Intestinal obstruction is a common medical problem and accounts for a large percentage of surgical admissions for acute abdominal pain. It develops when air and secretions are prevented from passing aborally as a result of either intrinsic or extrinsic compression (i.e., mechanical obstruction) or gastrointestinal (GI) paralysis (i.e., nonmechanical obstruction in the form of ileus or pseudo-obstruction). Small intestinal ileus is the most common form of intestinal obstruction; it occurs after most abdominal operations and is a common response to acute extra-abdominal medical conditions and intra-abdominal inflammatory conditions [see Table 1]. Acute colonic pseudo-obstruction occurs most frequently in the postoperative period or in response to another acute medical illness. Mechanical small bowel obstruction (SBO) is somewhat less common; such obstruction is secondary to intra-abdominal adhesions, hernias, or cancer in about 90% of cases [see Table 2]. Mechanical colonic obstruction accounts for only 10 to 15% of all cases of mechanical obstruction and most often develops in response to obstructing carcinoma, diverticulitis, or volvulus [see Table 3].

There are several different methods of classifying mechanical obstruction: acute versus chronic, partial versus complete, simple versus closed loop, and gangrenous versus nongangrenous. The importance of these classifications is that the natural history of the condition, its response to treatment, and the associated morbidity and mortality all vary according to which type of obstruction is present.

When chyme and/or gas can traverse the point of obstruction, obstruction is partial; when this is not the case, obstruction is complete. When the bowel is occluded at a single point along the intestinal tract, leading to intestinal dilatation, hypersecretion, and bacterial overgrowth proximal to the obstruction and decompression distal to the obstruction, simple obstruction is present. A closed-loop obstruction occurs when a segment of bowel is obstructed along its course by a single constrictive lesion that occludes both the proximal and the distal end of the intestinal loop and traps the bowel’s mesentery. When the blood supply to a closed-loop segment of bowel becomes compromised, leading to ischemia and eventually to bowel wall necrosis and perforation, strangulation is present. The most common causes of simple obstruction are intra-abdominal adhesions, hernias, and strictures; the most common causes of closed-loop obstruction are hernias, adhesions, and volvulus.

### Table 1 Causes of Ileus

<table>
<thead>
<tr>
<th>Intra-abdominal causes</th>
<th>Causes of Ileus</th>
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</thead>
<tbody>
<tr>
<td>Intraperitoneal problems</td>
<td>Peritonitis or abscess</td>
</tr>
<tr>
<td>Inflammatory condition</td>
<td>Mechanical: operation, foreign body</td>
</tr>
<tr>
<td>Chemical: gastric juice, bile, blood</td>
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<tr>
<td>Autoimmune: serositis, vasculitis</td>
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<tr>
<td>Intestinal ischemia: arterial or venous, sickle cell disease</td>
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<tr>
<td>Retroperitoneal problems</td>
<td>Pancreatitis</td>
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<tr>
<td>Retroperitoneal hematoma</td>
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<tr>
<td>Spine fracture</td>
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<tr>
<td>Aortic operation</td>
<td></td>
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<tr>
<td>Renal colic</td>
<td></td>
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<tr>
<td>Pyelonephritis</td>
<td></td>
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<tr>
<td>Metastasis</td>
<td></td>
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<tr>
<td>Extra-abdominal causes</td>
<td>Thoracic problems</td>
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<tr>
<td>Myocardial infarction</td>
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<tr>
<td>Pneumonia</td>
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<tr>
<td>Congestive heart failure</td>
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<td>Rib fractures</td>
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<tr>
<td>Metabolic abnormalities</td>
<td>Electrolyte imbalance (e.g., hypokalemia)</td>
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<tr>
<td>Sepsis</td>
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<td>Lead poisoning</td>
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<tr>
<td>Porphyria</td>
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<tr>
<td>Hypothyroidism</td>
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<tr>
<td>Hyperparathyroidism</td>
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<td>Uremia</td>
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<tr>
<td>Medicines</td>
<td>Opiates</td>
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<tr>
<td>Anticholinergics</td>
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<td>Alpha agonists</td>
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<td>Antihistamines</td>
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<tr>
<td>Catecholamines</td>
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<tr>
<td>Spinal cord injury or operations</td>
<td></td>
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<tr>
<td>Head, thoracic, or retroperitoneal trauma</td>
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<tr>
<td>Chemotherapy, radiation therapy</td>
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</table>

### Table 2 Causes of Small Bowel Obstruction in Adults

<table>
<thead>
<tr>
<th>Extrinsic causes</th>
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</thead>
<tbody>
<tr>
<td>Adhesions*</td>
</tr>
<tr>
<td>Hernias (external, internal [paraduodenal], incisional)*</td>
</tr>
<tr>
<td>Metastatic cancer*</td>
</tr>
<tr>
<td>Volvulus</td>
</tr>
<tr>
<td>Intra-abdominal abscess</td>
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<tr>
<td>Intra-abdominal hematoma</td>
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<tr>
<td>Pancreatic pseudocyst</td>
</tr>
<tr>
<td>Intra-abdominal drains</td>
</tr>
<tr>
<td>Tight fascial opening at stoma</td>
</tr>
<tr>
<td>Intraduodenal causes</td>
</tr>
<tr>
<td>Tumors*</td>
</tr>
<tr>
<td>Gallstones</td>
</tr>
<tr>
<td>Foreign body</td>
</tr>
<tr>
<td>Worms</td>
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<tr>
<td>Bezoars</td>
</tr>
<tr>
<td>Intramural abnormalities</td>
</tr>
<tr>
<td>Tumors</td>
</tr>
<tr>
<td>Strictures</td>
</tr>
<tr>
<td>Hematoma</td>
</tr>
<tr>
<td>Intussusception [see Figure 4]</td>
</tr>
<tr>
<td>Regional enteritis</td>
</tr>
<tr>
<td>Radiation enteritis</td>
</tr>
</tbody>
</table>

*Approximately 90% of all small bowel obstructions are secondary to adhesions, hernias, or tumors.
One of the most difficult tasks in general surgery is deciding when to operate on a patient with intestinal obstruction; however, new methods for detecting ischemic bowel and determining when obstruction will be amenable to nonoperative therapy are emerging. The purpose of the following discussion is to outline a safe, efficient, and cost-effective stepwise approach to making this difficult decision and optimizing the management of patients with this problem [see Figure 1]. Absolutes are few and far between: treatment must always be highly individualized. Consequently, the following recommendations are intended only as guidelines, not as surgical dicta.

Clinical Evaluation

HISTORY AND CLINICAL SETTING

When a patient complains of acute obstipation, abdominal pain and distention, nausea, and vomiting, the probability that either mechanical bowel obstruction or ileus is present is very high. Mechanical obstruction can often be distinguished from ileus or pseudo-obstruction on the basis of the location, character, and severity of abdominal pain as well as the setting within which the symptoms occur. Pain from mechanical obstruction is usually located in the middle of the abdomen, whereas pain from ileus and pseudo-obstruction is diffuse. Pain from ileus is usually mild, and pain from obstruction is typically more severe. In general, pain increases in severity and depth over time as obstruction progresses; however, in mechanical obstruction, pain severity may decrease over time as a result of bowel fatigue and atony. The periodicity of pain can help localize the level of obstruction: pain from proximal intestinal obstruction has a short periodicity (3 to 4 minutes), and distal small bowel or colonic pain has longer intervals (15 to 20 minutes) between episodes of nausea, cramping, and vomiting.

