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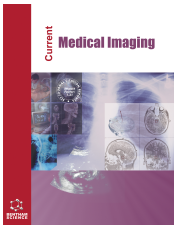

RESEARCH ARTICLE

Clinical Presentations, MDCT Features, and Treatment of Three Types of Adult Intussusceptions Based on the Location

Qiu-jie Dong[1,2,#], Jing Shi[3,#], Chun-lai Zhang[2], Xiao-guang Li[2], Xiao Chen[1,*] and Yi Wang[1,*]

[1]*Department of Nuclear Medicine, Daping Hospital, Army Medical University, Chongqing 400042, China*
[2]*Department of Radiology, Daping Hospital, Army Medical University, Chongqing 400042, China*
[3]*Department of Nursing, Hospital of Chengdu University of Traditional Chinese Medicine, Chengdu 610072, Sichuan Province, China*

Abstract:

Purpose:

This study aimed to explore the similarities and differences in clinical presentations, multidetector computed tomographic (MDCT) features, and treatment of three types of adult intussusceptions based on location.

Methods:

We retrospectively reviewed 184 adult patients with 192 intussusceptions. Depending on the location, intussusceptions were classified as enteric, ileocolic, and colonic types. The similarities and differences of clinical presentations, MDCT features, and treatment of three types of adult intussusception were compared. Meanwhile, the three types of intussusceptions were further divided into surgical and conservative groups based on the treatment. Uni- and multivariate logistic analyses were used to identify risk factors for intussusception requiring surgery.

Results:

Enteric and ileocolic intussusceptions were mainly presented with abdominal pain (78.46% and 85.71%). Hematochezia/melena (64.29%) was the main symptom of colonic intussusception. On MDCT, ileocolic intussusceptions were longer in length and had more signs of intestinal necrosis (hypodense layer, fluid collection and no/poor bowel wall enhancement) than enteric and colonic intussusceptions. Moreover, it was found that 93.88% (46/49) of ileocolic intussusception and 98.59% (70/71) of colonic intussusception belonged to the surgical group, whereas only 43.06% (31/72) of enteric intussusception belonged to the surgical group. Intussusception length (OR=1.171, P=0.028) and discernible lead point on MDCT (OR=21.003, P<0.001) were reliable indicators of enteric intussusception requiring surgery.

Conclusion:

Ileocolic intussusception may be more prone to intestinal necrosis than enteric and colonic intussusceptions, requiring more attention from clinicians. Surgery remains the treatment of choice for most ileocolic and colonic intussusceptions. Less than half of enteric intussusceptions require surgery, and MDCT features are effective in identifying them.

Keywords: Adult, Intussusception, Therapeutics, Multidetector computed tomography, Risk factors, Ischemia.

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1. INTRODUCTION

Intussusception is defined as the invagination of a portion of the intestine into another segment of the adjacent intestine [1 - 4]. Adult intussusception (AI) is a rare and complex lesion. Its exact pathogenesis is still not fully understood, but its etiology can be idiopathic, benign or malignant [2, 5]. The symptoms and signs of intussusception in adults are generally more insidious and less specific than intussusception in children, making clinical diagnosis difficult [4, 6, 7]. Various imaging techniques, such as X-ray, barium enema, ultrasound, and multidetector computed tomography (MDCT), are often needed to assist in diagnosis. MDCT is currently the most common and useful tool for diagnosing AI [1, 3, 8 - 11]. On

* Address correspondence to these authors at the Department of Nuclear Medicine, Daping Hospital, Army Medical University, Chongqing 400042, China; E-mails: ywhxl@qq.com and xiaochen229@foxmail.com
#These authors contributed equally to this work

MDCT, intussusception typically appears as a bowel-within-bowel appearance with or without mesenteric fat or vessels [9, 12]. Many transient adult intussusceptions are being captured by abdominal MDCT due to its widespread availability and application [3, 13 - 16]. Transient intussusception has been reported in many research works [5, 17, 18], leading to a reconsideration of the long-held view that all AIs necessitate surgery. Therefore, the management of AI still remains controversial.

The small intestine and large intestine have different functional and physiological characteristics. Depending on the location, AI can be divided into three types [19 - 21]: 1) enteric type, only involving the small bowel, including the duodenum, jejunum, and ileum, 2) ileocolic type (including ileocecal type), involving both small bowel and large bowel, and 3) colonic type (including colocolic and colorectal type) [7], only involving the large bowel. So far, there is no literature to discuss and report the treatment of AI in different locations simultaneously and compare their similarities and differences in clinical presentations, MDCT features, and treatment.

The main objective of this study is to provide a detailed description and comparison of the clinical presentations, MDCT features and treatment of different types of AI, and to find effective indicators for identifying intussusception that require surgery.

2. MATERIALS AND METHODS

2.1. Patient Population

This retrospective study was approved by our hospital's ethics committee, and the patient's written informed consent was waived. Searching our hospital's imaging reporting system, we found 349 adult visit records mentioning intussusception in MDCT report conclusions between January, 2012, to December, 2022. For patients with multiple MDCT visit records, the initial diagnosed MDCT images during the patient's treatment were selected and 54 records were excluded. Reviewing all images, the diagnosis of 47 intussusceptions was inconclusive, therefore they were excluded. The other 63 patients were excluded because they were not treated in our hospital. According to the location of intussusception on MDCT, there were three types: enteric, ileocolic, and colonic. One patient with both enteric and colonic intussusceptions was excluded as the patient could not belong to both enteric and colonic groups at the same time. The flow chart of the included patients is shown in Fig. (**1**).

