Surgery Open Science 20 (2024) 70–76

Contents lists available at ScienceDirect

Surgery Open Science

journal homepage: www.journals.elsevier.com/surgery-open-science

Research Paper

The utility of a CT grading scale in deciding on surgical intervention for patients with suspected small bowel obstruction

Marianne Becnel [a], Ikaikaolahui Danner [a], Maria De Los Santos [a], Lindsay J. Escobedo [a], Marie Mohrbacher [a], Jacob Young [a], Robert Patterson [a,b,*]

[a] Noorda College of Osteopathic Medicine, 2162 South 180 East, Provo, UT 84606, USA
[b] Intermountain Health American Fork Hospital, 170 N 1100 E, American Fork, UT 84043, USA

ARTICLE INFO

Keywords:
Small bowel obstruction
CT diagnosis
Grading systems

ABSTRACT

Background: A grading system was developed for computerized tomography (CT) scans evaluating patients with suspected small bowel obstruction (SBO). We hypothesized that patients with a higher grade of suspected SBO on CT scan would be more likely to require surgical intervention.

Methods: Retrospective chart review of patients who presented to the Emergency Room (ER) who had a CT of the abdomen and pelvis for suspected SBO. Patients were divided into 5 groups: Grade 1 (SBO unlikely), Grade 2 (probable partial or early SBO), Grade 3 (probable high grade SBO), Grade 4 (SBO with changes concerning for ischemia) and Not Graded.

Results: The CT scans of 655 patients were graded. Of the 22 patients with a grade 1 SBO, only 1 went for surgery (4.5 %). For grade 2 patients, 23 out of 299 had an operation (7.7 %), for grade 3 it was 84 out of 299 (28.1 %) and for grade 4 SBO, 25 out of 35 patients (71.4 %) had surgery. The p value is <0.00001. The three most common intraoperative findings were SBO obstruction from adhesions alone (48 % of cases), followed by incarcerated hernias (12 %) and ischemic bowel (9 %). Only 8 cases out of 133 operations (6 % of total) had no findings at time of surgery other than dilated bowel.

Conclusions: The CT grading scale for SBO developed at our institution shows excellent correlation between grade and going for surgery, with few negative results, and can be a useful tool among other factors for general surgeons when deciding whether or not to operate on a patient with suspected SBO.

Introduction

Deciding on whether or not to take a suspected small bowel obstruction (SBO) patient to the operating room is one of the more challenging dilemmas a general surgeon will encounter. Concerns include a nontherapeutic intervention, i.e., operating on a patient who has no significant findings and therefore did not need surgery, and observing a patient whose operation was delayed and would have benefited from earlier intervention. Factors that influence decision-making have traditionally included the history of the patient's presenting illness, the patient's surgical history, the physical exam, lab values such as white cell count and lactate level, and imaging studies, usually a CT of the abdomen and pelvis. The language indicating the possibility of a SBO on the CT study is left to the individual interpreting radiologist, and may contain vague phrases such as:

SBO cannot be ruled out
Findings are compatible with obstruction
Possible high grade SBO

The American Association for the Surgery of Trauma (AAST) has a five-level grading system for assessing bowel obstruction from adhesions. Its weaknesses include a lack of a level to indicate SBO is unlikely, causes of SBO other than adhesions, and inclusion of perforation which usually mandates surgical exploration and therefore removes the decision-making process on whether surgery is indicated. To our

* Corresponding author at: American Fork Specialty Clinic, 98 N 1100 E, Ste 202, American Fork, UT 84003, USA.
E-mail addresses: do25.mjbecnel@noordacom.org (M. Becnel), do25.ikdanner@noordacom.org (I. Danner), do25.mvdelossantos@noordacom.org (M.D.L. Santos), do25.ljescobedo@noordacom.org (L.J. Escobedo), do25.mlmohrbacher@noordacom.org (M. Mohrbacher), do25.jayoung@noordacom.org (J. Young), robert.patterson@imail.org (R. Patterson).

https://doi.org/10.1016/j.sopen.2024.05.016
Received 20 February 2024; Received in revised form 9 May 2024; Accepted 24 May 2024
Available online 31 May 2024

knowledge, the AAST grading system is not widely used by radiologists to communicate their concerns to general surgeons at time of patient presentation to the ER.

Our institution wished to develop an objective CT grading system that could be used by radiologists to guide surgeons with the decision to observe versus operate. The ideal grading system would be able to rule out another diagnosis such as enteritis or ileus that can mimic the findings of small bowel obstruction on CT scan, differentiate between partial versus complete obstruction, and alert the surgeon to urgent conditions such as ischemic bowel.

