Evaluation and management of small-bowel obstruction: An Eastern Association for the Surgery of Trauma practice management guideline

Adrian A. Maung, MD, Dirk C. Johnson, MD, Greta L. Piper, MD, Ronald R. Barbosa, MD, Susan E. Rowell, MD, Faran Bokhari, MD, Jay N. Collins, MD, Joseph R. Gordon, MD, Jin H. Ra, MD, *and* **Andrew J. Kerwin, MD**

BACKGROUND: Small-bowel obstruction (SBO) represents as many as 16% of surgical admissions and more than 300,000 operations annually in the United States. The optimal strategies for the diagnosis and management of SBO continue to evolve secondary to advances in imaging techniques, critical care, and surgical techniques. This updated systematic literature review was developed by the Eastern Association for the Surgery of Trauma to provide up-to-date evidence-based recommendations for SBO.

METHODS: A search of the National Library of Medicine MEDLINE database was performed using PubMed interface for articles published from 2007 to 2011.

RESULTS: The search identified 53 new articles that were then combined with the 131 studies previously reviewed by the 2007 guidelines. The updated guidelines were then presented at the 2012 annual EAST meeting.

CONCLUSION: Level I evidence now exists to recommend the use of computed tomographic scan, especially multidetector computed tomography with multiplanar reconstructions, in the evaluation of patients with SBO because it can provide incremental clinically relevant information over plains films that may lead to changes in management. Patients with evidence of generalized peritonitis, other evidence of clinical deterioration, such as fever, leukocytosis, tachycardia, metabolic acidosis, and continuous pain, or patients with evidence of ischemia on imaging should undergo timely exploration. The remainder of patients can safely undergo initial nonoperative management for both partial and complete SBO. Water-soluble contrast studies should be considered in patients who do not clinically resolve after 48 to 72 hours for both diagnostic and potential therapeutic purposes. Laparoscopic treatment of SBO has been demonstrated to be a viable alternative to laparotomy in selected cases. (*J Trauma Acute Care Surg*. 2012;73: S362–S369. Copyright © 2012 by Lippincott Williams & Wilkins)

KEY WORDS: Small-bowel obstruction; practice management guidelines; laparoscopy; surgery; diagnosis.

STATEMENT OF THE PROBLEM

Although small-bowel obstruction (SBO) has been recognized since the time of Hippocrates, surgical therapy for SBO did not become commonly accepted until the advent of anesthesia, antisepsis, and safer surgical techniques in the late 1800s.[1] At the same time, the increased prevalence of abdominal and pelvic surgery created a new source of SBO—postoperative adhesions. Adhesions are currently the leading cause of SBO in industrialized countries (~70%), followed by malignancy, inflammatory bowel disease, and hernias. SBO accounts for as many as 12% to 16% of surgical admissions and more than 300,000 operations annually in the United States. This represents more than 2.3 billion dollars in health care expenditures.[2–4]

Over the centuries, the management of SBO has evolved. Early treatments included bloodletting and ingestion of heavy metals. Advancements brought intestinal tube decompression and operative interventions. In 2007, the Eastern Association for the Surgery of Trauma (EAST) developed modern guidelines for the management of SBO that were subsequently published in the *Journal of Trauma* in 2008.[1] The guidelines offered 12 evidence-based recommendations for the diagnosis and management of SBO based on a systematic review of the English literature published between 1991 and 2006. However, optimal strategies are in constant flux secondary to advances in imaging techniques, critical care, and surgical techniques. For example, in the 5-year interim period, multiple

Submitted: March 14, 2012, Revised: June 22, 2012, Accepted: July 16, 2012.

From the Department of Surgery (A.A.M., D.C.J., G.L.P.), Section of Trauma, Surgical Critical Care, and Surgical Emergencies, Yale University School of Medicine, New Haven, Connecticut; Trauma Services (R.R.B.), Legacy Emanuel Hospital and Health Center, Portland, Oregon; Department of Surgery (S.E.R.), Oregon Health & Science University, Portland, Oregon; Department of Trauma and Burns (F.B.), Stroger Hospital of Cook County, Chicago, Illinois; Department of Surgery (J.N.C.), Eastern Virginia Medical School, Norfolk, Virginia; Department of Surgery (J.R.G.), Danbury Hospital, Danbury, Connecticut; Department of Surgery (J.R.G.), University of Vermont College of Medicine, Burlington, Vermont; and Department of Surgery (J.H.R., A.J.K.), University of Florida College of Medicine, Jacksonville, Florida.

This work was presented at the 25th Annual Scientific Assembly of the Eastern Association for the Surgery of Trauma, January 10-14-2012, in Lake Buena Vista, Florida.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text, and links to the digital files are provided in the HTML text of this article on the journal's Web site (www.jtrauma.com).

Address for reprints: Adrian Anthony Maung, MD, Department of Surgery, Section of Trauma, Surgical Critical Care, and Surgical Emergencies, Yale University School of Medicine, 330 Cedar Street (BB-310), New Haven, CT 06520; email: adrian.maung@yale.edu.

DOI: 10.1097/TA.0b013e31827019de

studies have further evaluated the role of computed tomographic (CT) scans in the diagnosis and management of SBO, as well as the increasing use and role of laparoscopy in the treatment of SBO. This update to the practice management guidelines was therefore developed, presented, and discussed at the 2012 EAST Annual Meeting.

PROCESS

A computerized search of the National Library of Medicine MEDLINE database was undertaken using the PubMed Entrez interface for English language citations during the period of 2007 through 2011 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])

The primary search identified 259 articles that met our criteria. After the exclusion of review and pediatric and inflammatory bowel disease articles, 53 new articles were identified. These articles detailed both prospective and retrospective studies examining adult patients with suspected or proven SBO. These articles were added to the 131 previous studies reviewed in the 2007 practice management guidelines (Appendix, Supplemental Digital Content 1, http://links.lww.com/TA/A200).[77–91,93–160] A group of 10 acute care surgeons collaborated to produce this practice management guidelines update. Each article was reviewed and graded according to the level of evidence (Table 1) by at least two surgeons. The correlation between the evidence and the level of recommendations as defined by EAST is as follows:

Level 1: 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 1 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 1 recommendation.

Level 2: 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 3: 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.

