

Guidelines for Management of Small Bowel Obstruction

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STATEMENT OF THE PROBLEM

The description of patients presenting with small bowel obstruction (SBO) dates back to the third or fourth century, when early surgeons created enterocutaneous fistulas to relieve a bowel obstruction. Despite this success with operative therapy, the nonoperative management of these patients with attempted reduction of hernias, laxatives, ingestion of heavy metals (e.g., lead or mercury), and leeches to remove toxic agents from the blood was the rule until the late 1800s, when antisepsis and aseptic surgical techniques made operative intervention safer and more acceptable. A better understanding of the pathophysiology of bowel obstruction and the use of isotonic fluid resuscitation, intestinal tube decompression, and antibiotics have greatly reduced the mortality rate for patients with mechanical bowel obstruction.^{1,2} However, the means for determining when a period of observation is warranted versus early surgical intervention continues to be an area of debate. With the advances in imaging techniques, additional information can be supplied to the clinical information obtained from the history and physical. The question of whether these technological advancements have allowed a more sophisticated evaluation of these patients is yet to be determined. In addition which tests supply the most information has yet to be clearly described.

Additionally, the optimal length of observation continues to be debated. In the era of a push toward shorter hospital stays correctly identifying patients who are to fail observation is even more important. It is important to analyze whether clinical or radiographic clues can increase our sensitivity in determining such patients.

Finally, as minimally invasive surgery grows and finds new applications are there reproducible benefits to the patients in pursuing these intervention as both a diagnostic and therapeutic intervention.

PROCESS

A computerized search of the National Library of Medicine MEDLINE database was undertaken using the PubMed Entrez interface. English language citations during the period of 1991 through 2006 using the primary search strategy:

Intestinal obstruction[mh] AND intestine, small[mh] AND humans[mh] NOT (case reports[pt] OR letter[pt] OR comment[pt] OR news[pt]).

Review articles were also excluded. The PubMed Related Articles algorithm was also employed to identify additional articles similar to the items retrieved by the primary strategy. Of approximately, 550 articles identified by these two techniques, those dealing with either prospective or retrospective studies examining SBO were selected, comprising 131 institutional studies evaluating diagnosis and management of adult patients with suspected or proven SBO. The articles were reviewed by a group of 11 trauma/critical care surgeons who collaborated to produce this practice management guideline (Table 1, Appendix).

The correlation between the evidence and the level of recommendations is as follows.

Level I. This recommendation is convincingly justifiable based on the available scientific information alone. It is usually based on Class I data; however, strong Class II evidence may form the basis for a Level I recommendation, especially if the issue does not lend itself to testing in a randomized format. Conversely, weak or contradictory Class I data may not be able to support a Level I recommendation.

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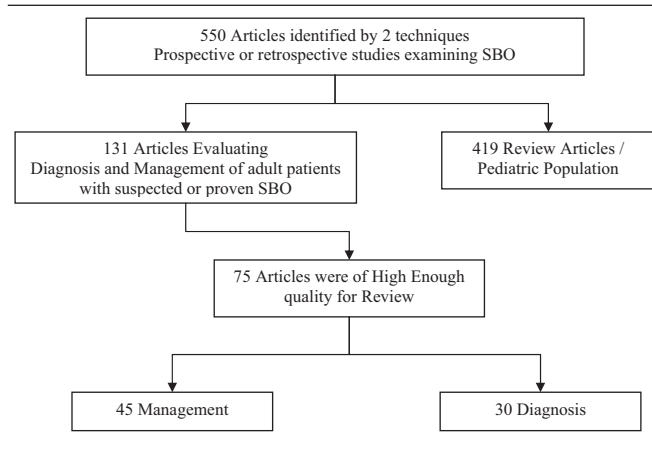
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Table 1 Methodology of Article Selection



Level II. This recommendation is reasonably justifiable by available scientific evidence and strongly supported by expert critical care opinion. It is usually supported by Class II data or a preponderance of Class III evidence.

Level III. This recommendation is supported by available data but adequate scientific evidence is lacking. It is generally supported by Class III data. This type of recommendation is useful for educational purposes and in guiding future studies.³

RECOMMENDATIONS

Diagnosis

1. All patients being evaluated for SBO should have plain films because of the fact that plain films are as sensitive as computed tomography (CT) to differentiate obstruction versus nonobstruction (Level III) (Fig. 1).

Appendix Practice Management Guidelines for Management of Small Bowel Obstruction in the Setting of Previous Abdominal Surgery

Reference	Class	Conclusions
Diagnosis—plain film/KUB Lappas ¹⁴	III	(N = 81; retrospective) Plain films help differentiate low grade from high grade but CT gives incremental and needed if plain film was inconclusive.
Maglinte ⁵	III	Plain films and CT have equal sensitivity for grade of obstruction. They recommend plain films initially on all suspected SBO with CT as a follow-up if needed for clinical purposes.
Diagnosis—CT Bogusevicius ³¹	I	Computer program that differentiates between complete and PSBO when 36 clinical variables, including the plain radiographic findings, are entered, but the time to diagnosis was only 1 h with the computer program and 16 h with contrast radiography.
Zalcman ¹²	II	(N = 144; retrospective) They specifically looked for reduced wall enhancement, wall thickening, mesenteric fluid mesenteric venous congestion, and ascites in order to determine presence of ischemia. Strangulation was prospectively diagnosed if reduced wall enhancement or 2 of the other 4 signs were present.
Lazarus ⁶⁸	II	(N = 34; retrospective) The feces sign helped identify the point of obstruction and was more likely in higher degrees of obstruction.
Obuz ¹¹		(N = 41; prospective) Helical CT (1998–2001) was 83% accurate in differentiating obstruction vs. nonobstruction, 85% accurate in determining cause, and 100% accurate in determining strangulation/ischemia.
Suri ⁷	II	(N = 32; prospective) Suspected SBO with plain radiographs, ultrasound, and CT scan (1990–1993). Plain radiography was 75% accurate, ultrasound was 84% accurate, and CT was 94% accurate at determining obstruction vs. no obstruction. Level of obstruction 60%, 70%, and 93%. Cause of obstruction 7%, 23%, and 87%.
Taourel ⁹	II	(N = 57; Prospective) Patients with suspicion of SBO (1991–1994). The surgeon was interviewed prior to the CT scan. In 33 pts the clinician wanted to differentiate between SBO or ileus and in 24 pts the clinician wanted to know the cause of SBO. CT correctly changed the differentiation between SBO and ileus in 21% of cases. CT changed the diagnosis (cause) of SBO in 43% and correctly changed presence or absence of strangulation in 23.
Catalano ⁶⁹	III	(N = 94; retrospective) Feces sign was only present in 7% of cases, only 1 of which had strangulation.
Chou ⁷⁰	III	(N = 146; retrospective) Evaluated four criteria: continuity of proximal SB, transition zone, intraluminal fluid, and colonic contents. The probability of true obstruction was calculated for each sign. Continuity 69%, transition zone abrupt 80%, high amount of SB fluid 79%, minimal colonic contents 90%.
Daneshmand ⁹	III	Retrospective study of 103 pts (1997–1998) with suspected SBO. Comparison of plain radiographs with CT in determining partial vs complete SBO and in determining cause. Plain films were 75% sensitive and 53% specific for partial vs. complete. CT was 92% sensitive and 71% specific. Cause was correctly determined or inferred to be adhesions by CT in 91% of cases.

