



Risk factors for surgery in pediatric intussusception in the era of pneumatic reduction[☆]

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Received 26 January 2013; accepted 3 February 2013

Key words:

Intussusception;
Pediatrics;
Pneumatic reduction;
Operative reduction

Abstract

Introduction: Surgical treatment is still necessary for intussusception management in a subgroup of patients, despite advances in enema reduction techniques. Early identification of these patients should improve outcomes.

Methods: The medical records of patients treated for intussusception at our institution from 2006 to 2011 were reviewed. Univariate and multivariate analyses, including stepwise logistic regression, were performed.

Results: Overall, 379 patients were treated for intussusception, and 101 (26%) patients required operative management, with 34 undergoing intestinal resection. The post-operative complication rate was 8%. On multivariate analysis, failure of initial reduction (OR 9.9, $p=0.001$ 95% CI, 4.6–21.2), a lead point (OR 18.5, $p=0.001$ 95% CI, 6.6–51.8) or free/interloop fluid (OR 3.3, $p=0.001$ 95% CI, 1.6–6.7) or bowel wall thickening on ultrasound (OR 3.3, $p=0.001$ 95% CI, 1.1–10.1), age <1 year at reduction (OR 2.7, $p=0.004$, 95% CI, 1.4–5.9), and abdominal symptoms >2 days (OR 2.9, $p=0.003$, 95% CI, 1.4–5.9) were significantly associated with a requirement for surgery. Similarly, a lead point (OR 14.5, $p=0.005$ 95% CI, 2.3–90.9) or free/interloop fluid on ultrasound (OR 19.8, $p=0.001$ 95% CI, 3.4–117) and fever (OR 7.2, $p=0.023$ 95% CI, 1.1–46) were significantly associated with the need for intestinal resection.

Conclusion: Abdominal symptoms >2 days, age <1 year, multiple ultrasound findings, and failure of initial enema reduction are significant predictors of operative treatment for intussusception. Patients with these findings should be considered for early surgical consultation or transfer to a hospital with pediatric surgical capabilities.

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[☆] Disclosures: The authors have no financial support or funding to disclose with regards to the preparation of this manuscript.

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Intussusception is a common cause of bowel obstruction and hospitalization of pediatric patients, with an incidence of over 56/100,000 patients [1]. While the diagnosis of intussusception can be readily made by ultrasound, the classic picture of vomiting, currant jelly stools, age less than 2 years, and a palpable abdominal mass is seen in less than

25% of children, resulting in delays in diagnosis [2]. The resultant delays can lead to bowel wall thickening and ischemia, making the reduction of the intussusception by air or contrast enemas either difficult or unsafe. The reported success rates of enema reduction range from 42% to 95% [3].

To date, no randomized trial has investigated the superiority of either pneumatic or contrast enema rates with respect to complication profiles, lengths of stay, and reduction rates. Retrospective reviews have conflicting conclusions with regards to the optimal approach, although certain risks and benefits are inherent in each technique [3–5]. As individual centers gain more experience with the pneumatic reduction technique, practice patterns continue to evolve. At our own center, pneumatic reduction has been the primary reduction method used for the past six years. However, other centers still prefer to use contrast enema reduction as a first line therapy [3,6].

The purpose of this study is to identify variables related to the need for operative management in the current era of intussusception treatment, which includes higher rates of pneumatic reduction and greater experience with ultrasound. We investigated variables related to the patients' clinical history and physical exam, the initial ultrasound findings, and the reduction procedure to identify predictors of both operative reduction and intestinal resection at a high-volume, pediatric tertiary care center. These findings should help to risk-stratify patients who are most likely to require surgical consultation or transfer to a center with pediatric surgical capabilities.

1. Methods

Patients identified with the ICD-9 diagnosis code of intussusception from 2006 to 2011 were included in the study. After IRB approval, a chart review was performed and clinical data information was collected, including basic demographics, imaging and procedural information, operative details, hospital course, and evidence of recurrence. Patients who had an intussusception diagnosed on ultrasound with spontaneous resolution in the emergency room were not included in the study.

At our institution, multiple, repeated attempts of reduction are allowed as long as progressive movement of the intussusceptum is seen during each attempt. Indications for an operation include failed reduction attempt(s), peritonitis on physical exam, signs of sepsis, evidence of perforation on imaging or during attempted enema, or significant concern for a pathologic lead point.