Methods

Our institution has a 25-physician radiology group that covers two hospitals: a medium-sized community hospital with 90 beds and approximately 30,000 ER visits per year, and a larger regional hospital 20 miles away with 395 beds and around 50,000 ER visits per year. Approximately 15 general surgeons work at the two hospitals. In 2016, multiple meetings were held between representatives from the General Surgery Department and the Radiology Department. After much discussion and a review of the then-current literature, a grading system was developed with 4 levels (Table 1.)

Examples of CT imaging for Grades 1 through 4 are found in Figs. 1–4.

When a patient presents to the ER at either hospital with a history or finding suggestive of SBO, the emergency physician usually orders bloodwork and a CT of the abdomen and pelvis which is then read by one of the radiologists, who assigns a SBO grade from 1 to 4, depending on radiologic findings. Upon reviewing the patient and their graded imaging studies, the general surgeon has a better idea as to whether the CT suggests the patient has a partial, complete or complicated (ischemic) SBO, which helps inform the decision for surgery versus observation.

After obtaining Institutional Review Board approval, a retrospective chart review was performed on patients who presented to either of the two hospitals from 2018 through 2020. The review started for 2018 patients with the concern that it might take radiologists some time to learn and implement the new grading scale. It ended in 2020 for concerns about the confounding effects of Covid-19. Included were patients who presented to the ER with abdominal pain suggestive of bowel obstruction and then had a CT scan. Excluded were patients who had findings of perforation such as free air.

Table 1
Small bowel obstruction grading scale.

Grade	Impression	CT findings
1	Probable ileus or gastroenteritis	-dilated small bowel, not likely due to obstruction
2	Probable partial or early small bowel obstruction	-mildly dilated small bowel -feces sign (particulate matter mixed with gas bubbles) -possible transition point -air in colon -non-distended stomach -skip dilation
3	Probable high-grade small bowel obstruction	-markedly dilated bowel -high grade transition -serrated beak -free fluid -wall thickening -continuous dilation -distended stomach
4	Small bowel changes concerning for ischemia	-pneumatosis -mesenteric edema -engorgement of vessels -closed loop obstruction -no wall enhancement -marked swelling of the mesentery

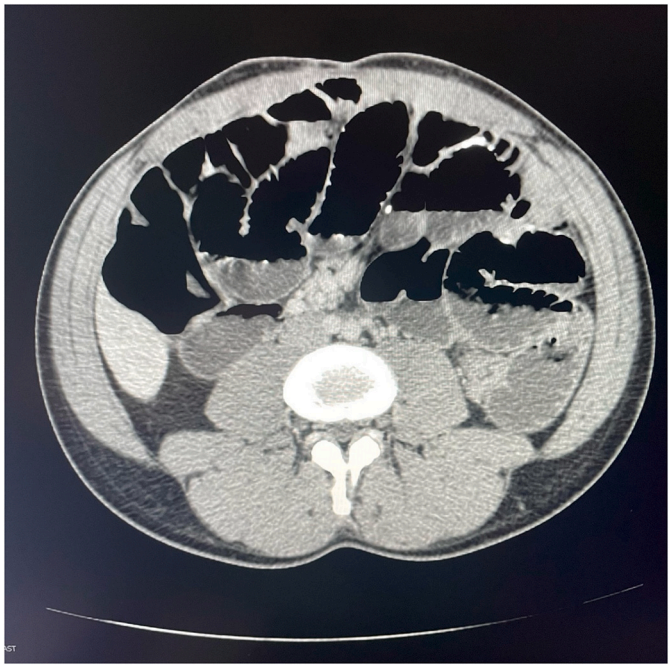

Fig. 1. Example of a Grade 1 SBO with the series of images showing dilated small bowel without a transition point, thought to be from enteritis or ileus.

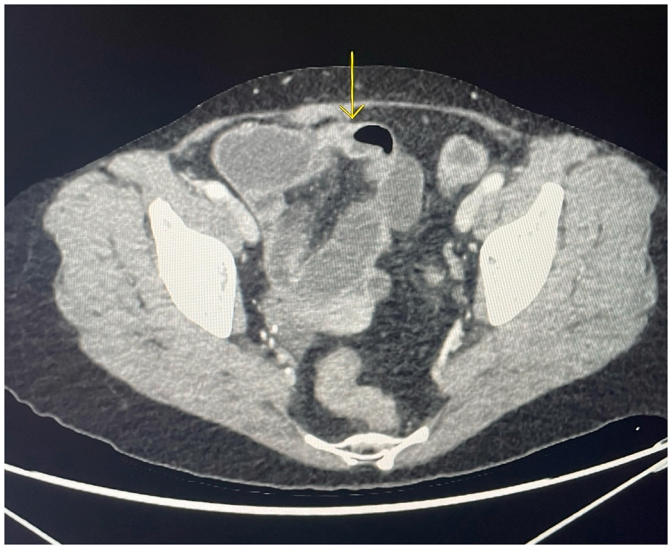

Fig. 2. Example of a Grade 2 SBO with the series of images showing dilated small bowel with a possible transition point, indicated by the yellow arrow.