Appendix Practice Management Guidelines for Management of Small Bowel Obstruction in the Setting of Previous Abdominal Surgery (continued)

Reference	Class	Conclusions
Gollub ⁷¹	III	Retrospective analysis of 1200+ CT scans of pts with suspected SBO at a cancer center. Whirl sign was found in 33 pts by a senior radiologist and 14 pts by a senior radiology resident. The whirl sign had a sensitivity of 64% for volvulus by the senior radiologist and much less by the resident. They concluded that the whirl sign is a relatively poor predictor of volvulus in this population.
Ha ¹³	III	(N = 84; retrospective) Patients with known outcomes, simple vs. strangulated SBO (1991–1996). They identified six CT findings as best at determining strangulation: reduced wall enhancement, serrated beak, ascites, and unusual course of mesenteric vasculature, mesenteric haziness, and mesenteric venous engorgement. Using these signs they were able to find 85% of strangulations.
Jaffe ⁷²	III	Retrospective analysis of added value of coronal reformations (2003–2004) in 100 pts with suspected SBO. Coronal images added confidence to the three reader's diagnostic accuracy of obstruction vs. no obstruction.
Kim ³²	III	Retrospective study of 146 CTs looking for strangulation vs no strangulation (1992–1998). Three radiologists were 72% to 82% accurate in determining strangulation. The four clinical criteria, fever, tenderness, tachycardia, leukocytosis, without CT findings were equally accurate, however.
Makita ¹⁰	III	Retrospective analysis of CT findings differentiating necrosis from nonnecrosis in 25 pts with proven strangulation. Findings predictive of necrosis were: ascites, vascular dilatation, mesenteric attenuation, and radial distribution, but mesenteric attenuation was most predictive.
Diagnosis—MRI Beall ²⁹	II	Prospective comparison of helical CT (oral/IV contrast) with ultrafast HASTE MRI in 44 pts with suspected SBO (1997–1998). Findings: CT (71%, sensitivity; 71% specificity) MR (95% sensitivity; 100% specificity) in differentiating obstruction vs. no obstruction. No mention of differentiating high-grade vs. low-grade obstruction. Limitations of MRI include lack of availability after hours, poor definition of cause of obstruction, and poor visualization of colonic obstructions.
Kim ²⁸	III	Prospective comparison of helical CT (oral/IV contrast) with HASTE MRI in 34 pts with a variety of SB diseases (1996–1999). 15 pts had suspected SBO. MRI and CT were both 100% accurate in diagnosing or excluding SBO. MRI was better at determining the precise cause of obstruction (73% vs. 60%). MRI poor at looking at omentum.
Lee ⁷³	III	MR with HASTE sequence can distinguish between normal small bowel and abnormal small bowel. Motion did not affect these studies.
Regan ³⁰	III	HASTE MR can be highly accurate in diagnosing SBO and identifying the level of obstruction 26/29 patients with SBO were said to have been correctly identified by HASTE MR (sensitivity 90%, specificity 86%) and 73% had the correct level of obstruction identified. Limitations identified include: absence of dilation in situations where prolonged NG suction has been employed, MRI is not good at identifying masses including malignancies, did not show inflammation as good as CT, and does not show viability.
Diagnosis—ultrasound Schmutz ²⁷	II	Ultrasound was performed on 123 patients who were evaluated for small bowel obstruction. Of these patients 14 had too much gas on initial evaluation and the study was not concluded. Overall accuracy was 81%. Determination of location of obstruction was 80% accurate in the true positives. Determination of cause of obstruction was 63% accurate in the true positives. The studies were performed by an experienced radiologist. Ultrasound was better in identifying the cause of obstruction than plain films.
Czechowski ²⁴	III	Retrospective review of 96 pts (1992–1993) who had acute abdomen and conventional radiography was not diagnostic. The study compares plain radiography vs. ultrasound in patients with suspected small bowel obstruction. The authors claim that ultrasound added information such as the location of the obstruction and whether strangulation was present (absence of peristalsis, extraluminal fluid).
Grassi ²⁵	III	Retrospective review of 184 patients (2002) in whom SBO was eventually confirmed. These pts all had both plain films and US. Purpose of the study was to determine if intraperitoneal fluid was helpful in differentiating high-grade vs. low-grade obstruction. The authors report that ultrasound was 100% accurate in finding free fluid but in 34 pts (20%), the free fluid was explained by medical causes. When these pts were excluded from analysis, surgery confirmed free fluid and either thin walled small bowel or impending necrosis in all pts.
Ko ²⁶	III	Retrospective review of 54 pts with known or suspected BO (1987–1992). Pts had already had plain films except for 2 pregnant pts. SBO was correctly diagnosed in 89%. Level of obstruction was correctly predicted in 76%. Cause of obstruction 20%. Ultrasound is better than plain film but does not show strangulation well.
Diagnosis—enteroclysis Boudiaf ¹⁷	II	CT enteroclysis is well tolerated reliable imaging allows detection of extraluminal disease. Should be routine for patients with low-grade obstruction in a nonacute setting.