Statistical analysis was performed using SAS (Version 9.3). Univariate analysis was performed using a chi-square test for categorical variables, and a Student's *t*-test for continuous variables. Mann–Whitney *U* tests were used for nonparametric data. Failure of an initial enema reduction attempt was defined as those patients who had a distinct (>2 h) delay between attempts at reduction or were taken directly to the OR after the first attempt. Ultrasound

characteristics were determined based on the radiology report and included bowel wall thickening, “diffuse, free fluid” or “interloop” fluid, and an indication that a potential lead point was identified. Patients who required an operative reduction of the intussusception were compared to those successfully managed without surgery. Of the patients who underwent surgery, those who required a bowel resection due to evidence of perforation, necrosis, or persistent bowel ischemia after reduction were compared to those managed with a simple manual operative reduction. A stepwise logistic regression analysis, evaluating for predictors of surgery and predictors of intestinal resection, was performed. A *p*-value of <0.05 was considered to be significant.

2. Results

A total of 379 patients with intussusception were treated at our institution over a 6 year period. The median age at admission was 11.9 months (range 2.2 months–13.9 years). Enema reduction was successful in 278 patients; 101 (26%) patients either failed reduction and required operative intervention or were taken directly to the operating room for treatment. Characteristics and outcomes of the surgical cohort are described in Table 1. Approximately one-third required intestinal resection at surgery, and 20% of the surgical patients demonstrated a distinct pathologic abnormality in the resected specimen that was felt to be a lead point for the intussusception.

Notably, two patients with bowel resections were diagnosed with malignant conditions. One patient found to

Table 1 Characteristics and outcomes of surgically treated patients (n = 101).

| Variable | Median (range) |
|--|-------------------------|
| Age at time of operation | 8.9 months (2.2–167) |
| Patients with intestinal resection | 34 (34%) |
| Ileostomy | 17 (17%) |
| Ileocolostomy | 10 (10%) |
| Resection of Meckel's/Cyst | 7 (7%) |
| Pathology of resected specimen | |
| Meckel's Diverticulum | 10 (10%) |
| Polyp | 4 (4%) |
| Duplication Cyst | 4 (4%) |
| Mucinous Adenocarcinoma | 1 (1%) |
| B-Cell Lymphoma | 1 (1%) |
| Patients with a frank perforation at operation | 7 (7%) |
| Post-operative length of stay (days) | 4 (1–40) |
| Complications | |
| Small bowel obstruction | 3 (3%) |
| Recurrence (reoperation at same admission) | 2 (2%) |
| Wound Infection | 2 (2%) |
| Delayed Bowel Perforation | 1 (1%) |
| Late Recurrence (reduced with enema) | 3 (3%) |

have adenocarcinoma presented at 13 years of age with intussusception. This patient complained of two days of abdominal pain and vomiting; on ultrasound, intussusception with very thick-walled bowel was seen, and he was taken straight to surgery due to the concern for bowel strangulation. Intraoperatively, he was found to have a large mass in the intussuscepted segment. The patient was subsequently diagnosed with Peutz–Jeghers syndrome. A patient with lymphoma presented at 7 years of age with non-specific abdominal pain, and was found to have an ileo-colic intussusception on ultrasound. In the fluoroscopy suite after successful ileo-colic reduction, a persistent ileo-ileal intussusception was diagnosed, and so the decision was made to proceed to surgery where a B-cell lymphoma was found in the resected segment of ileum.

The total post-operative complication rate was 8%; complications included small bowel obstruction requiring lysis of adhesions, wound infection, delayed perforation, and recurrence after reduction without bowel resection during the same admission. The two early recurrence patients had bowel resections at the repeated operation; one had a duplication cyst identified at pathology, and the other did not have significant pathologic findings.

When evaluating for the effect of different reduction techniques on operative rates, 30% of patients treated only at our institution with a hydrostatic enema required surgery, compared to 19.5% with only pneumatic reduction. In the 28 patients who had an initial pneumatic enema with a subsequent hydrostatic enema attempted after failure, 16 (57%) still required surgery. From 2006 to 2011, the use of a pneumatic enema as a first-line treatment for intussusception increased from 57% to 88% ($p=0.001$), while the operative rate decreased from 46% to 21% ($p=0.008$) (Fig. 1).

The results of the efficacy of multiple, delayed reduction attempts were evaluated. In our cohort, 8% (22/278) of patients avoided surgery with a delayed (>2 h) secondary attempt at reduction. The success rate decreased after each attempt was performed (Fig. 2).