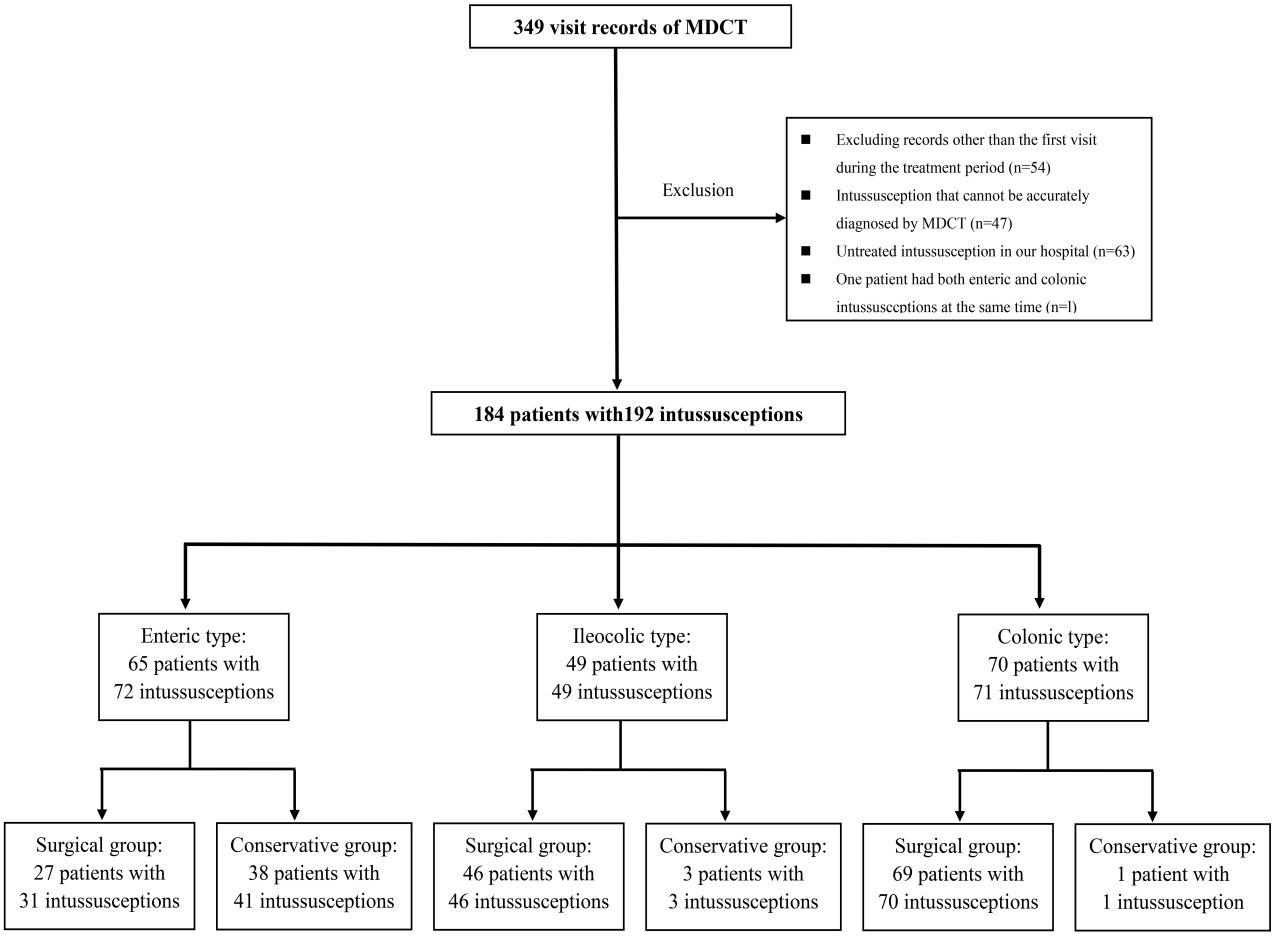


Fig. (1). Flow chart and grouping of the included patients.

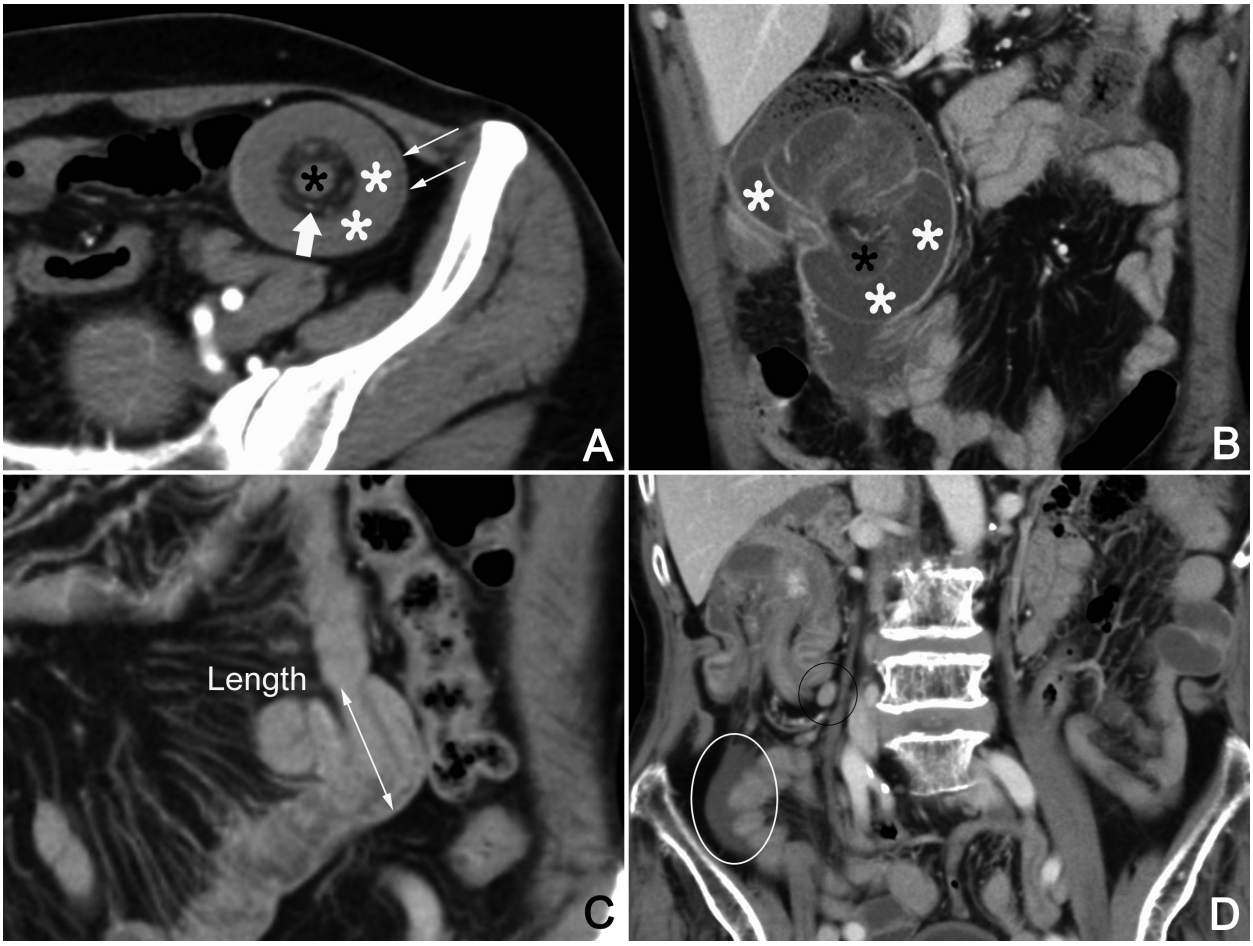


Fig. (2). Some MDCT features of intussusception. (**A**) shows the three layers of intussusception: the inner (the black asterisk), middle (white asterisks) and outer (thin arrows) layers. The thick arrow indicates the interposed mesenteric vessels and fat. (**B**) shows the hypodense layer (white asterisks) and fluid collection (black asterisk). (**C**) shows the intussusception length. (**D**) shows an enlarged lymph node (the black circle) and free peritoneal liquid (the white circle).

Patients with operative indications assessed by surgeons based on their medical records were classified into the surgical group, and those without operative indications or symptomatic relief after conservative treatment were categorized in the conservative group. Based on the patient's medical history, surgeons believed that surgery was indicated when the patient had one or more of the following conditions in addition to CT-indicated intussusception, including incomplete or complete ileus, suspected intestinal tumor, unexplained hematochezia/melena, and unremarkable symptomatic relief with symptomatic treatment. Two authors, assisted by a gastrointestinal surgeon in our hospital, examined the records of all patients in detail, assigned them to the corresponding groups, and recorded relevant clinical data, including age, sex, clinical symptoms and signs, treatment, and etiologies.

2.2. MDCT Examinations

All patients underwent at least one abdominal MDCT scan with different MDCT scanners (Lightspeed, GE Healthcare, Milwaukee, WI, USA and Philips Healthcare, Cleveland, OH, USA) during the study period. One hundred seventy-seven patients (with 185 intussusceptions) underwent plain and enhanced abdominal MDCT scans. For enhanced scans, arterial and portal phase images were obtained at approximately 20 s and 50 s after completion of the injection of the contrast medium. For image analysis, 3 mm sagittal images were reformatted selectively on the basis of 5 mm axial and 3 mm coronal images. All MDCT data were stored in the picture archiving and communication system (PACS).

2.3. Image Analysis

Two radiologists with 6 and 10 years of experience independently evaluated MDCT features of AI on the PACS system, and when the data were tallied, if significant differences in some data were found, they were re-evaluated under the guidance of another senior radiologist. For continuous data, the final data used was the average measured by two radiologists.

