Journal of Pediatric Surgery 52 (2017) 1313–1317

Contents lists available at ScienceDirect

Journal of Pediatric Surgery

journal homepage: www.elsevier.com/locate/jpedsurg

Strangulated small bowel obstruction in children

Yi-Jung Chang [a,b], Dah-Chin Yan [a,b], Jin-Yao Lai [b,c], Hsun-Chin Chao [a,b], Chyi-Liang Chen [b,d], Shih-Yen Chen [a,b], Ming-Han Tsai [b,d,e,*]

[a] Department of Pediatrics, Chang Gung Children's Hospital, Taoyuan, Taiwan
[b] Chang Gung University College of Medicine, Taoyuan, Taiwan
[c] Department of Pediatric Surgery, Chang Gung Children's Hospital, Taoyuan, Taiwan
[d] Molecular Infectious Disease Research Center, Chang Gung Memorial Hospital, Taoyuan, Taiwan
[e] Department of Pediatrics, Chang Gung Memorial Hospital, Keelung Branch, Keelung, Taiwan

ARTICLE INFO

Article history:
Received 11 August 2016
Received in revised form 5 March 2017
Accepted 7 March 2017

Key words:
Intestinal obstruction
Strangulation
Child
Necrosis

ABSTRACT

Background: Diagnosing intestinal strangulation as a complication of small bowel obstruction (SBO) remains a considerable challenge in children. We evaluated the clinicoradiological parameters for predicting the presence of a strangulated intestine.
Methods: We reviewed the medical records of 69 pediatric patients who underwent operation for acute SBO. Regression analysis was used to identify the parameters for predicting strangulated SBO.
Results: Of the 69 patients with SBO, **27** patients had intestinal strangulation and were awarded one point each towards the overall clinical score: intractable continuous abdominal pain, tachycardia, white blood cell count >13,600/mm^3, and abdominal distention. Patients with a clinical score ≥2 combined with the presence of ascites in ultrasound (US) results or with wall thickness and reduced wall contrast enhancement in abdominal computed tomography (CT) scans showed strong evidence for intestinal strangulation.
Conclusion: The combination of two or more clinical parameters, including intractable continuous abdominal pain, tachycardia, leukocytosis, and abdominal distention with the presence of ascites in US or wall thickness and reduced wall contrast enhancement in, is useful for the identification of strangulated SBO.
The type of study and level of evidence: Prognosis study; Level III.

Bowel obstruction accounts for more than 15% of admissions for abdominal pain from the emergency department. Intestinal strangulation is a worrying complication of acute small bowel obstruction (SBO), and has a mortality rate of up to 40% [1]. Determining whether the circulation of the intestine has been compromised is extremely important. Delayed diagnosis and misdiagnosis of intestinal obstruction are common and lead to increased morbidity and mortality. A presumptive diagnosis of SBO can be made based on the patient's medical history and a physical examination. However, clinical evaluation and laboratory assessment of SBO are insensitive and nonspecific, and there are no universally reliable clinical parameters that can predict irreversible ischemia in the setting of an intestinal obstruction. Imaging is generally required to confirm a diagnosis of SBO, judge the location of the obstruction, and identify the strangulated intestine. Among the various imaging modalities, abdominal computed tomography (CT), and ultrasound (US) play a vital role in diagnosis. Recent work has suggested that CT is a valuable tool for establishing the diagnosis of intestinal obstruction and detecting the early signs of strangulation, with reported sensitivities of more than 90% and a specificity of nearly 100% [2]. However, US is commonly used to assess SBO in children because, unlike CT, it does not expose patients to radiation. Clinically, not all patients receive preoperative abdominal CT or US. Thus, determining which patients require urgent operative management for strangulated SBO in children remains a significant challenge for clinicians due to the highly variable presentation and course of this disease. Despite the nature of this emergency, few studies have discussed the risk factors for intestinal strangulation in children with SBO over the past 15 years. Therefore, we retrospectively evaluated the clinical risk factors of strangulation and identified the image-based predictors of strangulated intestine.

