

# Prediction of surgical management for operated adhesive postoperative small bowel obstruction in a pediatric population

Yuhua Deng, MD<sup>a</sup>, Yongming Wang, MD<sup>a,b,\*</sup>, Chunbao Guo, MD PhD<sup>a,c,\*</sup>

## Abstract

Abdominal surgery might contribute to postoperative intraperitoneal adhesions, with a high rate of recurrence. In the present study, we aimed to analyze potential factors for the surgical intervention of operated adhesive postoperative small bowel obstruction (SBO) in pediatric patients and compare the outcomes of patients managed by conservative treatment or surgical operation for an episode of SBO.

From January 2007 to January 2017, the records of 712 patients admitted with SBO to Children's Hospital, Chongqing Medical University, were reviewed retrospectively. The patients were divided according to surgical intervention or conservative management. Potential predictors for surgical intervention were investigated, including the initial operation data and the current clinical variables. A Cox regression model was used to determine the independent risk factors of surgical intervention. A systematic follow-up for recurrence was performed based on surgical intervention or conservative management.

Among the 712 patients admitted with SBO, 266 patients were managed surgically and 446 patients were managed conservatively. In the multivariate analysis, the predictors for the surgical intervention included initial surgical features, such as elevated markers of inflammation (WBC, CRP), incision location (HR, 2.31; 95%CI, 1.29–5.26;  $P = .031$ ), and emergency procedure (HR, 1.46; 95%CI, 1.13–3.42;  $P = .014$ ), and current variables, such as crampy pain (HR, 4.66; 95%CI, 1.69–9.48;  $P < .001$ ), ascites (HR, 5.43; 95%CI, 1.84–13.76;  $P < .001$ ) and complete small bowel obstruction (HR, 3.21; 95%CI, 1.45–8.74;  $P < .001$ ). The median follow-up time (interquartile range) was 3.6 years (range, 1 month–8 years) for the entire study population. Twenty-one patients (9.2%) who had undergone surgical intervention were rehospitalized for a new SBO episode, as were 53 patients (14.9%) who had been managed conservatively ( $P = .028$ ; OR, 1.72, 95% CI, 1.00–2.95).

Operated adhesive postoperative SBO with the following characteristics should heighten vigilance for surgical intervention: an initial emergency procedure with midline incisions and the current strangulation status. New hospitalizations were lower after surgical management than conservative treatment.

**Abbreviations:** ASA = American Society of Anesthesiologists, ASBO = Adhesive small bowel obstruction, CI = confidence interval, CRP = C-reactive protein, CT = computed tomography, EBL = estimated blood loss, HR = hazard ratio, NGT = nasogastric tube, OR = odds ratio, PRBC = packed red blood cell, SBO = small bowel obstruction, SPSS = Statistical Product and Service Solutions, TPN = total parenteral nutrition, WBC = leukocyte, white blood cell.

**Keywords:** conservative management, prediction, small bowel obstruction, surgical intervention

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Compliance with Ethical Standards.

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All procedures performed in studies involving human participants were conducted in accordance with the ethical standards of the institutional and/or national research committee and the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. (In case humans are involved)

Informed consent was obtained from all individual participants included in the study.

All authors declare there are no conflicts of interest. (And/or in case humans were involved)

<sup>a</sup> Department of Pediatric General Surgery and Liver Transplantation, <sup>b</sup> Department of Neonatology, <sup>c</sup> Ministry of Education Key Laboratory of Child Development and Disorders, Children's Hospital, Chongqing Medical University, Chongqing, PR China.

\* Correspondence: Yongming Wang, Department of Neonatology, Children's Hospital, Chongqing Medical University, Chongqing, 400014, PR China, 136 Zhongshan 2nd Rd. Chongqing, 400014, PR China (e-mail: 785773319@qq.com), Chunbao Guo, Department of Pediatric General Surgery and Liver Transplantation, Children's Hospital of Chongqing Medical University, 136 Zhongshan 2nd Rd. Chongqing, 400014, PR China (e-mail: guochunbao@cqmu.edu.cn, guochunbao@foxmail.com).

