A Study of the Prediction of Bowel Resection due to Strangulated Small Bowel Obstruction

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Abstract

Background: In this retrospective study, we aimed to assess the predictive factors for bowel resection due to strangulated small bowel obstruction (SSBO).

Methods: We enrolled a total of 109 patients diagnosed with SSBO at surgery. They were divided into two groups: those who underwent bowel resection and those who did not. The clinical findings, blood test results, blood gas analysis results, computed tomography (CT) findings, and sequential organ failure assessment (SOFA) scores of the patients were examined and compared between the two groups.

Results: A univariate analysis indicated significant predictive factors to be a history of abdominal surgery, prolonged time from the onset of disease to the operation, increased C-reactive protein (CRP) level, decreased albumin, SOFA score, existence of closed-loop obstruction, and reduced enhancement of the intestinal wall at CT. A multivariate analysis indicated that a reduced enhancement of the intestinal wall and the existence of closed-loop obstruction were independent predictive factors. Strangulated bowel obstruction can progress to a serious condition. It is therefore crucial to predict preoperatively those patients who are likely to require bowel resection.

Conclusions: Assessing the reduced enhancement of the intestinal wall and the existence of closed-loop obstruction are required in order to determine whether or not resection of the incarcerated intestine with SSBO is necessary.

Key words: strangulated small bowel obstruction, prognostic factor, bowel resection, reduced enhancement of the intestinal wall, closed-loop obstruction

Introduction

Strangulated small bowel obstruction (SSBO) occurs when a closed loop of the intestine is formed as a result of mechanisms such as strangulation by a fibrous cord, torsion on the bowel, or intestinal hernia [1–3]. It impairs the blood supply to the loop along a spectrum that can range from partial transient ischemia followed by a full recovery after release of the obstruction to irreversible transmural necrosis. In ischemia without necrosis, releasing the obstruction is sufficient. In contrast, necrotic bowel segments must be resected.

A 35-year institutional experience revealed that 42% of cases of small bowel obstruction (SBO) were due to strangulation, while nonviable strangulation which have a 4-fold greater risk of death than viable strangulation accounted for 16% of cases [4]. Another study reported that patients with strangulated obstruction had 2 to 10 times higher rates of death than those with nonstrangulated obstruction [5,6]. Thus, in order to prevent strangulation and potential bowel necrosis leading to an increased mortality rate prompt differentiation of the characteristics of SBO is needed [6,7].

Strangulated obstruction may require immediate surgical intervention [5]. Preoperative recognition of a strangulated bowel with or without irreversible necrosis is important for surgeons to better plan surgical exploration [8].

In the present study, we explored the factors associated with bowel resection due to SSBO using the clinical parameters, including the medical history, laboratory test results, and computed tomography (CT) findings.

Methods

Patients and Study Design

The study protocol was approved by the Institutional Review Board of Mitoyo General Hospital, and it conformed to the concepts of the Declaration of Helsinki and its amendments. We enrolled a total of 109 patients diagnosed with SSBO at surgery between January 2009 and December 2019 in our hospital. Patients with large bowel obstruction, paralytic ileus, inguinal hernia, cancer-associated SBO, and postoperative adhesive SBO were excluded from the study.

Patients were divided into two groups according to the operative findings; the bowel resection group included patients found to have a strangulated small intestine requiring resection, and the non-bowel resection group included patients who did not require small intestine resection. The diagnosis of SSBO was based on the operative description and confirmed with pathology reports where possible.

The preoperative data gathered were the age, sex, history of abdominal surgery, time from the onset to the operation, admission vital signs, maximal preoperative temperature, heart rate, and results of all appropriate laboratory studies including hematologic, electrolyte, blood gas, and enzyme values.

All preoperative abdominal CT findings were reviewed by two attending radiologists who had been blinded to the operative findings. The studies were evaluated for the presence of ascites, abnormally running vessels, elevation of the mesentery density, closed-loop obstruction, and reduced enhancement of the intestinal wall (Fig. 1).

The sequential organ failure assessment (SOFA) score was used to assess the degree of serious illness [9].