Abdominal distention, nausea, and vomiting usually develop after pain has already been felt for some time. The patient should be asked what degree of abdominal distention is present and whether there has been a sudden or rapid change. Distention developing over many weeks suggests a chronic process or progressive partial obstruction. Massive abdominal distention coupled with minimal crampy pain, nausea, and vomiting suggests long-standing intermittent mechanical obstruction or some form of chronic intestinal pseudo-obstruction. The combination of a gradual change in bowel habits, progressive abdominal distention, early satiety, mild, crampy pain after meals, and weight loss also suggests chronic partial mechanical bowel obstruction. If the patient has undergone evaluation for similar symptoms before, any previous abdominal radiographs or contrast studies should be reviewed. The patient should be asked when flatus was last passed: failure to pass flatus may signal a transition from partial to complete bowel obstruction. Patients with an intestinal stoma (ileostomy or colostomy) who present with signs and symptoms of obstruction often report abdominal distention and pain after a sudden change in stomal output of stool, liquid, or air.

The patient should also be asked about (1) previous episodes of bowel obstruction, (2) previous abdominal or pelvic operations, (3) a history of malignancy, and (4) a history of intra-abdominal inflammation (e.g., inflammatory bowel disease, cholecystitis, pancreatitis, pelvic inflammatory disease, or abdominal trauma). The presence of various factors provides clues as to the etiology of the obstruction. If the patient has experienced episodes of obstruction before, one should ask about the etiology and the response to treatment. If the patient has ever undergone an abdominal operation, one should try to obtain and read the operative report, which can provide a great deal of helpful information (e.g., description of adhesions, assessment of their severity, and evaluation of intra-abdominal pathology and anatomy). If abdominal cancer was present, one should find out what operation was performed and attempt to determine the likelihood of intra-abdominal recurrence. Obstructive symptoms without a history of previous surgery or identified hernias should raise the suspicion for cancer. Symptoms that come and go suddenly over several days in a patient older than 65 years should increase the index of suspicion for gallstone ileus.4

The clinical setting often provides clues to the cause and type of bowel obstruction. In hospitalized patients, there is likely to be an associated medical condition or metabolic derangement that led to obstruction. A thorough review of the patient’s medical history and hospital course should be undertaken to identify precipitating events that could have led to intestinal obstipation. One should ask the patient about any previous abdominal irradiation and should note and take into account all medications the patient is taking, especially anticoagulants and agents with anticholinergic side effects. Patients who are receiving chemotherapy or have undergone abdominal radiation therapy are prone to ileus. Severe infection, fluid and electrolyte imbalances, narcotic and anticholinergic medications, and intra-abdominal inflammation of any origin may be implicated. Acute massive abdominal distention in a hospitalized patient usually results from acute gastric atony, small bowel ileus, or acute colonic pseudo-obstruction. Excessive anticoagulatation can lead to retroperitoneal, intra-abdominal, or intramural hematoma that can cause mechanical obstruction or ileus. Finally, there are specific problems that tend to arise in the

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Table 3 Causes of Colonic Obstruction

<table>
<thead>
<tr>
<th>Common causes</th>
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<tbody>
<tr>
<td>Cancer (primary, anastomotic, metastatic)</td>
</tr>
<tr>
<td>Volvulus</td>
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<tr>
<td>Diverticulitis</td>
</tr>
<tr>
<td>Pseudo-obstruction</td>
</tr>
<tr>
<td>Hernia</td>
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<tr>
<td>Anastomotic stricture</td>
</tr>
<tr>
<td>Unusual causes</td>
</tr>
<tr>
<td>Intussusception</td>
</tr>
<tr>
<td>Fecal impaction</td>
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<tr>
<td>Strictures (from one of the following)</td>
</tr>
<tr>
<td>Inflammatory bowel disease</td>
</tr>
<tr>
<td>Endometriosis</td>
</tr>
<tr>
<td>Radiation therapy</td>
</tr>
<tr>
<td>Ischemia</td>
</tr>
<tr>
<td>Foreign body</td>
</tr>
<tr>
<td>Extrinsic compression by a mass</td>
</tr>
<tr>
<td>Pancreatic pseudocyst</td>
</tr>
<tr>
<td>Hematoma</td>
</tr>
<tr>
<td>Metastasis</td>
</tr>
<tr>
<td>Primary tumors</td>
</tr>
</tbody>
</table>

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postoperative period; these are discussed more fully elsewhere [see Urgent Operation, Early Postoperative Technical Complications; and No Operation, Early Postoperative Obstruction, below].

**Physical Examination and Resuscitation**

The initial steps in the physical examination are (1) developing a sense of the patient’s illness and course and (2) assessing the patient’s vital signs, hydration status, and cardiopulmonary system. A nasogastric (NG) tube, a Foley catheter, and an intravenous (IV) line should be placed immediately while the physical examination is in progress. The volume and character of the gastric aspirate and urine are noted. A clear, gastric effluent is suggestive of gastric outlet obstruction. A bilious, nonfeculent aspirate is a typical sign of middle to proximal SBO or colonic obstruction.

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**Figure 1** An algorithm outlining an approach to the assessment and management of acute bowel obstruction. CT = computed tomography; IV = intravenous; NG = nasogastric; SBO = small bowel obstruction.
with a competent ileocecal valve. A feculent aspirate is a typical sign of distal, high-grade SBO. Volume replacement, if necessary, is initiated with isotonic saline or lactated Ringer solution. Adequate resuscitation is critical prior to taking the patient to the operating room; measurement and repletion of electrolytes that may have occurred from prolonged periods of vomiting should also be undertaken.

Fever or tachycardia may be present, suggesting that the obstruction may be a manifestation of an intra-abdominal abscess, or they may indicate perforation, especially if peritonitis is noted. Signs of pneumonia or myocardial infarction should be sought: these conditions, like intestinal obstruction, can have upper abdominal pain, distention, nausea, and vomiting as presenting symptoms. Dyspnea and labored breathing may occur secondary to severe abdominal distention or pain, in which case, immediate relief should be provided by placing the patient in the lateral decubitus position and offering narcotics as soon as the initial physical examination is performed. Jaundice raises the possibility of gallstone ileus or metastatic cancer.

Examination of the abdomen proceeds in an orderly manner from observation to auscultation to palpation and percussion. The patient is placed in the supine position with the legs flexed at the hip to decrease tension on the rectus muscles. The degree of abdominal distention observed varies, depending on the level of obstruction: proximal obstructions may cause little or no distention. Abdominal scars should be noted. Abdominal asymmetry or a protruding mass suggests an underlying malignancy, an abscess, or closed-loop obstruction. The abdominal wall should be observed for evidence of peristaltic waves, which are indicative of acute SBO.

Auscultation should be performed for at least 3 to 4 minutes to determine the presence and quality of bowel sounds. High-pitched bowel tones, tinges, and rushes are suggestive of an obstructive process, especially when temporally associated with waves of crampy pain, nausea, or vomiting. The absence of bowel tones is typical of intestinal paralysis but may also indicate intestinal fatigue from long-standing obstructions, closed-loop obstruction, or pseudo-obstruction.

Approximately 70% of patients with bowel obstruction have symmetrical tenderness, whereas fewer than 50% have rebound tenderness, guarding, or rigidity. Traditional teaching is that localized tenderness and guarding indicate underlying strangulated bowel; however, prospective studies have demonstrated that these physical findings are neither specific nor sensitive for detecting underlying strangulation or even obstruction. Nevertheless, most surgeons still believe that guarding, rebound tenderness, and localized tenderness reflect underlying strangulation and therefore are indications for operation. Patients with ileus tend to have generalized abdominal tenderness that cannot be distinguished from the tenderness of mechanical obstruction. Gentle percussion is performed over all quadrants of the abdomen to search for areas of dullness (suggestive of an underlying mass), tympany (suggestive of underlying distended bowel), and peritoneal irritation. A thorough search is made for inguinal, femoral, umbilical, and incisional hernias. The rectum is examined for masses, fecal impaction, and occult blood. If the patient has an ileostomy or a colostomy, the stoma is examined digitally to make sure that there is no obstruction at the level of the fascia.

It is important to note that no constellation of signs, symptoms, or physical examination findings can reliably presume the diagnosis of bowel obstruction 100% of the time, and a low threshold should be maintained to initiate further workup with laboratory and imaging studies when clinical suspicion exists.