Data collection

A data analyst with our institution searched patient charts during these three years for a diagnosis of SBO on CT scan. Patient charts were reviewed, and data inputted into a REDCap database that was designed for this study with the assistance of Intermountain Health researchers. Once all charts were reviewed, the data in REDCap were exported into an Excel spreadsheet for analysis. For all patients who had surgery, operative reports were read by a general surgeon who then determined the intraoperative findings and the operation performed.

Statistical analysis

Statistical significance regarding the likelihood of going for surgery

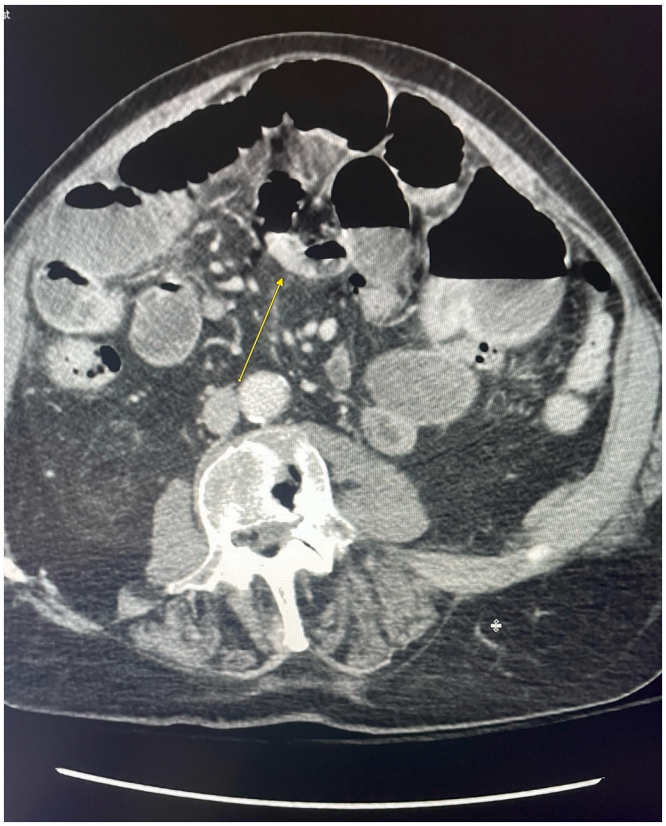

Fig. 3. Example of a Grade 3 SBO with the series of images showing more significantly dilated small bowel with a well-defined transition point, marked by the yellow arrow.

based on assigned grade for suspected SBO was analyzed using the chi-squared test in Python. Significance for variables with a mean was calculated with ANOVA for three or more variables, and a two sample *t*-test for two variables.

Results

A total of 972 charts were identified as being patients who presented to the ER with suspected SBO and had a CT scan. Female patients constituted 52.3 % of subjects, with an average age of 59.8 years, while male patients made up 47.7 % of subjects with an average age of 56.9 years. Of the 972 charts, 655 received a SBO obstruction score from a radiologist, while 317 CT scans were not graded (see Discussion). There was excellent correlation between the SBO grade assigned by the radiologist and the probability of the patient going for surgery, ranging from 4.5 % for Grade 1 patients to 71.4 % for Grade 4 patients, yielding a p value of <0.00001 (Table 2). The most common intraoperative finding was SBO from adhesions alone (48 % of all cases), followed by hernias (Table 3). Only 6 % of patients had a nontherapeutic operation. Two of these cases were Grade 2, five were in Grade 3, and one case was Grade 4.

The only Grade 1 patient had an operation 60 h after presentation to the ER. Mean time to surgery for Grade 2 was 63 h (SD = 51 h, range 5–224 h). For Grade 3 mean time to surgery was 43 h (SD = 48 h, range 4–244 h) and for Grade 4 it was 8 h (SD = 5 h, range 2–19 h) (Table 4). 100 % of Grade 4 patients went to the OR in under 24 h, with 60 % of those in <6 h. Surgeries for patients with a Grade 2 or 3 obstruction were spread over a much larger time frame (Figs. 5 and 6).

