($P < 0.001$) (*Table 2*). Inflammatory bowel disease was not present in patients with complicated intussusceptions (0 per cent), but was present in 13 per cent of patients with uncomplicated intussusceptions (*Table 1*).

Table 1 Patient and intussusception characteristics

Characteristic	All	Complicated intussusception	Uncomplicated intussusception
Patient characteristics	*n* = 75	*n* = 12	*n* = 63
Age (years)*	44.8(16)	46.0(19.6)	44.6(15.6)
Age range (years)	18–78	18–77	18–78
Sex			
Male	56 (75)	9 (75)	47 (75)
Female	19 (25)	3 (25)	16 (25)
Number of intussusceptions within the same CT scan			
1	58 (77)	12 (100)	46 (73)
2	9 (12)	0	9 (14)
3	7 (9)	0	7 (11)
6	1 (1)	0	1 (2)
History of malignancy			
No	59 (79)	10 (83)	49 (78)
Yes	16 (21)	2 (17)	14 (22)
History of metastatic disease			
No	61 (81)	10 (83)	51 (81)
Yes	14 (19)	2 (17)	12 (19)
Underwent abdominal surgery before the CT scan			
No	59 (79)	10 (83)	49 (78)
Yes	16 (21)	2 (17)	14 (22)
Inflammatory bowel disease			
No	67 (89)	12 (100)	55 (87)
Yes	8 (11)	0 (0)	8 (13)
Clinical symptoms			
No	40 (53)	1 (8)	39 (62)
Yes	35 (47)	11 (92)	24 (38)
Main indication for CT			
Staging/exclusion of a malignancy preoperative imaging	27 (36)	1 (8)	26 (41)
Evaluation of abdominal pain/acute abdomen	32 (43)	11 (92)	21 (33)
Detection of unclear infectious focus without abdominal pain	15 (20)	0 (0)	15 (24)
Exclusion of trauma sequelae	1 (1)	0 (0)	1 (2)
Signs of bowel obstruction			
No	63 (84)	3 (25)	60 (95)
Yes	12 (16)	9 (75)	3 (5)
Intussusception characteristics	*n* = 103	*n* = 12	*n* = 91
Type			
Enteroenteric	98 (95.1)	8 (67)	90 (99)
Enterocolic	5 (4.9)	4 (33)	1 (1)
Length (cm)*	5.3(3.3)	10.3(4.5)	4.7(2.5)
Length range (cm)	1.0–20.4	3.6–20.4	1.0–13.5
Diameter (cm)*	3.3(0.9)	4.5(1.0)	3.2(0.8)
Diameter range (cm)	1.2–5.9	2.5–5.8	1.2–5.9
Fat inclusion			
No	30 (29.1)	0	30 (33)
Yes	73 (70.9)	12 (100)	61 (67)
Vessel inclusion			
No	41 (39.8)	1 (8)	40 (44)
Yes	62 (60.2)	11 (92)	51 (56)
Visible tumour on CT scan within the intussusception			
No	99 (96.1)	8 (67)	91 (100)
Yes	4 (3.9)	4 (33)	0

Values in parentheses are percentages unless indicated otherwise; *values are mean(s.d.).

The distribution of present clinical symptoms and detected complicated intussusceptions by CT scans is presented in *Table 1*. Sensitivity (correctly identifying complicated intussusceptions) was 92 per cent (11 of 12), and specificity (correctly identifying uncomplicated intussusceptions) 62 per cent (39 of 63). Of all patients with clinical symptoms, only 31 per cent (11 of 35 patients) had complicated intussusceptions according to CT scans (PPV). Of those without clinical symptoms, 98 per cent (39 of 40 patients) had uncomplicated intussusceptions on CT scans (NPV). For history of malignancy, sensitivity was 17 per cent (2 of 12), specificity 77.8 per cent (49 of 63), PPV 13 per cent (2 of 16) and NPV 83 per cent (49 of 59). For signs of bowel obstruction, sensitivity was 75 per cent (9 of 12), specificity 95 per cent (60 of 63), PPV 75 per cent (9 of 12) and NPV 95 per cent (60 of 63).