### Investigative Studies

#### IMAGING

In general, one should obtain a chest x-ray in all patients with bowel obstruction to exclude subdiaphragmatic free air. In most cases, supine, upright, or lateral decubitus films of the abdomen can distinguish the type of obstruction present (mechanical or nonmechanical, partial or complete) and establish the general location of the obstruction (stomach, small bowel, or colon). A useful technique for evaluating abdominal radiographs is to look systematically for intestinal gas along the normal route of the GI tract, beginning at the stomach, continuing through the small bowel, and, finally, following the course of the colon to the rectum. The following questions should be kept in mind as this is done:

- Are there abnormally dilated loops of bowel, signs of small bowel dilatation, or air-fluid levels?
- Are air-fluid levels and bowel loops in the same place on supine and upright films?
- Is there gas throughout the entire length of the colon (suggestive of ileus or partial mechanical obstruction)?
- Is there a paucity of distal colonic gas or an abrupt cutoff of colonic gas with proximal colonic distention and air-fluid levels (suggestive of complete or near-complete colonic obstruction)?
- Is there evidence of strangulation (e.g., thickened small bowel loops, mucosal thumb printing, pneumatosis cystoides intestinalis, or free peritoneal air)?
- Is there massive distention of the colon, especially of the cecum or sigmoid (suggestive of either volvulus or pseudo-obstruction)?
- Are there any biliary or renal calculi, and is there any air in the biliary tree (suggestive of gallstone ileus or a renal stone that could be causing ileus)?

It is important to be able to distinguish between small and large bowel gas. Gas in a distended small bowel outlines the valvulae conniventes, which traverse the entire diameter of the bowel lumen [see Figure 2]. Gas in a distended colon, on the other hand, outlines the colonic haustral markings, which cross only part of the bowel lumen and typically interdigitate [see Figure 3 and Figure 4]. Distended small bowel loops usually occupy the central abdomen [see Figure 2], whereas distended large bowel loops are typically seen around the periphery [see Figure 3]. In patients with ileus, distention usually extends uniformly throughout the stomach, the small bowel, and the colon [see Figure 4], and air-fluid levels may be found in the colon and the small intestine.

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Patients with gastric outlet obstruction or gastric atony typically have a giant gastric bubble if no nasogastric tube has been placed, with little or no air in the small bowel or the colon. Patients with mechanical SBO usually have multiple air-fluid levels, with distended bowel loops of varying sizes arranged in an inverted U configuration [see Figure 5]. A dilated loop of small bowel appearing in the same location on supine and upright films suggests obstruction of a fixed segment of bowel by an adhesion or an internal hernia [see Figure 2 and Figure 5]. SBO is often accompanied by a paucity of gas in the colon. The complete absence of colonic gas is strongly suggestive of complete SBO; however, the presence of colonic gas does not exclude complete SBO in that there may have been unevacuated gas distal to a point of complete obstruction before the radiograph was taken. On the other hand, if repeat radiographs demonstrate decreased or absent colonic or rectal gas in a patient with SBO who previously had more colonic or rectal gas, it is probable that partial obstruction has become complete, and an operation may be indicated. High-grade obstruction of the colon with an incompetent ileocecal valve may manifest itself as distended small bowel loops with air-fluid levels, thereby mimicking SBO. Hence, it is sometimes necessary to perform a barium enema to exclude colonic obstruction.
see Figure 2, Figure 6, Figure 7, and Figure 8.

Massive gaseous distention of the colon is usually secondary to distal colonic or rectal obstruction, volvulus, or pseudo-obstruction [see Figure 2, Figure 6, Figure 7, and Figure 8]. There are well-defined radiographic criteria that are highly sensitive and specific for sigmoid volvulus. If there is any uncertainty regarding the presence, type, or level of colonic obstruction, immediate sigmoidoscopy followed by barium enema is diagnostic.

LABORATORY TESTS

Serum electrolyte concentrations, hematocrit, serum creatinine concentration, coagulation profile (prothrombin time [or international normalized ratio] and platelet count), and serum lactate are helpful in determining the severity of volume depletion, identifying ischemia, and guiding resuscitative efforts. If ileus is suspected, serum magnesium and calcium levels should be measured, and urinalysis should be done to check for hematuria.

Determination of Need for Operation and Classification of Obstruction

The combination of a thorough history, a carefully performed physical examination, and correctly interpreted abdominal radiographs usually allows an experienced surgeon to identify the type of bowel obstruction present and to decide whether a patient requires immediate, urgent, or delayed operation [see Table 4] or can safely be treated initially with nonoperative measures. On the other hand, even experienced surgeons have difficulty in properly identifying the cause and in deciding when to operate on a patient with intestinal obstruction. Given the importance of establishing a timely and accurate diagnosis on patient outcomes and costs of care, it is strongly recommended that all patients suspected of having intestinal obstruction be admitted to a surgical service; failure to do so can increase patient morbidity and mortality. An exception to this guideline may be patients admitted to a hospitalist service but with early surgical consultation, frequent reevaluation, and good interservice communication.

It is particularly important and useful to stratify patients into those with mechanical obstruction and those with non-mechanical obstruction. In patients with mechanical bowel obstruction, an effort should be made to determine whether the obstruction is partial or complete and whether it is accompanied by ischemia. This can be accomplished early in most cases using the aid of computed tomography (CT) with IV contrast and use of a water-soluble contrast medium (WSCM) challenge [see Adjunctive Tests, Ultrasonography, Fast Magnetic Resonance Imaging, and Computed Tomography; and Mechanical Obstruction, Immediate Operation, CT-based scoring systems, and Urgent Operation, Water-soluble contrast medium challenge, below]. Strong consideration for immediate operation may be given to patients with high-grade to complete obstruction and/or clinical or radiologic signs of ischemia; conversely, patients with partial bowel obstruction, especially from adhesions, rarely require an emergent operation. Finally, an effort should be made to establish the level and cause of obstruction because these factors often help guide therapy and affect the probability of success in response to specific therapeutic intervention. Patients with nonmechanical obstruction, which derives from ileus or pseudo-obstruction [see Ileus and Pseudo-obstruction, below], do not require immediate, or often any, operation.

ADJUNCTIVE TESTS

Sigmoidoscopy

When one is uncertain whether or not an obstruction is mechanical on the basis of the information at hand, additional diagnostic measures are immediately indicated. When large amounts of colonic air extend down to the rectum, a digital rectal examination and flexible or rigid sigmoidoscopy will readily exclude a rectal or distal sigmoid obstruction. Care must be exercised to avoid insufflating large amounts of air during endoscopy: excessive insufflation can cause overdistention of the colon above the level of the possible obstruction, which can be counterproductive and harmful. If sigmoidoscopy yields normal findings but partial colonic obstruction seems to be the correct diagnosis, a water-soluble contrast enema should be administered.9

Barium studies may be harmful in patients with acute obstruction when they are performed before the nature of the obstruction (complete or partial) is determined. Abdominal ultrasonography, although not as definitive as a contrast examination, is also able to diagnose suspected colonic obstruction in 85% of patients.10

Figure 5 Upright radiograph from the same patient as the supine radiograph in Figure 2 shows multiple air-fluid levels of varying size arranged in inverted Us. In the right lower pelvis, a loop of small bowel is seen in exactly the same location as on the supine abdominal film (black arrow), a finding suggestive of adhesive obstruction.
Figure 6  (a) Radiograph from a patient with massive sigmoid volvulus shows a distended ahastral sigmoid loop (white arrow), inferior convergence of the walls of the sigmoid loop to the left of the midline, and approximation of the medial walls of the sigmoid loop as a summation line (black arrow). (b) Barium enema of the colon shows a tapered obstruction at the rectosigmoid junction with a typical bird’s beak deformity (black arrow).