Appendix Practice Management Guidelines for Management of Small Bowel Obstruction in the Setting of Previous Abdominal Surgery (continued)

Reference	Class	Conclusions
Umschaden ⁷⁴	II	MR enteroclysis was performed on 18 patients with inflammatory disease and 12 patients with SBO. Findings between conventional and MR enteroclysis had a high concordance rate.
Barloon ⁷⁵	III	Enterocolysis accurately shows closed loop obstruction in 25 of 27 patients.
Maglinte ¹⁵	III	Retrospective study of 27 patients who were found to have closed loop obstruction on conventional enteroclysis performed 2–8 after admission for SBO. Of these patients, 25 were taken to the operating room and found to have a nonstrangulated closed loop obstruction.
Diagnosis—contrast studies		
Anderson ⁷⁶	I	Prospective randomized study comparing early barium upper gastrointestinal vs. plain radiography in patients admitted for SBO. The results did not show any difference in time to surgery, complications or length of stay between groups. But barium study correctly differentiated between operative and nonoperative SBO.
Blackmon ⁷⁷	III	(418 patients; retrospective) The study looks at the use of gastrograffin transit time to help in the diagnosis of patients admitted for with a diagnosis of SBO. Patients are given gastrograffin and undergo serial abdominal films. If the contrast does not reach the colon in 6 h, the study is said to be positive. One of the problems with this study is that close to 50% (65) of patients with a positive study did not require surgery. Two deaths resulted from gastrograffin aspiration.
Brochwicz-Lewinski ⁷⁸	I	Prospective randomized study of patients with suspected SBO who were divided into 2 groups based on if they had an upper gastrointestinal with small bowel follow-through (SBFT) or not. The group with the SBFT had a lower incidence of operation but this difference did not achieve statistical difference. The length of stay was not affected by the SBFT. The patients were randomized and the surgeons changed their clinical management plan based on the results.
Makanjuola ⁷⁹	III	49 pts had both CT and small bowel enema (SBE). 43 of 49 pts had definite intestinal obstruction (42 per surgery). SBE was more sensitive in detecting bowel obstruction than CT (100% vs. 83%). The 7 missed by CT had short segment stenosis. In clinically suspicious cases of obstruction where CT is negative, use SBE.
Sandikcioglu ¹⁶	I	Nonionic low osmolar weight contrast is an alternative to barium for contrast studies to evaluate for SBO.
Chung ⁸⁰	II	Safe procedure, early surgery should occur if patients have significant obstruction (contrast does not reach cecum in 4 h) and a 4 h cutoff for contrast reaching the cecum is predictive of outcome for SBO in those with history of surgery.
Joyce ⁸¹	II	Water-soluble contrast study is safe and easy to use and diagnostic study of choice for suspected SBO. Normal contrast study can rule out operative SBO.
Peck ⁸²	III	With equivocal findings of SBO, first CT and then SBFT should be used. The combined sensitivity and specificity are 95% and 86% respectively, higher than those of each alone.
Enochsson ⁸³	III	The outcome of oral contrast studies can be predicted by plain radiographs. Contrast studies are safe and may be therapeutic.
Dixon ⁸⁴	III	Routine use of SBE in evaluation of patients with suspected small bowel pathology demonstrates a very high sensitivity (93.1%) and specificity (96.9%) and obstruction had a sensitivity of 98%.
Conservative management—general considerations		
Conservative management—clinical indicators/time period		
Miller ³⁹	III	Patients are never free of risk for postop obstruction 2nd to adhesions (14% present >20 yr postop). Rate of recurrence was 33% overall [32% for operation, 34% (NS) for cons. mgmt], each recurrence raised risk of future recurrence. Colorectal procedures were more likely to result in matted adhesions vs. single bands and result in more readmits. Recurrence rates b/wk op and non op were similar.
Nauta ³⁶	III	Paper validates that complete SBO warrants no additional imaging other than plain films. 71% of PSBO by plain film without peritonitis resolved with conservative management. In patients with complete SBO, there was a very high rate of bowel resection (31%). This suggests that a complete SBO is a surgical disease.
Seror ⁸⁵	III	73% response to conservative tx in all SBO (complete and partial). No difference in white blood cell count, fever, or pulse in those who required surgery. No worse outcome in those watched over 5 d BUT no one who had not gotten better by 5 d got better w/o surgery. Weak support of conclusions.
Williams ⁴⁰	III	Incidence of recurrent SBO is higher in conservatively managed pts than in operatively managed pts (40.5% vs. 26.8%). Time to recurrence in conservative managed patients was shorter (153 vs. 411 d).
Miller ⁸⁶	III	Defined early postop bowel obstruction as within 50 d because had big group who presented b/wk 35–50 d. Most frequent procedure was a small bowel operation for SBO. 23% required operation. 3.3% strangulation. Suggests nonoperative management of postop obstruction.
Shih ⁸⁷	III	Article suggests if you wait too long, you will have complications.
Fevang ³³	II	Significant difference in strangulation between early and late operation; suggests surgeons can choose which patients need immediate surgery based on clinical evaluation. Operate for continuous pain, fever, tachycardia, peritonitis, leukocytosis, met acidosis.

Appendix Practice Management Guidelines for Management of Small Bowel Obstruction in the Setting of Previous Abdominal Surgery (continued)