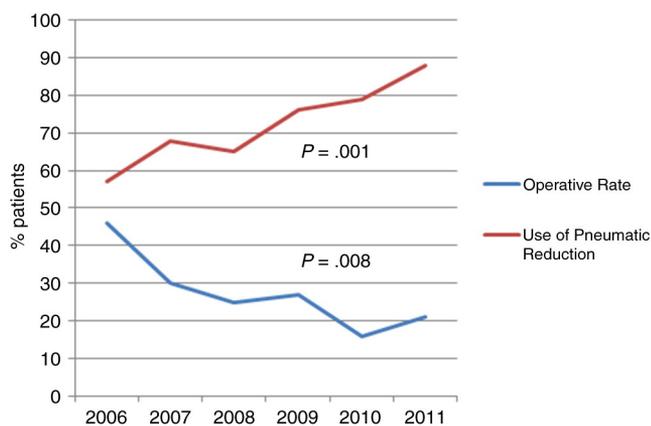


Fig. 1 Changes in operative rate and the use of pneumatic reduction over time.

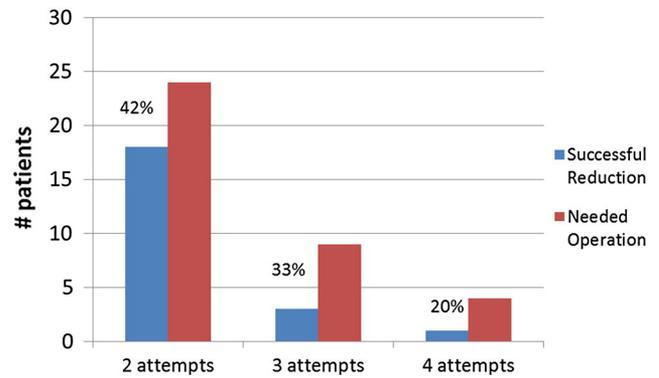


Fig. 2 Success rates after multiple attempts at reduction.

The surgically treated patients were compared to those who were managed non-operatively (Table 2). On univariate analysis, factors which were associated with the need for surgery were the use of hydrostatic enemas for reduction, failure of initial enema reduction, the presence of hematochezia, age <1 year, or pain >48 h. Findings on ultrasound predictive of the need for surgery were bowel wall thickening, a definable lead point, and free or interloop fluid.

In order to assess for independent predictors of operative intervention, a stepwise logistic regression analysis was performed (Table 3). The model included 326/379 patients. The ultrasound characteristics of a definable lead point, free or interloop fluid, and bowel wall thickening were significantly predictive of the need for operative intervention, as were failure of initial enema reduction, age <1 year at the time of presentation, and symptoms greater than 48 h.

We also investigated predictors of intestinal resection at surgery using a similar stepwise logistic regression analysis (Table 4). The radiographic findings of a lead point and free or inter-loop fluid on ultrasound and fever at presentation were independently predictive of the need for intestinal

Table 2 Univariate comparison of operative versus non-operative patients.

| Variable | Operative | Non-Operative | p-value |
|---------------------------------|-----------|---------------|----------|
| Greater than 2 days of symptoms | 42% | 23% | <0.001 * |
| Age <1 year | 38% | 54% | 0.005 * |
| Bloody Stool | 48% | 33% | 0.007 * |
| Palpable Abdominal Mass | 10% | 5% | 0.142 |
| Fever | 17% | 13% | 0.388 |
| Lead Point on US | 25% | 3% | <0.001 * |
| Fluid on US | 51% | 19% | <0.001 * |
| Bowel Wall Thickening on US | 18% | 4% | <0.001 * |
| >1 attempt at reduction | 38% | 8% | <0.001 * |
| Pneumatic Reduction | 64% | 77% | 0.019 * |
| Hydrostatic Reduction | 54% | 28% | <0.001 * |

INT=intussusception.

US=ultrasound.

* denotes statistical significance.

Table 3 Stepwise logistic regression model for significant predictors of operative reduction.

| Variable | OR (95% CI) | p-value |
|------------------------------------|-----------------|---------|
| Age <1 year at -reduction | 2.7 (1.4–5.9) | 0.004 |
| Symptoms >2 days | 2.9 (1.4–5.9) | 0.003 |
| Lead Point on Ultrasound | 18.5 (6.6–51.8) | <0.001 |
| Fluid on Ultrasound | 3.3 (1.6–6.7) | <0.001 |
| Bowel Wall Thickening | 3.3 (1.1–10.1) | <0.001 |
| Failure of initial enema reduction | 9.9 (4.6–21.2) | <0.001 |

resection at operation. Seven patients were found to have a frank perforation at the time of resection; four of these patients required needle decompression for tension pneumoperitoneum prior to laparotomy. Six of these perforations occurred after pneumatic attempts.