Figure 7  (a) Radiograph from a patient with cecal volvulus shows a dilated cecum with no air distally in the colorectum. Convergence of the medial walls of the loop (black arrow) points to the right, a typical finding in cecal volvulus. (b) Barium examination demonstrates a bird’s beak deformity tapering at the point of volvulus (large white arrow). Note walls of dilated cecum (small white arrows).
in the diagnosis of bowel obstruction, and studies of its diagnostic accuracy have been mixed. A recent study, however, found that abdominal radiographs were accurate in detecting acute SBO using three patterns of air-fluid levels and that senior radiologists were more accurate than less experienced readers.

Therefore, if the patient’s clinical profile and the results of physical examination are consistent with intestinal obstruction despite normal abdominal radiographs, abdominal ultrasonography, CT, or fast magnetic resonance imaging (MRI) should be performed immediately. All three modalities are highly sensitive and specific for intestinal obstruction when performed properly and interpreted by experienced clinicians. Ultrasonography, MRI, and CT are all capable of detecting the cause of the obstruction, as well as the presence of closed-loop or strangulation obstruction.

Sonographic criteria have been established for small bowel and colonic obstruction. (1) simultaneous observation of distended and collapsed bowel segments; (2) free peritoneal fluid; (3) inspissated intestinal contents; (4) paradoxical pendulating peristalsis; (5) highly reflective fluid within the bowel lumen; (6) bowel wall edema between serosa and mucosa; and (7) a fixed mass of aperistaltic, fluid-filled, dilated intestinal loops. Ultrasonography is well suited to critically ill patients: because it can be performed at the bedside, the risk associated with transport to the radiology suite is avoided. Recent prospective trials have also shown bedside ultrasonography to have superior diagnostic accuracy to abdominal plain films when performed by emergency department physicians, radiologists, and residents after appropriate training. Given that ultrasonography is relatively inexpensive, is easy and quick to perform, and often can provide a great deal of information about the location, nature, and severity of the obstruction, it is often used in regions outside the United States. However, concerns over interobserver variability, sonographer inexperience, obesity, impaired imaging relative to overlying bowel gas, and the ready availability of CT imaging have made ultrasonography an uncommon choice in the United States.

Fast MRI with T2-weighted (spin-spin relaxation time) images is an accurate modality to establish the location and cause of bowel obstruction. Because of its higher cost, decreased availability, longer study time, and lack of convincing incremental diagnostic gain compared with CT, MRI should not be used routinely for evaluating suspected high-grade SBO. It remains a useful option in children or pregnant patients.

The American College of Radiology recommends that patients with suspected complete or high-grade SBO and equivocal plain abdominal films undergo CT with IV contrast routinely. CT has several advantages over a small bowel contrast examination in this setting: (1) it can ascertain the level of obstruction, (2) it can assess the severity of the obstruction and determine its cause, and (3) it can detect closed-loop obstruction and signs of ischemia [see Figure 9, Figure 10, Figure 11, Figure 12, and Figure 13]. Furthermore, several scoring systems and models have been developed that use a combination of clinical and CT findings to detect ischemia and help predict the need for operative intervention [see Mechanical Obstruction, Immediate Operation,
Figure 9  Axial intravenous contrast–enhanced computed tomographic scan demonstrating the classic appearance of a closed-loop obstruction (between black arrowheads). There is a swirling appearance of the mesenteric vessels, also known as the “whirl sign” (short white arrow), accompanied by mesenteric edema (black arrow) and free intraperitoneal fluid (long white arrow). This patient was markedly tender and acitotic and had a leukocytosis. She was taken for laparotomy and found to have a small section of ischemic small bowel that was resected.

Figure 10  Axial intravenous contrast–enhanced computed tomographic scan demonstrating decreased bowel wall enhancement in a patient with ischemia secondary to adhesive small bowel obstruction. Note the mucosal detail in the normal bowel (white arrows), where the mucosal folds can clearly be seen. This is in contrast to the loss of detail in the areas of ischemia (black arrows). There is air in the colon (white arrowhead), a finding indicative of partial obstruction; however, because of evidence of ischemia, this patient was taken for laparotomy and found to have strangulated obstruction.

Figure 11  Axial intravenous contrast–enhanced computed tomographic scan demonstrating ischemic bowel obstruction. There is mesenteric edema (black arrowhead) and, importantly, pneumatosis intestinalis (black arrow), which can be distinguished from air within the bowel lumen given its appearance in antidependent bowel in a supine patient. A transition point from distended to decompressed bowel is demonstrated (white arrowhead). Note the normal mucosal enhancement (broken white arrow) compared to the decreased enhancement in the section of ischemic bowel (white arrowhead). These findings, combined with tachycardia and leukocytosis, prompted an early exploration.

Strangulation and Closed-Loop Obstruction, CT-based scoring systems, below]. CT can also detect inflammatory or neoplastic processes both outside and inside the peritoneal cavity and can visualize small amounts of intraperitoneal air or pneumatosis cystoides intestinalis not seen on conventional films [see Figure 11]. Prospective studies have demonstrated that the accuracy of CT in diagnosing bowel obstruction is higher than 95% and that its sensitivity and specificity are each higher than 94%. CT distinguishes colonic mechanical obstruction from pseudo-obstruction more accurately than conventional films do and thus is the preferred modality in many cases.
Mechanical Obstruction

Malignant bowel obstruction (MBO) is a serious complication and most commonly affects patients with abdominal and pelvic tumors. Some patients will present with advanced disease for which curative surgical intervention is not feasible. For those patients, palliative efforts should focus on controlling GI symptoms and restoring or preserving quality of life. Etiologies for MBO include extrinsic occlusion of the lumen, malignant infiltration of mesentery and intestinal muscle and serosal surfaces, and intraluminal obstruction. Avoidance of operation in patients with extrinsic obstruction due to carcinomatosis is desirable, and resolution may be obtained by medical or endoscopic means. Intestinal immobility secondary to opioids, certain antiemetics, and secondary adrenal insufficiency may all play a role in MBO.

Early and intensive pharmaco logical treatment with a combination of antise cretory drugs, analgesics, and antiemetics has been shown to be effective in controlling GI symptoms and even reverse functional MBO [see Figure 14]. Three prospective, randomized clinical trials demonstrated that octreotide significantly attenuated the severity of nausea and vomiting and the degree of subjective discomfort in patients with inoperable obstruction and permitted the discontinuation of NG tube decompression. One of these studies also demonstrated that octreotide significantly reduced the degree of fatigue and anorexia experienced. Malignant obstruction has been treated safely on an outpatient basis with octreotide, metoclopramide, morphine, and dexamethasone. Long-acting preparations of octreotide may aid in the development of protocols designed to keep patients at home as long as possible. Therefore, patients with terminal illness should be offered hospice care or home visiting nurse services with continuous octreotide infusion, IV rehydration, and decompression. Attention must always be paid to quality of life issues and to the patient’s interest in pursuing nonoperative forms of palliation. For many terminally ill or incurable patients with bowel obstruction, the most humane and sensible treatment comprises institution of comfort measures, including continuous morphine infusion, rehydration, and administration of antise cretory agents.

Self-expanding metallic stents

Many patients with gastric, duodenal, or colorectal MBO may be successfully treated by endoscopic deployment of self-expanding metallic stents (SEMSs) as a means of palliation or as a bridge surgery. Malignant obstruction of the gastric outlet or duodenum is a frequent late complication of gastric, duodenal, or pancreatic cancer and has been traditionally managed with surgical gastrojejunostomy. Two systematic reviews have found that placement of a SEMS for malignant gastroduodenal obstruction leads to faster resumption of oral intake, decreased length of hospital stay, lower incidence of delayed gastric emptying, and similar complication rates when compared with gastroenterostomy. In a multicenter, randomized trial comparing the two approaches, more rapid symptom improvement was noted in the stenting group, but longer-lasting results were achieved with gastrojejunostomy, with decreased need for re intervention. In general, for patients with shorter life...
expectancies (i.e., less than 2 months), SEMS is the preferred palliative therapy and is cost-effective. Long-term gastric or enteric decompression may also be achieved with percutaneous endoscopic gastrostomy or jejunostomy.