Intussusception consists of three layers: the inner, middle and outer layers. The first two are collectively called the intussusceptum, and the latter is called the intussuscipiens. The following MDCT features (Fig. **2**) were assessed for each intussusception: (1) types (based on the location); (2) appearances (it could be divided into target-sign, reniform-pattern and sausage-pattern based on axial CT images) [9]; (3) length (it is the maximum length measured along the long axis of the intussusceptum) [21]; (4) presence or absence of interposed fat and vessels; (5) presence or absence of

discernible lead point; (6) presence or absence of hypodense layer (it shows fluid-like hypodensity in the middle layer of the intussusception) and fluid/gas collection (between the inner and middle layers of the intussusception) [22]; (7) no or poor bowel wall enhancement (compared with adjacent normal intestine without intussusception); and (8) secondary changes included ileus, free peritoneal liquid, enlarged lymph nodes, *etc*. The criteria used by MDCT to diagnose secondary ileus caused by intussusception were proximal intestinal dilation (small bowel and large bowel greater than 2.5 cm and 6.0 cm in diameter, respectively, measured from outer wall to outer wall) and distal intestinal collapse.

2.4. Statistical Analysis

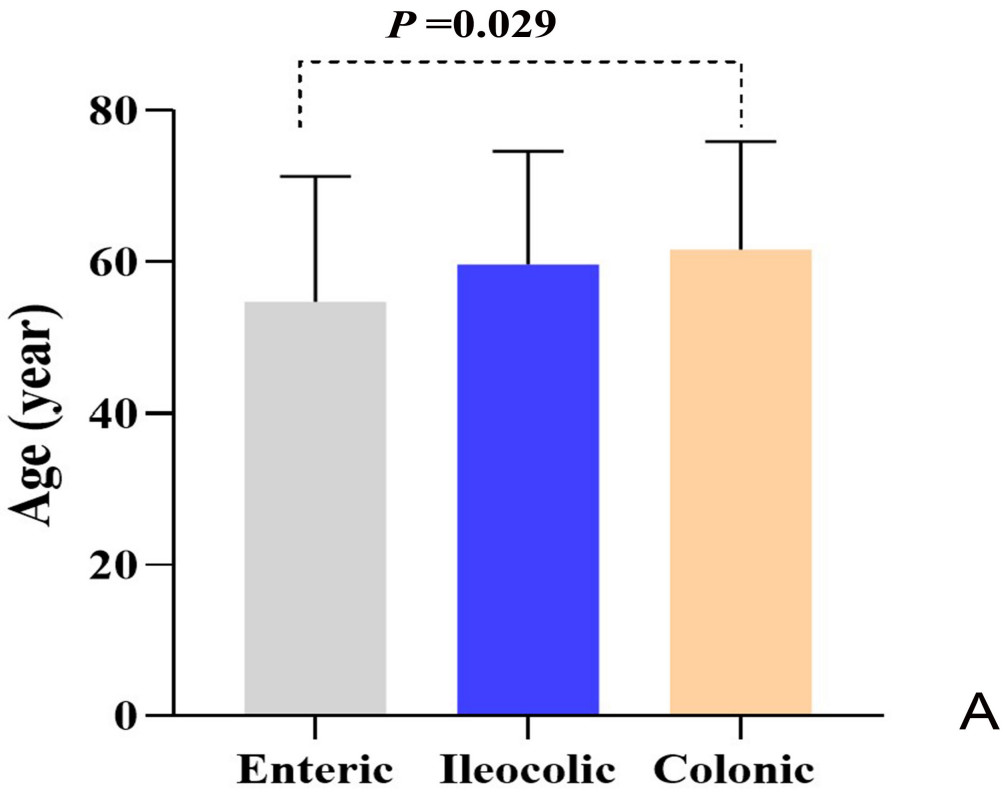
Frequency and percentage were used to describe the categorical data, and Pearson's Chi-square test or Fisher's exact test was used to determine whether the differences in categorical data between groups were statistically significant. The Bonferroni method was used for multiple comparisons among three groups. For continuous data, the Shapiro-Wilk test was used to evaluate its normality. Normal distribution data were described as mean ± standard deviation (SD). Student's *t*-test was used for comparison between two groups, and one-way analysis of variance or Kruskal-Wallis rank test, followed by Bonferroni method, was used for comparison among three groups. Skewed distribution data were described by median and inter-quartile range (IQR). The Mann-Whitney and Kruskal-Wallis rank tests were used for comparison of data between two groups and three groups, respectively. Uni- and multivariate regression analyses were used to identify risk factors for intussusception requiring surgery. For significant variables, receiver operating characteristic (ROC) curves were drawn, and the area under the ROC curve (AUC) was calculated. The ROC curve and the highest Youden index were used to determine the optimal cut-off value for significant continuous data. All statistical analyses and plots were performed with SPSS 25 (SPSS Inc., Chicago, USA) and Graph Pad Prism 8 (San Diego, CA, USA). Two-tailed p-value < 0.05 was considered significantly different.

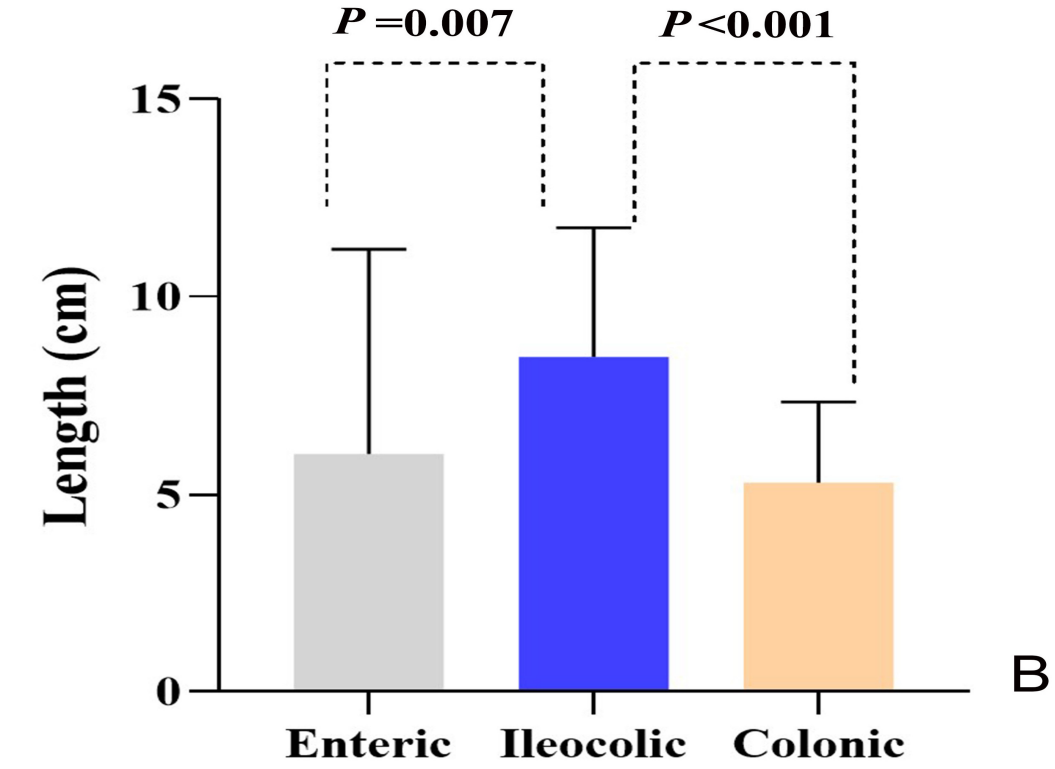
3. RESULTS

There were 184 patients with 192 intussusceptions, including 72 (37.50%) enteric, 49 (25.52%) ileocolic, and 71 (36.98%) colonic intussusceptions. One hundred seventy-seven patients had at least one intussusception, one patient had two colonic intussusceptions, one patient had three enteric intussusceptions, and five patients had two enteric intussusceptions each.