Intussusception level

Complicated intussusceptions were significantly longer (mean(s.d.) length 10.3(4.5) *versus* 4.7(2.5) cm; $P < 0.001$) and thicker (mean(s.d.) thickness 4.5(1.0) *versus* 3.2(0.8) cm; $P < 0.001$) than uncomplicated intussusceptions. All complicated intussusceptions had a length of at least 3.6 cm (*Table 2*). Enterocolic intussusceptions ($P = 0.002$) and vessel inclusions ($P = 0.023$) were

Table 2 Prediction of complicated intussusception

Characteristic	Odds ratio	*P*
Patient level*		
Age	1.01 (0.97, 1.04)	0.768
Sex	0.98 (0.24, 4.07)	0.977
History of malignancy	1.43 (0.28, 7.29)	0.668
History of metastatic disease	1.18 (0.23, 6.08)	0.846
Abdominal surgery prior to CT scan	1.43 (0.28, 7.29)	0.668
Inflammatory bowel disease‡	–	–
Clinical symptoms§	17.87 (2.17, 147.34)	0.007
Signs of bowel obstruction§	60.0 (10.46, 344.22)	<0.001
Intussusception level†		
Type	0.03 (0.00, 0.24)	0.002
Length	0.47 (0.25, 0.69)	<0.001
Diameter	1.53 (0.68, 2.37)	<0.001
Fat inclusion‡	–	–
Vessel inclusion	7.57 (1.32, 43.43)	0.023
Visible tumour on CT scan within the intussusception‡	–	–

Values in parentheses are 95 per cent confidence intervals. *On patient level, univariable binary logistic regressions were conducted. †On intussusception level, univariable generalized linear models were conducted. ‡Due to quasi-separated data, no analyses were conducted. §The reference category was no clinical symptoms and no signs of bowel obstruction.

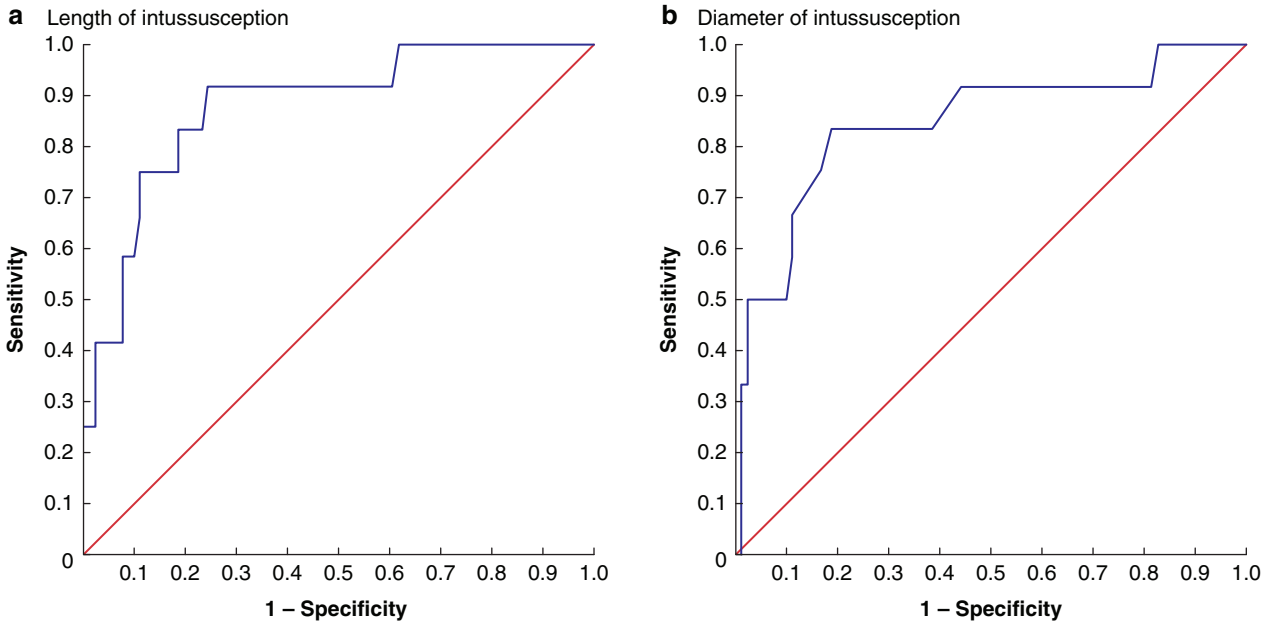

Fig. 5 Receiver operating curves

a Receiver operating curve on basis of length of intussusception. **b** Receiver operating curve on basis of diameter of intussusception.

more likely in complicated intussusceptions (*Table 2*). Fat inclusions were found in 100 per cent of complicated intussusceptions compared with 67 per cent of uncomplicated intussusceptions. No tumours were visible on CT scan in uncomplicated intussusceptions compared with four of 12 complicated intussusceptions (*Table 1*).