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## 1. Introduction

In more than 90% of patients following peritoneal cavity opening, obstructive structures (adhesions or bands) are expected regardless of the type of surgery.<sup>[1–3]</sup> Postoperative adhesions are the most frequent cause of small bowel obstruction (SBO) and account for more than 75 % of SBOs.<sup>[4]</sup> In Western societies, approximately 20 % of all surgical emergencies were caused by acute SBO.<sup>[5]</sup> For children, acute SBO occurs in 1% to 6% of cases after abdominal surgery, and the rate is dependent on the initial type of operation.<sup>[6,7]</sup> The operative procedures most frequently related to SBO in pediatric patients are appendectomy or surgery for peritonitis.<sup>[8]</sup>

The strategy for SBO management is implemented according to the clinical evaluation, biological tests, and imaging. When acute SBO patients fail to exhibit signs of strangulation, an initial trial of nonoperative management is suggested, including gastrointestinal drainage decompression, along with intravenous fluid resuscitation.<sup>[9]</sup> Successful resolution of the obstruction with nonoperative management has been reported in approximately 50% of adults.<sup>[10]</sup> In conservative management, regular reassessment is mandatory for the early recognition of signs and symptoms of strangulation that would require early operative intervention, depending mainly on the clinician's assessment. In some cases, patients must be subjected to surgical management as a result of nonresponse to a conservative strategy. Surgical treatment, including lysis of adhesions or segmental bowel resection, may seem paradoxical, as it might be the source of new adhesions similar to other abdominal surgeries and contribute to the recurrence of adhesive SBO. The ideal timing to pursue conservative management and when to switch to surgical intervention in this condition has not been addressed in pediatric populations. When the surgical intervention is delayed, the rate of postoperative complications, including bowel resection, may increase.<sup>[11]</sup> To guide recommendations for the surgical intervention of operated adhesive postoperative SBO in children, predictive factors for operative indications should be established to increase vigilance and guide the selection of the corresponding intervention, which would potentially improve clinical outcome.

Several recent studies have specifically evaluated potentially useful factors for predicting the necessity of operative interventions in acute SBO; however, very few, if any, pediatric patients were included.<sup>[12]</sup> Among these factors, the drainage volume and radiographic findings, such as complete obstruction, bowel wall thickness, and ascites, may be useful to determine indications for surgical intervention. In addition, a broader scope of variables related to specific pediatric conditions, including detailed information regarding the initial surgical characteristic features, may need to be elucidated. In this study, we reviewed a consecutive series of pediatric patients admitted with acute SBO, and we aimed to define the risk factors associated with surgical intervention for SBO, which would hopefully help health providers improve clinical practice and patient outcomes.

## 2. Patients and methods

### 2.1. Study participants

Between January 2007 and January 2017, we retrospectively investigated a series of 712 consecutively hospitalized patients who had been diagnosed with acute SBO at the Department of General Surgery, Chongqing Medical University, China (an urban tertiary care teaching hospital). The study was approved by the ethics committee of children's hospital, Chongqing

Medical University (IRB, No.: CHMU2018-017). An acute SBO episode was defined as admission to the hospital for a patient who had previously undergone abdominal surgery, with the following diagnostic criteria: presence of abdominal pain, vomiting, complete constipation (gas and feces), or the attending surgeon assigning the diagnosis of acute SBO. Patients were considered eligible upon meeting the following inclusion criteria: aged more than 1 year and less than 15 years and no other medication administration, such as chemotherapy. We excluded patients with other causes of SBO, such as gastrointestinal abnormalities (anorectal malformation, intestinal atresia, or Hirschsprung disease), intra-abdominal malignancy, incarcerated abdominal wall hernia and patients with recurrent SBO within 15 days of the previous laparotomy.

We retrospectively retrieved the institutional computerized medical records of all included patients based on the nature of the treatment (surgical vs conservative) regarding their past surgical history and current clinical data related to the SBO episode. In a patient's medical history, the phrase "initial operation" is used for the first operation, which should be related to the current acute SBO.

The clinical history and physical examination during the admission for SBO included the onset and course of nausea/vomiting, crampy pain, distension, fever, and bowel sounds. Laboratory data at admission were available in the medical records, including the leucocyte count or C-reactive protein (CRP) if available. The original radiographic studies at admission included ultrasound, plain abdominal films, or computed tomography (CT) scans when appropriate. The time interval since the previous laparotomy and the number of SBO recurrences were also noted.