TABLE 1. Grading of Scientific Evidence Based on the EAST Criteria

Class I	Prospective, randomized, controlled trials
Class II	Clinical studies in which the data were collected prospectively and retrospective analyses that were based on clearly reliable data. Types of studies so classified include observational studies, cohort studies, prevalence studies, and case-control studies.
Class III	Studies based on retrospectively collected data. Evidence used in this class includes clinical series, database or registry review, large series of case reviews, and expert opinion.

RECOMMENDATIONS

Diagnosis

1. CT scan of abdomen and pelvis should be considered in all patients with SBO because it can provide incremental information over plain films in differentiating grade, severity, and etiology of SBOs that may lead to changes in management. Level 1.
2. Water-soluble contrast study should be considered in patients who fail to improve after 48 hours of nonoperative management because a normal contrast study can rule out operative SBO. Level 2.
3. If available, multidetector CT scanner and multiplanar reconstruction should be used because they aid in the diagnosis and localization of SBOs. Level 3.
4. Magnetic resonance imaging (MRI) and ultrasound are potential alternatives to computed tomography but may have several logistical limitations. Level 3.
5. CT scan should be considered to aid in the diagnosis of small-bowel volvulus. Findings include multiple transition points, posterior location, and the "whirl" sign. Level 3.

Management

1. Patients with SBO and generalized peritonitis on physical examination or with other evidence of clinical deterioration such as fever, leukocytosis, tachycardia, metabolic acidosis, and continuous pain should undergo timely surgical exploration. Level 1.
2. Patients without the previously mentioned clinical picture can safely undergo initial nonoperative management for both partial and complete SBO, although complete obstruction has a higher level of failure. Level 1.
3. CT findings consistent with bowel ischemia should suggest a low threshold for operative intervention. Level 2.
4. Laparoscopic treatment of SBO is a viable alternative to laparotomy in selected cases. When successful, it may be associated with decreased morbidity and a shorter length of stay. Level 2.
5. Water-soluble contrast should be considered in the setting of partial SBO that has not resolved in 48 hours because it can improve bowel function (time to bowel movement), decrease length of stay, and is both therapeutic and diagnostic. Level 2.
6. Patients without resolution of the SBO by days 3 to 5 of nonoperative management should undergo water-soluble contrast study or surgery. Level 3.
7. Patients with SBO should generally be admitted to a surgical service because this has been shown to be associated with a shorter length of stay, less hospital charges, and lower mortality compared with admission to a medical service. Level 3.

SCIENTIFIC FOUNDATION

The evaluation of patients with suspected SBO endeavors not only to confirm the diagnosis but also to determine the need for and timing of surgery. The workup should distinguish mechanical obstruction from ileus, determine the cause of the obstruction, and differentiate partial (low-grade)

from complete (high-grade) obstructions. In addition, the patient should be assessed for signs of bowel ischemia.

An appropriate history and physical examination should be performed. Specific historical elements that should be discerned include previous abdominal operations, radiation, and other abdominal disorders (inflammatory bowel disease, neoplasm, etc.) that may cause SBO. The physical examination should include an evaluation for signs of systemic toxicity, a thorough abdominal examination, and an evaluation for potential external hernias. Laboratory studies should be performed to evaluate for the presence of metabolic derangements, acidosis, or leukocytosis. These may suggest that bowel ischemia is present, although the specificity is low.

Plain Radiography

Radiologic evaluation has traditionally started with a three-view abdominal radiograph series (upright chest radiograph, upright and supine abdominal radiographs) to confirm the diagnosis of SBO. Although there is Class III evidence to suggest that plain films and CT scans have similar sensitivity for detection of high-grade obstruction (86 vs. 82%), there is also data to suggest that plain films are less sensitive in the setting of partial bowel obstruction.[5] The overall sensitivity of abdominal radiographs for the detection of SBO ranges from 59% to 93% but is dependent on the radiologist's experience.[5–7] Small-bowel ileus and large-bowel obstruction may also mimic SBO findings in traditional planar radiographs. In addition, plain radiographs are nondiagnostic or nonspecific in many cases.[8] Plain films, however, currently remain part of the initial diagnostic evaluation because of their widespread availability, low cost, and ability to follow disease progression serially.

Computed Tomography

CT scans have been shown in Class II and III studies to be superior to plain film radiography in the overall diagnosis of SBO. They can also provide additional information that alters patient management. CT scans have been shown to be 83% to 94% accurate at diagnosing obstruction.[6,9] Findings consistent with SBO on CT scan include

1. a transition point with dilation of bowel proximally and decompression distally;
2. a decompressed colon; and
3. failure of intraluminal contrast to pass beyond the transition point.

CT scans can determine not only the level of obstruction (93%) but also the cause (80–91%) in most patients.[6,9,10] There are also Class II data to suggest that CT is 85% to 100% sensitive in detection of bowel ischemia.[9–13] CT findings suggestive of ischemia include

1. reduced bowel wall enhancement;
2. wall thickening;
3. mesenteric venous congestion;
4. mesenteric fluid;
5. unusual course of the mesenteric vasculature; and
6. ascites.

CT scans can also be used for the detection of small-bowel volvulus; predictors include multiple transition points, posterior location of transition point, and the presence of the whirl sign.[14] "Whirl sign" refers to a "characteristic swirl of the mesenteric fat and soft tissue attenuations with adjacent loops of small bowel surrounding rotated intestinal vessels."[92] Multidetector helical CT and multiplanar reformats may aid in the diagnosis of SBO by allowing visualization of the loops of bowel in multiple planes.[15,16]

Ultrasound and MRI

Class II and III data have demonstrated that ultrasound findings can diagnose SBO with accuracy comparable to plain films.[6,17–20] In addition, it can detect free fluid that may suggest the presence of ischemia.[21] Although experience with using ultrasound findings for diagnosing SBO is currently not widespread, the technique can be easily learned.[20]

Half-Fourier Acquisition Single-shot Turbo-spin Echo (HASTE) MRI has been shown in Class II and III studies to diagnose SBO with a high reported sensitivity (95%), specificity (100%), and accuracy at determining the level of obstruction (73%).[22–26] However, MRI may not be available at all centers (especially at night), has a longer scan time, and may not be as reliable in identifying the cause of obstruction.