3.1. Clinical Presentations

Among the 184 patients, the male-to-female ratio was 1.79:1, and the mean age was 58.66 years. The difference in age between the three groups was statistically significant (P=0.030), and further analysis showed that patients with colonic intussusception were older than patients with enteric intussusception (P=0.029) (Fig. **3**).

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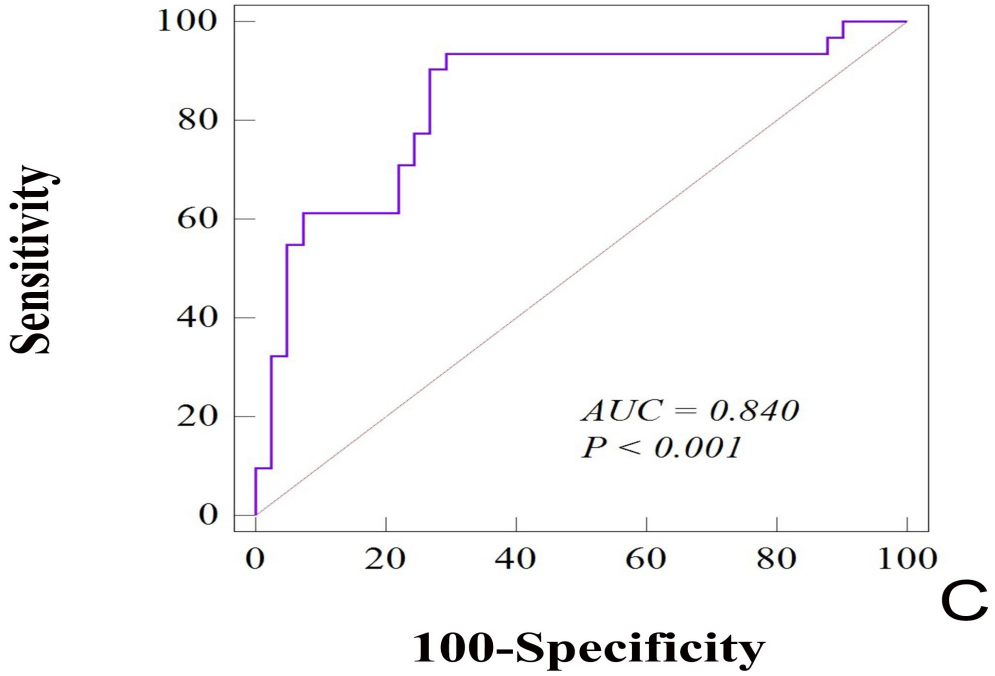
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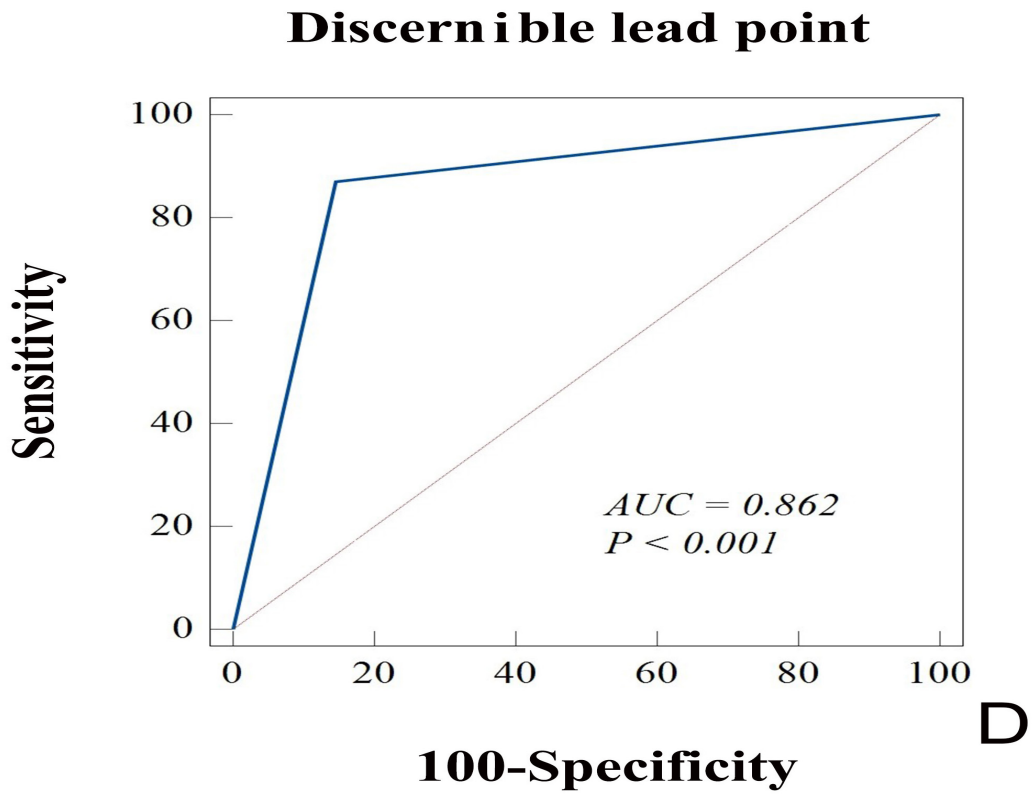


