Predictive Factors of Intestinal Ischaemia in Adhesive Small Bowel Obstruction

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ABSTRACT

Objective: To identify the predictive factors of intestinal ischaemia in adhesive small bowel obstruction (ASBO) and develop an intestinal ischaemia risk score.

Study Design: Observational study.

Place and Duration of the Study: Department of General Surgery, Shandong Provincial Qianfoshan Hospital, Jinan, Shandong, China, from January 2017 to February 2022.

Methodology: ASBO was determined by findings at laparotomy. The assessment of small bowel's viability was conducted through surgical inspection and subsequent histological examination of the surgical specimen. Univariate and multivariate analyses were conducted to ascertain the risk factors associated with intestinal ischaemia.

Results: In total, 79 patients were included. Factors entered into multivariate analysis associated with intestinal ischaemia were; rebound tenderness (odds ratio (OR): 7.8, 95% confidence interval (CI):1.7-35.3; p=0.008), procalcitonin (PCT) >0.5 ng/mL (OR: 11.7, 95% CI: 2.3-58.1; p=0.003), and reduced bowel wall enhancement on computerised tomography (CT) scan (OR: 12.2, 95% CI:2.4-61.5; p=0.003). Among patients with 0, 1, 2, and 3 factors, the rate of intestinal ischaemia increased from 0% to 49%, 72%, and 100%, respectively. According to the number of risk factors, the area under the receiver operating characteristic curve for the determination of intestinal ischaemia was 0.848 (95% CI: 0.764-0.932).

Conclusion: Rebound tenderness, PCT levels >0.5 ng/mL, and reduced bowel wall enhancement are risk factors of intestinal ischemic injury that require surgery within the context of ASBO. These factors need to be closely monitored that could assist clinicians in avoiding unnecessary laparotomies and selecting patients eligible for surgery.

Key Words: *Intestinal obstruction, Ischaemia, Adhesions*.

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INTRODUCTION

Small bowel obstruction (SBO) is one of the common surgical emergencies. Sometimes it is difficult to diagnose, progresses rapidly and often leads to the death of the patient.[1] Strangulating small bowel obstruction is defined as an SBO complicated by intestinal ischaemia. This is particularly important because strangulation or intestinal ischaemia is linked to an increased rate of morbidity and mortality.[2] The preoperative identification of such ischaemia would notify the surgeon of the necessity for prompt surgical intervention, thereby enhancing clinical outcomes and maybe saving the lives of patients.

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Predicting the clinical course and optimal timing for surgery remains challenging in cases of adhesive small bowel obstruction (ASBO), while hernias, tumours, and intussusception are more easily diagnosed and promptly treated with surgery. Current investigations have demonstrated the efficacy of CT in the detection and diagnosis of intestinal ischaemia, particularly in cases suffering from acute bowel obstruction.[3,4]

While there has been some progress, the identification of patients who require surgery keeps causing difficulties, emphasising the importance of early predictors of intestinal ischaemia. The objective of this study was to identify clinical, biological, and radiological parameters associated with intestinal ischaemia in patients with ASBO and establish a risk score for predicting the onset of intestinal ischaemia.

METHODOLOGY

The current study was approved from the Institutional Research and Ethics Board of Shandong Provincial Qianfoshan Hospital. Between January 2017 and February 2022, 79 adult patients with signs and symptoms of ASBO confirmed by laparotomy were evaluated for inclusion in the study. These patients under-

went contrast-enhanced CT before surgical interventions. Patients were excluded if they had ascites, recurrent carcinoma, laparotomy or laparoscopy within 6 weeks before inclusion. All clinical and laboratory features within 24 hours before surgery were researched. All CT scans were reviewed by two experienced radiologists who were unaware of the clinical course or clinical data. The assessment of small bowel's viability was conducted through surgical inspection (colour and peristalsis of the bowel wall and pulsation of the mesenteric arteries) and subsequent histological examination of the surgical specimen.

