

Computed tomography features associated with operative management for nonstrangulating small bowel obstruction

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Accepted for publication
Feb. 5, 2014

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DOI: 10.1503/cjs.008613

Background: The management of nonstrangulating small bowel obstruction (SBO) may require surgery, but the need for and timing of surgical intervention isn't always apparent. We sought to determine whether specific features on computed tomography (CT) can predict the necessity for operative management.

Methods: Two radiologists independently reviewed CT scans from all patients admitted to hospital with SBO between 2004 and 2006. We examined the association between radiographic features and operative management by univariate analysis using the χ^2 or Fisher exact test. Significant factors with high concordance between radiologists were entered into a multivariable stepwise logistic regression model.

Results: There were 228 patients with SBO, 63 of whom met our inclusion criteria and had CT scans available for review. Three CT features were frequently associated with operative management and had good concordance between radiologists: complete bowel obstruction, small bowel dilation greater than 4 cm and transition point. Transition point was the only significant factor predictive of operative management for SBO on multivariable logistic regression analysis (OR 19, 95% confidence interval 1.8–201, $p = 0.014$).

Conclusion: In patients with nonstrangulating SBO, the presence of a transition point on CT scan should alert the surgeon to the increased likelihood that operative management may be required.

Contexte : La prise en charge de l'occlusion du grêle sans étranglement peut nécessiter une chirurgie, mais il n'y a pas de règles claires pour déterminer le bien-fondé et le moment de l'intervention. Nous avons voulu déterminer si certaines caractéristiques spécifiques observées à la tomodensitométrie (TDM) permettent de prédire la nécessité d'une prise en charge chirurgicale.

Méthodes : Deux radiologistes ont passé en revue de manière indépendante les TDM de tous les patients hospitalisés pour obstruction du grêle entre 2004 et 2006. Nous avons analysé le lien entre les caractéristiques radiographiques et la prise en charge chirurgicale par analyse univariée à l'aide du test du χ^2 ou du test exact de Fisher. Les facteurs importants assortis d'une étroite concordance entre les radiologistes ont été intégrés à un modèle de régression logistique multivariée séquentielle.

Résultats : On a dénombré 228 patients atteints d'une occlusion du grêle, dont 63 répondaient à nos critères d'inclusion et pour lesquels on disposait de résultats de TDM à soumettre à l'examen des radiologistes. Trois caractéristiques à la TDM ont fréquemment été associées à la prise en charge chirurgicale, en plus de faire l'objet d'une bonne concordance entre les radiologistes : obstruction intestinale complète, dilatation du grêle de plus de 4 cm et point de transition (ou saut de calibre). Le point de transition a été le seul facteur prédictif important à l'égard de la prise en charge chirurgicale de l'occlusion du grêle à l'analyse de régression logistique multivariée (rapport de cotes 19; intervalle de confiance de 95 %, 1,8–201; $p = 0,014$).

Conclusion : Chez les patients qui présentent une occlusion du grêle sans étranglement, la présence d'un point de transition à la TDM devrait indiquer au chirurgien une plus grande probabilité de traitement chirurgical nécessaire.

The management of nonstrangulating small bowel obstruction (SBO) may require surgical intervention. The goal of operative management is to avoid the increased morbidity and mortality associated with intestinal strangulation while recognizing the potential for surgical morbidity and mortality. Unfortunately, both the requirement for surgery and the timing of surgical intervention may not always be readily apparent, which continues to challenge surgeons.¹

Various imaging modalities help the surgeon diagnose SBO.² Most radiographic methods are currently unable to predict which patients will benefit from early surgery; rather, they may illustrate strangulation once this has occurred.³ One exception is the administration of oral gastrograffin, as its appearance in the colon 24 hours after administration has been shown to successfully predict the nonoperative resolution of SBO.⁴

The role of computed tomography (CT) in predicting the need for surgical intervention in patients with nonstrangulating SBO is currently under active investigation. Two studies have shown the small bowel feces sign to be predictive of nonoperative resolution of SBO.^{5,6} However, there are conflicting reports on the association between other radiographic features, such as the presence of a transition point or ascites, and the need for surgical intervention.⁵⁻¹⁰ Furthermore, it is currently unknown whether the aforementioned CT findings are reliably interpreted by independent radiologists in the setting of nonstrangulating SBO. Ideally, radiographic features with both good interobserver correlation and a strong association with operative management will enable the surgeon to monitor selected patients who warrant careful observation for the increased likelihood of surgical intervention without progressing to intestinal strangulation. The purpose of this study was to determine whether specific features on CT scans exhibiting good interobserver correlation can predict the necessity for operative management in patients with nonstrangulating SBO.