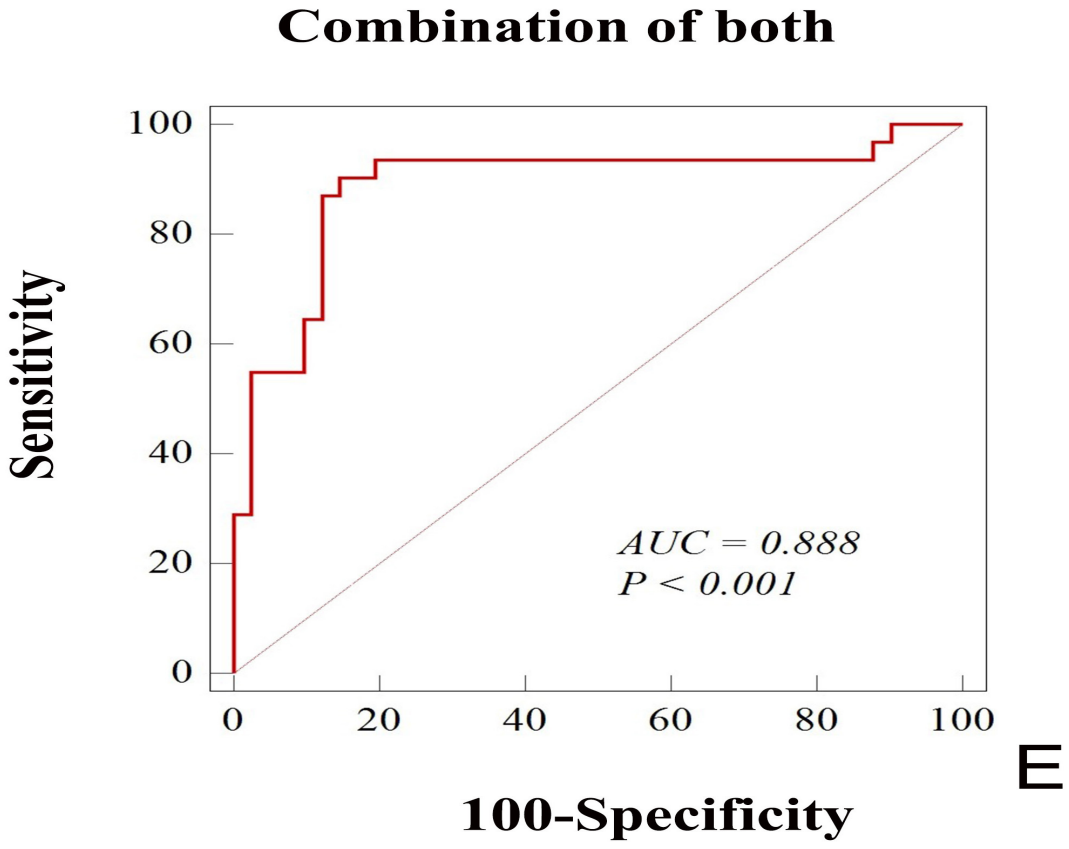


Fig. (3). Age was expressed by mean and standard deviation (**A**), and intussusception length was expressed by median and inter-quartile range (**B**). ROC curves for intussusception length (**C**), discernible lead point (**D**), and combination of both (**E**).

Sixteen patients (16/184, 8.70%) had a palpable abdominal mass on physical examination, and only two patients (2/184, 1.09%) presented with the typical triad of abdominal pain, bloody stools, and abdominal mass in pediatric intussusception. In clinical symptoms, there were statistically significant differences between the three groups in terms of abdominal pain (P=0.002), nausea/vomiting (P< 0.001), hematochezia/melena (P< 0.001), and changes in bowel habits (P< 0.001). Abdominal pain (78.46% and 85.71% *vs*. 58.57%) and nausea/vomiting (38.46% and 24.49% *vs*. 4.29%) were more frequent in patients with enteric and ileocolic intussusceptions than colonic intussusception, whereas patients with colonic intussusception presented with more hematochezia/melena (64.29% *vs*. 15.38% and 26.53%) and changes in bowel habits (45.71% *vs* 4.62% and 16.33%) than enteric and ileocolic intussusceptions. On physical examination, the frequency of abdominal tenderness differed among the three groups (P=0.018), and the frequency in patients with enteric and ileocolic intussusceptions was higher than those with colonic intussusception (53.85% and 51.02% *vs* 31.43%) (Table **1**).

3.2. MDCT Features

The appearance of three types of intussusceptions was mainly target-sign, with reniform-pattern being more numerous in colonic intussusception than enteric intussusception. Ileocolic intussusceptions tended to be longer in length (median, 8.46 cm *vs*. 6.03 and 5.30 cm) (Fig. **3**), and were more often associated with hypodense layer (40.82% *vs*. 5.56% and 7.04%), fluid collection (16.33% *vs*. 2.78% and 2.82%), no or poor bowel wall enhancement (55.56% *vs*. 11.11% and 14.71%) and enlarged lymph nodes (48.98% *vs*. 11.11% and 25.35%) than enteric and colonic intussusceptions. Enteric and ileocolic intussusceptions were more likely to induce ileus (20.83% and 22.45% *vs*. 2.82%) and free peritoneal liquid (20.83% and 22.45% *vs*. 4.23%) than colonic intussusception (Table **2**).

Table 1. Clinical features in 184 adult patients with intussusception.

Clinical Features	All (n=184)	Enteric Type (n=65)	Ileocolic Type (n=49)	Colonic Type (n=70)	*P*-value
Age (years; mean ± SD)	58.66±15.52	54.71 ± 16.59	59.67 ± 14.97	61.61 ± 14.26	0.030
Sex [*n*(%)]					0.240
Female	66 (35.87%)	25 (38.46%)	21 (42.86%)	20 (28.57%)	
Male	118 (64.13%)	40 (61.54%)	28 (57.14%)	50 (71.43%)	
Previous abdominal surgery [*n*(%)]	51 (27.72%)	17 (26.15%)	15 (30.61%)	19 (27.14%)	0.863
Clinical presentations [*n*(%)]					
Abdominal pain	134 (72.83%)	51 (78.46%) a	42 (85.71%) a	41 (58.57%) b	0.002
Abdominal distension	44 (23.91%)	14 (21.54%)	16 (32.65%)	14 (20.00%)	0.241
Nausea/vomiting	40 (21.74%)	25 (38.46%) a	12 (24.49%) a	3 (4.29%) b	<0.001
Exhaust and defecation stop	14 (7.61%)	9 (13.85%)	3 (6.12%)	2 (2.86%)	0.058
Diarrhea	24 (13.04%)	5 (7.69%)	7 (14.29%)	12 (17.14%)	0.253
Constipation	6 (3.26%)	1 (1.54%)	1 (2.04%)	4 (5.71%)	0.508
Hematochezia/melena	68 (36.96%)	10 (15.38%) a	13 (26.53%) a	45 (64.29%) b	<0.001
Changes in bowel habits	43 (23.37%)	3 (4.62%) a	8 (16.33%) a	32 (45.71%) b	<0.001
Belching/acid reflux	7 (3.80%)	4 (6.15%)	3 (6.12%)	0	0.070
Loss of weight	41 (22.28%)	11 (16.92%)	9 (18.37%)	21 (30.00%)	0.141
Abdominal tenderness	82 (44.57%)	35 (53.85%) a	25 (51.02%) a	22 (31.43%) b	0.018
Palpable abdominal mass	16 (8.70%)	3 (4.62%)	5 (10.20%)	8 (11.43%)	0.339

Note: The letter next to the numbers in each line indicates whether there is a difference between two-by-two comparisons of the categorical variables that are meaningful in the overall comparison between the three groups. The same letter indicates that the difference between the two groups is not statistically significant, and the different letter indicates that the difference between the two groups is statistically significant.

Table 2. MDCT features in 192 intussusceptions.

MDCT Features	All (n=192)	Enteric Type (n=72)	Ileocolic Type (n=49)	Colonic Type (n=71)	P-value
Appearance [*n*(%)]	-	-	-	-	<0.001
Target-sign	124 (64.58%)	54 (75.00%) a	30 (61.22%) a	40 (56.34%) a	-
Reniform-pattern	26 (13.54%)	1 (1.39%) a	5 (10.20%) a,b	20 (28.17%) b	-
Sausage-pattern	42 (21.88%)	17 (23.61%) a	14 (28.57%) a	11 (15.49%) a	-
Length [cm, M(IQR)]	6.07 (5.85)	6.03 (7.94)	8.46 (6.16)	5.30 (3.57)	<0.001
Discernible lead point [*n*(%)]	135 (70.31%)	33 (45.83%) a	35 (71.43%) b	67 (94.37%) c	<0.001
Hypodense layer [*n*(%)]	29 (15.10%)	4 (5.56%) a	20 (40.82%) b	5 (7.04%) a	<0.001
Fluid collection [*n*(%)]	12 (6.25%)	2 (2.78%) a	8 (16.33%) b	2 (2.82%) a	0.010

(Table 2) contd.....