Features of clinical manifestations included abdominal pain, vomiting, abdominal distension, and absence of stools. Features of the physical examination included temperature, tachycardia, tachypnea, and rebound tenderness. The laboratory factors included C-reactive protein (CRP), white blood cell (WBC) count, procalcitonin (PCT), creatinine, and urea. Radiological data included: reduced bowel wall enhancement, mesenteric venous congestion, mesenteric fluid, peritoneal fluid, and wall thickening (>3 mm).[5]

The Statistical Package for the Social Sciences (version 22.0, Chicago, Illinois, USA) was utilised for conducting statistical analyses. The mean ± standard deviation (SD) was used to characterise continuous variables. Categorical variables were characterised as numbers and percentages. The study employed univariate analysis to investigate the factors related to intestinal ischaemia. Categorical variables were analysed using either the Chi-square test or Fisher's exact test, while continuous variables were analysed using the independent sample t-test. Logistic regression was employed to conduct a multivariate analysis of the risk factors, encompassing clinical, biological, and radiological variables, with p-values <0.1 in the univariate analysis. These results were utilised to develop a scoring system based on the number of risk factors. The performance of the score was evaluated by measuring sensitivity, specificity, positive predictive value, negative predictive value, and Youden index.[6] A receiver operating characteristic (ROC) curve was plotted, and the area under the curve (AUC) was determined to assess the predictive capacity of the score. All tests were two-sided. The p-values <0.05 were considered significant.

RESULTS

In total, 79 patients diagnosed with ASBO were included; 50 (63%) patients underwent operation but had no evidence of intestinal ischaemia, and 29 (37%) patients were confirmed to have intestinal ischaemia. Of the total, 51 (64.6%) were male, while 28 (35.4%) were female. The average age was 56 (range 23–88) years. Two patients with intestinal ischaemia died as a result of septic shock and multiple organ dysfunction syndrome (MODS) induced by bowel necrosis.

The characteristics associated with intestinal ischaemia in univariate analysis are shown in Table I. Rebound tenderness (p=0.004), temperature >38°C (p=0.093), WBC>10×10^9/L (p=0.044), PCT >0.5 ng/mL (p=0.001) were significantly associated with intestinal ischaemia in the univariate analysis. The results of univariate analysis of CT findings are described in Table II. Univariate analysis demonstrated that reduced bowel wall enhancement (p<0.001), mesenteric venous congestion (p=0.094), peritoneal fluid (p=0.048), mesenteric fluid (p=0.035), and bowel wall thickening (p=0.033) exhibited significant association with intestinal ischaemia.

Multivariate analysis showed that rebound tenderness (OR: 7.8, p=0.008), PCT >0.5 ng/mL (OR: 11.7, p=0.003), and reduced bowel wall enhancement on CT (OR: 12.2, p=0.003) were independent predictive factors of intestinal ischaemia (Table III). Among patients with 0, 1, 2, and 3 factors, the rate of intestinal ischaemia increased from 0% to 49%, 72%, and 100%, respectively (Table IV). According to the number of risk factors, the value of the area under the ROC curve (AUC) for the identification of intestinal ischaemia was 0.848 (95% CI: 0.764-0.932) (Figure 1). Associated sensitivity, specificity, positive predictive value, negative predictive value, and Youden index are presented in Table IV.

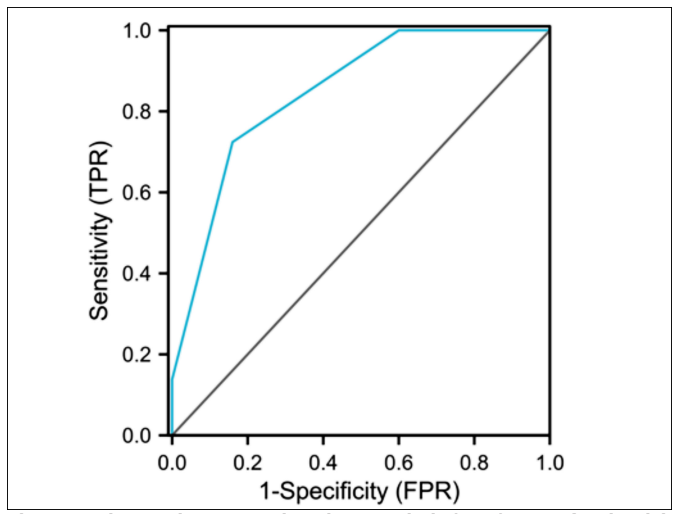

Figure 1: The receiver operating characteristic (ROC) curve for the risk score. The value of the area under the ROC curve (AUC) was 0.848 (95% CI: 0.764-0.932).