In the case of malignant colorectal obstruction, a robust body of evidence is mounting for the safety, efficacy, and cost-effectiveness of SEMS as palliative therapy alone or as a bridge to surgery in the case of resectable disease. For palliation, high technical and clinical success rates have been observed with prompt colonic decompression following stent placement in more than 90% of cases. The most common observed complications were stent migration (5 to 22%), early or late perforation (4 to 8%), and reobstruction (7 to 30%). Three randomized, controlled trials have compared palliative stenting versus palliative surgery revealing shorter time with resumption of oral intake and shorter hospital stay, but unacceptably high perforation rates in the SEMS group caused an early closure of one study. Systematic reviews have suggested that SEMS placement is safe and effective in achieving relief of obstruction, decreasing hospital stay, and improving quality of life with similar or fewer complications when compared with surgery. SEMSs do appear to be more prone to reobstruction; however, placement of a second stent will relieve reobstruction in most cases. Balloon dilation of malignant strictures prior to stenting has been associated with increased risk of perforation and should be avoided.

Malignant colorectal obstruction often presents acutely with significant metabolic derangements secondary to dehydration. Bowel may be distended and friable, making operating conditions hazardous. Most often these lesions are left-sided, and historical treatment has been a Hartmann procedure with creation of an end-colostomy. These emergency procedures are associated with high morbidity and mortality, and many of these colostomies will not be reversed. Placement of a SEMS provides an opportunity for patient stabilization, completion of a proper staging workup, and the opportunity to pursue an elective resection and often primary anastomosis. Placement of a SEMS followed by surgery leads to higher rates of primary anastomo-
Morbidity, lower rates of colostomy, shorter hospital stays, and possibly fewer complications. Three randomized, controlled trials address the use of SEMSs as a bridge to surgery, with mixed results; however, two of the three trials were plagued by lower than average technical and clinical success rates for SEMS deployment. In a well-designed randomized, controlled trial, Cheung and colleagues found that SEMS placement followed by elective laparoscopic colonic resection resulted in significantly lower blood loss, pain scores, incidence of anastomotic leak, and wound infection than those treated with emergency open surgery. Sixty-six percent of patients in the SEMS group underwent successful one-stage operation versus 38% with emergency surgery. Another surgical approach is segmental colectomy and primary anastomosis with intraoperative colonic irrigation; however, a recent systematic review failed to find an advantage over manual colonic decompression. Further study of endoscopic and surgical management of acute malignant colorectal obstruction is warranted as prospective, randomized, controlled trials have been conflicting.

**IMMEDIATE OPERATION**

Traditional teaching has been that all patients with complete bowel obstruction, whether of the small or large intestine, should undergo immediate operation unless extraordinary circumstances (e.g., diffuse carcinomatosis, terminal illness, radiation enteritis, or sigmoid volvulus that responds to sigmoidoscopic decompression) are present. The fear is that if one attempts to manage complete intestinal obstruction nonoperatively, one risks delaying definitive treatment of patients with intestinal ischemia and subjecting them to significantly increased morbidity and mortality should perforation or severe infection develop. However, in the absence of findings suggestive of ischemia or strangulation, high-grade to complete SBO will resolve without surgery in 37 to 46% of cases. Rocha and colleagues reported that in a cohort of patients initially managed nonoperatively but progressing to surgery in an average time of 68 hours, there was no difference in mortality or requirement for bowel resection at the time of operation compared with the immediate surgery group. Consensus guidelines now suggest that a trial of nonoperative management in patients with likely adhesive SBO is appropriate, with the knowledge that high-grade to complete obstruction carries a higher risk of failure of nonoperative management and a shorter time to recurrence. Immediate operation should be strongly considered when bowel obstruction is associated with peritonitis and/or collective clinical and radiographic signs of bowel ischemia. Immediate operation remains unequivocally indicated for patients with incarcerated, strangulated hernias, suspected or confirmed strangulation, sigmoid volvulus accompanied by systemic toxicity or peritoneal irritation, colonic volvulus proximal to the sigmoid colon, or sigmoid volvulus that cannot be reduced endoscopically. These conditions will not resolve without operation and are associated with increased morbidity, mortality, and cost if diagnosis and treatment are delayed. The only time one would not operate immediately on any patient with one of these diagnoses is when the patient requires cardiopulmonary stabilization or additional resuscitation or refuses operation. Whenever there is any doubt as to the presence of any of these conditions, additional diagnostic tests (e.g., IV contrast–enhanced CT scan) are indicated to confirm or exclude them.

**Strangulation and Closed-Loop Obstruction**

Morbidity and mortality from intestinal obstruction vary significantly and depend primarily on the presence of strangulation and subsequent infarction. Strangulation obstruction occurs in approximately 10% of all patients with small intestinal obstruction. It carries a mortality of 10 to 37%, whereas simple obstruction carries a mortality of less than 5%. Early recognition and immediate operative treatment of strangulation obstruction are the only current means of decreasing this mortality. Strangulation obstruction occurs most frequently in patients with incarcerated hernias, closed-loop obstruction, or volvulus; hence, identification of any of these specific causes of obstruction is an important and clear indication for immediate operation.

Surgeons often base the decision of whether to operate on patients with bowel obstruction on the presence or absence of the so-called “classic signs” of strangulation obstruction—continuous abdominal pain, fever, tachycardia, peritoneal signs, and leukocytosis—and on their clinical experience. Unfortunately, these classic signs, even in conjunction with abdominal x-rays and clinical judgment, are incapable of reliably detecting closed-loop or gangrenous bowel obstruction. In fact, one prospective clinical trial concluded that the five classic signs of strangulation obstruction and experienced clinical judgment were neither sensitive, specific, nor predictive of strangulation: in more than 50% of the patients who had intestinal strangulation, the condition was not recognized preoperatively. Such findings suggest that early nonoperative recognition of intestinal strangulation is not feasible without advanced imaging (CT, ultrasonography, or fast MRI).

Many investigators have examined the role of CT alone in the diagnosis of ischemia and strangulation. A systematic review of 11 studies (seven prospective trials and four retrospective studies) demonstrated a positive predictive value of 79% and a negative predictive value of 93% of CT to detect ischemia, suggesting that CT scanning can reliably diagnose ischemic bowel. However, there were no standard criteria among the studies included for the diagnosis of strangulation. Reduced bowel wall enhancement on IV contrast–enhanced CT has been identified by multiple reports as an independent predictor of ischemia (odds ratio 4.87 to 143) using maximal attenuation of a region of interest can detect subtle differences in enhancement and improve the diagnostic accuracy.

**Table 6**

<table>
<thead>
<tr>
<th>Independent Predictors of Ischemia on Computed Tomographic Scan</th>
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<tr>
<td>Free fluid volume &gt; 500 cc on computed tomographic scan</td>
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<tr>
<td>Mesenteric edema</td>
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<tr>
<td>Lack of a “small bowel feces sign”</td>
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<tr>
<td>Abnormal swirling course of mesenteric vessels (also known as “whirl sign”)</td>
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<tr>
<td>Reduced bowel wall enhancement</td>
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of this sign; however, this novel technique is currently not widely used in clinical practice. Using multivariate logistic regression models, free fluid volume greater than 500 cc on a CT scan [see Figure 9], mesenteric edema [see Figure 9 and Figure 13], lack of a “small bowel feces sign” [see Figure 12], and an abnormal vascular course of mesenteric vessels (also known as the “whirl sign”) [see Figure 9 and Figure 13] have all been identified as independent predictors of bowel ischemia.

CT-based scoring systems To assist in operative decision making, a great deal of effort has gone into the development of scoring systems that combine various historical, examination, laboratory, and radiologic findings to diagnose ischemia and/or predict the need for operative exploration [see Table 6]. Although sensitivity in predicting the need for operation and the presence of strangulation with these models is low, such approaches may provide a means for objective early diagnosis of patients with ischemia and reduce delays in operation for at-risk patients. Taken together, there is a growing body of evidence that CT scan with IV contrast, when appropriately combined with clinical features, can reliably assist in identifying patients with ischemia who will benefit from early laparotomy.