3. Discussion

Identification of risk factors for surgery is important to decrease delays and improve salvage of the intussuscepted bowel. Other studies have examined potential predictors of the need for operative reduction in pediatric intussusception patients, and results have been varied. Some have reported that patient-related factors such as rectal prolapse, a longer duration of symptoms, bloody diarrhea, and dehydration are predictive of the need for surgery, while conversely one study found that the length of symptoms was not [7–12]. Our results confirm that a longer duration of symptoms and infancy are associated with an increased risk of failing non-operative reduction. While we hypothesized that an older age would predispose a child to the need for surgery, we actually found that younger patients were more likely to require an operation. It is possible that our radiologists were less willing to attempt aggressive reduction in infants.

Previous studies have noted that interloop fluid and free fluid during enema reduction indicate a potentially increased risk of surgery, while bowel wall thickness does not portend an increased risk [13–16]. Our study found that these three ultrasound characteristics were significantly predictive of failure of non-operative reduction. Although the need for an additional attempt at non-operative reduction was predictive of an increased possibility of surgery in our series, repeated

attempts of reduction are still indicated since these have been shown to be safe by other authors [15]. In our series, the overall success rate of multiple attempts was 8%, and argues for allowing multiple attempts as long as progressive movement is seen on each attempt. Children who have had a prior unsuccessful attempt at reduction would benefit from referral to a dedicated children's hospital where an experienced radiologist can make an additional attempt at reduction with the surgery team standing by.

With any reduction technique, experience with the procedure increases successful outcomes [3]. Our data demonstrate a decreased operative rate with an increased use of pneumatic enema. Multiple studies have examined if hydrostatic or pneumatic enemas result in higher rates of successful non-operative reduction without reaching a definitive conclusion. Each technique has its own risks and benefits [3,11]. In our own series, a hydrostatic enema was found to be a predictor on univariate analysis of failing non-operative reduction. As pneumatic reduction is considered the first line therapy at our institution, hydrostatic reduction is used as a second line therapy in difficult cases, and was seen in a disproportionately high percentage of the surgical cohort. Thus, in our experience, initial attempts with pneumatic reduction do appear to result in higher rates of success, but a randomized trial is needed to definitively answer this question.

Our operative rate of 26% is less than the average rate reported from larger national studies [17,18]. The morbidity of surgery in our series was low, with a median length of stay of 4 days and a complication rate of 8%. This is comparable with other reported studies [2,19,20]. Twenty percent of our patients had a lead point identified in the resected specimen. Patients who had bowel resection without an identifiable lead point had evidence of partial or full thickness necrosis on the final pathologic report. Although the majority of patients had a Meckel's diverticulum, two patients had a lymphoma or adenocarcinoma in the resected specimen [21]. Of the 10 patients in our series older than 5 years, 8 had a pathologic source of their intussusception, supporting the notion that a surgeon should have a high index of suspicion of underlying pathology when older children present with intussusception.

Over one-third of our patients had an intestinal resection at operation, which is within the widely varied rates reported in the literature (2.4%–46%) [19,22]. Seven patients had frank perforation at the time of the operation, and four of these patients had required needle decompression for tension pneumoperitoneum during their pneumatic enema procedure. The underlying mechanism for intestinal ischemia is multifactorial, but does appear to be related to duration of symptoms, as our patients who required resection had more days of pain (4.8 vs 2.5, $p=0.008$) and a higher rate of transfer with a consequent delay of care (60% vs 38%, $p=0.048$). We found in our series that certain ultrasound characteristics (a lead point or free fluid) were found to be

Table 4 Stepwise logistic regression model for significant predictors of intestinal resection.

| Variable | OR (95% CI) | p-value |
|--------------------------|-----------------|---------|
| Fever | 7.2 (1.1–46) | 0.023 |
| Lead Point on Ultrasound | 14.5 (2.3–90.9) | 0.005 |
| Fluid on Ultrasound | 19.8 (3.4–117) | 0.001 |

predictive of intestinal resection on multivariate analysis. This finding should alert the emergency room physician or the radiologist to call for a surgical consultation.

Heterogeneity with respect to the number of reduction attempts and level of aggressiveness with each allowed by independent surgeons and radiologists is a limitation of this study. Additionally, while the management of these patients is governed by an institutional protocol, there are no formal, standardized guidelines for treatment in place. Given our results, the development of evidence-based guidelines on an institutional level seems warranted.

In conclusion, our analysis of the treatment of a contemporary cohort of intussusception patients cared for at a large, tertiary-care children's hospital showed that a longer history of pain, presentation as an infant, and a lead point, bowel wall thickness, and free or interloop fluid identified on ultrasound are independent risk factors for surgery. Practitioners who work in community settings or in hospitals without adequate pediatric surgical capabilities should consider early transfer to a higher level of care when available.

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