The initial operation data included preoperative data, such as pre-existing comorbidities, coexisting health conditions, laboratory, and medical imaging data. Operative data, such as surgical approach, (open or laparoscopic), use of drains, small bowel resection, site of operation, American Society of Anesthesiologist (ASA) score, operative time, intraoperative estimated blood loss (EBL), intraoperative hemoglobin levels, and the receipt of packed red blood cells (PRBC) transfusion. In children, the intraoperative microbiological data, and the postoperative outcomes, such as infectious complications and other organ complications until day 30 after the operation were assessed.

### 2.2. Management and follow-up

The same treatment protocol for acute SBO was carried out for all patients in this study, including conservative management and surgical intervention. The patients with ileus symptoms started conservative management with the cessation of enteral feeding and gastrointestinal decompression, as well as intravenous fluid hydration. Usually, total parenteral nutrition (TPN) was started on the second day of SBO in our clinical practice. The choice of surgical management was determined according to the patient's condition based on close clinical observation, including worsening of clinical symptoms (continuous pain, constantly increased drainage, peritoneal irritation, or fever) and radiographic findings (liquid levels, small bowel dilatation, and absent gas in large bowel), which suggested clinical suspicion of strangulation. Decision making for surgical intervention was determined according to the preference and experience of the attending surgeon on duty.

Patients were systematically followed up through telephone calls at 1, 6, 12, 18, and 24 months by the operating surgeon. The

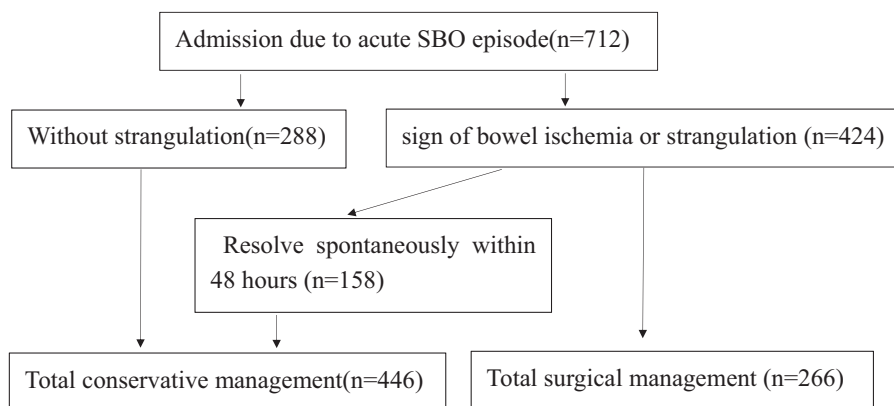


Figure 1. Study flowchart.

final follow-up was performed on January 30, 2017. The date and type of acute SBO readmission managed in the same or another surgical unit were collected.

### 2.3. Statistical analysis

The statistical analyses were conducted using the Statistical Product and Service Solutions (SPSS) statistical package (version 17.0, SPSS Inc., Chicago, IL). All variables were expressed as means ± standard errors for continuous data and as numbers with percentages for categorical data based on the conservative and operative management groups in the derivation cohort. Univariate analyses using Fisher’s exact test, trend test, Student’s *t* test, or Mann–Whitney *U* test were conducted to compare the categorical or continuous variables, where appropriate. The fully adjusted multivariable Cox regression model was performed using stepwise procedure, and the factors with a *P* value ≤.10 in the univariate analyses were included in this model. Relative risks were expressed as hazard ratio (HR) with a 95% confidence interval (CI), and statistical significance was accepted at a two-tailed *P* value <.05.

## 3. Results

### 3.1. Patient characteristics

From January 2007 to January 2017, there were 712 eligible pediatric patients admitted to our institute with a diagnosis of acute SBO following 15 different types of initial operations. Figure 1 demonstrates the flowchart of included patients. Table 1 summarizes features of the initial abdominal operations performed and time interval between this operation and current admissions. Emergency procedures accounted for approximately two-thirds (467/712) of eligible admissions. The single procedure that accounted for the largest proportion of acute SBO was emergency exploratory laparotomy (203/712), followed by appendicitis (162/712), small bowel anastomosis (98/712), and small bowel and colon fistulation (79/712). Selected hepatobiliary surgery (24/712) and hernia corrective surgery (24/712) had the lowest admission rates.