DISCUSSION

Intestinal ischaemia and necrosis are life-threatening complications of SBO. The early and accurate recognition of intestinal ischaemia and surgical management are important to reduce the mortality and avoid complications.[7] However, emergency surgery cannot be tolerated by patients in poor general condition. Furthermore, several studies have shown that conservative treatment is effective in many cases[8] and unnecessary laparotomy may result in new adhesion formation. Therefore, this study aimed to establish a risk score that would assist surgeons in selecting the right treatment plan.

In multivariate analysis, three independent predictive factors of ischaemia and requiring emergency operation were identified; rebound tenderness, PCT >0.5 ng/mL, and reduced bowel wall enhancement on CT.

Table I: Characteristics of 79 retrospective patients with ASBO on univariate analysis.

	No-ischaemia n = 50 (%)	Ischaemia n = 29 (%)	Overall n = 79 (%)	p-value
Age, years*	56.34±13.30	55.48±12.82	56.03±13.05	0.780§
Gender (male)	31 (62)	20 (69)	51 (65)	0.533¶
Diabetes	7 (14)	7 (24)	14 (18)	0.255¶
Hypertension	9 (18)	8 (28)	17 (22)	0.318¶
Coronary heart disease	14 (28)	9 (31)	23 (29)	0.775¶
Abdominal pain	45 (90)	28 (97)	73 (92)	0.406¶
Vomiting	14 (28)	11 (38)	25 (32)	0.360¶
Abdominal distention	31 (62)	21 (72)	52 (66)	0.347¶
Absence of stools	43 (86)	23 (79)	66 (84)	0.440¶
Rebound tenderness	9 (18)	14 (48)	23 (29)	0.004¶
Temperature >38℃	2 (4)	5 (17)	7 (9)	0.093¶
Tachycardia >90/min	8 (16)	7 (24)	15 (19)	0.374¶
Tachypnea >20/min	10 (20)	9 (31)	19 (24)	0.269¶
CRP, mg/L*	38.62±19.52	46.34±23.00	41.45±21.05	0.117§
Creatinine, mmol/L*	78.9±19.9	85.5±22.0	81.3±20.8	0.173§
Urea, mmol/L*	7.13±2.19	7.76±2.65	7.36±2.37	0.262§
WBC >10×10^9/L	21 (42)	19 (66)	40 (51)	0.044¶
PCT >0.5 ng/mL	24 (48)	25 (86)	49 (62)	0.001¶

** mean±SD, CRP = C-reactive protein, WBC = White blood cell, PCT = Procalcitonin, § Independent sample t-test and ¶ Chi-square test or Fisher's exact test was used.*

Table II: Computerised tomography signs of ASBO on univariate analysis.

	No-ischaemia n=50 (%)	Ischaemia n=29 (%)	Overall n=79 (%)	p-value
Reduced bowel wall enhancement	5 (10)	15 (52)	20 (25)	<0.001§
Mesenteric venous congestion	23 (46)	19 (66)	42 (53)	0.094§
Peritoneal fluid	23 (46)	20 (69)	43 (54)	0.048§
Mesenteric fluid	24 (48)	21 (72)	45 (57)	0.035§
Bowel wall thickening	11 (22)	13 (45)	24 (30)	0.033§

§ Chi-square test was used.

Table III: Multivariate logistic regression analysis of variables correlated with intestinal ischaemia.

	p-value	Odds ratio (OR)	95% CI
Rebound tenderness	0.008	7.8	1.7-35.3
Temperature >38℃	0.484	-	-
WBC >10×10^9/L	0.537	-	-
PCT >0.5 ng/mL	0.003	11.7	2.3-58.1
Reduced bowel wall enhancement	0.003	12.2	2.4-61.5
Mesenteric venous congestion	0.566	-	-
Peritoneal fluid	0.920	-	-
Mesenteric fluid	0.053	-	-
Bowel wall thickening	0.263	-	-

WBC = White blood cell, PCT = Procalcitonin, CI = Confidence interval.

