Differentiation Between Surgical and Nonsurgical Intussusception: A Diagnostic Model Using Multi-Detector Computed Tomography

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ABSTRACT

Background: The differentiation of surgical from nonsurgical adult intussusception may enable the appropriate selection of management strategies. Objective: This study aimed to investigate the diagnostic potential of multidetector computed tomography (MDCT) features to differentiate surgical from nonsurgical adult intussusception and develop a diagnostic model. Methods: A retrospective study was performed on 96 patients with intussusceptions at the University Medical Center Hospital between January 2014 and January 2020. Two radiologists reviewed all images, and intussusception characteristics were documented. The location of intussusception, length, diameter, interposed fat thickness, lead point, and complications were evaluated. Based on the results, a diagnostic tree model was developed to differentiate between surgical and nonsurgical adult intussusception. Results: A total of 99 intussusceptions in 96 patients (mean age: 53.0 ± 16.5 years), including 35 (35.3%) enterenteric, 27 (27.3%) enterocolic, and 37 (37.4%) colocolic lesions, were evaluated. Of the enterenteric intussusceptions, 22 (62.9%) were surgical, including 19 (79.2%) with lead points. Among colon intussusceptions, 63 (98.4%) were surgical, and 100% had lead points. The characteristics used to predict surgical intussusceptions included lead point presence, length ≥ 5.0 cm, diameter ≥ 3.2 cm, interposed fat thickness ≥ 0.5 cm, and complications (p < 0.001). Based on these features, we established a diagnostic tree model that correctly classified 96 (97%) of 99 lesions. Conclusion: Our study reinforces the importance of MDCT for the diagnosis and guided management of adult intussusceptions. The characteristics that predicted surgical intussusceptions included lead points, length, diameter, interposed fat thickness, and complications. A systematic approach using this diagnostic tree model could be used to distinguish surgical and nonsurgical adult intussusception. Keywords: adult intussusception, CT, lead point.

1. BACKGROUND

An intussusception is a form of bowel obstruction in which part of the intestine invaginates into an adjacent segment (1). Intussusception is often observed in children from six to 18 months old (2). In contrast, only 5% of intussusception occurs in adults, accounting for 1% - 3% of all bowel obstructions and fewer than 0.1% of all adult hospital admissions (3-6). Adult intussusceptions are often associated with causative structural lesions, especially malignant tumors (1, 6, 7). Unlike children, adults with intussusception often present without the typical symptomatic triad of abdominal pain, vomiting, and bloody stool. Therefore, prior to the development of multidetector computed tomography (MDCT), the diagnosis of intussusception in adults tended to be challenging and was often performed based on surgical findings.

The detection of intestinal intussusception has been facilitated by the widespread use of increasingly advanced CT technology, especially among patients presenting with nonspecific and recurrent abdominal pain. Adult intussusception necessitates surgical intervention due to the high incidence of malignancy (8). However, the increasingly frequent use of CT scans has increased the de-
tection of transient intussusceptions without underlying pathology, which can be treated nonsurgically (9). In a review of 41 adults with 44 intussusceptions diagnosed postoperatively, Wang et al found tumors associated with 54.5% of the diagnosed intussusceptions, including 27.3% that were malignant (10).

Therefore, the preoperative differentiation of intussusceptions that require surgical intervention from those that can be treated nonsurgically is vital for treatment planning.

To date, several CT characteristics, including reniform configuration, the presence of a hypo-dense layer in the lesion on unenhanced CT, lead point, features of vascular compromise, increased length, and location (5-7, 11-16), have previously been used to differentiate between surgical and nonsurgical intussusceptions. Surprisingly, no study has systematically analyzed all potentially identifying features to determine which can be reliably used to distinguish between nonsurgical and surgical intussusceptions, which can be clinically significant for treatment outcomes.

2. OBJECTIVE

Therefore, we aimed to evaluate multiple CT characteristics associated with intussusceptions and subsequently develop a stepwise, diagnostic tree model to increase the accuracy and facilitate the differentiation of self-limiting cases from those that require surgery in adults.