Patients were categorized into surgical intervention or conservative management groups according to their treatment. Among 712 pediatric admissions, 266 patients (61.5 %) underwent an operation (surgical group) and 446 patients (38.5 %) were treated with medical management (conservative group).

We subsequently explored clinical characteristics of the 2 groups to identify significant predicting variables for surgical intervention. The variables included current admission characteristics and the initial surgical features. Table 2 shows clinical characteristics of the current admission. Patient age and sex were not associated with surgical intervention (Table 2). Laboratory findings, such as markers of inflammation, were also equally distributed between the 2 groups. The surgical intervention group was significantly more likely to show presence of continuous pain, peritonitis, complete small bowel obstruction and ascites when compared to the conservative group. Thirty-one patients (11.7%) from the surgical group and 62 patients (13.9%) from the conservative group had one or more previous operations for SBO (*P* = .23).

Table 3 summarizes the initial clinical characteristics of the 2 groups, including preoperative and perioperative variables, and postoperative complications. In univariable analysis, several variables were significantly associated with surgical management. Patients with surgical intervention had significantly higher ASA (*P* = .005) scores and more emergency operations (*P* < .001) than patients with conservative management. Initial midline incisions were performed more frequently in patients with surgical intervention (*P* = .016). Initial inflammation had a significant

Table 1

Initial abdominal operations and interval from initial abdominal operations to current SBO.

Type of initial surgery	Cases (%)	Month from abdominal operation to ASBO admission (median and range)
Emergency		
Appendectomy	162 (22.8)	6.3 (1.2–52.1)
Emergency exploratory laparotomy	203 (28.5)	5.3 (1.0–53.2)
Reposition of intussusception	89 (12.5)	11.2 (3.4–46.7)
Others	13 (1.8)	10.4 (3.6–50.5)
Selected operation		
Small bowel anastomosis	98 (13.8)	11.8 (5.7–51.5)
Hernia corrective surgery	24 (3.4)	13.6 (6.4–38.9)
Small bowel and colon fistulation	79 (11.1)	6.8 (1.1–50.7)
Hepatobiliary surgery	24 (3.4)	16.3 (9.5–48.6)
Others	20 (2.8)	12.4 (4.6–52.4)
Operation type, N (%)		
Open	597 (83.9)	12.4 (1.2–52.4)
Laparoscopic	115 (16.1)	12.4 (1.0–51.9)

ASBO = adhesive small bowel obstruction, SBO = small bowel obstruction.

**Table 2****Clinical characteristics of the current admission based on conservative management or surgical intervention.**

Management	Conservative (n = 446)	Surgical (n = 266)	P values
Male: female	251:195	152:114	.44
Age, years	4.7 ± 2.4	5.1 ± 2.6	.18
Mean body weight (kg)	11.9 ± 5.4	12.2 ± 5.5	.42
Current white blood cell (WBC), g/L	9.1 ± 3.8	8.9 ± 4.2	.27
Current C-reaction protein (CRP), mmol/L	11.6 ± 3.8	12.2 ± 3.7	.38
Distension, n (%)	138 (29.6)	97 (36.5)	.27
Crampy pain, n (%)	118 (26.5)	153 (57.5)	.000
Nausea/vomiting, n (%)	349 (78.3)	208 (78.2)	.18
Duration of symptoms before admission, ds	2.7 ± 1.9	3.1 ± 2.3	.17
Interval from the last laparotomy, mo Median (range)	8.6 (2.6–51.6)	9.2 (2.4–52.8)	.26
Ascites (B ultrasound), n (%)	37 (8.3)	125 (47.0)	.000
Plain abdominal film findings, n (%)			
Positive air fluid level	365 (81.8)	214 (80.5)	.36
Dilatation of small intestine	227 (50.9)	169 (63.5)	.000
Positive colon gas	197 (44.2)	26 (9.8)	.000
Complete small bowel obstruction	183 (41.0)	228 (85.7)	.000
previous operations for adhesive small bowel obstruction (ASBO), n (%)	62 (13.9)	31 (11.7)	.23

ASBO = adhesive small bowel obstruction, CRP = C-reactive protein, WBC = white blood cell

impact on the current surgical intervention. In the patients who underwent surgical intervention, elevated markers of inflammation (WBC count, CRP) were observed more frequently when compared to the patients subjected to conservative management ( $P < .001$ ). Other factors associated with an operative intervention included presence of peritonitis at initial operation ( $P = .008$ ), bowel resection ( $P = .001$ ), and infectious complications ( $P = .039$ ).