METHODS

Patients

We identified patients discharged with a diagnosis of SBO between June 2004 and March 2006 from 3 tertiary care hospitals with joint academic affiliation. We included those who had a CT scan performed within 48 hours of admission. Exclusion criteria were history of intra-abdominal cancer, inflammatory bowel disease, abdominal surgery within 30 days, previous abdominal or pelvic radiation, comorbidities precluding surgical intervention, immediate surgical intervention based on clinical evaluation and transfer from outside hospitals. From the hospital's electronic database and written patient records, we collected information on patient demographics, clinical and laboratory data, operative findings and pathological specimens when a resection was performed. Recurrence of SBO within 2 years was documented.

We acquired CT data from the level of the diaphragm to the lesser trochanters. Oral contrast consisted of 20 mL of ioxithalamate mixed in 1000 mL of water and was administered 1 hour before the study. Rectal contrast, when given, consisted of 3 mL of ioxithalamate in 150 mL of water, 10 mL of iohexol-300 in 250 mL of water or 15 mL of iodixanol in 500 mL of water at hospitals 1, 2 and 3, respectively. Intravenous contrast was iodixanol, administered as 2 mL/kg to a maximum of 150 mL at a rate of 3 mL/second, and the data were acquired in the portal venous phase with a 60- to 70-second delay. Data were obtained on multidetector CT scanners: a single- or 16-slice scanner at hospital 1, a 4- or 64-slice scanner at hospital 2, and a 4- or 16-slice scanner at hospital 3. Based on a review of the literature for commonly described CT radiographic features in patients with SBO and at the recommendation of a body radiologist, we evaluated 9 CT features: ascites, beak sign, complete bowel obstruction, internal hernia, diameter at point of maximal small bowel dilation (in centimetres), small bowel feces sign, target sign, transition point and whirl sign.^{1,3,11,12} Definitions of these features are provided in Table 1, with selected illustrations in Figure 1. Two radiologists (P.V. and

Table 1. Definitions of CT features seen in patients with small bowel obstruction^{2,12,13}

CT feature	Definition
Ascites	Presence of excess peritoneal fluid
Beak sign	Tapering of the dilated bowel to form what resembles a bird's beak at the point of obstruction
Complete bowel obstruction	Lack of oral contrast distal to the point of obstruction
Internal hernia	Presence of a mesenteric defect through which intestinal loops traverse
Maximal small bowel dilation	Measurement of the largest small bowel diameter from 1 outer wall to the opposite outer wall
Small bowel feces sign	Intraluminal particulate matter containing gas bubbles identified in the dilated small bowel segment
Target sign	Thickened enhancing bowel wall with submucosal edema giving the appearance of 3 concentric rings, with inner and outer rings displaying high attenuation and a middle ring displaying low attenuation
Transition point	A discrete, focal change in calibre from dilated bowel proximally to collapsed bowel distally
Whirl sign	Stretched mesenteric vessels converging to a point of intestinal torsion

CT = computed tomography.

J.K.), blinded to both clinical outcome and prior CT reports, independently analyzed the CT scans. Consensus was achieved through joint consultation. The local research ethics board approved our study protocol.

Statistical analysis

The primary outcome was operative management for SBO. The secondary outcome was recurrence of SBO within 2 years of discharge from hospital.