Contrast Studies and Enteroclysis

Contrast examination of the small bowel can be helpful particularly in identifying cases of low-grade or partial SBO that can be difficult to detect on CT scan.[27,28] Fluoroscopic, CT, and MRI enteroclysis techniques have all been used but have not been compared directly with themselves to determine which is superior in SBO patients. Both nonionic low-osmolar-weight contrast and barium can be used.[29] Contrast studies can be used in conjunction with CT for equivocal cases of SBO with an increased combined sensitivity and specificity.[30] Water-soluble contrast studies can accurately predict the need for surgery and reduce the need for operation and shorten hospital stay.[31–34] Although more labor intensive than CT scanning, contrast studies may offer greater sensitivity in the detection of intraluminal or mural etiologies of obstruction.

Initial Management: Operative Versus Nonoperative

Early operative management should be pursued in patients with suspected bowel strangulation because this is associated with an increased morbidity and mortality. Clinical indicators, which include fever, leukocytosis, tachycardia, continuous pain, metabolic acidosis, peritonitis, and the systemic inflammatory response syndrome (SIRS), correctly identify bowel ischemia in approximately 40% to 50% of cases.[35–37] The addition of imaging studies will identify most patients who need early operative intervention (70–96%).[38–40]

The initial management of patients with complete SBO remains controversial. Although complete SBO is associated with a higher requirement for small-bowel resection (31%) in some series,[41] others have demonstrated that nonoperative management is still successful in 41% to 73% of patients with complete obstruction.[42–44]

Operative management of both partial and complete SBO is associated with lower reoccurrence rates and longer disease-free interval when compared with nonoperative management.[45–48]

Patients without clinical or radiologic signs and symptoms of bowel ischemia can safely undergo initial nonoperative management. Progression to bowel ischemia in the setting of partial SBO is unlikely to occur with nonoperative management (3–6%),[35] but patients need to be monitored with serial abdominal examinations and laboratory studies. Nonoperative management is overall successful in 65% to 80% of patients, especially in the setting of partial SBO and early postoperative period SBO.[42,43,49,50] Most patients improve within 2 to 5 days after initiation of therapy.[35,50] Failure to regain bowel function after 5 days suggests the need for an operation.

Hypertonic Contrast in Partial SBO

In patients who do not have resolution of SBO within 48 hours of admission, Class I and II data support performing contrast studies before operative intervention to differentiate complete from partial SBO.[51–53] For patients with a partial SBO, the water-soluble contrast study may itself be therapeutic because it causes a shift of fluid into the intestinal lumen, thus increasing the pressure gradient across the site of obstruction. This may speed the return of bowel function and decrease the overall length of stay.[51,52,54–58]

Operative Approach: Open Versus Laparoscopic

A preponderance of Class III studies has demonstrated that laparoscopic surgery for SBO is a safe and acceptable alternative to open surgery. Although previously reserved only for simple SBO, current literature supports the use of laparoscopy in complex SBO with dilated bowel and multiple previous abdominal operations.[59,60] The appropriate setting not only depends on the patient but also on the surgeon's experience. A meta-analysis of 29 studies and 2005 patients reported a conversion rate of 29% and an enterotomy rate of 7%.[61] Patients with a single-band adhesive obstruction have a higher success rate.[59,62–64] Successful laparoscopic surgery is associated with an earlier recovery of bowel function and a shorter length of stay.[62,65–67]

Adjuncts

Antibiotics

Broad-spectrum antibiotics are sometimes administered because of concerns that bacterial translocation may occur in the setting of SBO; however, there are only limited data to support or refute this practice.[68]

Prevention

Although a number of agents have been studied for the prevention of SBO through a reduction of postoperative adhesions, currently, the most promising technology is bioresorbable membranes. Several products are available on the market, including sodium hyaluronate–based carboxymethylcellulose (Seprafilm). The available data supporting its use are mixed at best. Two prospective trials in patients undergoing intestinal resection or gastrectomy, respectively, showed no significant difference in SBO with the use of Seprafilm, although in the intestinal resection study, the Seprafilm group had a lower rate of SBO that required reoperation.[69,70] Other retrospective trials have reported a decreased incidence of SBO with the use of Seprafilm.[71–74] Placing Seprafilm near an anastomosis should be done with trepidation because it has been associated with higher rates of anastomotic leak.[75]

Admitting Service

There are Class III data to suggest that patients with SBO admitted to a surgical service have shorter length of stay, less hospital charges, shorter time to surgery, and lower mortality than patients admitted to medical service.[76] This may be confounded by a number of factors. Patients who are unable to tolerate or are unwilling to undergo an operation can be considered for admission to a medical service.

SUMMARY

Evaluation and management of SBO continue to evolve with advances in medical technology and techniques. Since the publication of the EAST practice management guideline on SBO in 2008, there has been increased support for the use of CT scans to confirm the diagnosis of SBO and assist in determining the initial clinical management. Minimally invasive surgery is being used with increasing frequency and in more complex cases. In the current era of cost containment and regulatory agencies analysis of outcomes, further studies are needed to better delineate the expected short- and long-term outcomes after both nonoperative and operative management of SBO.

AUTHORSHIP

A.A.M. and D.C.J. performed the literature search. All authors participated in review of the available literature, data analysis and development of the recommendations. A.A.M., D.C.J., and G.L.P. wrote the manuscript. All authors participated in critical revisions.

DISCLOSURE

The authors declare no conflicts of interest.

REFERENCES

1. Diaz JJ, Bokhari F, Mowery NT, et al. Guidelines for management of small bowel obstruction. *J Trauma*. 2008;64:1651–1664.
2. Hwang JY, Lee JK, Lee JE, et al. Value of multidetector CT in decision making regarding surgery in patients with small-bowel obstruction due to adhesion. *Eur Radiol*. 2009;19:2425–2431.
3. Ray NF, Denton WG, Thamer M, et al. Abdominal adhesiolysis: inpatient care and expenditures in the United States in 1994. *J Am Coll Surg*. 1998;186:1–9.
4. Sikirica V, Bapat B, Candrilli SD, et al. The inpatient burden of abdominal and gynecological adhesiolysis in the US. *BMC Surg*. 2011;11:13.
5. Maglinte DD, Reyes BL, Harmon BH, et al. Reliability and role of plain film radiography and CT in the diagnosis of small-bowel obstruction. *AJR Am J Roentgenol*. 1996;167:1451–1455.
6. Suri S, Gupta S, Sudhakar PJ, et al. Comparative evaluation of plain films, ultrasound and CT in the diagnosis of intestinal obstruction. *Acta Radiol*. 1999;40:422–428.
7. Thompson WM, Kilani RK, Smith BB, et al. Accuracy of abdominal radiography in acute small-bowel obstruction: does reviewer experience matter? *AJR Am J Roentgenol*. 2007;188:W233–W238.