3. MATERIALS AND METHODS

This retrospective study was conducted at the University Medical Center, Ho Chi Minh City, in accordance with the Declaration of Helsinki. The protocol was approved by the Human Research Ethics Committee of the University Medical Center of Ho Chi Minh City. Written informed consent was waived by the Human Research Ethics Committee of the University Medical Center of Ho Chi Minh city.

Subjects

The medical records and CT imaging results for all patients who were diagnosed with intussusception and managed at our hospital between January 1, 2014, and January 31, 2020, were retrospectively reviewed. Data were collected and analyzed for the following parameters: demographics; clinical and pathological findings, including known diagnoses of gastrointestinal disease, malignancy, or metastases; preoperative radiological studies; diagnosis; underlying causes; treatment options (surgical vs. nonsurgical) for the intussusception; surgical findings; and the duration of follow-up.

CT protocol

No patient preparation was required. CT examinations were performed on either 64-slice (Somatom Definition AS+, Siemens Healthineers, Germany) or 128-slice (Somatom Definition AS+, Siemens Healthineers, Germany) CT scanners with patients in the supine position. The scanning parameters were as follows: tube voltage: 100–120 kVp; automatic tube current modulation: 100–110 mAs); pitch: 1.0–1.3 mm; matrix: 512 × 512; and slice thickness: 0.625–1 mm.

Abdominopelvic CT examinations were performed without contrast, and the arterial and venous phases were obtained after the administration of intravenous (IV) contrast material (Xenetix 300 mgI/ml, Guerbet, France; Ultravist 300 mgI/ml, Bayer, Germany; Omnipaque 300 mgI/ml, GE Healthcare, Ireland). The arterial phase was performed 30–35 seconds after an IV contrast injection, and the venous phase was performed 60–70 seconds after an IV contrast injection. Multiplanar (sagittal, coronal, and axial) images were reconstructed for the diagnosis of intussusception.

Image analysis

Images were interpreted and analyzed independently by two radiologists with more than 5 years of experience analyzing CT abdominal imaging. The images were analyzed on a picture archiving and communication system (PACS). The radiologists were aware that the patients had an intussusception, but they were unaware of any other clinical information. In cases of discrepancies between the interpretations of the two radiologists, a discussion was organized by another senior radiologist to achieve a consensus.

The following characteristics were assessed for each intussusception: the presence and location, length, diameter, interposed fat thickness, lead point, and complications.

Clinical data

For surgical lesions, all surgical records, including indication, pathology, and surgical findings, were obtained to determine the cause of intussusception. For nonsurgical lesions, follow-up records, including clinical examination and abdominal CT/ultrasound (US) examination results, were obtained.

Statistical analysis

For each CT characteristic, a 2 × 2 contingency table was used to calculate the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy. Stepwise logistic regression analysis was used to identify the group of features that yielded the best prediction of surgical intussusception. All analyses were performed using STATA, version 14 (STATA Corp., Texas, USA). A p-value < 0.05 was considered significant for all analyses. Data are presented as the mean ± standard deviation (SD).

4. RESULTS

A total of 96 patients were included in this study, consisting of 55 males and 41 females. The male:female ratio was 1.3:1, and ages at the time of diagnosis ranged from 21 to 89 years, with a mean of 53.0 ± 16.5 years. On CT, 93 (96.9%) patients had one intussusception each, and 3 (3.1%) patients had two intussusceptions each.

Types of intussusception

The total of 99 lesions were stratified, as follows: 35 (35.3%) enterocoeletic, 27 (27.3%) enterocolic, and 37 (37.4%) colocolic intussusceptions. No mismatch between the types of intussusception was recorded between the two radiologists.
Surgical versus nonsurgical intussusceptions

Surgery was performed for 85 patients (85 lesions, 85.9%), and the remaining 11 patients (14 lesions, 14.1%) were treated conservatively. All of the 14 nonsurgical intussusceptions (100%) were transient intussusceptions, as supported by follow-up CT, US, and clinical examinations. Of the 85 surgical intussusceptions, 18 (20.7%) were transient lesions (3 enteroenteric, 2 enterocolic, and 13 colocolic) with successful reduction, and 67 (77%) were persistent on surgery (19 enteroenteric, 25 enterocolic, and 23 colocolic).