Table IV: The risk factor's diagnostic value for the identification of intestinal ischaemia.

Score value	Sensitivity	Specificity	PPV	NPV	Youden index
One factor	1	0.400	0.492	1	0.400
Two factors	0.724	0.840	0.724	0.840	0.564
Three factors	0.138	1	1	0.667	0.138

PPV = Positive predictive value, NPV = Negative predictive value.

An intestinal ischaemia risk score was established depending on the number of predictive factors. This suggests that (i) urgent surgery should be performed in the presence of all three factors, (ii) when only one or two factors are present, close monitoring of these factors is necessary or laparotomy should be cautious, (iii) conservative management is reasonable in the absence of all three factors.

In a meta-analysis conducted to evaluate the diagnostic efficacy of various biomarkers in the context of intestinal ischaemia, Evennett *et al.* determined a 0.80 (95% CI: 0.66–0.91) sensitivity and a relatively low 0.50 (95% CI: 0.31–0.69) specificity of WBC for diagnosing intestinal ischaemia.[9] Leukocytosis did not offer much help in distinguishing individuals with or without intestinal ischaemia

because of its low diagnostic specificity. According to Salem *et al.*, CRP values exhibited an inability to distinguish between non-specific abdominal pain and surgical conditions necessitating either operative or nonoperative treatment.[10] D-dimer test was neither sensitive nor specific in diagnosing strangulation.[11]

Rebound tenderness is generally used to diagnose acute abdominal pain. The presence of voluntary or involuntary guarding, rebound tenderness, as well as abdominal rigidity may indicate that the SBO has been further worsened by transmural ischaemia or bowel perforation. Rebound tenderness was a significant predictive factor for intestinal ischaemia.[12,13] Procalcitonin (PCT) is the 116-amino acid precursor to calcitonin[14] as a marker of infection. PCT has been shown to be a marker for inflammation and sepsis in a number of clinical studies,[15] and also for intestinal ischaemia after acute intestinal obstruction.[16] The findings of this investigation indicate a strong association between PCT levels and the occurrence of intestinal ischaemia, in accordance with other studies. Markogiannakis *et al*. found that an elevated PCT level was a predictive factor for intestinal ischaemia, especially with levels above 1 ng/mL.[16] In 2013, Cosse *et al*. found that patients who underwent surgery with intraoperative ischaemia had higher PCT levels than those who underwent surgery without ischaemia.[17] In a recent study, Cosse *et al*. investigated a total of 128 patients diagnosed with intestinal ischaemia and revealed a substantial correlation between PCT values and several clinical outcomes, including intestinal necrotic damage, the degree of tissue damage, and fatality.[18] Therefore, there is a strong correlation between PCT and the onset of intestinal ischaemia or necrosis. However, more extensive clinical studies are needed to determine the PCT level threshold with which higher diagnostic values may be obtained.

Besides good diagnostic efficiency for small bowel obstruction, CT scans can show 61%-100% specificity and 73%-100% sensitivity in predicting bowel ischaemia.[4] Although adhesions cannot be seen directly on a CT scan, a CT scan can accurately distinguish between various causes of obstruction by ruling out other possibilities. In 2012, guidelines[19] based on systematic literature review recommended CT findings that may indicate ischaemia include the following signs, such as reduced bowel wall enhancement, wall thickening, mesenteric venous congestion, unusual course of the mesenteric vasculature, mesenteric fluid, as well as ascites. In this study, the most specific indicator for detecting intestinal ischaemia and necrosis in patients with SBO was the presence of reduced bowel wall enhancement. The results obtained from meta-analysis[4] demonstrated that reduced bowel wall enhancement had been the best indicator of ischaemia on CT, and the presence of this indication resulted in an 11-fold increase in the pretest probability of ischaemia. This CT sign is due to a blockage of arteriovenous microcirculation in the bowel wall (by the dilatation of the small bowel or by rotation of the occluded bowel loop around their vascular pedicle), with intestinal wall vessel engorgement, exudation, and final mural haemorrhage. As a result of this dynamic process, bowel wall infusion is altered. The remaining CT indicators that were investigated exhibited a diminished predictive value. The mesenteric fluid sign had the best sensitivity and was lack of specificity simultaneously. O'Daly *et al*. found that peritoneal fluid was an independent predictor of surgery and should warn the surgeon that the patient was three times more likely to require surgery.[20] The results of studies were controversial, probably because their diagnostic performance may vary depending on their criteria (i.e., peritoneal fluid volume, mesenteric fluid extension). These findings may reflect an increased risk of bowel wall ischaemia, and provide more relevant information as evidence of bowel ischaemia warranting urgent surgery.