Reference	Class	Conclusions
Ryan ⁸⁸	III	The 3-yr rate for SBO following a colorectal procedure is 3.6%. 48% required operation on first admission for SBO, only one for strangulation.
Conservative management—adjuncts		
Assalia ⁴⁴	I	100 mL of GG sped return of bowel function (time to first stool) from 23.4 h to 6.2 h. GG decreased LOS from 4.4 d to 2.2 d. Trend to improvement in conservative mgmt but not statistically significant (21% control vs. 10% GG $p = 0.52$). No GG complications.
Biondo ⁸⁹	I	All patients who passed Gastrografin to the colon w/in 24 h tolerated early feeding and did not require operation. They operated on every patient who did not pass GG to the colon in 24 h with no further trial of rx—CANNOT say that failure to pass GG predicts nonoperative failure (they didn't try) but they claim that every patient who failed had a closed loop at surgery (not strangulation).
Burge ⁴⁵	I	100 mL of GG reduced time to resolution of SBO from 21 h to 12 h. LOS decreased by 1 d. GG did not change the number of people who failed nonoperative mgmt.
Chen ⁹⁰	I	Patients treated with MgOxide, Lactobacillus, and Simethicone for PSBO (by GG study) had a higher incidence of nonoperative mgmt (77 V 90% $p < 0.01$). This combination of meds may reduce need for operation in PSBO.
Choi ⁴⁶	I	They randomized GG vs. surgery after 48 h of cons mgmt and showed that most of the GG patients did not require surgery.
Fevang ⁴⁸	I	In this nonblinded study GG mixed with barium had no effect on resolution of SBO, need for operation, rate of strangulation. Resolution was not different from the literature (PSBO 76%; Complete 41%).
Yagci ⁴⁹	II	Time to first stool shorter in Urografin (UG) group. UG group had better nonoperative mgmt rate (89.4 to 75.4% $p < 0.05$). UG group had shorter LOS (2.73 d vs. 6.1 d).
Gowen ⁹¹	III	In patients w/o signs of strangulation, a nasally placed long tube (using endoscopy to pass into the jejunum) had a 90% resolution rate for SBO.
Roadley ⁹²	III	Finding GG in the colon 4 h postadministration reliably predicts successful nonoperative mgmt.
Conservative management—antibiotics		
Sagar ⁹²	II	Bacteria were found in mesenteric lymph nodes at a much greater frequency in obstructed vs. nonobstructive patients (39.9% vs. 7.3% $p, 0.001$). Postoperative septic complications were more likely in pts that had + mes. Lymph nodes (36.1% vs. 11.1% $p < 0.05$).
Conservative management—nutrition		
Operative intervention—general considerations		
Fevang ³⁷	III	Study suggesting lower risk of recurrence if treated surgically. However, risk of needing surgery if future episode is the same. The highest risk is after 5 yr, but can occur even decades later. Multiple matted adhesions have more recurrence than single bands (at least those rx'd surgically).
Landercasper ³⁸	III	Rate of recurrence is higher with nonop mgmt (38% vs. 21% $p < 0.001$). Complete SBO v. Partial—no difference in recurrence either op or nonop. Op vs. nonop no difference in mortality.
Early operative—clinical indications/subgroups		
Tortella ⁹³	II	(N = 341; prospective) Patients who had a laparotomy for penetrating trauma. The hypothesis is that they would have a higher incidence of post-operative SBO, defined as SBO in 6 mo post-exploration. The incidence was higher, 7.4% as compared to a reported 0.69% for postoperative SBO.
Meagher ⁹⁴	III	(N = 330; retrospective) Patients with appendectomy/tubo-ovarian procedures are more likely to require operative intervention (95% vs. 53).
Potts ⁹⁵	III	(N = 117) Patients with fever and leukocytosis that are in their 80s most likely have Acute cholecystitis and viscous perforation.
Velasco ⁹⁶	III	(N = 5) Postlaparoscopic SBOs will need surgical resolution and will not resolve spontaneously as up to 73% will do after laparotomy.
Huang ⁹⁷	III	(N = 19) Volvulus although rare in adults can occur, and will always need surgical therapy.
Takeuchi ³⁴	III	(N = 280; retrospective) Purpose was to identify aspects of clinical or laboratory exam that would identify patients with gangrenous bowel. Only 92 (24%) of the 280 patients required surgery and 37 of these had strangulation or intestinal gangrene (13) with small bowel resection. Only factors that were significant for gangrenous small bowel were SIRS (12/13) vs. (1/24), elevated or low WBC, and base deficit or acidosis.
Tsumura ³⁵	III	(N = 95) SIRS and abdominal guarding are predictive of strangulation in SBO.
Ellis ⁹⁸	III	(N = 118) Patients with surgical correction of SBO after history of colon surgery. Patients often get SBO from reoccurrence and it carries higher morbidity and mortality.
Matter ⁹⁹	III	(N = 248) Purpose to look for what types of operations would lead to future SBO. The previous surgeries were divided into 4 groups: upper abdominal, small bowel resection, appendectomy/gynecology, and colon resection. The procedure that led to most SBO/yr was appendectomy - 3.1. SBO occurred earliest after resection of small bowel and then colon, with in the first year. Complete obstruction was highest after small bowel resection, 20/26, though only three required surgery.

Appendix Practice Management Guidelines for Management of Small Bowel Obstruction in the Setting of Previous Abdominal Surgery (continued)

Reference	Class	Conclusions
Montz ¹⁰⁰	III	(N = 98) Retrospective review patients who had radical hysterectomy for nonadnexal gynecologic cancer. Radiation greatly increases incidence of SBO.
Early operative—radiographic indications		
Chen ¹⁰¹	II	(N = 121) US demonstrating increase in bowel wall thickness >3 mm are indicator for surgery. Divided into 2 groups: Group 1—initial SB wall thickness >3 mm, group 2—SB wall <3 mm. 9 (18.4%) of group 1 patients needed surgery and only 4 (5.6%) of group 2.
Chen ¹⁰²	II	Urografin in the colon at 8 h predicts successful nonoperative treatment. Oral gastrograffin is a good diagnostic tool for prediction of the success of nonoperative management of SBO.
Perea Garcia ¹⁰³	II	Conclusion is that earlier use of contrast can lead to earlier decision as to need of surgery or progression of nonoperative management of SBO.
Early operative—time period		
Sosa ¹⁰⁴	III	(N = 97) Retrospective analysis of 115 admissions for 97 patients with SBO. Three groups: early operation (<24 h) N = 21, nonoperative management group B1 failed, N = 33, and successful, N = 62. Primary reason for early operation was tenderness or surgeon's choice. Four bowel resections secondary to strangulation in this group. The group with the only two deaths, highest complication rate 36%, and highest strangulation rate was group B1.
Late operative—clinical indications/subgroups		
Ellozy ¹⁰⁵	II	(N = 95) Prospective surveillance of 242 operations performed of 225 patients and monitoring for early post-operative SBO (EPSBO). The majority of the procedure involved the colon, and 45 patients had previous SBO. There were 23 incidents of EPSBO. Twenty resolved by day 6 with just NG suction. The other three had surgery on day 2, day 16 and day 29 with the latter with SB necrosis and resection. There were no factors identified with this small group of patients predictive of EPSBO.
Andersson ¹⁰⁶	III	Interesting study looking at the national registry of all Swedish hospitals and the appendectomies done over the past 30+ years. 245,400 patients underwent appendectomy over that time period and there were 2,659 SBO operations since on the patients. There were 245,400 matched controls with 245 operations for SBO. Cumulated risk of surgery for SBO after appendectomy after 4 wk is 0.41, at 1 yr, 0.63, at 10 yr 0.97, and at 30 yr 1.30. This is lower than previously though. The cumulative risk increases with the operative diagnosis with mesenteric adenitis at 1.42 at 30 yr, perforated appendicitis at 2.76, and other at 3.24. Acute appendicitis carries the lowest risk of appendicitis at 0.75.
Edna ¹⁰⁷	III	(N = 472) Study of 472 patients with operation for colorectal CA followed for 5.5 yr to establish the incidence of SBO. 351 had a curative procedure, the other 121 palliative. 36/351 of the curative developed an SBO that needed surgery, while 5/121 of the palliative procedures developed SBO postoperation. Etiology of SBO cancer in half and these patients' post-op mortality was much higher. >1,000 mL blood loss at initial surgery leads to a higher rate of SBO, as does the greater dissection of a curative procedure.
Fraser ¹⁰⁸	III	(N = 52) Retrospective review of 15 yr of experience to find 52 patients with immediate post-operative SBO. 22 of these patients needed surgical correction. Timing of SBO was about 8 d post-op. timing to beginning of symptoms to surgery was 5 d. Rate of nonoperative treatment was 60%, and these patients had less complications and less LOS.
Siporin ¹⁰⁹	III	(N = 44) Retrospective review of 1475 patients with either AAA repair or Graft replacement of the Aorta for occlusive disease to identify the incidence of SBO in this population. Forty four patients with SBO in the immediate post-operative period (to 30 d) found. 18 required operation, lysis of adhesions and 2 resections.
Butler ¹¹⁰	III	(N = 54; Retrospective) Patients with complete or partial SBO after surgery at some time for cancer. Thirty-seven (69%) of these patients had operative therapy. Sixty-seven percent of the group had chemo/radiation therapy. Fifty percent had known recurrence. Twenty five of 37 with surgery had recurrent cancer as the cause of the CA. Only 11 patients cleared nonoperatively. Forty-nine percent of the operative patients had major complications, and the operative mortality was 16%, in hospital mortality of 22%.
Late operative—radiographic Indications		
Choi ⁴⁷	II	(N = 212) 100 mL of Gastrografin used 48 h post-SBO without improvement delineated those who needed surgery (contrast not in colon at 24 h) and those who did not (contrast in colon at 24 h). The need for OR reduced by 74% with a strangulation rate of 0.8%.
Onoue ¹¹¹	II	(N = 107) 40 mL Gastrografin + 40 mL water provided within 24 h of SBO admission after NGT decompression and IVF. Gastrograffin is useful in identifying and treating SBO nonoperatively, though the incidence of strangulation is not affected.
Late operative—time period		
Cox ⁴³	III	(N = 123) two or more indicators (fever, tachycardia, constant pain, WBC >16) of SB strangulation on admission demonstrates by OR 76% nonviable SB. Without indicators, 69% managed nonop with resolution of SB. Evidence does not support author's statement to abandon nonop at 48 h