1. Materials and methods

A retrospective chart review was conducted for patients admitted to the Chang Gung Memorial Hospital from the hospital's emergency department over a period of 15 years (January 2000 to December 2014) with clinical symptoms of bowel obstruction, whose diagnosis was subsequently confirmed by surgery. Approval was obtained from the

Abbreviations: SBO, small bowel obstruction; CT, computed tomography; US, ultrasound; ICU, intensive care unit; ROC, receiver operating characteristic; LR, likelihood ratio.

* Corresponding author at: Department of Pediatrics, Chang Gung Memorial Hospital, Keelung Branch, No. 222, Mai-Chin Road, Anle 204, Keelung, Taiwan. Tel.: +886 2 24313131x2626; fax: +886 2 4313161.
E-mail address: drtsai1208@gmail.com (M.-H. Tsai).

http://dx.doi.org/10.1016/j.jpedsurg.2017.03.002
0022-3468/

Institutional Review Board of our hospital before commencement of this study. Patients over the age of 17 years were excluded from analysis, as were those who had chronic bowel obstruction, non-operative conservative treatment, intussusception, malrotation with volvulus, or appendicitis. The included patients were those had SBO but observed for determining the need for and timing of surgery (such as adhesive small bowel obstruction) or without confirming the preoperative diagnosis (such as Meckel's diverticulum, or internal herniation). A diagnosis of SBO was made based on clinical, radiological, and operative findings. Data collection began when the patients presented to the emergency department and included the following: patient demographics, time interval between onset of symptoms and arrival at the emergency department, vital signs, symptoms, abdominal clinical examination findings, laboratory studies, radiological investigations, obstruction etiology, operative findings, time interval between arrival and operation, admission to the intensive care unit (ICU), length of hospital stay, and the final outcome. To identify the predictors of intestinal strangulation, patients were divided into two groups according to their operative findings: patients with strangulated intestine and those without intestinal strangulation. Comparison between the groups was performed with univariate analyses. Multivariate analyses were also conducted to identify the independent predictive factors of strangulation. The definition of intestinal strangulation was the appearance of ischemic bowel documented by the conclusion of surgery on the surgeon's operation note. Patients who had experienced abdominal pain for more than 30 min with a pain score greater than 7, and who were treated with intravenous or intramuscular opioids or analgesics were defined as having intractable continuous abdominal pain. Tachycardia was defined according to age, as follows: newborns to children aged 3 months, >205 bpm awake; children aged 3 months to 2 years, >190 bpm awake; children aged 2–10 years, >140 bpm awake; children older than 10 years, >100 bpm awake. The term of abdominal distention was reserved for patients who show a visible increase in abdominal girth or measured by abdominal circumference ruler during the hospital stay. The sign of abdominal tenderness was the pain or discomfort recorded on the admission's note when physical examined by clinicians based on patient's verbal prove or facial expression. The Data are presented as means ± standard deviation or the number of patients and percentage. Univariate analyses were performed, where applicable, with the chi-squared test and Fisher's exact test for categorical variables and the Mann–Whitney U test for numerical variables. Receiver operating characteristic (ROC) curve analysis of the statistical significance of numerical variables was performed, and the Youden index was calculated to best evaluate the cut-off point for the diagnosis of intestinal strangulation. Multivariate analyses were conducted using logistic regression analyses; strangulation was identified as the independent variable, and all other significant variables in the univariate or ROC analyses were included as dependent variables. A clinical score was constructed based on the final logistic regression model, in which one point was assigned for the presence of each predictive factor. The sensitivity and specificity of the radiological findings were examined, as well as the likelihood ratio (LR) of strangulation. The predictive power of the clinico-radiological parameter was also demonstrated separately for strangulation by calculating the sensitivity, specificity, and LR.