The major strengths of this study are: this study is rare that identifies predictive factors for intestinal ischaemia in specific ASBO, exclusive of external hernias, intussusception, inflammation, and tumours. The diagnosis of adhesions and ischaemia based on surgery is accurate. The present study is subjected to a number of limitations. As a retrospective investigation, larger prospective studies are needed to identify predictive factors for intestinal ischaemia in ASBO and verify this study's preliminary conclusion. Moreover, some materials were lacking, such as serum lactate levels and picture information. After all, it was a retrospective study, and the intraoperative description based on surgical records about abdominal adhesions and necrosis was not detailed and precise enough.

In emergency situations, these predictive factors could assist in the selection of cases who are suitable candidates for surgery prior to the onset of peritonitis or shock. As early diagnosis of intestinal ischaemia could help prevent bowel resection, reduce complications and lower mortality, surgeons should pay high attention to these factors.

CONCLUSION

Rebound tenderness, PCT >0.5 ng/mL and reduced bowel wall enhancement are risk factors of intestinal ischemic injury that require surgery within the context of ASBO. These factors need to be closely monitored that could assist clinicians in avoiding unnecessary laparotomies and selecting patients eligible for surgery.

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ETHICAL APPROVAL:
This study was conducted after obtaining ethical approval from Shandong Provincial Qianfoshan Hospital.

PATIENTS' CONSENT:
Informed consents were obtained from the patients to publish the data.

COMPETING INTEREST:
The authors declared no competing interest.

AUTHORS' CONTRIBUTION:
XL: Conceptualisation, data curation, formal analysis, investigation, methodology, and drafting.
MT: Funding acquisition, data curation, project administration, validation, drafting, review and editing.
YL: Data curation, investigation, validation, drafting, review and editing.
YZ, JC: Methodology, validation, drafting, review and editing.
All authors approved the final version of the manuscript to be published.