MDCT Features	All (n=192)	Enteric Type (n=72)	Ileocolic Type (n=49)	Colonic Type (n=71)	P-value
No/poor bowel wall enhancement [*n*(%)]	43* (23.24%)	8 (11.11%) a	25^ (55.56%) b	10# (14.71%) a	<0.001
Interposed vessels [*n*(%)]	143 (74.48%)	44 (61.11%) a	39 (79.59%) a,b	60 (84.51%) b	0.004
Interposed fat [*n*(%)]	87 (45.31%)	30 (41.67%)	28 (57.14%)	29 (40.84%)	0.155
Free peritoneal liquid [*n*(%)]	29 (15.10%)	15 (20.83%) a	11 (22.45%) a	3 (4.23%) b	0.005
Ileus [*n*(%)]	28 (14.58%)	15 (20.83%) a	11 (22.45%) a	2 (2.82%) b	0.002
Enlarged lymph nodes [*n*(%)]	50 (26.04%)	8 (11.11%) a	24 (48.98%) b	18 (25.35%) a	<0.001

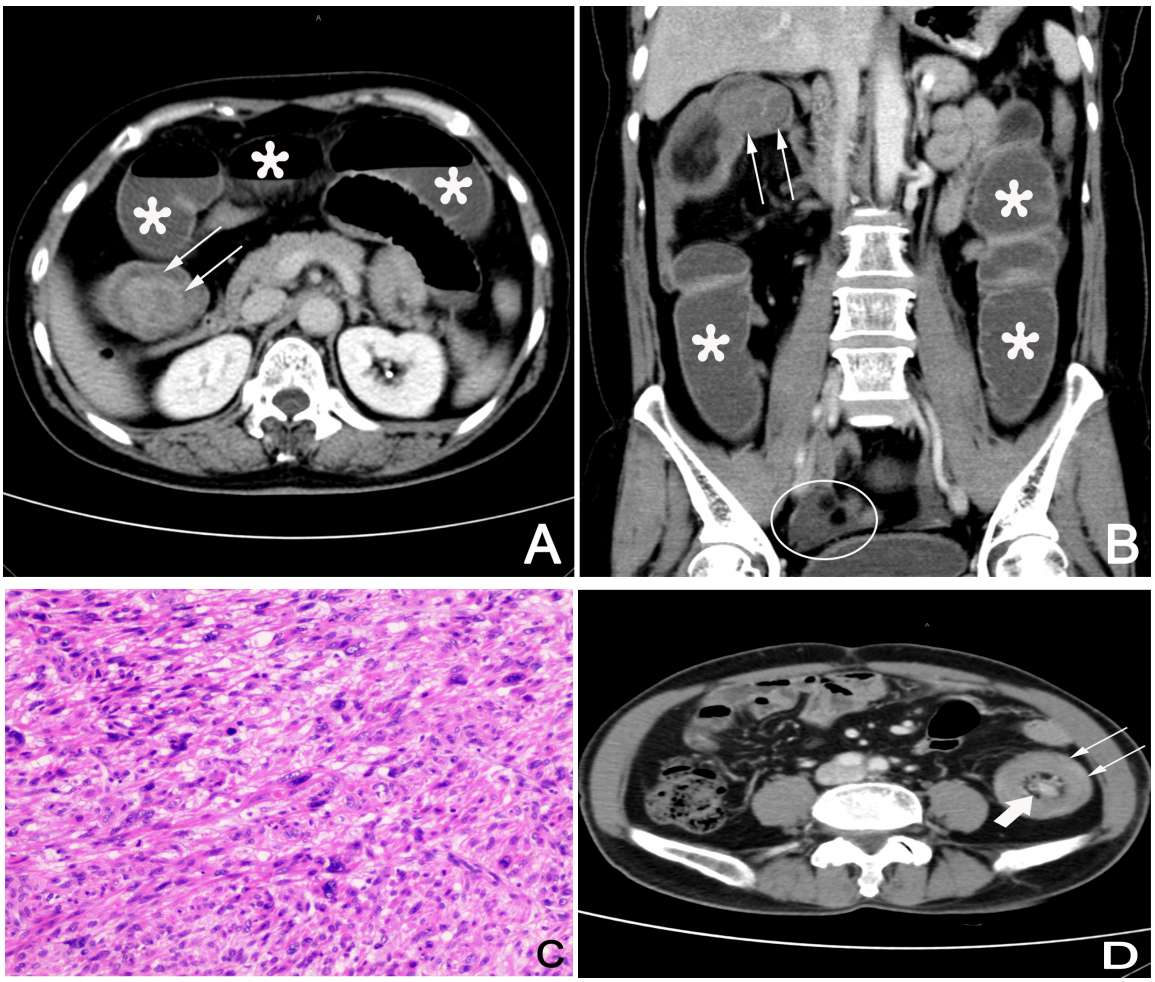
Note: The number of intussusception in each group receiving enhanced scanning: *=185; ^=45; #=68.
Same as Table **1**.

3.3. Treatment

3.3.1. Enteric Intussusception

There were 72 enteric intussusceptions in 65 patients.

Twenty-one patients (with 25 intussusceptions) had operative indications and underwent surgical treatment. Six patients (with 6 intussusceptions) were evaluated by surgeons as having operative indications, but they refused to operate in our hospital due to many underlying diseases and limited economic ability. Among the 25 (25/31, 80.65%) surgically treated enteric intussusceptions, 2 (2/25, 8.00%) were idiopathic intussusceptions, and 23 (23/25,92.00%) were secondary to lead points, including 8 (8/23, 34.78%) malignancies (Fig. **4**) and 15 (15/23, 65.22%) benign lesions. One intussusception (1/25, 4.00%) was pathologically confirmed to have ischemic necrosis.



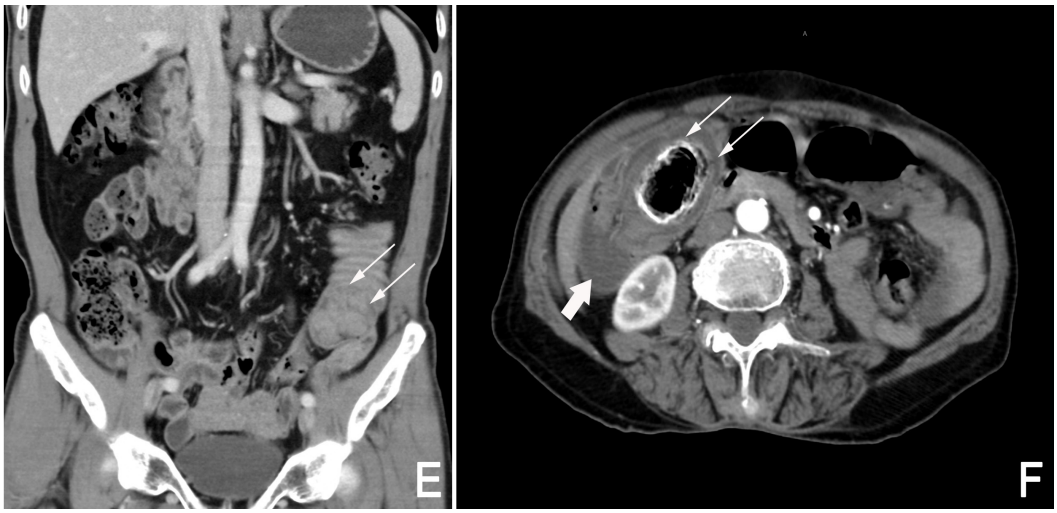


Fig. (4). Enteric, ileocolic, and colonic intussusceptions with discernible lead points. Contrast-enhanced MDCT of the abdomen in the axial (**A**) and coronal (**B**) images revealed an enteric intussusception with ileus (asterisks) and free peritoneal liquid (circle). The arrows (**A** and **B**) indicate the discernible lead point, and the patient underwent laparotomy, and the pathological result (**C**, HE, ×100) was an undifferentiated pleomorphic sarcoma. Abdominal MDCT showed target signs (thin arrows) and interposed mesenteric vessels (thick arrow) in the axial image (**D**). An irregular mass was seen in the coronal image (**E**) as the lead point (arrows) of colonic intussusception and was pathologically confirmed to be an adenocarcinoma. A mixed-density bezoar (thin arrows) and the hypodense layer (thick arrow) were seen on the axial image (**F**) of the abdominal MDCT.