Incarcerated or Strangulated Hernias A hernia that is incarcerated, tender, erythematous, warm, or edematous is an indication for immediate operation. Primary or incisional hernias may not be palpable in obese patients, in which case, advanced imaging should be performed [see Figure 12].

Nonsigmoid Volvulus and Sigmoid Volvulus with Systemic Toxicity or Peritoneal Signs All intestinal volvuli are closed-loop obstructions and thus carry a high risk of intestinal strangulation, infarction, and perforation. Patients typically present with acute, colicky abdominal pain, massive distention, nausea, and vomiting. Sigmoid volvulus is the most common form of colonic volvulus, followed by cecal volvulus. Abdominal radiographs are fairly diagnostic for colonic volvulus [see Figure 6, Figure 7, and Figure 13]. In contrast, small bowel volvulus may not be visualized on plain radiographs, because the closed loop fills completely with fluid and no air-fluid level can be seen. Small bowel volvulus is readily detected by ultrasonography or CT; one or both of these procedures should be performed in patients presenting with signs and symptoms of bowel obstruction and normal abdominal radiographs [see Figure 9]. Small bowel or cecal volvulus is an indication for immediate operation.

If one observes signs of systemic toxicity, a bloody rectal discharge, fever, leukocytosis, or peritoneal irritation in a patient with sigmoid volvulus, the patient should undergo immediate operation; if all of these signs are absent, the patient should undergo sigmoidoscopy. When there are no signs of peritonitis or generalized toxicity, sigmoidoscopic decompression is safe and effective in more than 95% of patients with sigmoid volvulus. If mucosal gangrene or a bloody effluent is noted at the time of sigmoidoscopy, immediate operative intervention is necessary even in the absence of any clinical signs or symptoms of strangulation. After sigmoidoscopy, the patient can undergo elective bowel preparation and a single-stage sigmoid resection before being discharged from the hospital. If, however, clinical toxicity, a bloody rectal discharge, fever, or peritoneal irritation arises at any time after sigmoidoscopic decompression while the patient is being prepared for an elective procedure, immediate operation is indicated.

Patients with volvulus proximal to the sigmoid colon should undergo immediate operation regardless of whether peritoneal irritation is present. The incidence of strangulation infarction is high in such patients, and nonoperative therapy often fails. If the diagnosis of nonsigmoid colonic volvulus is in doubt, a barium enema is indicated to exclude colonic pseudo-obstruction.
**Fecal Impaction**

Complete colonic obstruction secondary to fecal impaction in the rectum can sometimes be successfully relieved through disimpaction at the bedside; however, this can be difficult and extremely uncomfortable for the patient. The most expeditious and successful method of relieving the obstruction is to disimpact the patient while he or she is under general or spinal anesthesia. In one study, the pulsed-irrigated enhanced-evacuation procedure, which can be performed at the bedside, successfully resolved fecal impaction in approximately 75% of geriatric patients. In another study, administration of a polyethylene glycol 3350 solution over 3 days successfully resolved intestinal obstruction from fecal impaction in 75% of pediatric patients.

**Urgent Operation**

**Failure of Water-Soluble Contrast Medium Challenge at 24 Hours**

It is usually safe to manage partial bowel obstruction initially by nonoperative means: a nil per os (NPO) regimen, NG tube decompression, and analgesics. Such therapy is successful in most cases, especially if the cause of obstruction is postoperative adhesions, but there is always the risk that strangulation obstruction already exists but is undetected. Routine CT with IV contrast in all patients undergoing nonoperative management is indicated to decrease this possibility. Furthermore, there is the risk that while the patient is being observed, partial obstruction will progress to complete, unresolving obstruction, or strangulation and perforation will develop. Repeated examination of the abdomen by the same clinician is the most sensitive way of detecting progressive obstruction and clinical deterioration. Examinations should be performed no less frequently than every 3 hours. If abdominal pain, tenderness, or distention increases or the gastric aspirate changes from nonfeculent to feculent, abdominal exploration is usually indicated. It is therefore crucial to be alert to such changes in the patient’s condition.

**Water-soluble contrast medium challenge** Level 1a evidence now exists supporting the use of WSCM (also known as Gastrografi or dimitrozoate meglumine) as a diagnostic and therapeutic tool in the management of patients with adhesive SBO. WSCM administered orally or via a NG tube that arrives in the colon within 4 to 24 hours of administration can predict the resolution of SBO with 96% sensitivity and 98% specificity and should be used routinely to aid in determining which patients are unlikely to resolve with nonoperative management [see Figure 15]. There are no reported complications related directly to the administration of WSCM and no difference in overall complication rates. Importantly, these studies excluded all patients with clinical signs of ischemia or strangulation [see Immediate Operation, Strangulation and Closed-Loop Obstruction, CT-based scoring systems, above]. At the time of initial CT, or after a short waiting period (i.e., 1 to 2 hours) to allow for adequate decompression, a WSCM meal of 50 to 150 mL should be administered via a NG tube, which is clamped for 4 hours. If there is no sign of strangulation by either clinical or CT findings, a waiting period of 24 hours with close clinical follow-up should begin. If at 24 hours no contrast is visible within the colon on an upright abdominal plain film, the patient should progress to operative intervention as the obstruction is unlikely to resolve. Level 1a evidence also indicates that WSCM may accelerate resolution of partial SBO [see No Operation, Adhesive Partial Small Bowel Obstruction, below].

**Early Postoperative Technical Complications**

When normal bowel function initially returns after an abdominal operation but then is replaced by a clinical picture suggestive of early postoperative mechanical obstruction, the explanation may be a technical complication of the operation (e.g., phlegmon, abscess, intussusception, a narrow anastomosis, an internal hernia, or obstruction at the level of a stoma). An early, aggressive diagnostic workup should be performed to identify or exclude these problems because they are unlikely to respond to NG decompression or other forms of conservative management. It is critical to know exactly what was done within the abdomen in the course of the operation. To this end, one should try to speak directly with the operating surgeon rather than attempt to deduce the needed information from the operative report.
If the patient had peritonitis or a colonic anastomosis at the initial operation, one should order a CT scan to look for an intra-abdominal abscess. An abscess or a phlegmon at the site of an anastomosis is usually secondary to anastomotic leakage and is an indication for reoperation or endoscopic stenting in some cases. CT can also identify intra-abdominal hematomas, which should be evacuated through early reoperation. In patients recovering from a proctectomy, herniation of the small bowel through a defect in the pelvic floor is a common cause of intestinal obstruction. Oral contrast studies can help identify patients with an internal hernia, intussusception, or anastomotic obstruction and should be performed after the CT scan. A retrograde barium examination by gravity drainage should be performed in patients thought to have a problem related to a stoma or an intestinal anastomosis. High-pressure contrast examination should be avoided to reduce trauma to the anastomosis. When none of the above factors appear to be the cause of the postoperative obstruction, it is reasonable for the surgeon to assume that the obstruction is secondary to postoperative adhesions, which are best treated conservatively (see below).

NO OPERATION

In selected patients, nonoperative management of partial bowel obstruction is highly successful and carries an acceptably low morbidity and mortality. Nonoperative management is most often successful in patients with obstruction secondary to intra-abdominal adhesions, occurring in the immediate postoperative period, or deriving from an inflammatory condition (e.g., inflammatory bowel disease, radiation enteritis, or diverticulitis).

Adhesive Partial Small Bowel Obstruction

Adhesions are the major cause of bowel obstruction. Obstruction resulting from adhesions can occur as early as 1 month or as late as 20 years after operation. Adhesive partial SBO is treated initially with NG tube decompression, IV rehydration, and analgesia.