Outcome Measures

The main outcome examined was the factors predictive of a strangulated small bowel necessitating operative resection in patients with SSBO.

Statistical Analyses

Statistical analyses were performed using the Statistical Package for Social Science (SPSS) version 24 (Chicago, IL, USA) software program. The chi-square and Fisher's exact tests were used to compare

categorical variables, and Student's t-test or the Mann-Whitney test was used to compare continuous variables. Subsequently, receiver operating-characteristic (ROC) curves were constructed to illustrate the sensitivity and false positive rate (1-specificity) of SOFA scores for the prediction of bowel resection. A multiple logistic regression analysis was performed to identify significant predictors associated with the need for bowel resection. All tests were two-sided and P values lower than 0.05 were considered significant.

Results

Patient Group Characteristics

The mean age of the patients was 73.3 (range 18–94) years old, with 46 male and 63 female patients (Table 1). Adhesion or stricture was the primary etiology in patients with SSBO and volvulus was the second-most common. Thirty-three (30%) patients had no history of laparotomy, whereas 76 (70%) had undergone previous abdominal operations. Gynecologic surgery was the most frequent previous abdominal operation.

Clinical Characteristics

The 109 patients were divided into the bowel resection group (n = 38) and non-bowel resection group (n = 71) (Table 2). There was no statistical difference in age and sex between the two groups. A history of abdominal operation was present in 87% of the bowel resection group and 61% of the non-bowel resection group (P = 0.004). The bowel resection group showed a significantly longer time from the onset to the operation than the non-bowel resection group (P = 0.033). There was no significant difference in systemic inflammatory response syndrome (SIRS) and shock between the two groups.

Blood Test and Blood Gas Analysis Results

The bowel resection group had significantly higher average C-reactive protein (CRP) and lower average albumin (Alb) levels than the non-bowel resection group (Table 3). There was no significant difference in the blood gas results between the two groups.

CT Findings

Multiple CT scan findings including evidence of a closed-loop obstruction and reduced enhancement of the intestinal wall were significantly more common in the bowel resection group than in the non-bowel resection group (Table 4). There was no significant difference in the presence of ascites, abnormally running vessels, and elevation of the mesentery density between the two groups.

SOFA Score

The bowel resection group had a significantly higher average SOFA score than the non-bowel resection group (P = 0.028) (Table 5). In addition, the bowel resection group had a significantly lower average renal function score for SOFA than the non-bowel resection group (P = 0.011).

Multivariate Analysis Results

Nearly every variable proved insignificant in the logistic regression analysis, with the exception of reduced enhancement of the intestinal wall on CT with an odds ratio (OR) of 87.7 ($P < 0.001$) and a closed-loop obstruction on CT with an OR of 59.4 ($P < 0.001$) (Table 6).

Discussion

Strangulated obstruction is a life-threatening form of SBO. Hashimoto et al. reported the morbidity (31.3%) and mortality (5.4%) rate associated with SSBO [10]. A prompt diagnosis of SSBO and surgical intervention are important for avoiding a serious outcome, such as perforation, sepsis, and death [6]. A number of previous studies have evaluated the accurate and early diagnosis of SSBO, but early detection remains difficult; thus, the identification of more reliable diagnosis tools is urgently required. Identifying the preoperative predictive factors for bowel resection with SSBO is important. In the present study, we explored the factors predictive of the need for bowel resection due to SSBO using clinical parameters.

Significant predictive factors on a univariate analysis were the presence of a history of abdominal surgery, prolonged time from the onset of disease to the operation, increased CRP, decreased Alb, increased SOFA score, existence of closed-loop obstruction, and reduced enhancement of the intestinal wall at CT. However, we found in our regression analysis of multiple clinical variables that CT alone (specifically a reduced enhancement of the intestinal wall and the existence of closed-loop obstruction) was a moderately sensitive indicator of which patients with SSBO would require bowel resection.