Regarding the classification system detecting bowel ischemia in patients taken for surgery: Of the 25 operative patients classified as Grade 4 (SBO with concerns for ischemia), 15 were found to have bowel ischemia at time of surgery, while 10 did not. Of the remaining 108 operative patients, 4 were found to have unsuspected ischemia, all of which were Grade 3 patients. This gives a sensitivity of 79 %, specificity of 91 %, positive predictive value of 60 %, and a negative predictive

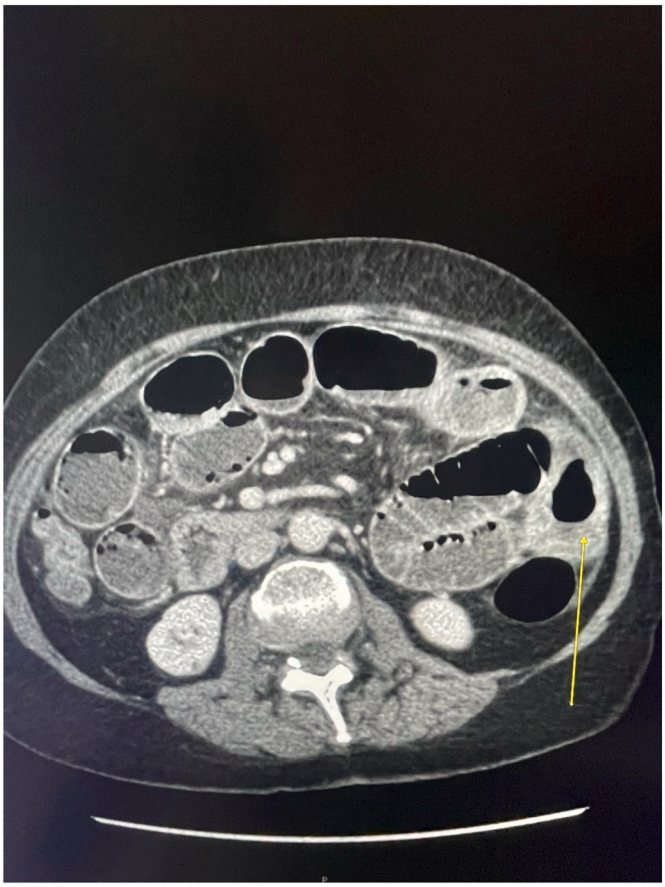

Fig. 4. Example of a Grade 4 SBO with an area of small bowel with suspected ischemia, indicated by the yellow arrow.

Table 2
Patients going for surgery as a function of SBO grade.

Grade	n	Had surgery	Percent
1	22	1	4.5 %
2	299	23	7.7 %
3	299	84	28.1 %
4	35	25	71.4 %
Total	655	133	20.3 %

Table 3
Intraoperative findings.

Diagnosis	n	Percent of total
Adhesions only, single or multiple	62	48
Hernias, all types	15	12
Ischemic bowel	12	9
Dilated bowel only (negative lap)	8	6
Volvulus	7	5
Bezoar	6	5
Closed loop obstruction	5	4
Stricture	4	3
Diverticulitis	3	2
Intussusception	3	2
Neoplasm	3	2
Endometriosis	1	1
Large bowel obstruction	1	1

Table 4
Time from ER presentation to surgery.

Grade	n	Mean time to surgery (hours)	Range	Standard Deviation
1	1	60	n/a	n/a
2	23	63	5–224	51
3	84	43	4–244	48
4	25	8	2–19	5

Table 5
Findings of ischemia in operative patients.

For all operative patients	Had ischemia	Did not have ischemia
Ischemia predicted (Grade 4 patients)	15	10
Ischemia not predicted (Grades 1–3)	4	104

Sensitivity = 79 %.
Specificity = 91 %.
Positive Predictive Value = 60 %.
Negative predictive value = 96 %.

value of 96 % (Table 5). Of note, the diagnosis of ischemia was a clinical perception by the operating surgeon, based on the appearance of the bowel and included both partial/transient ischemia which improved after intervention, and complete ischemia resulting in bowel resection.

Values for white blood cell count (WBC) and serum lactate were also reviewed (Tables 6, 7 and 8). There was no statistical difference in WBC between grades, although there was a slightly higher WBC in patients going for surgery versus observed patients ($p = 0.0385$). Serum lactate was higher in Grade 4 patients compared to all other grades ($p < 0.0001$) as well as in surgical versus observed patients ($p < 0.0001$).

Results showed that the grade of SBO correlated strongly with the likelihood of surgery. Statistical analysis using chi-squared in Python returned a p value of <0.00001.

Statistical analysis using ANOVA showed no difference in mean time to surgery between grade 2 and grade 3 patients ($p = 0.159$) but did show a difference between grade 2 and grade 4 patients ($p = 0.0001$) and well as between grade 3 and grade 4 patients ($p = 0.001$).

Statistical analysis using ANOVA showed no significant differences between grades ($p = 0.09$).

Statistical analysis using ANOVA showed a significant difference between Grade 4 patients compared to all other Grades ($p < 0.0001$), but not between Grades 1 through 3 compared to each other.

Statistical analysis using a two sample *t*-test showed a slightly higher WBC in patients taken for surgery versus observed patients ($p = 0.0385$). When calculating significance for lactate value, the surgical group had a significantly higher lactate than the observation group (2.6 vs. 1.8, $p < 0.0001$).