We performed multivariate analysis using a Cox regression model by entering the significant factors identified in univariate analysis. The interrelated factors were identified and entered into the represented model. Two other factors with a  $P$  value  $> .05$  and  $\leq .10$  were included in multivariate analysis: EBL ( $P = .083$ ) and operation duration ( $P = .058$ ). The other factors with a  $P$  value  $> .10$  were not included in the multivariate analysis. The multivariate analysis indicated that the predictors for surgical intervention included initial features, such as elevated markers of inflammation (WBC, CRP), incision location (HR, 2.31; 95CI, 1.29–5.26;  $P = .031$ ), and emergency procedure (HR, 1.46; 95CI, 1.13–3.42;  $P = .014$ ), and current variables, such as crampy pain (HR, 4.66; 95CI, 1.69–9.48;  $P < .001$ ), ascites (HR, 5.43; 95CI, 1.84–13.76;  $P < .001$ ) and complete small bowel obstruction (HR, 3.21; 95CI, 1.45–8.74;  $P < .001$ ) (Table 4).

The maximum follow-up time was 8 years, and the median follow-up time (interquartile range) was 3.6 years (range, 3 months–8 years) for the entire study population. Around 584 patients [82.0 % of the patients (584/712)] were included in the follow-up at the end of the study. The association between type of treatment (surgical or conservative) and risk of recurrence is shown in Table 5. We determined that the incidence of constipation was lower for patients treated surgically compared to patients managed non-operatively; however, no significant difference was identified ( $P = .036$ ; Odds ratio [OR], 1.46, 95% CI, 0.98–2.17). The most common cause for hospital readmission

**Table 3****Clinical characteristics of the initial operation based on conservative management or surgical intervention.**

Management	Conservative (n = 446)	Surgical (n = 266)	P values
Drainage, n (%)	259 (58.1)	163 (61.3)	.38
WBC (L) on previous admission	7.3 ± 4.6	11.2 ± 5.4	.002
CRP (mmol/L) on previous admission	9.2 ± 5.7	13.9 ± 6.5	.012
Peritonitis, n (%)	169 (37.9)	126 (47.4)	.008
Scheduling conditions			
Emergency	267 (59.9)	200 (75.2)	.000
Elected	179 (40.1)	66 (24.8)	
The American Society of Anesthesiologist (ASA) classification			
ASA1-2	347 (77.8)	183 (68.8)	
ASA3-4	99 (22.2)	83 (31.4)	.005
Operation duration, min	95.2 ± 63.2	117.5 ± 67.6	.058
Blood transfused, n (%)	58 (13.0)	41 (15.4)	
Estimated blood loss (EBL), mL	27.1 ± 24.8	30.8 ± 26.5	.083
Incision location			
Midline incisions	138 (30.9)	104 (39.1)	.016
McBurney incisions	187 (41.9)	96 (36.1)	.072
Transverse incisions	69 (15.5)	32 (12.0)	.12
Others	72 (16.1)	34 (12.8)	.13
Bowel resection, n (%)	137 (30.7)	112 (42.1)	.001
Wound classification, n (%)			
Clean	59 (13.2)	26 (9.8)	.10
Clean contaminated	134 (30.0)	64 (24.1)	.05
Contaminated	115 (25.8)	59 (22.2)	.16
Septic	158 (35.4)	117 (44.0)	.014
Operation type, N (%)			
Open	367 (82.3)	230 (86.5)	
Laparoscopic	79 (17.7)	36 (13.5)	.50
Microbiological positive, n (%)	94 (21.1)	46 (17.3)	.13
Infectious complications, n (%)	67 (15.0)	27 (10.2)	.039

CRP = C-reactive protein, EBL = estimated blood loss, WBC = white blood cell.

was surgery-related acute SBO. Twenty-one patients (9.2 %) from the surgical group were rehospitalized for a new SBO episode, as were 53 patients (14.9 %) from conservative group ( $P = .028$ ; OR, 1.72, 95% CI, 1.00–2.95). Of these patients, 10 patients (4.4%) in the surgical group and 22 patients (6.2%) in the conservative group were subjected to emergency surgery for suspected bowel strangulation ( $P = .23$ ). Bowel strangulation segments underwent resection in 4 patients in the surgical group and 8 patients in the conservative group ( $P = .47$ ).