In twenty-two patients (with 23 intussusceptions), no obvious intussusception was found in re-imaging after a short period of review, which was self-limiting intussusception (Fig. **5**). The symptoms of 16 patients (with 18 intussusceptions) resolved significantly after conservative treatment.

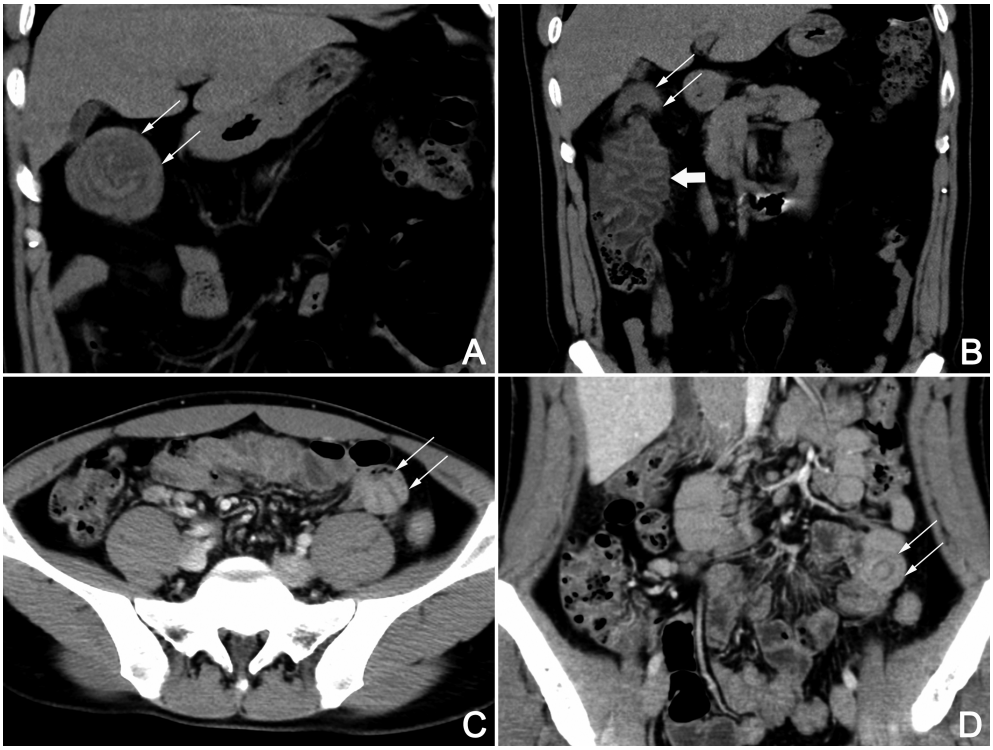


Fig. (5). Self-limiting intussusception. A 48-year-old male presented to the emergency department with abdominal pain and diarrhea for one day. Unenhanced abdominal coronal MDCT images (**A** and **B**) showed short colonic intussusception (thin arrows). The wall of the ascending colon was thickened and swollen (thick arrow), and colitis was diagnosed at discharge. One day later, a repeat MDCT was performed, and the intussusception was not shown. A 30-year-old male presented to our emergency department with abdominal pain, diarrhea, and nausea for two days. Enhanced abdominal MDCT images (**C** and **D**) showed no obvious abnormalities except for short enteric intussusception (thin arrows) in the left lower abdomen, and a repeat MDCT one day later showed no intussusception.

Table 3. Lead points of surgically treated adult intussusception (*n*=126).

Etiologies	Enteric Type (*n*=23)	Ileocolic Type (*n*=40)	Colonic Type (*n*=63)	Total
Benign	-	-	-	-
Adenoma	4	1	9	14
Polyp	2	2	-	4
Lipoma	5	4	3	12
Inflammation	1	5	2	8
GIST	2	-	-	2
HP	1	-	-	1
Schwannoma	-	1	-	1
Bezoar	-	1	-	1
Subtotal	15	14	14	43
Malignant	-	-	-	-
Carcinoma	-	19	49	68
Lymphoma	3	6	-	9
Metastatic tumor	1	-	-	1
Malignant GIST	1	-	-	1
Liposarcoma	1	-	-	1
LAMN	-	1	-	1
Malignant melanoma	1	-	-	1
UPS	1	-	-	1
Subtotal	8	26	49	83
Total	23	40	63	126

Abbreviations: HP, heterotopic pancreas; GIST, gastrointestinal stromal tumor; UPS, undifferentiated pleomorphic sarcoma; LAMN, low-grade appendiceal mucinous neoplasm.

3.3.2. Ileocolic Intussusception

There were 49 intussusceptions in 49 patients, and each patient only had one intussusception.

Forty patients (with 40 intussusceptions) had operative indications and underwent surgical treatment. Two patients (with 2 intussusceptions) were confirmed to be adenocarcinoma by colonoscopy biopsy and refused operation in our hospital. In addition, 4 patients (with 4 intussusceptions) refused to operate in our hospital after being evaluated by surgeons as having operative indications. Each of the 40 intussusceptions (40/46, 86.96%) treated surgically had a lead point, including 26 (26/40, 65.00%) malignant tumors (Table **3**) and 14 (14/40, 35.00%) benign lesions (Fig. **4**). Seven intussusceptions (7/40, 17.50%) were pathologically confirmed to have ischemic necrosis.

Three patients (with 3 intussusceptions) had no clear operative indications. One patient was admitted to the hospital with abdominal pain, abdominal distension, nausea and vomiting, and the symptoms were relieved after conservative treatment. An intussusception was found in one patient during routine tumor monitoring, and there were no abdominal symptoms or signs. One patient was treated in our hospital for abdominal pain and distension. The doctor combined-biopsy and laboratory results to consider the cause of intussusception as intestinal tuberculosis comprehensively and recommended anti-tuberculosis treatment.

3.3.3. Colonic Intussusception

There were 71 colonic intussusceptions in 70 patients.

Sixty-two patients (with 63 intussusceptions) had operative indications and underwent surgical treatment. Two patients (with 2 intussusceptions) received a biopsy (1 adenoma and 1 adenocarcinoma) and refused operation in our hospital. Two patients (with 2 intussusceptions) were recommended to undergo neoadjuvant chemotherapy before surgery after being diagnosed with rectal cancer through colonoscopy biopsy. In addition, 3 patients (with 3 intussusceptions) refused further surgical treatment in our hospital after being evaluated by surgeons as having operative indications. Each of the 63 intussusceptions (63/70, 90.00%) treated by surgery had a lead point, including 49 (49/63, 77.78%) malignant tumors (Fig. **4**) and 14 (14/63, 22.22%) benign lesions (Table **3**). One intussusception (1/63, 1.59%) was pathologically confirmed to have ischemic necrosis.

One patient presented to the emergency department with abdominal pain and diarrhea for one day. One day later, the patient underwent enhanced MDCT scans, and no colonic intussusception was found, which was self-limiting intussusception (Fig. **5**).

3.4. Uni- and Multivariate Logistic Regression of Enteric Intussusception Requiring Surgery

Except for the abdominal tenderness, there were no significant differences in all clinical presentations between the surgical and conservative groups (Table **S1**). The proportion of different intussusception appearances varied between the surgical and conservative groups (P=0.001). The length of enteric intussusceptions in the surgical group was significantly longer (median, 11.29 *vs* 3.62 cm, P<0.001) than in the conservative group. Interposed vessels (P=0.001), interposed fat (P<0.001), discernible lead point (P<0.001), and no/poor bowel wall enhancement (P=0.018) were more likely to be reported in the surgical enteric intussusception group (Table **S2**).