Receiver operating curves are shown in *Fig. 5*. The overall accuracy of intussusception length was 0.88 (95 per cent c.i. 0.78 to 0.98) and intussusception diameter was 0.85 (95 per cent c.i. 0.71 to 0.98). According to the highest Youden index, the optimal threshold value for intussusception length was 5.80 cm with a sensitivity of 91.7 per cent and a specificity of 75.8 per cent. The optimal threshold value for intussusception diameter was 3.85 cm with a sensitivity of 83.3 per cent and a specificity of 81.3 per cent.

Discussion

The current study identified 103 enteroenteric and enterocolic intussusceptions in 75 patients resulting in surgical management in 12 patients, a figure similar to those of other recent studies that have used imaging to identify intussusception[4,5]. This means that 91 of 103 (88 per cent) intussusceptions detected on CT scans did not require surgery. In contrast to many previous studies, the current study resulted in a diagnosis of 'uncomplicated intussusception' in nearly three out of four patients (46 of 63) on the basis of surgical findings or unremarkable follow-up imaging with resolution of the previously detected intussusception.

The present series highlighted several significant differences between complicated and uncomplicated intussusceptions. All intussusceptions in which an endoluminal tumour was detected

on CT were complicated. If an intussusception was enterocolic it was more likely than enteroenteric intussusception to be complicated, in line with previous studies[4,5]. In the present study, only one of five enterocolic intussusceptions was uncomplicated. Complicated intussusceptions were more likely in patients with signs of bowel obstruction than those without ($P < 0.001$), being present in nine of 12 patients compared with three of 63, with uncomplicated intussusception.

The decision to perform surgery relies on clinical features and CT imaging. It seems highly unlikely that an intussusception diagnosed on a CT scan in an asymptomatic patient represents complicated intussusception. Statistical analyses in the present study indicated that the feature 'clinical symptoms' differed significantly in patients with complicated intussusception from those without. Because most patients with complicated intussusceptions had clinical symptoms and only one patient from this group had no clinical symptoms, this feature had a high sensitivity of 92 per cent (11 of 12 patients) and NPV of 98 per cent (39 of 40). Many patients with uncomplicated intussusceptions also showed matching clinical symptoms, so this resulted in poor specificity of 62 per cent (39 of 63 patients) and a poor PPV (31 per cent (11 of 35)).

Length and diameter of intussusception have previously been evaluated repeatedly to distinguish between uncomplicated and complicated intussusceptions[4,5]. In the present study, complicated intussusceptions were significantly longer and thicker than uncomplicated intussusceptions. These results are in line with a previous study, showing significant differences in length and diameter of complicated and uncomplicated intussusception[4]. While the present study and others[4,5] indicate that intussusceptions with a length less than 3.5 cm are more likely to be uncomplicated, intussusceptions equal to or longer than 3.6 cm represented nearly two thirds of those that were uncomplicated.

The present study has several limitations. The study was performed retrospectively at a single institution. The search methodology included only lesions that were mentioned in the radiology reports so it is possible that some intussusceptions were undetected. Owing to the low number of complicated intussusceptions, it was not possible to perform multivariable analysis. Some variations in CT technique, where oral or intravenous contrast was omitted, might have impaired morphological analysis of the intussusceptions. The diagnosis of uncomplicated intussusception was made in some patients on the basis of uneventful clinical follow-up, although it is possible that some of these patients developed symptoms again and were surgically treated at other hospitals, so the number of surgical lesions may have been underestimated.

Clinical features of bowel obstruction, type and length of intussusception, and a visible tumour within an intussusception on a CT scan are critical features of complicated intussusception requiring surgical intervention.

Acknowledgements

Because of the sensitive nature of the data collected for this study, requests to access the data set from qualified researchers trained in human subject confidentiality protocols may be sent to the corresponding author and will be considered by the authors. No preregistration exists for the study reported in this article. A.S. and R.M.-W. contributed equally to the manuscript.

Disclosure. The authors declare no conflict of interest .

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