Features of intussusception

The features of the intussusceptions examined in this study, including the length, diameter, fat interposed thickness, presence of a lead point, and complications, are shown in Table 1.

| Parameters                  | All intussuception (n = 99) | Surgical lesions (n = 85) | Nonsurgical lesions (n = 14) |
|-----------------------------|-----------------------------|---------------------------|-------------------------------|
| Length (cm)                 | 8.1 ± 4.4 (2.2–22.9)        | 8.8 ± 4.3 (3.1–22.9)     | 3.8 ± 1.4 (2.2–6.3)          |
| Diameter thickness (cm)     | 4.4 ± 1.1 (2.4–6.7)         | 4.6 ± 1.0 (2.4–6.7)      | 2.9 ± 0.4 (2.4–3.8)          |
| Interposed fat thickness (cm)| 0.68 ± 0.46 (0.1–2.03)     | 0.75 ± 0.45 (0.1–1.20)   | 0.31 ± 0.25 (0.1–0.9)        |
| Lead point                  | 84/99                       | 82/85                     | 2/14                         |
| Complications               | 16/99                       | 16/85                     | 0/14                         |

Table 1. Features of intussusception lesions

The mean length of all intussusceptions was 8.1 ± 4.4 cm, and a significant difference in the mean length was identified between the two groups (nonsurgical: 3.8 ± 1.4 cm vs. surgical: 8.8 ± 4.3 cm, p < 0.001).

The mean diameter was 4.4 ± 1.1 cm for all intussusceptions, and a significant difference in the mean diameter was identified between the two groups (nonsurgical: 2.9 ± 0.4 cm vs. surgical: 4.6 ± 1.0 cm, p < 0.001).

The mean fat thickness was 0.68 ± 0.46 cm for all intussusceptions, and a significant difference in the mean fat thickness was identified between the two groups (nonsurgical: 0.31 ± 0.25 cm vs. surgical: 0.74 ± 0.46 cm, p < 0.001).

Surgery was performed for 85 patients (85 lesions, 85.9%), whereas the remaining 11 patients (14 lesions, 14.1%) were treated conservatively. In this study, 82/85 of the surgically treated intussusceptions featured lead points, whereas only 1 of 14 nonsurgical intussusceptions had a lead point.

For enteroenteric intussusceptions, 22 (62.9%) were managed with surgery, of which 19 (79.2%) had lead points (5 lipomas, 4 polyps, 1 schwannoma, 1 gastric choriostoma, 1 cavernous hemangioma, 2 leiomyomas, 3 lymphomas, 1 malignant peripheral nerve sheath tumor, and 1 adenocarcinoma). In contrast, 63 (98.4%) colon-involved intussusceptions were treated with surgery, and 100% had lead points (45 malignant lesions (38 carcinomas, 6 lymphomas, 1 gastrointestinal stromal tumor) and 18 benign lesions (6 lipomas, 1 tuberculosis, 3 mucocele appendix, 4 polyps, 1 acute ulcerative colitis, 1 appendicitis, 1 cavernous hemangioma of the colon, and 1 lymphangioma)).

In this study, 16 (16.2%) lesions were associated with complications, including bowel obstruction (13 cases), ischemia (2 cases), and perforation (1 case).

Non-surgical and surgical intussusception

The receiver operating characteristic curve was used to determine the cut-off value for all CT intussusception features, including the length, diameter, and fat interposed thickness, required to differentiate between surgical and nonsurgical lesions.