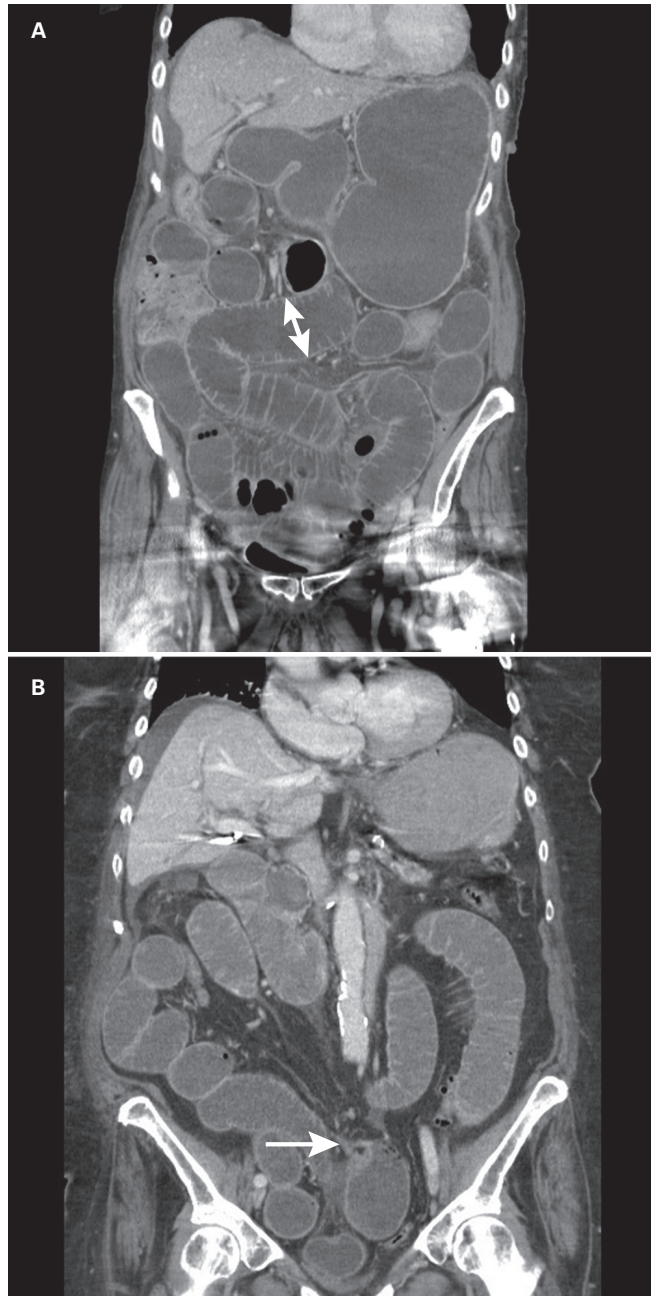


Fig. 1. Illustrations of computed tomography (CT) scan features. **(A)** Diameter at point of maximal small bowel dilation **(B)** transition point.

Baseline characteristics between patients undergoing operative management and those managed nonoperatively were compared using the χ^2 test or Student *t* test as appropriate. We tested associations between each of the radiographic features and the primary outcome of surgical intervention using either the χ^2 test or Fisher exact test for sample sizes of fewer than 6 patients. Concordance was calculated between the 2 independent radiologists using κ for those features with a significance of $p < 0.05$ on univariate analysis. Features with both $p < 0.05$ and $\kappa > 0.5$ on univariate analysis were entered stepwise into a multivariable logistic regression model to obtain adjusted odds ratios (OR) with 95% confidence intervals (CI). Finally, we compared recurrence of SBO in the surgical and nonsurgical groups using the χ^2 test. We considered results to be significant at $p < 0.05$.

RESULTS

There were 228 patients with a diagnosis of SBO during the specified time interval. Of these, 104 patients were excluded: history of intra-abdominal cancer ($n = 43$), inflammatory bowel disease ($n = 20$), abdominal surgery within 30 days ($n = 17$), abdominal or pelvic radiation ($n = 3$), comorbidities precluding surgical intervention ($n = 4$), clinical parameters to mandate immediate surgical intervention ($n = 8$), and transfer from other hospitals ($n = 9$). Of the remaining 124 patients, 63 had CT images available for review. Of these 63 patients, 27 (43%) underwent operative management and 36 (57%) were managed nonoperatively (Fig. 2).