Appendix Practice Management Guidelines for Management of Small Bowel Obstruction in the Setting of Previous Abdominal Surgery (continued)

Reference	Class	Conclusions
Operative approach—laparoscopic vs. open		
Borzellino ⁵¹	III	(N = 65) Using laparoscopy, 6.5% intraop complication, 20% conversion rate and 15.4% recurrence. US guide to enter abdomen without any injury on entrance. Relative contraindications such as massive distention, no free quadrant, and suspected strangulation discussed. Author emphasizes success with numbers above.
Chopra ⁵²	III	(N = 75) Using laparoscopy, 4.3% SB resection, 32% conversion rate, and overall lower OR time, infectious complications, postop ileus, and LOS. Author states “viable option.”
Duepre ⁶¹	III	(N = 716) Use of laparoscopy for bowel resection decreases ventral hernia and SBO requiring hospital readmission. SB requiring operative intervention was similar between laparoscopy and open.
Wullstein and Gross ⁵⁵	III	(N = 104) Using laparoscopy, 17.3% perforation, 51.9% conversion, and longer operative times. Post-operative complications, return of bowel function, and LOS less for laparoscopy.
Leon ⁵³	III	(N = 40) Laparoscopy successful 35% assisted 30%, and 35% conversion. . Reasons for conversion included dense adhesions, need for bowel resection, Crohns, 2 cancers and large lymph nodes. Those converted longer LOS.
Levard ⁵⁴	III	(N = 308) Laparoscopy conversion rate 45.4%. Factors that favor laparoscopic success are SBO post appendectomy, with bands as cause, with less then 2 previous surgeries, and shorter time of symptoms. Those not converted had shorter LOS, fewer complications, and earlier bowel function.
Liau and Cheah ⁵⁶	III	(N = 9) Conversion rate of 22%.
Suter ⁵⁹	III	(N = 15) Enteroclysis guided laparoscopy conversion rate of 6.7%.
Suzuki ⁵⁷	III	(N = 40) Laparoscopy conversion rate of 40%. Intraop enterotomies 10%. Late recurrence 2.5%.
Tsumura ⁵⁸	III	(N = 83) 57% initial success rate with duration of surgery (>120 min) and bowel diameter (>4 cm) predictive of conversion. Reoperation rate of 9%. Bowel perforation and need for conversion increased postop complications.
Pekmezci ¹¹²	III	(N = 21) 57% laparoscopy only, 24% assisted, 19% conversion rate. Utilizing laparoscopy (+/-assisted) diminished time for bowel function and LOS.
Strickland ⁶⁰	III	(N = 25) Complete adhesiolysis 72%. Lap assisted 24%. Open 4%. Utilizing laparoscopy (±assisted) diminished time for bowel function and LOS.
Operative approach—adjuncts		
Fazio ⁶⁵	I	(N = 1791) Pt blinded randomized multicenter trial to eval Seprafilm. The overall rate of post-operative SBO showed no difference with or without Seprafilm. However, Seprafilm did have lower (1.8 vs. 3.4%) of SBO requiring reoperation (N = 90).
Kieffer ¹¹³	III	(N = 16) Using internal stenting with Baker jejunal tube, recurrent rate of obstruction was 25%. Nonobstructive intra-abdominal complication rate 18.7%.
Meissner ⁶³	II	(N = 186) With internal splinting, 9% complications, 2% procedural complications, 3% reoperation. No early SBO. Lower late SBO compared to historical outcome data.
Kudo ⁶⁶	III	(N = 51) Early SBO was lower with Seprafilm evident by earlier diet intake and less abdominal complaints. No reoperations were required in either group.
Meissner ⁶⁴	III	(N = 34) Intestinal tube splinting showed nonstatistical fewer early and late SBO.
Mohri ⁶⁷	III	(N = 184) Incidence of early SBO lower with Sepprfilm. No difference in surgical site infection.
Sprouse ¹¹⁴	III	(N = 34) Transgastric thow tube had no long term (>4 yr) with pts who had operative intervention for adhesion SBO. Follow-up recorded via phone calls to patients (25 of 34). Complications all related to gastrostomy (25%).
Rodriguez-Ruesga ¹¹⁵	III	(N = 47) Complex surgical patient with median 4 previous laparotomies. 23.4% recurrent SBO, only 2 required reoperation.
Korenaga ¹¹⁶	III	(N = 48) 22.9% presented with mechanical obstruction and antecolic anastomosis found to be predictive factor. 45% required reoperation.
Poon ¹¹⁷	II	(N = 214) SBO following LAR is 10.3%, the majority benign and not malignant recurrence. Diverting ileostomy increases incidence of early SBO.
Holmdahl ¹¹⁸	III	Survey sent out to surgical department heads in Sweden. 84% (87 units) response rate. >4,700 admissions for adhesion SBO, 47% operative rate. Over 1500 operations/y complicated by previously formed adhesions. Author suggests washing gloves and suturing peritoneum could help but no evidence provided.
SBO in pregnancy		
Meyerson ¹¹⁹	III	Nine cases over 15 yr and 150,386 deliveries. Previous surgery 8 of 9 cases. Operation required in 8 of 9 patients. No maternal deaths. 3 of 9 fetal deaths (22–30 wk).