For all intussusceptions, the cut-off values for length, diameter, and fat interposed thickness were 5 cm (area under the receiver operating characteristic curve (AUC): 0.92), 3.2 cm (AUC: 0.94), and 0.5 cm (AUC: 0.80), respectively (Figure 1).

![Figure 1. Receiver operating characteristic (ROC) curves for length, diameter, and fat interposed thickness characteristics of adult intussusception.](image)

The sensitivity, specificity, PPV, NPV, and accuracy of these features are shown in Table 2.

| CT features | Sensitivity (%) | Specificity (%) | PPV (%) | NPV (%) | Accuracy (%) |
|-------------|----------------|----------------|---------|---------|--------------|
| Length (≥5 cm) | 90.6 | 78.6 | 96.3 | 57.9 | 88.9 |
| Diameter (≥3.2 cm) | 90.6 | 85.7 | 97.5 | 60.0 | 89.9 |
| Fat interposed thickness (≥0.5 cm) | 64.7 | 78.6 | 94.8 | 26.8 | 66.7 |
| Lead point | 96.5 | 85.7 | 97.6 | 80.0 | 94.9 |
| Complication | 18.8 | 100 | 100 | 16.9 | 30.3 |

Table 2. Performance of CT Features for the Diagnosis of Surgical Lesions

CT: computed tomography; PPV: positive predictive value; NPV: negative predictive value

The characteristics that were capable of predicting surgical intussusceptions were the presence of a lead point, length ≥5 cm, diameter thickness ≥3.2 cm, interposed fat thickness ≥0.5 cm, and the presence of complications.

Diagnostic tree model

Using the identified characteristic features and our experience, we were able to establish a simple diagnostic tree model (Figure 2) that was able to correctly classify 96 (97%) of 99 lesions.

5. DISCUSSION

Intussusception occurs more frequently in children than adults (2). The underlying causes, clinical scenarios, and management strategies for intussusception differ markedly between adults and children. Up to 90% of pediatric intussusception cases are idiopathic, and enema
Differentiation Between Surgical and Nonsurgical Intussusception

therapy is the first choice for treatment. In contrast, adult intussusception is uncommon, accounting for only 1%–3% of all bowel obstruction cases, and is often associated with an underlying etiology (2, 8).

Adult intussusception was infrequently detected on MDCT in this study. Over a 6-year period, 61,203 pelvic abdominal MDCT examinations were performed, and only 96 intussusception cases were identified at our hospital, accounting for 0.15% of the total pelvic abdominal MDCT examinations, which is in line with the numbers reported by Lvoff et al (0.05%) (12) and Rea et al (0.04%) (15).

Adult intussusceptions are more likely to be associated with structural causes, especially when they involve the colon (17, 18). In this study, 84 (84.9%) intussusceptions featured lead points, including 20 (57.1%) enteroenteric lesions, and 64 (100%) colonic lesions. This result was comparable with the results of the study by Agha et al, which reported that 92% of adult intussusceptions were associated with a causative factor (1). Similarly, another study demonstrated that a pathological cause could be identified in 92.3% of adult intussusception cases.

Of the 35 identified enteroenteric intussusceptions in the present study, 20 (57.1%) had a lead point, of which 14 (70%) were benign, and 6 (30%) were malignant, which is similar to the results of Barussaud et al, who reported that 37% of enteric lesions were malignant (19). All of the colon-involved intussusceptions featured a lead point, with 45 of 64 (70.3%) malignant lesions, 84% (38/45) of which were primary adenocarcinomas. Among the benign colonic lesion, 6 of 19 (31.6%) were lipomas. According to Barussaud et al (19), 58% of colonic lesions were malignant, of which 85% were primary adenocarcinomas, which are to the proportions identified in the current study. However, benign colonic lesions were identified as lipomas in 80% of the cases examined by Barussaud et al, which is a higher proportion than identified in our study. In our study, intussusceptions involving the colon accounted for 65%, a larger proportion than enteroenteric intussusceptions, which was similar to the findings by Brayton et al (3), in which the percentages of colon-involved and enteroenteric intussusceptions were 61% and 39%, respectively.