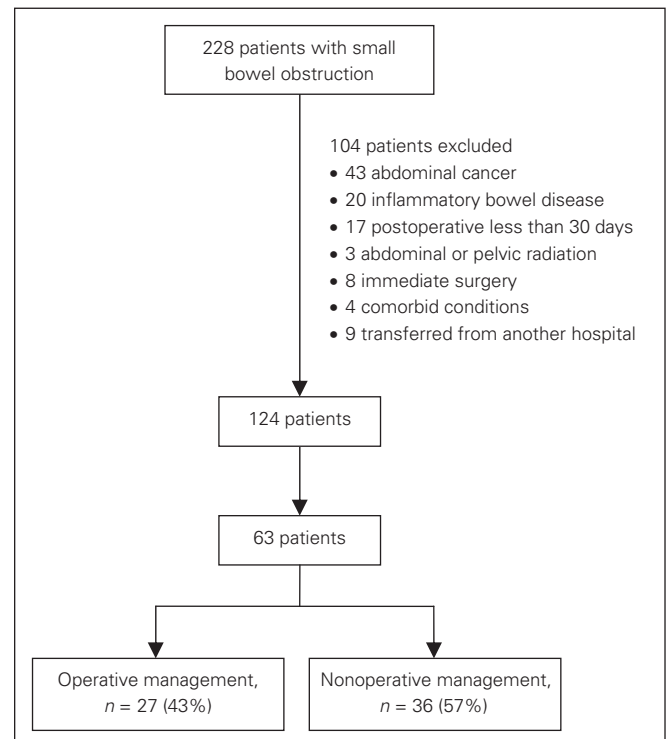


Fig. 2. Selection of patients with small bowel obstruction.

All patients undergoing operative management were confirmed to have SBO at surgery. The etiologies for obstruction included adhesions ($n = 21$), incisional hernias ($n = 3$), mesenteric mass ($n = 1$), appendicitis ($n = 1$) and peristomal hernia ($n = 1$). In 6 patients with adhesions,

there were concomitant diagnoses of internal hernia ($n = 5$) and small bowel volvulus ($n = 1$). Seven patients (26%) required small bowel resection; small bowel ischemia was confirmed pathologically in 6 of these patients.

There was no significant difference in baseline demographic characteristics between the operative and nonoperative groups (Table 2). The presence of abdominal tenderness on examination and white blood cell count on admission were similar between the groups. Patients with a history of multiple abdominal procedures were more likely to require surgical intervention (OR 2.8, 95% CI 0.90–8.8, $p = 0.08$), although this was not significant.

Of the 9 radiographic features studied, 5 were significantly associated with surgical intervention: beak sign (OR 10, 95% CI 3.1–32, $p < 0.001$), complete bowel obstruction (OR 8.5, 95% CI 2.6–28, $p < 0.001$), maximal small bowel dilation greater than 4 cm (OR 5.1, 95% CI 1.5–7.9, $p = 0.010$), small bowel feces sign (OR 3.6, 95% CI 1.1–12, $p = 0.039$) and transition point (OR 32, 95% CI 4.0–270, $p < 0.001$). Those features not achieving statistical significance were the presence of ascites ($p = 0.14$) and target sign ($p = 0.71$). Internal hernia and whirl sign were found in 6 (22%) and 5 (19%) patients, respectively, and all 11 patients were submitted to operative management. The type of CT contrast used was not significant between the operative and nonoperative groups (Table 3).

Table 2. Demographic and clinical characteristics of patients with small bowel obstruction managed operatively and nonoperatively

Clinical factor	Group; no. (%)*		<i>p</i> value
	Surgery, <i>n</i> = 27	No surgery, <i>n</i> = 36	
Sex			0.82
Female	15 (56)	21 (58)	
Male	12 (44)	15 (42)	
Mean age, yr	64	63	0.87
No. of previous surgeries			0.08
> 1	19 (70)	18 (50)	
1	6 (22)	16 (44)	
0	2 (7)	2 (6)	
Abdominal tenderness			0.17
Yes	22 (82)	34 (94)	
No	3 (11)	2 (6)	
Unknown	2 (7)	0 (0)	
Mean WBC $\times 10^3/\text{mm}^3$	13	12	0.36

WBC = white blood cell count.
*Unless otherwise indicated.