Some studies suggest that the nature of the previous abdominal operation or the type of adhesions present may influence the probability that the obstruction will respond to medical therapy. Operations associated with a lower likelihood of response to medical therapy include those performed through a midline incision; those involving the aorta, colon, rectum, appendix, or pelvic adnexa; and those done to relieve previous carcinomatous obstruction. Matted adhesions, which are more common in patients who have undergone midline incisions or colorectal procedures, are less amenable to conservative management than a simple adhesive band. In the context of this kind of operative history, strong consideration should be given to surgical intervention if the obstruction does not resolve within 24 hours—unless comorbid medical conditions tip the risk-benefit balance in the direction of nonoperative therapy.

When operative adhesiolysis is performed, the mortality is 5% for all comers; however, it may be as high as 30% for patients with strangulation or necrotic bowel necessitating intestinal resection. In view of this substantial difference in mortality, it is extremely important to determine which patients have ischemic bowel at presentation. Given the high reliability of IV contrast-enhanced CT for the detection of ischemia [see Immediate Operation, Strangulation and Closed-Loop Obstruction, CT-based scoring systems, above], it should be performed routinely in all patients to be given a trial of nonoperative management.

After exclusion of patients with contraindications to nonoperative management on clinical or radiologic grounds, the key factor in determining whether to continue with nonoperative management is WSCM challenge followed by a period of close observation [see Urgent Operation, Failure of Water-Soluble Contrast Medium Challenge at 24 Hours, Water-soluble contrast medium challenge, above]. During this observation period, the overall clinical picture (vital signs, laboratory values, abdominal examination findings, nature of NG aspirate) should be continuously evaluated, ideally by the same examiner. Analgesics can be safely administered, and repeat abdominal examinations should be performed at 3-hour intervals when the influence of narcotics has waned. Repeat abdominal x-rays should be obtained no later than 24 hours after WSCM administration. If contrast is visible in the colon within 24 hours on an upright abdominal radiograph, then nonoperative management is likely to succeed and should be continued [see Figure 15]. There is heterogeneity among published reports regarding the time interval prior to follow-up abdominal radiograph, and shorter intervals than 24 hours may be appropriate. If abdominal pain and/or distention are increasing, or the gastric aspirate changes from bilious to feculent, strong consideration should be given to operation. Importantly, WSCM administration has been shown to decrease the time to resolution of SBO by almost 20 hours and to reduce hospital length of stay by nearly 2 days when compared with standard therapy.

By quickly identifying patients who are unlikely to resolve nonoperatively and accelerating the resolution of partial SBO, administration of WSCM can shorten the expected hospital stay and thereby reduce the cost of care. Thus, intragastric administration of WSCM is the logical first step in managing suspected partial SBO from adhesions or postoperative ileus. Even if bowel function does not return within 24 hours but a partial obstruction is demonstrated, continued observation is safe, and resolution without operation is still highly probable. Eventually, there will be a point beyond which continued observation is no longer cost-effective in comparison with operative adhesiolysis (especially laparoscopic adhesiolysis). In the first prospectively validated model for managing bowel obstruction, drainage of more than 500 mL from the NG tube at day 3, when combined with an age over 65 and the presence of ascites on CT, demonstrated a positive predictive value of 72% for requiring operation. Drainage volume of gastric aspirate, particularly on hospital day 3, appears to be another important factor to consider when deciding if a patient should progress to operative therapy. Additional prospective trials are necessary to determine the appropriate time interval before operative treatment is pursued.

Experimental studies in animals suggest that there may be some benefit from administration of somatostatin analogues in patients undergoing nonoperative treatment of bowel obstruction as a result of the potent effects these substances exert on intestinal sodium, chloride, and water absorption. In one study, animals with either complete or closed-loop
partial SBO were given either long-acting somatostatin or saline; the treatment group had significantly less intestinal distension, less infarction, and longer survival than the control group.\textsuperscript{70,71} In a prospective, randomized clinical trial evaluating the use of somatostatin in patients who had complete SBO without clinical or radiologic evidence of strangulation, the treatment group was less likely to need operation, had less proximal intestinal distention, and exhibited decreased mucosal necrosis proximal to the point of obstruction.\textsuperscript{72} These results have not been replicated in further studies.

**Laparoscopic adhesiolysis** A recent systematic review of over 2,000 cases has confirmed that laparoscopic adhesiolysis for acute SBO is both feasible and safe.\textsuperscript{73} Laparoscopic or laparoscopy-assisted lysis of adhesions relieves bowel obstruction in more than 70% of patients and is associated with lower morbidity, earlier return of bowel function, and a shorter hospital stay than open operative lysis. An average conversion rate of 29% was observed; the majority of conversions were related to dense adhesions, bowel ischemia requiring resection, or iatrogenic bowel injury. The overall enterostomy rate was 6.6%, with the majority recognized at the time of operation.\textsuperscript{73} To minimize the risk of bowel injury at the beginning of the operation, the first trocar is inserted under direct vision and the incision is placed well away from any previous scars.\textsuperscript{74} Meticulous, atraumatic handling of edematous bowel, avoidance of electrocautery, and a low threshold for early conversion are critical to minimize the risk of perforation.\textsuperscript{75,76} In spite of its demonstrated safety and efficacy, current opinion still demonstrates a reluctance to embrace laparoscopic lysis of adhesions.\textsuperscript{77} In 2002, a study examining the Nationwide Inpatient Sample revealed that only 11.4% of over 6,000 randomly selected operations for SBO were attempted laparoscopically\textsuperscript{78} [see Video 1, online version only].

There are no prospective, randomized, controlled clinical trials comparing laparoscopic adhesiolysis with open adhesiolysis.\textsuperscript{79} Two retrospective, matched-pair, intention-to-treat analyses have demonstrated lower morbidity (16 to 19% versus 40 to 45%) and reduced hospital stay (7 to 11 days versus 13 to 18 days, in respective studies).\textsuperscript{76,80} A 45 to 52% rate of conversion either for completion of adhesiolysis, resection of necrotic bowel, or management of complications was observed. Large, retrospective series suggest that conversion rates may be much lower (15 to 30%) with conservative patient selection.\textsuperscript{79,81} It is important to note that laparoscopic operations converted to open operations have essentially the same morbidity, cost, and length of stay as primary open operations; however, early conversions in response to dense adhesions or poor visibility carry significantly less morbidity than reactive conversions in response to an iatrogenic injury.\textsuperscript{73} In the report by Wullstein and Gross, intraoperative perforations were more common overall in the laparoscopic group than in the open group, but this difference was largely eliminated when patients from the laparoscopic group who underwent conversion to open lysis were not considered.\textsuperscript{80} In the other retrospective controlled trial, Khaikin and colleagues reported no intraoperative perforations in the laparoscopic group, which they attributed to meticulous operative technique and a low threshold for conversion.\textsuperscript{76}

There is conflicting evidence regarding indications for attempted laparoscopic adhesiolysis. Patients with two or more previous laparotomies had a higher incidence of intraoperative complications and an increased rate of conversion than those with fewer laparotomies in one study;\textsuperscript{82} on the other hand, a systematic review found that the number of previous laparotomies was not associated with unsuccessful laparoscopic adhesiolysis in multiple studies.\textsuperscript{83}

Appendectomy was the only previous operation predictive of laparoscopic success. Bowel dilatation greater than 4 cm on preoperative imaging may be associated with conversion, but reports are conflicting. Consistently, a documented history of dense adhesions has been associated with a higher rate of conversion. Primary laparotomy may still be an appropriate choice for such patients as well as those with complex pathology, for example, a history of malignancy or inflammatory bowel disease. When laparoscopic adhesiolysis fails to identify and relieve an obvious point of obstruction or when adhesiolysis is inadequate or unsafe, conversion to an open approach is indicated. Conversion should not be viewed as failure but rather as sound surgical judgment. At present, the laparoscopic approach appears best suited to those patients who have undergone fewer previous operations, especially if they have undergone appendectomy only, as well as those in whom the probable cause of obstruction is from one to several adhesive bands.\textsuperscript{73}

One must be vigilant in monitoring for signs or symptoms of a missed enterotomy in patients treated laparoscopically as these injuries may present in a delayed fashion and prompt recognition is key to reducing the morbidity associated with this complication.