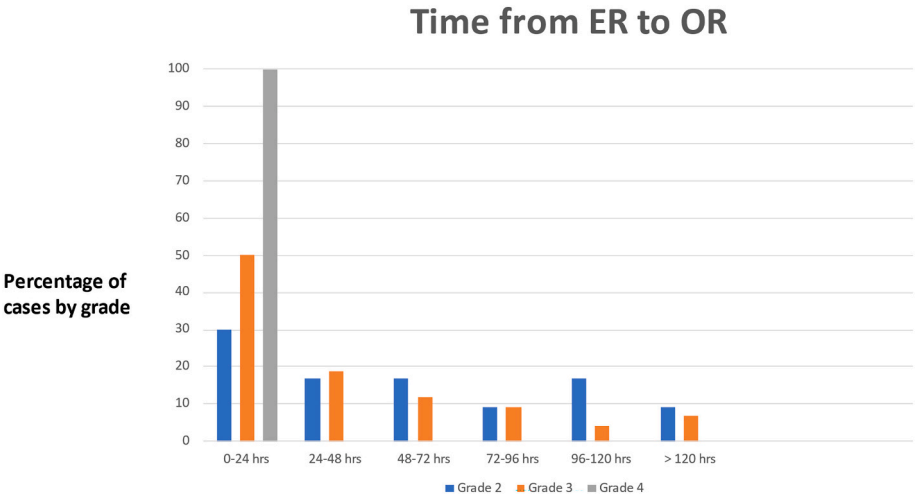

Fig. 5. Time from ER presentation to surgery by SBO grade.

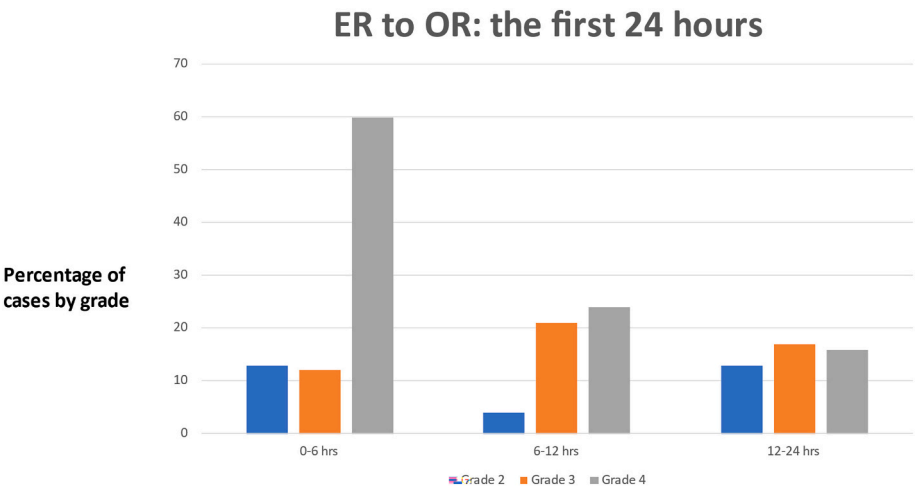

Fig. 6. Percentage of patients in each grade taken for surgery in the first 24 h.

Table 6
WBC of patients by SBO grade.

Grade	n	Mean WBC (K/mcL)	Standard Deviation
1	22	11.1	4.1
2	299	11.3	5.0
3	299	12.4	6.2
4	35	11.9	5.0

Table 7
Initial plasma lactic acid of patients by SBO grade.
Note: Not every patient had a plasma lactic acid level drawn.

Grade	n	Mean lactate value (mmol/L)	Standard Deviation
1	13	1.4	0.5
2	165	2.1	1.0
3	182	2.2	1.3
4	31	4.4	3.2

Discussion

Bowel obstruction is a major problem in the US healthcare system. In various studies and papers, the percentage of patients presenting with bowel obstruction who require surgery varies from 15 % to 75 %, with most papers quoting an operative rate of about 20 % to 30 %. Over 300,000 operations for bowel obstruction are performed annually with up to 30,000 deaths related to this disease (1–11). Due to the complexities of healthcare financing in America, exact costs are difficult to determine but a 2018 financial analysis estimated the annual cost of treating SBO was around $3.8 billion (12,13). A 2023 study showed the average cost of laparoscopic cases across the US was $16,000 +/− $14,800 while for robotic cases the number was $18,300 +/− $13,900 (14). One recent study (2019) showed SBO patients treated surgically have a cost-to-treat that is 7.2 times greater than patients treated non-surgically (15).

Given the high costs and potential morbidities associated with surgery, an accurate method to determine which SBO patients need surgery and which can be safely observed would be of great benefit, as this would result in less expense and improved outcomes for both the individual patient and the healthcare system. Not surprisingly, numerous studies have attempted to either develop a multivariate prediction model (2,16–18) or look at specific findings on CT images which would predict the need for surgery (19–22). Results have been mixed.