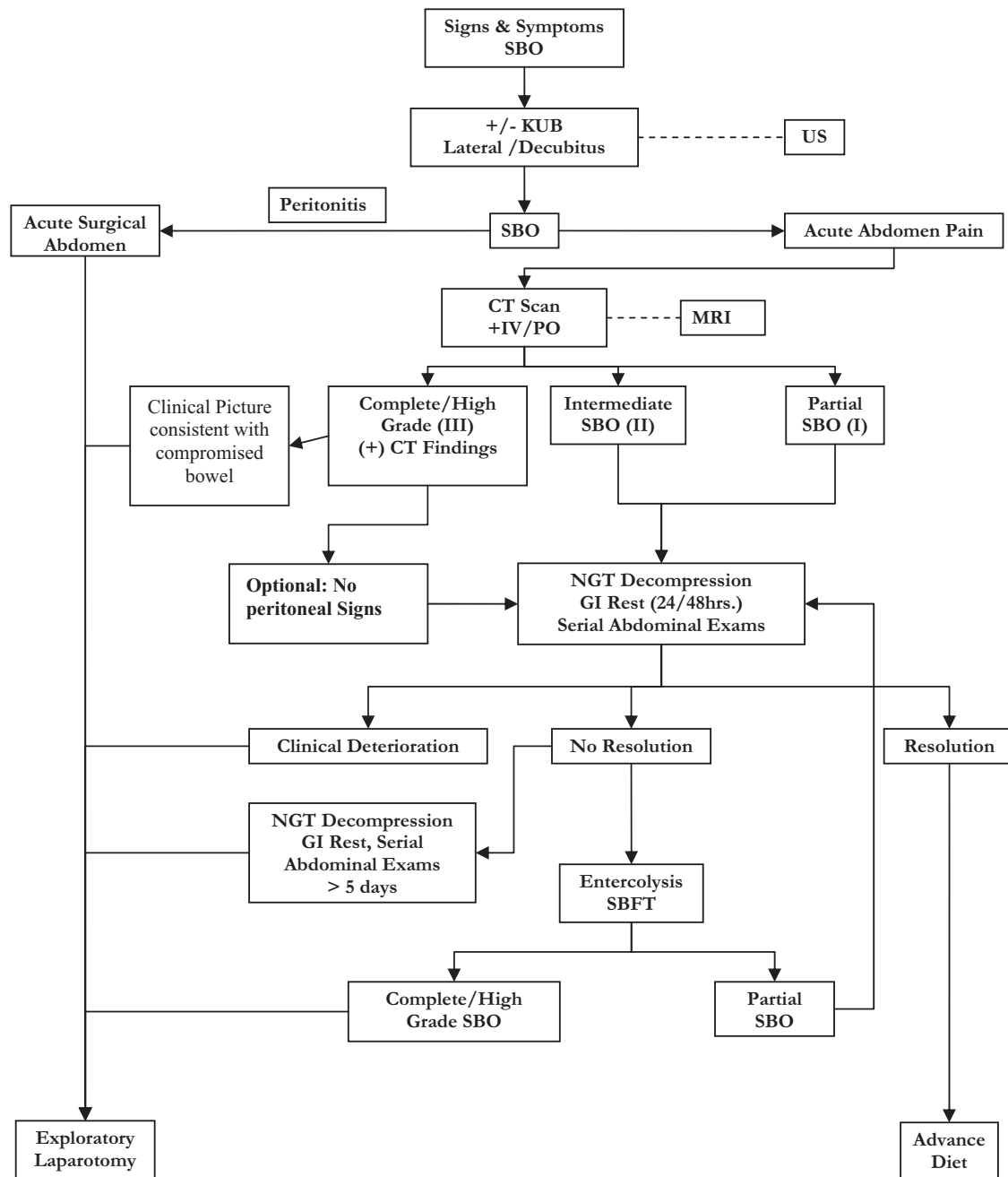


Fig. 1. Clinical flow diagram for SBO.

2. All patients with inconclusive plain films for complete or high grade SBO should have a CT (with intravenous and oral contrast) as CT scan gives incremental information over plain films in regard to differentiating grade of obstruction and etiology of SBO leading to changes in planned management (intravenous contrast can be omitted when a patient has an established contrast allergy) (Level I).
3. Multiple signs on CT suggesting strangulation should suggest a low threshold for operative intervention (Table 2) (Level II).
4. Magnetic resonance imaging (MRI) and ultrasound are an alternative to CT with similar sensitivity and identification of etiology, but have several logistical limitations (Level III).
5. There is a variety of literature that contrast studies should be considered for patients who fail to improve after 48 hours of conservative management as a normal contrast study can rule out operative SBO (Level II).
6. Nonionic low osmolar weight contrast is an alternative to barium for contrast studies to evaluate for SBO for diagnostic purposes (Level I).