We also identified a larger percentage of intussusceptions with a lead point that required surgical intervention (85.9%) compared with previous studies, including 16% and 17.2% in reports by Lvoff et al (12) and Tresoldi et al (7), respectively. This discrepancy could be attributed to the higher number of colonic intussusceptions with a lead point identified in our study.

Differentiating nonsurgical from surgical intussusceptions plays a crucial role in guiding treatment management. The thorough interpretation of MDCT characteristics can facilitate the determination of whether patients should be promptly treated with surgical or conservative procedures (Figures 3 and 4), which could result in a significant reduction in unnecessary surgical interventions. We suggest the use of the diagnostic tree model to distinguish non- from surgical intussusceptions based on MDCT features.

Among our cases, 16 (16.2%) lesions were associated with complications, including 13 (81.3%) associated with bowel obstruction, 2 (12.5%) with bowel ischemia, and 1 (6.3%) with bowel perforation (Figure 5). When complica-
When intussusceptions are present, patients should be surgically treated in an urgent manner to prevent the development of more severe conditions. All of the colon-involved intussusceptions in the present study featured a lead point, including 45 of 64 (70.3%) associated with malignant lesions. In several other studies, the rate of malignant lead points ranged from 28% to 80% (5, 7, 8, 15). Our results suggested that all colon-involved intussusceptions should be classified as surgical. In contrast, the percentage of enteroenteric intussusceptions with a lead point identified in this study was lower (57.1%) than those in colon-involved cases.

For enteroenteric intussusceptions, in addition to the presence of a lead point, other MDCT characteristics that could be used to stratify the nonsurgical and surgical groups included the length, diameter, and interposed fat thickness of the intussusception. Based on the receiver operating characteristic curves, the cut-off values for differentiation between the two groups were 5.0 cm, 3.2 cm, and 0.5 cm, respectively. Lvoff et al (12) and Sundaram et al (16) suggested that a length of less than 3.5 cm would be a useful MDCT quantitative indicator for the diagnosis of nonsurgical enteroenteric intussusceptions, and another study showed that enteroenteric intussusceptions shorter than 3.5 cm were the most likely to resolve spontaneously (20). Compared with previous studies, the present study recommends a higher cut-off value for intussusception length for the distinction of surgical and nonsurgical cases. No difference between our group and previous studies was observed for the diameter cut-off value (16, 21). We recommend that enteroenteric intussusceptions with a length less than 5.0 cm and a diameter less than 3.2 cm that lack a lead point can be classified as nonsurgical cases.

Specific limitations should be acknowledged when interpreting our observations. Our study was a retrospective design with intrinsic selection bias. The sample size was relatively small, and the data were collected at a single center.

6. CONCLUSION

Our study supports the application of MDCT to define intussusception characteristics during diagnosis and treatment management in adults. The characteristics that were capable of predicting surgical intussusceptions included the presence of a lead point, the length, diameter, and interposed fat thickness of the lesion, and complications. A systematic approach using our diagnostic tree model might facilitate the differentiation between nonsurgical and surgical intussusceptions in adults, although additional investigations remain necessary to validate this approach.

- Ethical approval and Declaration of patient consent: The study was approved by the Human Research Ethics Committee of the University Medical Center of Ho Chi Minh City. The written informed consent was waived by the Human Research Ethics Committee of the University Medical Center of Ho Chi Minh City.
- Author’s contribution: Vo Tan Duc and Nguyen Minh Duc contributed equally to this article as co-first authors. Vo Tan Duc, Phan Cong Chien, and Nguyen Minh Duc gave a substantial contribution to the acquisition, analysis, and data interpretation. Phan Cong Chien and Nguyen Minh Duc had a part in preparing the article for drafting and revising it critically for important intellectual content. Each author gave final approval of the version to be published and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.
- Conflicts of interest: There are no conflicts of interest to declare.
- Financial support and sponsorship: Nil.

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