2. Results

A total of 69 children with bowel obstruction, including 50 boys and 19 girls with an average age of 7.0 years, were reviewed. During laparotomy, 27 (39.1%) patients were found to have intestinal strangulation (Group 1), and 42 patients underwent lysis of the intestinal obstruction without strangulation (Group 2). Eighteen (66.6%) patients in Group 1 underwent bowel resection for necrosis. **The other 9 patients with intestinal strangulation who did not receive bowel resection had great improvement of bowel loops after reduction or decompression operation. They did not have re-explored as a "second look" and had the smooth postoperative hospital course**. The clinical and radiological characteristics of the patients are summarized in Table 1. Sex, the duration of symptoms, and the time interval between arrival at the emergency department and the operation were not statistically different between the groups. Patients in the strangulation group were older and had a prolonged hospital stay (17.4 ± 26.5 vs. 10.6 ± 6.0 days, $P = 0.038$) with a high intensive care unit (ICU) admission rate (38.5% vs. 19.0%, $P < 0.001$). **Twenty-five (36.2%) patients had the previous abdominal surgery**. Adhesion was the major cause of obstruction (33.3%), followed by Meckel's diverticulum (24.6%), and internal hernia (20.2%). Internal hernia was associated with a higher rate of strangulation with 54.5% compared other etiology ($P = 0.031$). No mortality occurred in our series. Patients in Group 1 were more likely to be misdiagnosed in the emergency department than those in Group 2 (66.6% vs. 11.9%, $P < 0.001$). The most common misdiagnosis in the strangulation group was acute gastritis (38.8%), followed by encephalopathy (11.1%), myocarditis (5.5%), seizure disorder (5.5%), and diabetes ketoacidosis (5.5%).

Among all 69 patients, abdominal pain was the most common complaint (85.5%), followed by vomiting (82.6%) and fever (15.9%). Abdominal distention (39.1%) was the most common sign, followed by abdominal tenderness (30.4%) and tachycardia (26.1%). The results of univariate analyses between the strangulation and non-strangulation groups are shown in Table 2. Patients in the strangulation group more frequently presented with tachycardia, hypotension, intractable continuous abdominal pain, abdominal tenderness, abdominal distension, muscle guarding, and leukocytosis. Abdominal distention had a sensitivity of 66.6% and specificity of 76.4% for strangulated intestines. Muscle guarding had a high specificity and relatively low sensitivity (95.2% and 22.2%). Intractable continuous abdominal pain was 37.7% sensitive and 95.2% specific for strangulation. Most (75%) patients with severe abdominal pain did not have peritonitis. The duration of symptoms and the time from presenting to the emergency department to undergoing surgery did not differ between the groups (23.3 ± 30.6 h vs. 38.6 ± 47.5 h, $P = 0.784$). There were 64 (92.8%) patients who underwent plain abdominal radiography, and 51.5% of them showed SBO. Abdominal US was the second most common preoperative radiological exam (63.8%), followed by abdominal CT (44.9%), lower gastrointestinal tests (23.1%), and upper gastrointestinal test (2.8%). In all, 44 abdominal USs were performed; it revealed bowel obstruction with ascites in 22 (50%) patients. Ascites assessed by US was 72.2% sensitive and 62.5% specific for intestinal strangulation. The number of patients who received US and abdominal CT examinations did not significantly differ between the strangulation and non-strangulation groups (66.6% vs. 61.9%, $P = 0.625$ and 51.8% vs. 41.7%, $P = 0.417$, respectively). A total of 31 (44.9%) preoperative abdominal CT scans were performed and 22.2% revealed bowel obstruction with suspected ischemic changes such as increased bowel wall thickening and/or diminished wall contrast enhancement as assessed by CT.

Risk factors were determined by comparing patients with and without a strangulated bowel using univariate analyses. The numerical variables of the laboratory findings revealed significant leukocytosis.

Table 1
Compared Clinical and radiological characteristic of the patients with or without strangulation bowel.

	Strangulation (n = 27)	Non-strangulation (n = 42)	*p*
Age in y (mean, SD)	7.3(5.2)	6.8 (4.9)	0.728
Sex (% male)	70.3%	73.8%	0.755
Preoperative CT scan	14 (51.8%)	17 (40.7%)	0.417
Preoperative US	18 (66.6%)	26 (61.9%)	0.625
Duration of symptoms (D)	1.6 ± 1.0	1.9 ± 1.4	0.361
Decision to operate (Hr)	23.3 ± 30.6	38.6 ± 47.5	0.146
Hospital Stay (D)	17.4 ± 26.5	10.6 ± 6.04	0.038
ICU admission	13 (48.1%)	8 (19%)	0.015