Specific to CT findings only, several studies (20–22) found correlation between CT findings and operative findings but these studies did not use a grading scale and were not used to preoperatively predict the need for surgical intervention.

Several authors have attempted to develop a multivariate model to predict the need for surgery in SBO. One paper (17) concluded that four criteria (vomiting, absence of small bowel feces sign, free intraperitoneal fluid and mesenteric edema) were associated in univariate analysis with the need for surgery. When combined into a multivariate analysis, the same four factors had a sensitivity of 96 % and a positive predictive value of 90 % for identifying patients who required operative intervention. The same lead author published another paper a year later (18) that found equivalent predictive ability with only three criteria: mesenteric edema, lack of small bowel feces sign, and a history of obstipation.

Table 8
Select lab values for surgical patients vs. observational patients.

Status	n	Mean WBC (K/mcL)	Mean lactate value (mmol/L)
Had surgery	133	12.1, SD = 7.9	2.6, SD = 2.1
No surgery	522	11.0, SD = 4.7	1.8, SD = 1.1

Table 9
American Association for the Surgery of Trauma (AAST): Grading Criteria for Intestinal Obstruction Due to Adhesions.

AAST grade	Description	CT findings
I	Partial SBO	Normal imaging or minimal intestinal distension
II	Complete SBO; bowel viable and not compromised	Intestinal distension with transition point; delayed contrast flow with some distal contrast; no evidence of bowel compromise
III	Complete SBO with compromised but viable bowel	Intestinal distension with transition point and no distal contrast flow; evidence of complete obstruction or impending bowel compromise
IV	Complete SBO with non-viable bowel or perforation with localized spillage	Evidence of localized perforation or free air; bowel distension with free air or free fluid
V	SB perforation with diffuse peritoneal contamination	Bowel perforation with free air and free fluid

A 2022 review paper of different prognostic score indexes, including the two in the preceding paragraph, concluded that prediction score index models for SBO had the potential to improve patient outcomes and reduce resource consumption (2). However, another review paper published a few years previously (16) which looked at randomized controlled studies, meta-analysis and other related evidence-based studies concluded that predicting conservative versus operative management of bowel obstruction remained imprecise and difficult. Thus no single scoring system has yet emerged and been widely adopted to predict the need for surgery in SBO.

Other grading scales

The American Association for the Surgery of Trauma (AAST) has a five-level score for grading the severity of intestinal obstruction due to adhesions, based on CT findings, available for review on their web site (28) (See Table 9). The AAST grading system is different than the one presented in this study in that there are five grades compared to four grades in the study system, plus the AAST does not have a grade for 'SBO unlikely'.

Several papers on SBO and the AAST grading system have been published (13,23–25). These papers looked at how clinical outcomes, such as 30-day mortality, correlated positively with the AAST grade. None of these studies used the AAST grading system to predict the need for surgery when the patient is first assessed. The grading system in this study was developed specifically to aid surgeons proactively with the decision of whether or not to operate.

In one retrospective chart review paper from 2007 (26), a radiologist developed a scoring system to predict the need for surgery in small bowel obstruction based on 7 radiologic findings: dilated small bowel, transition point, ascites, complete obstruction, partial obstruction, closed loop and free air. Of 96 patients diagnosed with SBO, just over half were taken to the operating room. The radiologist, who reviewed imaging after surgery, was blinded to clinical results. In the study, the scoring system predicted the need for surgery 75 % of the time. No further statistical analysis was provided.

A surprising finding of our study was the number of radiologists who regularly did not use the grading scale when interpreting images, despite previously agreeing to do so. Out of 972 charts included in the study, only 655 (67 %) had an SBO grade assigned by the interpreting radiologist. Rather than assigning a grade from 1 to 4, the rest of the dictations include phrases such as, 'may indicate small bowel obstruction'; or 'suggestive of a high-grade bowel obstruction.' Informal interviews with a half-dozen radiologists revealed a variety of responses. One radiologist who used the system all the time was unaware and surprised that his

colleagues were not doing the same, as use of the grading scale is supposedly a standard practice of their radiology group. One radiologist said that the grading scale did not come up automatically as part of a dictation template, and so was often forgotten. Another radiologist said he just didn't feel comfortable "being put into a box." Another radiologist echoed this feeling, saying for him the presence of a small bowel obstruction was simply a 'yes or no' thing and shouldn't have probabilities assigned.