8. Maglinte DD, Heitkamp DE, Howard TJ, et al. Current concepts in imaging of small bowel obstruction. *Radiol Clin North Am*. 2003;41: 263–283.
9. Obuz F, Terzi C, Sokmen S, et al. The efficacy of helical CT in the diagnosis of small bowel obstruction. *Eur J Radiol*. 2003;48:299–304.
10. Daneshmand S, Hedley CG, Stain SC. The utility and reliability of computed tomography scan in the diagnosis of small bowel obstruction. *Am Surg*. 1999;65:922–926.
11. Makita O, Ikushima I, Matsumoto N, et al. CT differentiation between necrotic and nonnecrotic small bowel in closed loop and strangulating obstruction. *Abdom Imaging*. 1999;24:120–124.
12. 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;28:727–732.
13. Zalcman M, Sy M, Donckier V, et al. Helical CT signs in the diagnosis of intestinal ischemia in small-bowel obstruction. *AJR Am J Roentgenol*. 2000;175:1601–1607.
14. Sandhu PS, Joe BN, Coakley FV, et al. Bowel transition points: multiplicity and posterior location at CT are associated with small-bowel volvulus. *Radiology.* 2007;245:160–167.
15. Shah ZK, Uppot RN, Wargo JA, et al. Small bowel obstruction: the value of coronal reformatted images from 16-multidetector computed tomography—a clinicoradiological perspective. *J Comput Assist Tomogr.* 2008;32:23–31.
16. Atri M, McGregor C, McInnes M, et al. Multidetector helical CT in the evaluation of acute small bowel obstruction: comparison of nonenhanced (no oral, rectal or IV contrast) and IV enhanced CT. *Eur J Radiol*. 2009; 71:135–140.
17. Schmutz GR, Benko A, Fournier L, et al. Small bowel obstruction: role and contribution of sonography. *Eur Radiol*. 1997;7:1054–1058.
18. Czechowski J. Conventional radiography and ultrasonography in the diagnosis of small bowel obstruction and strangulation. *Acta Radiol*. 1996;37:186–189.
19. Ko YT, Lim JH, Lee DH, et al. Small bowel obstruction: sonographic evaluation. *Radiology.* 1993;188:649–653.
20. Unlüer EE, Yavaşi O, Eroğlu O, et al. Ultrasonography by emergency medicine and radiology residents for the diagnosis of small bowel obstruction. *Eur J Emerg Med*. 2010;17:260–264.
21. Grassi R, Romano S, D'Amario F, et al. The relevance of free fluid between intestinal loops detected by sonography in the clinical assessment of small bowel obstruction in adults. *Eur J Radiol*. 2004;50:5–14.
22. Beall DP, Fortman BJ, Lawler BC, et al. Imaging bowel obstruction: a comparison between fast magnetic resonance imaging and helical computed tomography. *Clin Radiol*. 2002;57:719–724.
23. Kim JH, Ha HK, Sohn MJ, et al. Usefulness of MR imaging for diseases of the small intestine: comparison with CT. *Korean J Radiol*. 2000; 1:43–50.
24. Regan F, Beall DP, Bohlman ME, et al. Fast MR imaging and the detection of small-bowel obstruction. *AJR Am J Roentgenol*. 1998;170: 1465–1469.
25. Lee JK, Marcos HB, Semelka RC. MR imaging of the small bowel using the HASTE sequence. *AJR Am J Roentgenol*. 1998;170:1457–1463.
26. Takahara T, Kwee TC, Haradome H, et al. Peristalsis gap sign at cine magnetic resonance imaging for diagnosing strangulated small bowel obstruction: feasibility study. *Jpn J Radiol*. 2011;29:11–18.
27. Maglinte DD, Nolan DJ, Herlinger H. Preoperative diagnosis by enteroclysis of unsuspected closed loop obstruction in medically managed patients. *J Clin Gastroenterol*. 1991;13:308–312.
28. Dixon PM, Roulston ME, Nolan DJ. The small bowel enema: a ten year review. *Clin Radiol*. 1993;47:46–48.
29. Sandikcioglu TG, Torp-Madsen S, Pedersen IK, et al. Contrast radiography in small bowel obstruction. A randomized trial of barium sulfate and a nonionic low-osmolar contrast medium. *Acta Radiol*. 1994;35: 62–64.
30. Peck JJ, Milleson T, Phelan J. The role of computed tomography with contrast and small bowel follow-through in management of small bowel obstruction. *Am J Surg*. 1999;177:375–378.
31. Branco BC, Barmparas G, Schnüriger B, et al. Systematic review and meta-analysis of the diagnostic and therapeutic role of water-soluble contrast agent in adhesive small bowel obstruction. *Br J Surg*. 2010;97: 470–478.
32. Chung CC, Meng WC, Yu SC, et al. A prospective study on the use of water-soluble contrast follow-through radiology in the management of small bowel obstruction. *Aust N Z J Surg*. 1996;66:598–601.
33. Tresallet C, Lebreton N, Royer B, et al. Improving the management of acute adhesive small bowel obstruction with CT-scan and water-soluble contrast medium: a prospective study. *Dis Colon Rectum*. 2009;52: 1869–1876.
34. Joyce WP, Delaney PV, Gorey TF, et al. The value of water-soluble contrast radiology in the management of acute small bowel obstruction. *Ann R Coll Surg Engl*. 1992;74:422–425.
35. Fevang BT, Jensen D, Svanes K, et al. Early operation or conservative management of patients with small bowel obstruction? *Eur J Surg*. 2002;168:475–481.
36. Takeuchi K, Tsuzuki Y, Ando T, et al. Clinical studies of strangulating small bowel obstruction. *Am Surg*. 2004;70:40–44.
37. Tsumura H, Ichikawa T, Hiyama E, et al. Systemic inflammatory response syndrome (SIRS) as a predictor of strangulated small bowel obstruction. *Hepatogastroenterology.* 2004;51:1393–1396.
38. Zielinski MD, Eiken PW, Heller SF, et al. Prospective, observational validation of a multivariate small-bowel obstruction model to predict the need for operative intervention. *J Am Coll Surg*. 2011;212:1068–1076.
39. Zielinski MD, Eiken PW, Bannon MP, et al. Small bowel obstruction—who needs an operation? A multivariate prediction model. *World J Surg*. 2010;34:910–919.
40. Kim JH, Ha HK, Kim JK, et al. Usefulness of known computed tomography and clinical criteria for diagnosing strangulation in small-bowel obstruction: analysis of true and false interpretation groups in computed tomography. *World J Surg*. 2004;28:63–68.
41. Nauta RJ. Advanced abdominal imaging is not required to exclude strangulation if complete small bowel obstructions undergo prompt laparotomy. *J Am Coll Surg*. 2005;200:904–911.
42. Seror D, Feigin E, Szold A, et al. How conservatively can postoperative small bowel obstruction be treated? *Am J Surg*. 1993;165:121–125.
43. Tanaka S, Yamamoto T, Kubota D, et al. Predictive factors for surgical indication in adhesive small bowel obstruction. *Am J Surg*. 2008;196: 23–27.
44. Fevang BT, Jensen D, Fevang J, et al. Upper gastrointestinal contrast study in the management of small bowel obstruction—a prospective randomised study. *Eur J Surg*. 2000;166:39–43.
45. Fevang BT, Fevang J, Lie SA, et al. Long-term prognosis after operation for adhesive small bowel obstruction. *Ann Surg*. 2004;240:193–201.
46. Landercasper J, Cogbill TH, Merry WH, et al. Long-term outcome after hospitalization for small-bowel obstruction. *Arch Surg*. 1993;128: 765–770.
47. Miller G, Boman J, Shrier I, et al. Natural history of patients with adhesive small bowel obstruction. *Br J Surg*. 2000;87:1240–1247.
48. Williams SB, Greenspon J, Young HA, et al. Small bowel obstruction: conservative vs. surgical management. *Dis Colon Rectum*. 2005;48: 1140–1146.
49. Jeong WK, Lim SB, Choi HS, et al. Conservative management of adhesive small bowel obstructions in patients previously operated on for primary colorectal cancer. *J Gastrointest Surg*. 2008;12:926–932.
50. Cox MR, Gunn IF, Eastman MC, et al. The safety and duration of nonoperative treatment for adhesive small bowel obstruction. *Aust N Z J Surg*. 1993;63:367–371.
51. Choi HK, Law WL, Ho JW, et al. Value of gastrografin in adhesive small bowel obstruction after unsuccessful conservative treatment: a prospective evaluation. *World J Gastroenterol*. 2005;11:3742–3745.
52. Choi HK, Chu KW, Law WL. Therapeutic value of gastrografin in adhesive small bowel obstruction after unsuccessful conservative treatment: a prospective randomized trial. *Ann Surg*. 2002;236:1–6.
53. Onoue S, Katoh T, Shibata Y, et al. The value of contrast radiology for postoperative adhesive small bowel obstruction. *Hepatogastroenterology.* 2002;49:1576–1578.
54. Assalia A, Schein M, Kopelman D, et al. Therapeutic effect of oral Gastrografin in adhesive, partial small-bowel obstruction: a prospective randomized trial. *Surgery.* 1994;115:433–437.