Table 4. Binary logistic regression of enteric intussusception requiring surgical intervention.

Variables	B	SE	Wald	P-Values	Odds Ratio (95% CI)
Univariate analysis	-	-	-	-	-
Intussusception length	0.284	0.072	15.581	<0.001	1.328 (1.154–1.529)
Intussusception appearance*	1.899	0.640	8.808	0.003	6.681 (1.906-23.416)
Discernible lead point	3.673	0.694	27.976	<0.001	39.375 (10.095–153.584)
Interposed vessels	1.894	0.581	10.627	0.001	6.644 (2.128–20.747)
Interposed fat	2.311	0.558	17.123	<0.001	10.083 (3.375–30.127)
No/poor bowel wall enhancement	2.457	1.100	4.990	0.025	11.667 (1.351-100.713)
Multivariate analysis	-	-	-	-	-
Discernible lead point	3.045	0.740	16.906	<0.001	21.003 (4.920–89.658)
Intussusception length	0.158	0.072	4.833	0.028	1.171 (1.017–1.349)

Note: *The reference category was non-sausage pattern (including target-sign and reniform-pattern).

Univariate and multivariate logistic regression (Table **4**) showed that intussusception length and discernible lead point were feasible predictors for enteric intussusception requiring surgery, and ROC curves were performed for the two variables (Fig. **3**). Based on the ROC curve and Youden index, the cut-off value for intussusception length was 4.56 cm, and the sensitivity and specificity were 93.55% and 70.73%, respectively. For discernible lead points, the sensitivity was 87.10%, specificity was 85.37%, positive predictive value was 81.82%, and negative predictive value was 89.74%. The AUC of intussusception length and discernible lead point were 0.840 (95% CI: 0.742-0.938) and 0.862 (95% CI: 0.769–0.955), and the combined AUC of the two indexes was 0.888 (95% CI: 0.801-0.976).

4. DISCUSSION

The anatomical structure and physiological function of the small intestine and large intestine are different, and the clinical presentations and MDCT features of intussusception occurring in different locations are also different. Ileocolic intussusception is classified into the enteric type [21] and the colonic type [15]. For most ileocolic intussusceptions, it is difficult to determine from MDCT presentations alone whether the lead point originates in the ileum or the colon [3]. Therefore, this study discussed and compared various characteristics of different types of AIs.

Overall, abdominal pain remains the most common symptom of AI in our study, which is in line with the previous studies [3, 8, 10]. However, depending on the site of intussusception, symptoms of incomplete ileus, such as abdominal pain and nausea/vomiting, are more common in both enteric and ileocolic intussusceptions, whereas hematochezia/melena and changes in bowel habits are more common in the colonic intussusception.

Fujimoto T [22]. believed that hypodense layer, fluid, and gas collection on MDCT were effective predictors in predicting the degree of vascular compromise in intussusception. Our study found that ileocolic intussusception was more often associated with hypodense layer and fluid collection compared to enteric and colonic intussusceptions. Intussusception length in ileocolic intussusception was found to be longer than enteric and colonic intussusceptions. The longer the intussusception length, the greater the possibility of the mesenteric vessel invagination and the higher the possibility of intestinal ischemia necrosis. At the same time, the proportion of pathologically diagnosed intestinal necrosis in ileocolic intussusception was larger than that in enteric and colonic intussusceptions. The occurrence of this phenomenon may indicate a greater probability of ileocolic intussusception with vascular compromise than enteric and colonic intussusceptions. Due to the limited number of intestinal necrosis diagnosed by pathology in the study, this conclusion needs to be further confirmed by a larger sample size.

In our study, 27 patients with 31 enteric intussusceptions had operative indications, 21 patients with 25 intussusceptions underwent surgery and obtained complete histological diagnosis, and 8 intussusceptions were due to malignancies. For enteric intussusception, it is more urgent and important to determine which one requires surgical intervention. The discernible lead point on MDCT and intussusception length are possible risk factors for predicting whether an enteric intussusception requires surgery. Ileus was one of the operative indications, but the difference between ileus found on MDCT was not statistically significant. This may be related to the different timing of MDCT examination in the course of disease, or it may be related to the fact that some patients had been treated in other hospitals before coming to our hospital for treatment.

Abdominal MDCT is helpful in identifying intussusception with the lead point [7, 12]. The existence of a lead point on MDCT is one of the risk factors for enteric intussusception requiring surgical intervention, which is similar to the previous opinion [21, 23]. Enteric intussusceptions in the surgical group had longer lengths than those in the conservative group. Lvoff [17] considered the intussusception length as the main factor in distinguishing the majority of self-limiting enteric intussusception detected by CT from the minority of enteric intussusception requiring surgery and calculated a cut-off value of 3.5 cm to distinguish them. Sundaram [18], however, argued that many enteric intussusceptions that did not require surgery were longer than 3.5 cm in length and believed that these CT features were not helpful in diagnosing surgical intussusception in adults, which is consistent with the views of other authors [2, 15]. In our study, the cut-off value for intussusception length was 4.56 cm, which was slightly longer than the 3.5cm in the previous study, and the sensitivity of using this cut-off

value to determine whether enteric intussusception requires surgery was as high as 93.55%.

More than 90% of ileocolic and colonic intussusceptions were recommended for surgical treatment by surgeons, which was in general agreement with previous findings [18]. In addition, malignancies accounted for 60-70% of surgically treated ileocolic and colonic intussusceptions, which were in line with the findings of previous studies [7, 11, 24]. Therefore, we completely concur with previous authors [4, 25] that the majority of intussusceptions involving the colon are caused by malignant tumors and surgery is the preferable treatment regardless of the intussusception length.

There are several limitations in our study. First, this was a ten-year retrospective study, which had inherent selection bias. Second, the treatment of patients included in the study was not examined by the same group of surgeons but by surgeons from different departments at different times. Third, like most single-center studies, ours involved only a single institution and represented only a narrow range of people.

CONCLUSION

The clinical presentations and MDCT features of the three types of AIs are different. Ileocolic intussusceptions exhibit more suggestive features of vascular compromise on MDCT, which should be taken seriously by clinicians. Ileocolic and colonic intussusceptions are rarely self-limiting, and surgery is routinely recommended as the treatment of choice. Less than half of enteric intussusceptions require surgical intervention, which is more likely when the intussusception length exceeds 4.56 cm, and there is a discernible lead point on MDCT.

LIST OF ABBREVIATIONS

MDCT	=	Multidetector Computed Tomography
CT	=	Computed Tomography
SD	=	Standard Deviation
IQR	=	Inter-quartile Range
ROC	=	Receiver Operating Characteristic
OR	=	Odds Ratio
CI	=	Confidence Interval
AUC	=	Area under the ROC Curve
GIST	=	Gastrointestinal Stromal Tumor
HP	=	Heterotopic Pancreas
UPS	=	Undifferentiated Pleomorphic Sarcoma
LAMN	=	Low-grade Appendiceal Mucinous Neoplasm

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This retrospective study was approved by Daping Hospital ethics committee.

HUMAN AND ANIMAL RIGHTS

No animals were used in this research. All procedures performed in studies involving human participants were in accordance with the ethical standards of institutional and/or research committee and with the 1975 Declaration of Helsinki, as revised in 2013.

CONSENT FOR PUBLICATION

The patient's written informed consent was waived.

STANDARDS OF REPORTING

STROBE guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

The datasets used and/or analysed during the current study are available from the corresponding author [Y.W] upon reasonable request.

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CONFLICT OF INTEREST

There are no conflict of interest to report.

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SUPPLEMENTARY MATERIALS

Supplementary material is available on the Publisher's website.

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