Another interesting finding in the study was the fate of the patients who were graded as level 4 but did not have any surgery. Level 4 on the SBO grading scale indicates a complete SBO with possible complications, such as ischemia or a closed loop obstruction. In our study, a total of 10 patients (out of 35 grade 4 patients) were identified as having level 4 SBO findings on CT but were not taken for surgery. Review of these charts showed that all patients had a history of multiple abdominal surgeries and were generally well known to the admitting surgeon. Two of the 10 patients had surgery within the prior week and were re-admitted after discharge due to pain with nausea and vomiting. Eight of the 10 had abdominal exams that described the abdomen as soft and non-distended with no or minimal pain to palpation; one of the two exceptions was a Crohn's patient experiencing a flare-up who subsequently responded to medical therapy while the other had metastatic cancer. Six of the 10 had gastrografin small bowel studies shortly after admission, with all of these showing passage of contrast into the colon within 8 h. None of these 10 patients had surgery and nine were discharged after nonoperative management: average length of stay was 5 days. The only patient not discharged home was a patient who presented with severe abdominal pain and a concerning physical exam. This 48-year-old male had carcinomatosis and limited life expectancy and chose to be placed in hospice care rather than have another operation. He died two days after admission.

Of the 25 Grade 4 patients who were taken to surgery for concerns for obstruction plus ischemic bowel, 7 were found to have frankly ischemic gut and underwent bowel resection. 8 patients were found to have partial ischemia that 'pinked up' during the surgery and did not have a bowel resection. 10 patients had no small bowel ischemia at time of surgery. By comparison, 4 out of 84 (5 %) Grade 3 patients who went for surgery had findings of ischemic bowel which were not appreciated preoperatively on the CT scan. No Grade 2 or Grade 1operative patients had ischemic bowel.

Limits of study

This study used only a single observer to interpret the CT findings. The same images viewed by more than one radiologist may have had a different SBO grade assigned (27).

Although the SBO grade scale predicted who would be taken to surgery, it did not predict who would benefit from surgery. There is a possibility that some patients with adhesions only may have improved without surgical intervention, although it is of course impossible to rewind and determine this on an individual patient basis. Noted again is that only 8 out of 133 patients had no significant findings at time of surgery other than dilated bowel.

Another limitation of the study is that it did not account for the role of a gastrografin small bowel study. Some patients had the decision to go for surgery based on a combination of the initial CT scan, which was graded in this study, plus the results of a subsequent gastrografin challenge which was usually initiated within hours of admission. Non-passage of oral contrast into the colon is generally considered to be an indication of a complete or non-improving partial SBO and frequently influences the decision to proceed to the operating room. It is possible that the combination of the two studies may have a stronger predictive value of whom will be taken for surgery compared to either study in isolation.

Conclusions

The large number of patients who had CT findings concerning for small bowel obstruction but never had surgery, regardless of the SBO level assigned by the radiologist, reinforces several teachings about small bowel obstruction. First, the diagnosis is often not clear. CT findings of SBO are mimicked by those of enteritis and ileus. Clinical correlation of the patient's imaging with their presentation and physical exam is absolutely essential. Second, not all patients with SBO will require surgical intervention, again regardless of the SBO grade.

Finally, the decision of whether or not to take a patient with suspected SBO to the operating can be challenging. Our study shows that the chances of taking a patient to surgery increases with increasing severity of the SBO scale assigned by the radiologist upon reviewing the patient's CT scan. However, it is only one factor among many that influence the decision. For example, this study also showed a higher WBC count and lactate level in operative versus observed patients. Informal interviews with the six general surgeons at one of the hospitals involved in the study showed that all six found the grading scale to be of some utility when evaluating a patient with potential SBO but was not the only criteria when making the decision to operate.

This study is the first to look at utilization of a grading scale for CT diagnosis of SBO to prospectively predict the need for surgical intervention. The results show excellent correlation between grade and going for surgery, and that the grading scale can be a useful tool to assist surgeons in deciding whether or not a patient with suspected SBO should have an operation. However, it should be used as one factor among many when a surgeon evaluates an SBO patient for potential surgery.

The authors would like to acknowledge the assistance of Intermountain Health with this study.

Funding sources

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Ethics approval

This research Project was approved by the Intermountain Health Institutional Review Board, which includes ethical considerations in the review process.

CRediT authorship contribution statement

Marianne Becnel: Formal analysis, Data curation. **Ikaikaolahui Danner:** Data curation. **Maria De Los Santos:** Data curation. **Lindsay J. Escobedo:** Data curation. **Marie Mohrbacher:** Data curation. **Jacob Young:** Data curation. **Robert Patterson:** Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization.

Declaration of competing interest

All of the authors declare that they have no conflict of interest and no potential for personal gain with respect to this research project.