55. Burge J, Abbas SM, Roadley G, et al. Randomized controlled trial of Gastrografin in adhesive small bowel obstruction. *Aust N Z J Surg*. 2005; 75:672–674.
56. Yagci G, Kaymakcioglu N, Can MF, et al. Comparison of Urografin versus standard therapy in postoperative small bowel obstruction. *J Invest Surg*. 2005;18:315–320.
57. Kumar P, Kaman L, Singh G, et al. Therapeutic role of oral water soluble iodinated contrast agent in postoperative small bowel obstruction. *Singapore Med J*. 2009;50:360–364.
58. Di Saverio S, Catena F, Ansaloni L, et al. Water-soluble contrast medium (Gastrografin) value in adhesive small intestine obstruction (ASIO): a prospective, randomized, controlled, clinical trial. *World J Surg*. 2008; 32:2293–2304.
59. Pearl JP, Marks JM, Hardacre JM, et al. Laparoscopic treatment of complex small bowel obstruction: is it safe? *Surg Innov*. 2008;15:110–113.
60. Wang Q, Hu ZQ, Wang WJ, et al. Laparoscopic management of recurrent adhesive small-bowel obstruction: long-term follow-up. *Surg Today*. 2009;39:493–499.
61. O'Connor DB, Winter DC. The role of laparoscopy in the management of acute small-bowel obstruction: a review of over 2,000 cases. *Surg Endosc*. 2012;26:12–17.
62. Lee IK, Kim DH, Gorden DL, et al. Selective laparoscopic management of adhesive small bowel obstruction using CT guidance. *Am Surg*. 2009;75:227–231.
63. Grafen FC, Neuhaus V, Schöb O, et al. Management of acute small bowel obstruction from intestinal adhesions: indications for laparoscopic surgery in a community teaching hospital. *Langenbecks Arch Surg*. 2010; 395:57–63.
64. Ghosheh B, Salameh JR. Laparoscopic approach to acute small bowel obstruction: review of 1,061 cases. *Surg Endosc*. 2007;21:1945–1949.
65. Pekmezci S, Altinli E, Saribeyoglu K, et al. Enteroclysis-guided laparoscopic adhesiolysis in recurrent adhesive small bowel obstructions. *Surg Laparosc Endosc Percutan Tech*. 2002;12:165–170.
66. Strickland P, Lourie DJ, Suddleson EA, et al. Is laparoscopy safe and effective for treatment of acute small-bowel obstruction? *Surg Endosc*. 1999;13:695–698.
67. Zerey M, Sechrist CW, Kercher KW, et al. Laparoscopic management of adhesive small bowel obstruction. *Am Surg*. 2007;73:773–778.
68. Sagar PM, MacFie J, Sedman P, et al. Intestinal obstruction promotes gut translocation of bacteria. *Dis Colon Rectum*. 1995;38:640–644.
69. Fazio VW, Cohen Z, Fleshman JW, et al. Reduction in adhesive small-bowel obstruction by Seprafilm adhesion barrier after intestinal resection. *Dis Colon Rectum*. 2006;49:1–11.
70. Hayashi S, Takayama T, Masuda H, et al. Bioresorbable membrane to reduce postoperative small bowel obstruction in patients with gastric cancer: a randomized clinical trial. *Ann Surg*. 2008;247:766–770.
71. Kawamura H, Yokota R, Yokota K, et al. A sodium hyaluronate carboxymethylcellulose bioresorbable membrane prevents postoperative small-bowel adhesive obstruction after distal gastrectomy. *Surg Today*. 2010; 40:223–227.
72. Tabata T, Kihira T, Shiozaki T, et al. Efficacy of a sodium hyaluronate-carboxycellulose membrane (seprafilm) for reducing the risk of early postoperative small bowel obstruction in patients with gynecologic malignancies. *Int J Gynecol Cancer*. 2010;20:188–193.
73. Mohri Y, Uchida K, Araki T, et al. Hyaluronic acid-carboxycellulose membrane (Seprafilm) reduces early postoperative small bowel obstruction in gastrointestinal surgery. *Am Surg*. 2005;71:861–863.
74. Kudo FA, Nishibe T, Miyazaki K, et al. Use of bioresorbable membrane to prevent postoperative small bowel obstruction in transabdominal aortic aneurysm surgery. *Surg Today*. 2004;34:648–651.
75. Beck DE, Cohen Z, Fleshman JW, et al. A prospective, randomized, multicenter, controlled study of the safety of Seprafilm adhesion barrier in abdominopelvic surgery of the intestine. *Dis Colon Rectum*. 2003;46: 1310–1319.
76. Oyasiji T, Angelo S, Kyriakides TC, et al. Small bowel obstruction: outcome and cost implications of admitting service. *Am Surg*. 2010;76: 687–691.