REFERENCES

1. Al Samaraee A, Bhattacharya V.Facing the unexpected: unusual causes of mechanical small bowel obstruction in adults. *Clin J Gastroenterol* 2021; **14(5)**:1287-302. doi:10.1007/s12328-021-01450-2.
2. Scaglione M, Galluzzo M, Santucci D, Trinci M, Messina L, Laccetti E, *et al*. Small bowel obstruction and intestinal ischemia: emphasizing the role of MDCT in the management decision process. *Abdom Radiol* (NY) 2022; **47(5)**:1541-55. doi:10.1007/s00261-020-02800-3.
3. Rondenet C, Millet I, Corno L, Boulay-Coletta I, Taourel P, Zins M. Increased unenhanced bowel-wall attenuation: a specific sign of bowel necrosis in closed-loop small-bowel obstruction. *Eur Radiol* 2018; **28(10)**:4225-33. doi:10.1007/s00330-018-5402-6.
4. Millet I, Taourel P, Ruyer A, Molinari N. Value of CT findings to predict surgical ischemia in small bowel obstruction: A systematic review and meta-analysis. *Eur Radiol* 2015; **25(6)**:1823-35. doi:10.1007/s00330-014-3440-2.
5. Huang X, Fang G, Lin J, Xu K, Shi H, Zhuang L. A prediction model for recognizing strangulated small bowel obstruction. *Gastroenterol Res Pract* 2018; **2018**:7164648. doi:10.1155/2018/7164648.
6. Chen D, Chen G, Jiang W, Fu M, Liu W, Sui J, *et al*. Association of the collagen signature in the tumor microenvironment with lymph node metastasis in early gastric cancer. *JAMA Surg* 2019; **154(3)**:e185249. doi:10.1001/jamasurg.2018.5249.
7. Demessence R, Lyoubi Y, Feuerstoss F, Hamy A, Aubé C, Paisant A, *et al*. Surgical management of adhesive small bowel obstruction: Is it still mandatory to wait? - An update. *J Visc Surg* 2022; **159(4)**:309-19. doi:10.1016/j.jviscsurg.2022.02.002.
8. Podda M, Khan M, Di Saverio S. Adhesive Small Bowel Obstruction and the six w's: Who, How, Why, When, What, and Where to diagnose and operate? *Scand J Surg* 2021; **110(2)**:159-69. doi:10.1177/1457496920982763.
9. Evennett NJ, Petrov MS, Mittal A, Windsor JA. Systematic review and pooled estimates for the diagnostic accuracy of serological markers for intestinal ischemia. *World J Surg* 2009; **33(7)**:1374-83. doi:10.1007/s00268-009-0074-7.
10. Salem TA, Molloy RG, O'Dwyer PJ. Prospective study on the role of C-reactive protein (CRP) in patients with an acute abdomen. Ann R *Coll Surg Engl* 2007; **89(3)**:233-7. doi:10.1308/003588407X168389.
11. Bogusevicius A, Grinkevicius A, Maleckas A, Pundzius J. The role of D-dimer in the diagnosis of strangulated small-bowel obstruction. *Medicina (Kaunas)* 2007; **43(11)**:850-4.
12. Eren T, Boluk S, Bayraktar B, Ozemir IA, Yildirim Boluk S, Tombalak E, *et al*. Surgical indicators for the operative treatment of acute mechanical intestinal obstruction due to adhesions. *Ann Surg Treat Res* 2015; **88(6)**:325-33. doi:10.4174/astr.2015.88.6.325.
13. Patterson JW, Kashyap S, Dominique E. Acute Abdomen. Treasure Island (FL): StatPearls Publishing; 2022.
14. Gregoriano C, Heilmann E, Molitor A, Schuetz P. Role of procalcitonin use in the management of sepsis. *J Thorac Dis* 2020; **12(Suppl 1)**:S5-15.doi:10.21037/jtd.2019.11.63.
15. Tan M, Lu Y, Jiang H, Zhang L. The diagnostic accuracy of procalcitonin and C-reactive protein for sepsis: A systematic review and meta-analysis. *J Cell Biochem* 2019; **120(4)**:5852-9. doi:10.1002/jcb.27870.
16. Markogiannakis H, Memos N, Messaris E, Dardamanis D, Larentzakis A, Papanikolaou D, *et al*. Predictive value of procalcitonin for bowel ischemia and necrosis in bowel Obstruction. *Surgery* 2011; **149(3)**:394-403. doi:10.1016/j.surg.2010.08.007.
17. Cosse C, Regimbeau JM, Fuks D, Mauvais F, Scotte M. Serum procalcitonin for predicting the failure of conservative management and the need for bowel resection in patients with small bowel obstruction. *J Am Coll Surg* 2013; **216(5)**:997-1004. doi:10.1016/j.jamcollsurg.2012.12.051.
18. Cosse C, Sabbagh C, Browet F, Mauvais F, Rebibo L, Zogheib E, *et al*. Serum value of procalcitonin as a marker of intestinal damages: type, extension, and prognosis. *Surg Endosc* 2015; **29(11)**:3132-9. doi:10.1007/s00464-014-4038-0.
19. Maung AA, Johnson DC, Piper GL, Barbosa RR, Rowell SE, Bokhari F, *et al*. Evaluation and management of small-bowel obstruction: an Eastern Association for the Surgery of Trauma practice management guideline. *J Trauma Acute Care Surg* 2012; **73(5 Suppl 4)**:S362-9. doi:10.1097/TA.0b013e31827019de.
20. O'Daly BJ, Ridgway PF, Keenan N, Sweeney KJ, Brophy DP, Hill AD, *et al*. Detected peritoneal fluid in small bowel obstruction is associated with the need for surgical intervention. *Can J Surg* 2009; **52(3)**:201-6.