References

[1] ten Broek RP, Issa Y, van Santbrink EJ, et al. Burden of adhesions in abdominal and pelvic surgery: systematic review and met-analysis. BMJ 2013;347:f5588.
[2] Coco D, Leanza S, Fiume I. Small bowel obstruction: a prognostic score index for surgery – a review. PrzGastroenterol 2022;17(3):177–82.
[3] Musiienko AM, Shakerian R, Gorelik A, et al. Impact of introduction of an acute surgical unit on management and outcomes of small bowel obstruction. ANZ J Surg 2016;86:831–5.
[4] Di Saverio S, Coccolini F, Galati M, et al. Bologna guidelines for diagnosis and management of adhesive small bowel obstruction (ASBO): 2103 update of the evidence-based guidelines from the world society of emergency medicine ASBO working group. World J Emerg Surg 2013;8:42.

[5] Gore RM, Silvers RI, Thakrar KH, et al. Bowel obstruction. Radiologic Clinics 2015; 53:1225–40.
[6] Behman R, Nathens A, Mason S, et al. Association of surgical intervention for adhesive small-bowel obstruction with the risk of recurrence. JAMA Surg 2019;154 (5):413–20.
[7] Williams S, Greenspon J, Young H, et al. Small bowel obstruction: conservative vs. surgical management. Dis Colon Rectum 2005;48(6):1140–6.
[8] Kulayat M, Doerr R. Small bowel obstruction. *Surgical Treatment: Evidence-based and Problem Oriented*. Holzheimer R, Mannick J, editors. Munich:Zuckschwerdt; 2001.
[9] Edwards M, Kupper C, Croft C, et al. Adhesive closed-loop small bowel obstruction. Clin Pract Cases Emerg Med 2018 Feb;2(1):31–4.
[10] Schick M, Kashyap S, Meseeha M. Small bowel obstruction. https://www.ncbi.nlm.gov/books/NBK448079/; 2023.
[11] Maung A, Johnson D, Piper G, 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):S362–9.
[12] Healthcare cost and utilization project. https://hcupnet.ahrq.gov/; 2018.
[13] McFadden N, Brown S, Howard S, et al. Validity of the American Association for the Surgery of Trauma intestinal obstruction grading system. Surg Pract Science 2022;9:100086.
[14] Ng A, Sanaiha Y, Bakhtiyar S, et al. National analysis of cost disparities in robotic-assisted versus laparoscopic abdominal operations. Surgery 2023;173:1340–5.
[15] Hernandez M, Finnesgard E, Shariq O, et al. Disease severity and cost in adhesive small bowel obstruction. World J Surg 2019;43(12):3027–34.
[16] Pujahari A. Decision making in bowel obstruction: a review. J Clin Diagn Res 2016; 10(11):PE07-PE12.
[17] Zielinski M, Eiken P, Bannon M, et al. Small bowel obstruction – who needs an operation? A multivariate prediction model. World J Surg 2010;34(5):910–9.
[18] Zielinski M, Eiken P, Heller S, et al. Prospective, observational validation of a multivariate small-bowel obstruction model to predict the need for operative intervention. J Am Coll Surg 2011;212(6):1068–76.
[19] Pricolo V, Curley F. CT scan findings do not predict outcome of nonoperative management in small bowel obstruction: retrospective analysis of 108 consecutive patients. Int J Surg 2016;27:88–91.
[20] Barnett R, Younga J, Harris B, et al. Accuracy of computed tomography in small bowel obstruction. Am Surg 2013;79(6):641–3.
[21] Pongpornsup S, Tarachat K, Srisajjakul S. Accuracy of 64 sliced multi-detector computed tomography in diagnosis of small bowel obstruction. J Med Assoc Thai 2009;92(12):1651–61.
[22] Deshmukh S, Shin D, Willmann J, et al. Non-emergency small bowel obstruction: assessment of CT findings that predict for surgery. Eur Radiol 2011;21(5):982–6.
[23] Hernandez M, Birindelli A, Bruce J, et al. Application of the AAST EGS grade for adhesive small bowel obstruction to a multi-national population. World J Surg 2018;42:3581–8.
[24] Hernandez M, Haddad N, Cullinane D, et al. The American Association for the Surgery of Trauma severity grade is valid and generalizable in adhesive small bowel obstruction. J Trauma Acute Care Surg 2018 Feb;84(2):372–8.
[25] Baghdadi Y, Morris D, Choudry A, et al. Validation of the anatomic severity score developed by the American Association for the Surgery of Trauma in small bowel obstruction. J Surg Res 2016;204(2):428–34.
[26] Jones K, Mangram A, Lebron R, et al. Can a computed tomography scoring system predict the need for surgery in small bowel obstruction? Am J Surg 2007;194(6): 780–4.
[27] Kato K, Mizunuma K, Sugiyama M, et al. Interobserver agreement on the diagnosis of bowel ischemia: assessment using dynamic computed tomography of small bowel obstruction. Jpn J Radiol 2010;28(10):727–32.
[28] https://www.aast.org/resources-detail/egs, accessed 01/04/2024.