#### 4. Discussion

In the present study, we first demonstrated that 37.4% (266/712) of pediatric patients admitted with acute SBO underwent an

**Table 4****Multivariable analyses of the predictive factors for surgical intervention.**

Variables	HR (95% CI)	P values
Initial operation features		
WBC	2.15 (1.32–4.65)	.007
CRP	1.96 (1.15–3.78)	.018
Incision location	2.31 (1.29–5.26)	.031
Emergency procedure	1.46 (1.13–3.42)	.014
Current admission variables		
Crampy pain	4.66 (1.69–9.48)	<.001
Ascites	5.43 (1.84–13.76)	<.001
Complete small bowel obstruction	3.21 (1.45–8.74)	<.001

CRP = C-reactive protein, HR = hazard ratio, WBC = white blood cell.

**Table 5****Follow-up outcomes in pediatric patients based on conservative management or surgical intervention.**

Management	Conservative (n = 356)	Surgical (n = 228)	P values	Odds ratio (95% CI)
Constipation, N (%)	98 (27.5)	47 (20.6)	.036	1.46 (0.98–2.17)
Hospital readmission, N (%)	53 (14.9)	21 (9.2)	.028	1.72 (1.00–2.95)
Re-operation for ASBO, N (%)	22 (6.2)	10 (4.4)	.23	1.44 (0.67–3.09)
Small bowel resection (%)	8 (2.2)	4 (1.8)	.47	1.29 (0.38–4.33)

ASBO = adhesive small bowel obstruction.

operative intervention. Based on the data of a retrospective cohort of 712 pediatric patients, we also identified, for the first time, the impact of several variables for surgical intervention in patients with operated adhesive postoperative SBO using a multivariate Cox regression analysis. Considering the high rate of missing data, these findings should be interpreted with caution. We also followed the outcomes of patients treated by surgical or conservative management and determined that patients treated via surgery were less likely to require rehospitalization than those treated via conservative approach. These data delineate several key issues, including risk factors and outcomes associated with surgical intervention for postoperative acute SBO across pediatric surgical specialties.

Abdominal operations in children might cause postoperative SBO, with variations depending on the type of initial operation. Moreover, the proportion of children with SBO who require reoperation is discussed controversially.<sup>[13]</sup> Some studies have indicated that approximately one-half of children admitted with postoperative acute SBO required an operative intervention.<sup>[14]</sup> Another report has suggested that up to 80% of acute SBO cases required surgery, although conservative management was first attempted for a mean interval of 48 hours.<sup>[15,16]</sup> Our data were different than the previous assertion, although a considerable number of patients were subjected to operative intervention. We determined the spectrum of disease was different, and acute SBO may be more common with specific abdominal operations; moreover, the duration of symptoms in our patients was commonly shorter, which might account for this disparity. Acute SBO is often caused by the original procedure, which might be more severe and may be performed on pediatric patients who, on average, have more comorbidities with a higher proportion of emergency exploratory procedures than patients who undergo simpler procedures.<sup>[17,18]</sup> In this research, the rate was highest for children who underwent emergency exploratory laparotomy (65.6%, 467/712). Obstruction is uncommon after selected hepatobiliary surgery and hernia corrective surgery, which occurred in approximately 1% of the current cohort. In this analysis, we deliberately excluded neonates because differentiating cases of SBO from other surgical causes of obstruction in this age group is difficult using billing data as previously reported.