In strangulated closed-loop SBO, a single constrictive lesion occludes the bowel loop [11]. Because the mesenteric artery withstands external pressure better than the mesenteric vein the venous outflow is compromised first. An impaired venous outflow with persistent arterial inflow leads to the accumulation of blood in the capillary system, increasing the intravascular hydrostatic pressure and, secondarily, impairing the microvascular wall permeability. The result is plasma extravasation into the bowel wall. In the event of persistent or severe compression at the obstruction site, the arterial flow is stopped, causing oxygen deprivation with further damage to the micro vascular wall. Red blood cells extravasate into the bowel wall, producing hemorrhagic foci [12]. These ischemic hemorrhagic lesions initially affect the mucosa and then spread outward to the other bowel wall layers, ultimately resulting in transmural necrosis.

Few studies [13–15] have investigated the usefulness of CT findings for predicting bowel necrosis. Necrotic bowel segments must be removed, while segments with reversible ischemia can be preserved if they recover after the release of the obstruction. Balthazar et al. reported high bowel-wall attenuation in incarcerated loops with severe ischemia and infarction but did not evaluate the performance of signs for predicting irreversible necrosis [13]. Nakashima et al. reported that five patients with increased bowel wall attenuation had transmural bowel necrosis [14]. However, on a univariate analysis this sign did not significantly predict strangulation or bowel wall necrosis, probably because of insufficient statistical

power. Furthermore, the exclusion of patients who underwent only unenhanced CT may have led to the underestimation of the prevalence of increased unenhanced bowel-wall attenuation [16].

Increased unenhanced bowel wall attenuation significantly predicted intestinal strangulation in several studies [8, 16, 17], but none measured the performance of this sign for predicting irreversible necrosis. Kohga et al. suggested an indirect quantitative method for assessing increased unenhanced bowel wall attenuation involving the computation of the mean bowel attenuation on axial sections. Values of ≥ 16.5 HU are associated with necrosis [8]. However, the reproducibility and interobserver agreement for selecting the measurement sites were not evaluated. Furthermore, this method requires measurement of as many slices as possible in order to allow selection of the highest value, which is not feasible in the emergency setting, when necrosis requiring surgery must be detected as promptly as possible.

Ronden et al. reported that increased unenhanced bowel wall attenuation was the only significant predictor of necrosis in strangulated closed-loop SBO [18]. In our study, a reduced enhancement of the intestinal wall and the existence of closed-loop obstruction were found to be independent predictive factors for bowel resection with SSBO.

Distinguishing bowel necrosis from non-necrosis with SSBO is pivotal for developing a well-considered preoperative strategy and planning urgent surgery [7]. Preoperative knowledge of bowel necrosis is valuable for surgeons as they are thus better informed and better prepared for the possible need for bowel resection.

Several limitations associated with the present study warrant mention. First, this was a retrospective study and our data are based on the medical examinations performed at our hospital. Selection bias therefore could not be completely avoided. Second, due to the single-center setting, this model requires further validation. Further large-scale and well-designed studies are needed.

Conclusions

We have reassessed the value of a comprehensive array of clinical, laboratory, and imaging criteria for the prediction of which patients with SSBO will require resection of the small bowel. A multivariate analysis indicated that reduced enhancement of the intestinal wall and the existence of closed-loop obstruction were independent predictive factors for bowel resection with SSBO.

Abbreviations

ALB
Albumin
CRP
C-reactive protein
CT
Computed tomography

OR
Odds ratio
ROC
Receiver operating-characteristic
SBO
Small bowel obstruction
SIRS
Systemic inflammatory response syndrome
SOFA
Sequential organ failure assessment
SPSS
Statistical Package for Social Science
SSBO
Strangulated small bowel obstruction

Declarations

Ethical Approval and Consent to participate

Not applicable

Consent for publication

Not applicable

Availability of supporting data

Please contact the authors for data requests

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

T Udaka designed the study, acquired the data, analyzed and interpreted the data, and drafted and revised the manuscript. H Asano helped to acquire the data and revised the manuscript. IE, OY, HA, and MK helped to revise the manuscript. All authors read and approved the final manuscript.

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Tables

Due to technical limitations, Tables 1-6 are provided in the Supplementary Files section.

Figures

Figure 1

(a) Representative CT showing closed-loop obstruction with a beak sign (Arrow). (b) Representative CT scan showing reduced enhancement of the intestinal wall (Arrow).

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Table3.xlsx](#)
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