Table 2 Radiographic Markers of SBO

	High Grade Bowel Obstruction or Strangulation	Intermediate Signs	Low Grade Bowel Obstruction
KUB	Air-fluid levels of differential height in the same loop		
CT Scan	Air fluid width of 25 mm or more Continuous dilation of proximal small bowel Transition zone Intraluminal fluid Colonic contents	Mesenteric fluid Mesenteric venous congestion Ascites Configuration of obstructed bowel loop (serrated beak) Bowel-wall thickness (<5 mm) Contrast enhancement pattern of the involved bowel wall	
Ultrasound	Reduced wall enhancement Feces sign Mesenteric attenuation Absence of peristalsis Extraluminal fluid (no medical cause) Absent Doppler flow signals >3 mm bowel wall thickening ⁵	Whirl sign ⁴	
MRI Contrast Study	No contrast in the colon at 24 h		Contrast in the colon in 8 h

Additional Recommendations

Multidetector computed tomography (MDCT) enterography, initially designed to study intraluminal disease of the small bowel, can be used in cases of SBO. Coronal reformations views can add confidence to the radiologist interpretation.

Management

1. Patients with plain film finding of SBO and clinical markers (fever, leukocytosis, tachycardia, metabolic acidosis, and continuous pain) or peritonitis on physical examination warrant exploration (Level I).
2. Patients without the above mentioned clinical picture with a partial SBO (PSBO) or a complete SBO can undergo nonoperative management safely. A complete obstruction has a higher level of failure and approximately 30% of these patients will require bowel resection secondary to compromised bowel (Level I).
3. Patients without resolution of their SBO by day 3 to 5 of nonoperative management should undergo water soluble study or surgery (Level III).
4. There is no significant difference with regard to the decompression achieved, the success of nonoperative treatment, or the morbidity rate after surgical intervention comparing long tube decompression with the use of nasogastric tubes (Level I).
5. Water soluble contrast (Gastrograffin) given in the setting of PSBO can improve bowel function (time to BM), decrease length of stay, and is both therapeutic and diagnostic (Level II).
6. In a highly selected group of patients, the laparoscopic treatment of SBO should be considered and leads to a shorter hospital length of stay (Level II).

Scientific Foundation**Historical Background**

Mechanical SBO is the most frequently encountered surgical disorder of the small intestine. Although a wide range of etiologies for this condition exist, intra-abdominal adhesions related to prior abdominal surgery is the etiologic factor in up to 75% of cases of SBO. More than 300,000 patients are estimated to undergo surgery to treat adhesion-induced SBO in the United States annually.⁴

Diagnostic Evaluation of SBO

The diagnostic evaluation should focus on the following goals: distinguishing mechanical obstruction from ileus; determining the etiology of the obstruction; discriminating partial (low grade) from complete (high grade) obstruction; and discriminating simple from strangulating obstruction.

Important elements to obtain on history include prior abdominal operations (suggesting the presence of adhesions) and the presence of abdominal disorders (e.g., intra-abdominal cancer or inflammatory bowel disease) that may provide insights into the etiology of obstruction. Upon examination, a meticulous search for hernias (particularly in the inguinal and femoral regions) should be conducted. The stool should be checked for gross or occult blood, the presence of which is suggestive of intestinal strangulation.

Plain Films. The diagnosis of SBO is usually confirmed with radiographic examination. The abdominal series consists of a radiograph of the abdomen with the patient in a supine position, a radiograph of the abdomen with the patient in an upright position, and a radiograph of the chest with the patient in an upright position. There is class III evidence to suggest that plain films are as sensitive as CT for the detection of a high grade bowel obstruction (86% vs. 82%).⁵ Data also suggests that plain films are less sensitive in the setting

of low grade or partial bowel obstruction. The sensitivity of abdominal radiographs in the detection of SBO ranges from 70% to 86%.^{6,7} Despite these limitations, abdominal radiographs remain an important study in patients with suspected SBO because of their widespread availability and low cost.

CT. There is numerous class II data to suggest that CT provides incremental information over other imaging forms to the level, etiology, and accuracy at differentiating low grade from high-grade bowel obstruction leading to changes in planned management.⁷⁻⁹ CT scanning is 80% to 90% sensitive and 70% to 90% specific in the detection of SBO.⁶ The findings of SBO include a discrete transition zone with dilation of bowel proximally, decompression of bowel distally, intraluminal contrast that does not pass beyond the transition zone, and a colon containing little gas or fluid.

There is class II data to suggest that CT is 85% to 100% sensitive for ischemia and strangulation later confirmed by surgery.^{8,10-12} Ischemia was suggested on CT with serrated beak, unusual course of mesenteric vasculature, mesenteric haziness, reduced wall enhancement, wall thickening, mesenteric fluid, mesenteric venous congestion, and ascites.¹¹⁻¹³ CT scanning also offers a global evaluation of the abdomen and may therefore reveal the etiology of obstruction.^{6,7,14} The global picture afforded is especially relevant when evaluating the acute abdomen when multiple etiologies are on the differential diagnosis.

Enteroclysis. A limitation of CT scanning is its low sensitivity (<50%) in the detection of low-grade or PSBO. A subtle transition zone or unsuspected closed loop obstruction may be difficult to identify in the axial images obtained during CT scanning. In such cases, contrast examinations of the small bowel, either small-bowel series (small-bowel follow-through) or enteroclysis, can be helpful.¹⁵ Nonionic low osmolar weight contrast is an alternative to barium for contrast studies to evaluate for SBO.¹⁶ These examinations are more labor intensive and less-rapidly performed than CT scanning, but may offer greater sensitivity in the detection of luminal and mural etiologies of obstruction, such as primary intestinal tumors, with sensitivity and specificity approaching 100% when coupled with CT.¹⁷ Enteroclysis is rarely performed in the acute setting, but offers greater sensitivity than small-bowel series in the detection of lesions that may be causing PSBO.¹⁷

MDCT Entrography. With the rapidly evolving radiographic imaging technology, the literature has yet to adequately study new imaging techniques. MDCT enterography, initially developed to study diseases of the small bowel, has also been used in the diagnosis of SBO.^{18,19} MDCT differs from routine CT in that it makes use of thin sections and large volumes of enteric contrast material to better display the small bowel lumen and wall. MDCT enterography displays the entire thickness of the bowel wall; it allows examinations of deep ileal loops in the pelvis without superimposition, and permits evaluation of the surrounding mesentery and perien-

teric fat. In clinical practice, CT enterography is replacing enteroclysis.^{20,21}

Coronal reformations as oppose to sagittal views are being used to add confidence to the radiologist interpretation. Although MDCT with 3-dimensional imaging commonly used in vascular reformations are also being used for diseases of the small bowel.^{22,23}