Table 3. Univariate analysis of CT features in operative and nonoperative patients, and κ values for features with $p < 0.05$

CT feature	Group; no. (%)		OR (95% CI)	<i>p</i> value	κ
	Surgery, <i>n</i> = 27	No surgery, <i>n</i> = 36			
Ascites	14 (52)	12 (33)	2.2 (0.77–6.0)	0.14	
Beak sign	20 (74)	8 (22)	10 (3.1–32)	< 0.001	0.43
Complete bowel obstruction	17 (63)	6 (17)	8.5 (2.6–28)	< 0.001	0.52
Internal hernia	6 (22)	0 (0)			
SB dilation > 4 cm	23 (85)	19 (53)	5.1 (1.5–7.9)	0.010	0.63
SB feces sign	10 (37)	5 (14)	3.6 (1.1–12)	0.039	0.30
Target sign	3 (11)	3 (8)	1.4 (0.26–7.4)	0.71	
Transition point	26 (96)	16 (44)	32 (4.0, 266)	< 0.001	0.66
Whirl sign	5 (19)	0 (0)			
Intravenous contrast	22 (82)	32 (89)	0.55 (0.13–2.28)	0.41	
Oral contrast	24 (89)	33 (92)	0.73 (0.13–3.9)	0.71	
Rectal contrast	6 (22)	6 (17)	1.43 (0.40–5.0)	0.58	

CI = confidence interval; CT = computed tomography; OR = odds ratio; SB = small bowel.

Table 4. Multivariable model of CT features associated with operative management for small bowel obstruction

CT feature	OR (95% CI)	<i>p</i> value
Complete bowel obstruction	3.2 (0.15, 13)	0.09
SB dilation > 4 cm	0.87 (0.15, 4.9)	0.88
Transition point	19 (1.8, > 200)	0.014

CI = confidence interval; CT = computed tomography; OR = odds ratio; SB = small bowel.

Of the 5 radiographic features achieving statistical significance, 3 showed good correlation between radiologists with κ values greater than 0.5: complete bowel obstruction ($\kappa = 0.52$), maximal small bowel dilation greater than 4 cm ($\kappa = 0.63$) and transition point ($\kappa = 0.66$; Table 3). These 3 features were entered into a multivariable stepwise logistic regression model. Transition point retained statistical significance (OR 19, 95% CI 1.8–201, $p = 0.014$), while complete bowel obstruction ($p = 0.09$) and maximal small bowel dilation greater than 4 cm ($p = 0.88$) did not; including complete bowel obstruction and small bowel dilation did not significantly improve the fit of the model (Table 4). A transition point was identified in all 7 patients requiring a small bowel resection.

Recurrence of SBO did not differ significantly ($p = 0.75$) between the groups, occurring in 3 (12%) patients managed operatively and 5 (14%) patients managed nonoperatively.

DISCUSSION

The current role of CT in the management of SBO lies in its ability to diagnose obstruction, to define the etiology and probable location of the obstruction, and to differentiate nonstrangulating from strangulating obstruction. Computed tomography assessment is effective, with a sensitivity of 83%–100% and specificity of 61%–93%.³ In patients with nonstrangulating SBO, there are limited data on whether CT may help predict which patients will require surgical intervention. While a surgeon's decision to operate ultimately depends on the patient's clinical condition, CT features predictive for operative management of patients with nonstrangulating SBO may facilitate care. Such CT findings could target a subset of these patients for heightened vigilance in an effort to minimize operative delay, thereby reducing the increased morbidity and mortality from intestinal ischemia and associated complications.

The cohort of patients in this study with nonstrangulating, adhesive SBO is representative of analogous populations in comparable studies. The proportion of patients having had multiple, 1 or no prior abdominal surgeries is corroborated by previous studies, and the operative rate of 43% lies within the widely reported range of 27%–66%.¹⁴ The rates of small bowel resection and small bowel ischemia are comparable to those reported in another recent study.⁷ Furthermore, the similar recurrence rates of SBO in operative and nonoperative patients are also supported by current literature.^{14,15}

Other studies have shown that clinical findings and laboratory measurements at initial presentation are inadequate to predict the need for surgical intervention.¹⁶ Consistent with previous reports,^{17,18} the presence of abdominal tenderness or leukocytosis at admission in the present study had no predictive value for requiring surgical intervention. There was, however, a trend

toward operative management in patients having undergone more than 1 previous abdominal surgery; this finding may be explained by the development of extensive adhesions often anticipated in patients with multiple prior surgeries.