77. Lappas JC, Reyes BL, Maglinte DD. Abdominal radiography findings in small-bowel obstruction: relevance to triage for additional diagnostic imaging. *AJR Am J Roentgenol*. 2001;176:167–174.
78. Maglinte DD, Reyes BL, Harmon BH, et al. Reliability and role of plain film radiography and CT in the diagnosis of small-bowel obstruction. *AJR Am J Roentgenol*. 1996;167:1451–1455.
79. Bogusevicius A, Maleckas A, Pundzius J, et al. Prospective randomised trial of computer-aided diagnosis and contrast radiography in acute small bowel obstruction. *Eur J Surg*. 2002;168:78–83.
80. Lazarus DE, Slywotsky C, Bennett GL, et al. Frequency and relevance of the "small-bowel feces" sign on CT in patients with small-bowel obstruction. *AJR Am J Roentgenol*. 2004;183:1361–1366.
81. Taourel PG, Fabre JM, Pradel JA, et al. Value of CT in the diagnosis and management of patients with suspected acute small-bowel obstruction. *AJR Am J Roentgenol*. 1995;165:1187–1192.
82. Catalano O. The faeces sign. A CT finding in small-bowel obstruction. *Radiologe*. 1997;37:417–419.
83. Chou CK, Mak CW, Huang MC, et al. Differentiation of obstructive from nonobstructive small bowel dilatation on CT. *Eur J Radiol*. 2000; 35:213–220.
84. Gollub MJ, Yoon S, Smith LM, et al. Does the CT whirl sign really predict small bowel volvulus? Experience in an oncologic population. *J Comput Assist Tomogr*. 2006;30:25–32.
85. Ha HK, Kim JS, Lee MS, et al. Differentiation of simple and strangulated small-bowel obstructions: usefulness of known CT criteria. *Radiology*. 1997;204:507–512.
86. Jaffe TA, Martin LC, Thomas J, et al. Small-bowel obstruction: coronal reformations from isotropic voxels at 16-section multidetector row CT. *Radiology*. 2006;238:135–142.
87. Jancelewicz T, Vu LT, Shawo AE, et al. Predicting strangulated small bowel obstruction: an old problem revisited. *J Gastrointest Surg*. 2009; 13:93–99.
88. Hong SS, Kim AY, Kwon SB, et al. Three-dimensional CT enterography using oral gastrografin in patients with small bowel obstruction: comparison with axial CT images or fluoroscopic findings. *Abdom Imaging*. 2010;35:556–562.
89. Jang KM, Min K, Kim MJ, et al. Diagnostic performance of CT in the detection of intestinal ischemia associated with small-bowel obstruction using maximal attenuation of region of interest. *AJR Am J Roentgenol*. 2010;194:957–963.
90. Hodel J, Zins M, Desmottes L, et al. Location of the transition zone in CT of small-bowel obstruction: added value of multiplanar reformations. *Abdom Imaging*. 2009;34:35–41.
91. Delabrousse E, Lubrano J, Jehl J, et al. Small-bowel obstruction from adhesive bands and matted adhesions: CT differentiation. *AJR Am J Roentgenol*. 2009;192:693–697.
92. Duda JB, Bhatt S, Dogra VS. Utility of CT whirl sign in guiding management of small-bowel obstruction. *AJR Am J Roentgenol* 2008;191: 743–747.
93. Rocha FG, Theman TA, Matros E, et al. Nonoperative management of patients with a diagnosis of high-grade small bowel obstruction by computed tomography. *Arch Surg*. 2009;144:1000–1004.
94. Colon MJ, Telem DA, Wong D, et al. The relevance of transition zones on computed tomography in the management of small bowel obstruction. *Surgery*. 2010;147:373–377.
95. Boudiaf M, Jaff A, Soyer P, et al. Small-bowel diseases: prospective evaluation of multidetector row helical CT enteroclysis in 107 consecutive patients. *Radiology*. 2004;233:338–344.
96. Umschaden HW, Szolar D, Gasser J, et al. Small-bowel disease: comparison of MR enteroclysis images with conventional enteroclysis and surgical findings. *Radiology*. 2000;215:717–725.
97. Barloon TJ, Lu CC, Honda H, et al. Does a normal small-bowel enteroclysis exclude small-bowel disease? A long-term follow-up of consecutive normal studies. *Abdom Imaging*. 1994;19:113–115.
98. Ohmiya N, Arakawa D, Nakamura M, et al. Small-bowel obstruction: diagnostic comparison between double-balloon endoscopy and fluoroscopic enteroclysis, and the outcome of enteroscopic treatment. *Gastrointest Endosc*. 2009;69:84–93.