Ultrasound. Class II data suggests ultrasound is comparable with plain film for the diagnosis, etiology, and strangulation in SBO and can better identify free fluid which may signal the need for operative intervention.^{7,24-27}

MRI. Class II data reports the accuracy MRI at least approaches that of CT with both differentiating obstruction versus no obstruction at an almost 100% sensitivity.²⁸ MRI has also been shown to be effective in defining location and etiology of obstruction with at least equivalent accuracy of CT.²⁸⁻³⁰ Limitations of MRI include lack of availability after hours, poor definition of mass lesions, and poor visualization of colonic obstructions did not show inflammation as well as CT, and does not show viability.^{29,30}

Evaluation of the Evidence Supporting Early Operative Management

The standard therapy for SBO is expeditious surgery. The rationale for this approach is to minimize the risk for bowel strangulation, which is associated with an increased risk for morbidity and mortality. The literature would suggest that clinical signs supported by simple imaging studies can identify the vast majority of patients presenting with surgical SBO.^{31,32} Early operative intervention in patients with fever, leukocytosis, peritonitis, tachycardia, metabolic acidosis, and continuous pain will identify strangulation 45% of the time.³³⁻³⁵ Complete SBO should be operated on early as the primary mode of therapy. Studies would suggest that 31% to 43% of patients with complete SBO or peritonitis will resolve without requiring some form of bowel resection.^{33,36}

Other reported benefits of the operative management of SBO is the description by class II data that reports lower reoccurrence rate and longer disease free intervals with operative intervention when compared with conservative management.³⁷⁻⁴⁰

Evaluation of the Evidence Supporting Conservative Management

Exceptions to the recommendation for expeditious surgery for intestinal obstruction include PSBO, obstruction occurring in the early postoperative period, intestinal obstruction as a consequence of Crohn's disease, and carcinomatosis.

Progression to strangulation (3%–6% with conservative management) is unlikely to occur with PSBO, and an attempt at nonoperative resolution is warranted.³³ Level II data suggests that nonoperative management has been documented to be successful in 65% to 81% of patients with PSBO or in patients without peritonitis.¹ Of those successfully treated nonoperatively, only 5% to 15% have been reported to have

symptoms that were not substantially improved within 48 hours after initiation of therapy.^{33,41-43} Therefore, most patients with partial small obstruction whose symptoms do not improve within 48 hours after initiation of nonoperative therapy should undergo surgery. There has been some level III data to suggest that this time period can be safely lengthened to 5 days without increasing the likelihood of strangulation necessitating bowel resection although definite data to support these claims is not available.² Patients undergoing nonoperative therapy should be followed with serial abdominal examinations for signs of peritonitis which would necessitate immediate operative intervention.

Adjuncts to Conservative Management

Hypertonic Contrast in PSBO. The administration of hypertonic water-soluble contrast agents, such as Gastrografin used in upper gastrointestinal and small bowel follow-through examinations, causes a shift of fluid into the intestinal lumen, thereby increasing the pressure gradient across the site of obstruction. Level II data suggests that this effect may speed the return of bowel function (time to bowel movement) and decrease the length of stay of patients undergoing nonoperative management of PSBO.⁴⁴⁻⁴⁹

Operative Approach

Successful laparoscopic surgery for bowel obstruction is being reported with greater frequency. Reported data suggest that up to 60% of SBO cases caused by adhesions may be amenable to laparoscopic therapy.⁵⁰ The reported conversion rate is 20% to 51.9%⁵¹⁻⁵⁸ and the complication rate (bowel injury) is 6.5% to 18.0%.^{51,52} Conversion to open procedure have been reported secondary to density of adhesions, inability to fix the obstruction, cause of obstruction not amenable to laparoscopic therapy, intestinal necrosis, and intestinal perforation. Factors that favor laparoscopic success are SBO postappendectomy, with bands as cause, with less than two previous operations, and shorter time of symptoms.⁵⁴ It has been reported that conversion rate can be decreased to as low as 6.9% when the surgery is guided by preoperative enteroclysis.⁵⁹ The laparoscopic treatment of SBO appears to be effective and leads to a shorter hospital stay in a highly selected group of patients.^{53,60} There has also been literature to support that patients treated with laparoscopic intervention have lower hernia rate and SBO but require the same amount of operative intervention.⁶¹ Patients fitting the criteria for consideration of laparoscopic management include those with (1) mild abdominal distention allowing adequate visualization, (2) a proximal obstruction, (3) a partial obstruction, and (4) an anticipated single-band obstruction. Currently, patients who have advanced, complete, or distal SBOs are not candidates for laparoscopic treatment. Unfortunately, the majority of patients with obstruction are in this group. Similarly, patients with matted adhesions or those who remain distended after nasogastric intubation should be managed with conventional laparotomy. Therefore, the future role of laparoscopic

procedures in the treatment of these patients remains to be defined.

Adjuncts to Surgery

Antibiotics

Broad-spectrum antibiotics are commonly administered because of concerns that bacterial translocation may occur in the setting of SBO; however, there are no controlled data to support or refute this approach.⁶²

Long Tube

Prospective randomized trials demonstrated no significant differences with regard to the decompression achieved, the success of nonoperative treatment, or the morbidity rate after surgical intervention compared with the use of nasogastric tubes. Furthermore, the use of these long tubes has been associated with a significantly longer hospital stay, duration of postoperative ileus, and postoperative complications in some series. Therefore, it appears that long intestinal tubes offer no benefit in the preoperative setting over nasogastric tubes.^{63,64}

Hyaluronic Acid-Carboxycellulose Membrane (Seprafilm)

The overall rate of postoperative SBO showed no difference with or without Seprafilm. However, Seprafilm did have lower (1.8% vs. 3.4%) of SBO requiring reoperation.⁶⁵⁻⁶⁷

SUMMARY

To summarize, plain abdominal radiographs are usually diagnostic of bowel obstruction in more than 60% of the cases, but further evaluation (possibly by CT or barium radiography) may be necessary in 20% to 30% of cases. CT examination is particularly useful in patients with a history of abdominal malignancy, in postsurgical patients, and in patients who have no history of abdominal surgery and present with symptoms of bowel obstruction. Barium studies are recommended in patients with a history of recurring obstruction or low-grade mechanical obstruction to precisely define the obstructed segment and degree of obstruction.

FUTURE INVESTIGATIONS

Future studies should be conducted in a prospective, randomized fashion concentrating on the timing of operative intervention for SBO.

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