Understanding which features of operations carry greater risk of subsequent SBO will be helpful to prevent acute SBO events, as well as clinic visits, readmission or surgery. It is appropriate to consider as many aspects and variables as feasible to develop clinically reliable, relevant, and practical predictors. Previous reports have suggested that older age, the presence of ascites, and a high nasogastric tube (NGT) drainage volume are critical factors for subsequent surgical management.<sup>[19]</sup> Another report has suggested radiographic findings of complete SBO as a significant factor that indicates the need for surgery,<sup>[20]</sup> and a scoring system based solely on CT findings has been developed to predict surgical management.<sup>[21]</sup> We examined an extensive list

of clinical characteristics of acute SBO patients, particularly the patients' initial operative features, duration of operation, EBL, type of surgery, location of incision, and site of previous operation, which might represent the underlying cause of the following small bowel obstruction. To the best of our knowledge, no previous studies have analyzed these multiple factors to identify predictors for surgery among acute SBO pediatric patients. We determined that indications for surgical intervention of acute SBO in our department were highly initial procedure specific. Patient characteristics were less predictive than acuity of illness, particularly severe peritonitis, thus supporting the notion that acute SBO requiring reoperation tends to be associated with surgical comorbidities, rather than baseline patient characteristics. In our study, an emergency procedure and incision location are the major predictors for surgical intervention. Our results also suggested that simpler procedures, such as hernia surgery, have low reoperation rates. This result is of importance for the decision-making process regarding optimal treatment.

The follow-up evaluation showed that patients in whom operative intervention was required had a considerably higher rate of bowel resection (37.5%, 12/32) compared with a previous report, which suggested a 31% rate of bowel resection among patients requiring operation. They proposed 48 hours as the point when a decision regarding surgery should be made, as a result of the decreasing chance of nonoperative resolution.<sup>[22]</sup> Our experiences support the practice of shorting the observation period for resolution of obstruction. Surgical treatment is recommended in the absence of bowel function recovery within 24 hours after an oral water-soluble contrast agent test.<sup>[23]</sup> Otherwise, an early operative intervention for acute SBO should be considered in order to avoid a higher rate of bowel ischemia. A delay may increase the likelihood that bowel resection will become necessary. Based on this observation, it seems reasonable to attempt conservative management for patients without signs of severity. Clearly, the benefit of surgical treatment must be balanced against the risks associated with surgery, particularly for patients with comorbidities.<sup>[24]</sup> Thus, an individualized treatment plan should be considered of the SBO episode, as well as the general medical condition of the patient. Our study also suggested that patients treated with surgery for SBO had less frequent constipation symptoms than patients managed nonoperatively, which supports the active selection of operation for acute SBO.

Our study has several limitations. First, our study represents retrospective database analysis, in which unmeasured differences, known selection and treatment bias may be confounders and may thus limit generalizability of findings. The data were collected locally in a single institution, thus reflecting our institution's experience, and only represent approximately 20% of all general surgery procedures performed in our hospital over the study period; moreover, the conduction of interviews by the operating surgeon creates a bias, because poor results will not be reported

adequately. An additional limitation to this study is that some patients may have been readmitted to the local hospitals without our knowledge, in which case the readmission rate in this study would be underestimated. However, because we are a regional tertiary care referral center, the majority of patients treated at our institution for their index admission are directed back here for care if a subsequent complication arises. Furthermore, because the reoperation covers a broad range of surgery, it is difficult to make more concrete conclusions regarding the reoperation rates of specific surgical types, which is important for identifying the key processes of care. Studies on this topic that include multiple participating hospitals would benefit from including a larger number of patients.

## 5. Conclusions

In conclusion, the following characteristics should increase vigilance for surgical intervention: an initial emergency procedure with midline incision and the strangulation status. However, the benefit of conservative treatment must be carefully weighed against the potentially increased risk of bowel resection with further delay on a case-by-case basis. Additional prospective studies are required to confirm our findings.

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## Author contributions

Yuhua Deng and Chunbao Guo designed the study, analyzed the data, and evaluated the manuscript. Hai Zhu and Fabao Hao performed the statistical analyses and analyzed the data. Chunbao Guo analyzed the data and wrote the manuscript.

**Investigation:** Yongming Wang.

**Software:** Yongming Wang.

**Writing – original draft:** Yuhua Deng, chunbao guo.

**Writing – review & editing:** Yuhua Deng, chunbao guo.

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