99. Anderson CA, Humphrey WT. Contrast radiography in small bowel obstruction: a prospective, randomized trial. *Mil Med*. 1997;162:749–752.
100. Blackmon S, Lucius C, Wilson JP, et al. The use of water-soluble contrast in evaluating clinically equivocal small bowel obstruction. *Am Surg*. 2000;66:238–242.
101. Brochwicz-Lewinski MJ, Paterson-Brown S, Murchison JT. Small bowel obstruction—the water-soluble follow-through revisited. *Clin Radiol*. 2003;58:393–397.
102. Makanjuola D. Computed tomography compared with small bowel enema in clinically equivocal intestinal obstruction. *Clin Radiol*. 1998; 53:203–208.
103. Enochsson L, Runold M, Fenyo G. Contrast radiography in small intestinal obstruction, a valuable diagnostic tool? *Eur J Surg*. 2001;167: 120–124.
104. Bogusevicius A, Grinkevicius A, Maleckas A, et al. The role of D-dimer in the diagnosis of strangulated small-bowel obstruction. *Medicina (Kaunas)*. 2007;43:850–854.
105. Miller G, Boman J, Shrier I, et al. Readmission for small-bowel obstruction in the early postoperative period: etiology and outcome. *Can J Surg*. 2002;45:255–258.
106. Shih SC, Jeng KS, Lin SC, et al. Adhesive small bowel obstruction: how long can patients tolerate conservative treatment? *World J Gastroenterol*. 2003;9:603–605.
107. Ryan MD, Wattchow D, Walker M, et al. Adhesional small bowel obstruction after colorectal surgery. *Aust N Z J Surg*. 2004;74:1010–1012.
108. Biondo S, Pares D, Mora L, et al. Randomized clinical study of Gastrografin administration in patients with adhesive small bowel obstruction. *Br J Surg*. 2003;90:542–546.
109. Chen SC, Lee CC, Yen ZS, et al. Specific oral medications decrease the need for surgery in adhesive partial small-bowel obstruction. *Surgery.* 2006;139:312–316.
110. Gowen GF. Long tube decompression is successful in 90% of patients with adhesive small bowel obstruction. *Am J Surg*. 2003;185:512–515.
111. Roadley G, Cranshaw I, Young M, et al. Role of Gastrografin in assigning patients to a nonoperative course in adhesive small bowel obstruction. *Aust N Z J Surg*. 2004;74:830–832.
112. Atahan K, Aladağli I, Cökmez A, et al. Hyperosmolar water-soluble contrast medium in the management of adhesive small-intestine obstruction. *J Int Med Res*. 2010;38:2126–2134.
113. Ji ZL, Li JS, Yuan CW, et al. Therapeutic value of sesame oil in the treatment of adhesive small bowel obstruction. *Am J Surg*. 2010;199: 160–165.
114. Srinivasa S, Kahokehr AA, Sammour T, et al. Use of statins in adhesive small bowel obstruction. *J Surg Res*. 2010;162:17–21.
115. Butt MU, Velmahos GC, Zacharias N, et al. Adhesional small bowel obstruction in the absence of previous operations: management and outcomes. *World J Surg*. 2009;33:2368–2371.
116. Tingstedt B, Isaksson J, Andersson R. Long-term follow-up and cost analysis following surgery for small bowel obstruction caused by intra-abdominal adhesions. *Br J Surg*. 2007;94:743–748.
117. Duron JJ, du Montcel ST, Berger A, et al. Prevalence and risk factors of mortality and morbidity after operation for adhesive postoperative small bowel obstruction. *Am J Surg*. 2008;195:726–734.
118. Tortella BJ, Lavery RF, Chandrakantan A, et al. Incidence and risk factors for early small bowel obstruction after celiotomy for penetrating abdominal trauma. *Am Surg*. 1995;61:956–958.
119. Meagher AP, Moller C, Hoffmann DC. Nonoperative treatment of small bowel obstruction following appendicectomy or operation on the ovary or tube. *Br J Surg*. 1993;80:1310–1311.
120. Potts FEt, Vukov LF. Utility of fever and leukocytosis in acute surgical abdomens in octogenarians and beyond. *J Gerontol A Biol Sci Med Sci*. 1999;54:M55–M58.
121. Velasco JM, Vallina VL, Bonomo SR, et al. Postlaparoscopic small bowel obstruction. Rethinking its management. *Surg Endosc*. 1998;12: 1043–1045.
122. Huang JC, Shin JS, Huang YT, et al. Small bowel volvulus among adults. *J Gastroenterol Hepatol*. 2005;20:1906–1912.
123. Ellis CN, Boggs HW Jr, Slagle GW, et al. Small bowel obstruction after colon resection for benign and malignant diseases. *Dis Colon Rectum*. 1991;34:367–371.
124. Matter I, Khalemsky L, Abrahamson J, et al. Does the index operation influence the course and outcome of adhesive intestinal obstruction? *Eur J Surg*. 1997;163:767–772.
125. Montz FJ, Holschneider CH, Solh S, et al. Small bowel obstruction following radical hysterectomy: risk factors, incidence, and operative findings. *Gynecol Oncol*. 1994;53:114–120.
126. Schwenter F, Poletti PA, Platon A, et al. Clinicoradiological score for predicting the risk of strangulated small bowel obstruction. *Br J Surg*. 2010;97:1119–1125.
127. O'Daly BJ, Ridgway PF, Keenan N, et al. Detected peritoneal fluid in small bowel obstruction is associated with the need for surgical intervention. *Can J Surg*. 2009;52:201–206.
128. Chen SC, Lee CC, Hsu CY, et al. Progressive increase of bowel wall thickness is a reliable indicator for surgery in patients with adhesive small bowel obstruction. *Dis Colon Rectum*. 2005;48:1764–1771.
129. Chen SC, Chang KJ, Lee PH, et al. Oral urografin in postoperative small bowel obstruction. *World J Surg*. 1999;23:1051–1054.
130. Perea Garcia J, Turegano Fuentes T, Quijada Garcia B, et al. Adhesive small bowel obstruction: predictive value of oral contrast administration on the need for surgery. *Rev Esp Enferm Dig*. 2004;96:191–200.
131. Sosa J, Gardner B. Management of patients diagnosed as acute intestinal obstruction secondary to adhesions. *Am Surg*. 1993;59:125–128.
132. Ellozy SH, Harris MT, Bauer JJ, et al. Early postoperative small-bowel obstruction: a prospective evaluation in 242 consecutive abdominal operations. *Dis Colon Rectum*. 2002;45:1214–1217.
133. Andersson RE. Small bowel obstruction after appendicectomy. *Br J Surg*. 2001;88:1387–1391.
134. Edna TH, Bjerkeset T. Small bowel obstruction in patients previously operated on for colorectal cancer. *Eur J Surg*. 1998;164:587–592.
135. Fraser SA, Shrier I, Miller G, et al. Immediate postlaparotomy small bowel obstruction: a 16-year retrospective analysis. *Am Surg*. 2002;68: 780–782.
136. Siporin K, Hiatt JR, Treiman RL. Small bowel obstruction after abdominal aortic surgery. *Am Surg*. 1993;59:846–849.
137. Butler JA, Cameron BL, Morrow M, et al. Small bowel obstruction in patients with a prior history of cancer. *Am J Surg*. 1991;162:624–628.
138. Komatsu I, Tokuda Y, Shimada G, et al. Development of a simple model for predicting need for surgery in patients who initially undergo conservative management for adhesive small bowel obstruction. *Am J Surg*. 2010;200:215–223.
139. Deshmukh SD, Shin DS, Willmann JK, et al. Nonemergency small bowel obstruction: assessment of CT findings that predict need for surgery. *Eur Radiol*. 2011;21:982–986.
140. Borzellino G, Tasselli S, Zerman G, et al. Laparoscopic approach to postoperative adhesive obstruction. *Surg Endosc*. 2004;18:686–690.
141. Chopra R, McVay C, Phillips E, et al. Laparoscopic lysis of adhesions. *Am Surg*. 2003;69:966–968.
142. Duepree HJ, Senagore AJ, Delaney CP, et al. Does means of access affect the incidence of small bowel obstruction and ventral hernia after bowel resection? Laparoscopy versus laparotomy. *J Am Coll Surg*. 2003;197: 177–181.
143. Wullstein C, Gross E. Laparoscopic compared with conventional treatment of acute adhesive small bowel obstruction. *Br J Surg*. 2003;90: 1147–1151.
144. Leon EL, Metzger A, Tsiotos GG, et al. Laparoscopic management of small bowel obstruction: indications and outcome. *J Gastrointest Surg*. 1998;2:132–140.
145. Levard H, Boudet MJ, Msika S, et al. Laparoscopic treatment of acute small bowel obstruction: a multicentre retrospective study. *Aust N Z J Surg*. 2001;71:641–646.
146. Liauw JJ, Cheah WK. Laparoscopic management of acute small bowel obstruction. *Asian J Surg*. 2005;28:185–188.
147. Suter M, Zermatten P, Halkic N, et al. Laparoscopic management of mechanical small bowel obstruction: are there predictors of success or failure? *Surg Endosc*. 2000;14:478–483.