In comparison with other studies to date that have explored the association between CT radiographic features and the need for subsequent surgical intervention in patients with SBO, the present study consists of a strictly defined cohort. The study population was selected to consist only of patients with suspected adhesive nonstrangulating SBO through predefined exclusion criteria. Patients were excluded for clinical suspicion of strangulation that would require immediate operative management. Patients were also excluded if there was the potential for favouring nonoperative management owing to other medical circumstances, such as in patients with incurable intra-abdominal malignancy, inflammatory bowel disease, recent abdominal surgery, prior abdominal or pelvic radiation, or severe comorbid illnesses.^{18,19} By using 2 expert radiologists blinded to each other's interpretations and to patient outcomes, only CT findings with good interobserver correlation were included in the multivariable logistic regression model. Our study was specifically designed to achieve results that may be more readily extrapolated to the surgical management of patients with nonstrangulating SBO at other centres.

An identifiable transition point on CT was most significantly associated with the need for operation in patients with nonstrangulating SBO, both on univariate and multivariate analyses. A transition point was also the only consistent CT finding in all patients who required a small bowel resection. The association is plausible, given the discrete and localized change in intestinal calibre seen in a transition point. Our results suggest that a transition point represents a fixed rather than a transient point of intestinal obstruction unlikely to resolve without operative intervention. Four studies^{6,8–10} to date have evaluated the clinical relevance of a transition point; however, only the study by Hwang and colleagues⁸ supports the finding of an increased likelihood of operative management. All 4 of these studies were subject to less stringent inclusion/exclusion criteria and may not represent the population of patients targeted in the present study. Furthermore, CT interpretation in these studies may have been subject to observer bias, as analysis was performed by either a single radiologist or without blinding, or was based on findings extracted from the original CT reports.

In the present study, complete bowel obstruction was significantly associated with surgical intervention on univariate analysis, clearly a sound and probably anticipated clinical decision. Although not significant on

multivariate analysis and perhaps a function of the small number of patients involved, there was a clear association with operative management in patients with this CT finding on univariate analysis (OR 8.5, 95% CI 2.6–28). Other studies have reported a similar association on univariate analysis.^{8,10} The absence of orally administered contrast beyond a fixed point of obstruction (i.e., complete bowel obstruction) may be a sufficient indication for surgical intervention.

The positive correlation between small bowel feces sign and operative management found in the present study is discordant with the findings of 2 recent studies.^{5,6} That said, the small bowel feces sign was previously reported to occur more frequently in patients with moderate and high-grade SBO.¹¹ While further prospective studies are required to clarify this discrepancy, modest interobserver agreement among reporting radiologists, as demonstrated in this study, may limit the usefulness of the small bowel feces sign in guiding clinical decision making.

Additional CT features, which have not been extensively reported in the literature, were evaluated in the present study. Identification of an internal hernia and whirl sign, although infrequent, was found only in the group of surgically managed patients. In the setting of SBO, an internal hernia may be similar in clinical behaviour to an incarcerated external hernia. Entrapped small bowel is unlikely to reduce spontaneously, prompting operative intervention. The whirl sign suggests stretching of the mesenteric vessels toward a point of intestinal torsion; such tension on the small bowel mesentery may signify an irreversible consequence of intestinal obstruction that requires surgical correction. Although it was not possible to calculate an OR for these 2 CT features, internal hernia and whirl sign appear to represent findings with a physiologic basis and clinical rationale for surgical intervention.

CONCLUSION

The management of patients with nonstrangulating SBO remains a clinical challenge. While the timing and need for surgery ultimately depends on the surgeon's assessment of the patient's condition and course in hospital, the presence of a transition point on early CT scan should alert the surgeon to an increased likelihood that operative management will be required to resolve the SBO. Heightened awareness driven by CT findings should prompt close patient monitoring to minimize delay in surgical intervention and thereby reduce the potential risk for intestinal ischemia and its consequences in this population.

Acknowledgements: We thank Kevin Chan, MD, for his help with data entry.

Competing interests: None declared.

Contributors: All authors designed the study, acquired and analyzed the data, wrote and reviewed the article and approved the final version for publication.

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