148. Suzuki K, Umehara Y, Kimura T. Elective laparoscopy for small bowel obstruction. *Surg Laparosc Endosc Percutan Tech*. 2003;13:254–256.
149. Tsumura H, Ichikawa T, Murakami Y, et al. Laparoscopic adhesiolysis for recurrent postoperative small bowel obstruction. *Hepatogastroenterology.* 2004;51:1058–1061.
150. Khaikin M, Schneidereit N, Cera S, et al. Laparoscopic vs. open surgery for acute adhesive small-bowel obstruction: patients' outcome and cost-effectiveness. *Surg Endosc*. 2007;21:742–746.
151. Kieffer RW, Neshat AA, Perez LM, et al. Indications for internal stenting in intestinal obstruction. *Mil Med*. 1993;158:478–479.
152. Meissner K. Effectiveness of intestinal tube splinting: a prospective observational study. *Dig Surg*. 2000;17:49–56.
153. Meissner K. Small bowel obstruction following extended right hemicolectomy and subtotal colectomy: assessing the benefit of prophylactic tube splinting. *Dig Surg*. 2001;18:388–392.
154. Sprouse LR, 2nd, Arnold CI, Thow GB, et al. Twelve-year experience with the Thow long intestinal tube: a means of preventing postoperative bowel obstruction. *Am Surg*. 2001;67:357–360.
155. Rodriguez-Ruesga R, Meagher AP, Wolff BG. Twelve-year experience with the long intestinal tube. *World J Surg*. 1995;19:627–630.
156. Korenaga D, Yasuda M, Takesue F, et al. Factors influencing the development of small intestinal obstruction following total gastrectomy for gastric cancer: the impact of reconstructive route in the Roux-en-Y procedure. *Hepatogastroenterology.* 2001;48:1389–1392.
157. Poon JT, Law WL, Chu KW. Small bowel obstruction following low anterior resection: the impact of diversion ileostomy. *Langenbecks Arch Surg*. 2004;389:250–255.
158. Holmdahl L, Risberg B. Adhesions: prevention and complications in general surgery. *Eur J Surg*. 1997;163:169–174.
159. Bristow RE, Santillan A, Diaz-Montes TP, et al. Prevention of adhesion formation after radical hysterectomy using a sodium hyaluronate-carboxymethylcellulose (HA-CMC) barrier: a cost-effectiveness analysis. *Gynecol Oncol*. 2007;104:739–746.
160. Meyerson S, Holtz T, Ehrinpreis M, et al. Small bowel obstruction in pregnancy. *Am J Gastroenterol*. 1995;90:299–302.