By reducing the number of days spent in the hospital when compared with open surgery, laparoscopic lysis of adhesions stands to significantly decrease the cost associated with adhesive SBO. Few studies have examined cost directly, but Khaikin and colleagues demonstrated a reduction in total hospital charges of over $30,000 with a totally laparoscopic approach compared with an open approach.\textsuperscript{76} Importantly, these cost benefits disappeared when patients who underwent conversion to open lysis of adhesions were considered with the laparoscopic group. Another important potential cost benefit of laparoscopic adhesiolysis is that it results in fewer intra-abdominal adhesions than open laparotomy,\textsuperscript{84,85} and thus may reduce the risk of recurrent bowel obstruction. No studies comparing recurrence rates after laparoscopic versus open adhesiolysis have yet been performed.

**Early Postoperative Obstruction**

Early postoperative mechanical SBO is not uncommon: it occurs in approximately 10% of patients undergoing abdominal procedures.\textsuperscript{86} Postoperative bowel obstruction is often difficult to diagnose because it gives rise to many of the same signs and symptoms as postoperative ileus: obstruction, distention, nausea, vomiting, abdominal pain, and altered bowel sounds. In most cases, there are radiographic signs indicative of small bowel obstruction rather than ileus; however, in some cases, abdominal x-rays fail to diagnose the obstruction.\textsuperscript{87} Traditionally, when plain radiographs are equivocal, an upper GI barium study with follow-through views is the next test performed to distinguish ileus from obstruction.
partial or complete SBO; however, such studies may yield the wrong diagnosis in as many as 30% of cases. A water-soluble contrast study may prove useful in this scenario, although its previously described accuracy in determining which cases of SBO will require operation was not tested in the setting of recent operation. WSCM may also have therapeutic benefits in the treatment of ileus [see Nonmechanical Obstruction, Ileus, below].

Early postoperative obstruction is caused by adhesions in about 90% of patients. When there are no signs of toxicity and no acute abdominal signs, such obstruction can usually be managed safely with NG decompression. As many as 87% of patients respond to NG suction within 2 weeks. About 70% of the patients who respond to nonoperative treatment do so within 1 week, and an additional 25% respond during the following 7 days. If postoperative obstruction does not resolve in the first 2 weeks, it is unlikely to do so with continued nonoperative therapy, and reoperation is probably indicated; about 25% of patients whose postoperative obstruction was initially treated nonoperatively eventually require reoperation. An exception to this guideline arises in patients known to have severe dense adhesions (sometimes referred to as obliterator peritonitis) in response to multiple sequential laparotomies. These patients may have a combination of mechanical obstruction and diffuse small bowel and colonic ileus. The risk of closed-loop obstruction, volvulus, or strangulation in this group of patients is low. Repeat laparotomies and attempts to lyse adhesions may lead to complications, the development of enterocutaneous fistulas, or exacerbation of the adhesions. Often the best approach to managing these patients is observation for prolonged periods (i.e., months). Total parenteral nutrition (TPN) is indicated.

Because the risk of intestinal strangulation in patients with postoperative adhesive obstruction is extremely low (< 1%), one can generally treat these patients nonoperatively for longer periods. In fact, the conservative approach is often the wise one: reoperation may do more harm than good (e.g., by causing enterotomies and inducing denser adhesions). The traditional indications for operation in patients with early postoperative obstruction include (1) deteriorating clinical status, (2) worsening obstructive symptoms, and (3) failure to respond to nonoperative management within 2 weeks. With the rising cost of hospitalization, it might, in fact, be more cost-effective to reoperate on patients who have persistent obstruction after 7 days. This speculation would have to be tested by a well-organized cost-benefit study conducted in a prospective fashion.

Some physicians have maintained that long intestinal tubes are beneficial in the management of postoperative bowel obstruction. However, there is no convincing evidence that long intestinal tubes are any better for resolving bowel obstruction than conventional NG tubes. In fact, some authorities have reported that the use of such tubes increases morbidity. One prospective, randomized clinical trial that addressed this issue found no differences between the two types of tube with respect to the percentage of patients who were able to avoid operation, the incidence of complications, the time between admission and operation, or the duration of postoperative ileus.

**Inflammatory Conditions**

Partial bowel obstruction secondary to inflammatory bowel disease, radiation enteritis, or diverticulitis usually resolves with nonoperative therapy. Bowel obstruction accompanying an acute exacerbation of Crohn disease usually resolves with NG suction, IV antibiotics, and antiinflammatory agents. If, however, CT detects an intra-abdominal abscess, there is evidence of a chronic stricture, or the patient exhibits persistent obstructive symptoms, an operation may be necessary. Similarly, bowel obstruction arising from acute enteritis caused by radiation exposure or chemotherapy usually resolves with supportive care. Chronic radiation-induced strictures are problematic; astute clinical judgment must be exercised to determine when operative treatment is the best option.

Patients with acute diverticulitis typically present with a history of altered bowel movements, fever, leukocytosis, localized pain, tenderness, and guarding in the left lower quadrant of the abdomen. Approximately 20% of patients with colonic diverticulitis also present with signs and symptoms of partial colonic obstruction. A CT scan should be obtained early in all patients with diverticulitis to ascertain whether there is a pericolic abscess that could be drained percutaneously. Partial colonic obstruction in these patients usually resolves with antibiotic therapy, an NPO regimen, and NG decompression. If obstructive symptoms persist for more than 7 days or if obstructive symptoms from a documented stricture recur, operation is indicated.

**Elective Operation**

**Nontoxic, Nontender Sigmoid Volvulus**

Patients with nontoxic, nontender sigmoid volvulus whose bowel obstruction is initially treated successfully with sigmoidoscopic decompression are at risk for recurrent colonic obstruction. Accordingly, these patients should undergo elective sigmoid resection after complete bowel preparation during their index admission [see Figure 14].

**Recurrent Adhesive or Stricture-Related Partial Small Bowel Obstruction**

Many patients whose adhesive bowel obstruction resolves experience no further obstructive episodes. If a patient does present with recurrent obstruction from presumed adhesions, either a contrast examination of the bowel or CT is indicated to determine whether there is a surgically correctable point of stenosis. A strong argument can be made that non–high-risk patients should undergo elective operation after presenting with their second episode of mechanical obstruction. Similarly, patients with recurrent obstruction from strictures of any sort should undergo elective operation given that these lesions are unlikely to resolve [see Figure 14].

**Partial Colonic Obstruction**

The most common causes of partial colonic obstruction are colon cancer, strictures, and diverticulitis. Cancer and strictures usually must be managed surgically because they generally go on to cause obstruction later. Strictures from ischemia or endometriosis usually call for elective colonic resection. Inflammatory strictures from diverticulitis may
resolve; however, if obstructive symptoms persist or if barium enema examination continues to yield evidence of colonic narrowing, elective resection is warranted.

When abdominal x-rays suggest distal colonic obstruction, digital examination and rigid sigmoidoscopy are performed to exclude fecal impaction, tumors, strictures, and sigmoid volvulus. If obstruction is proximal to the sigmoidoscope, barium contrast examination is indicated. If barium examination does not demonstrate mechanical obstruction, a presumptive diagnosis of colonic pseudo-obstruction is made.

The morbidity and mortality associated with elective colorectal procedures are significantly lower than those associated with emergency colonic surgery. Furthermore, immediate operation for left-sided colonic obstruction almost always necessitates the creation of a diverting colostomy. If a colostomy takedown subsequently proves necessary, the overall cost of caring for the patient will be significantly higher than it would have been had a single-stage procedure been performed. For these reasons, one should initially treat partial colonic obstruction with NG suction, enemas, and IV rehydration in the hope that the obstruction will resolve and that the patient thus can undergo mechanical and antibiotic bowel preparation and a single-stage procedure comprising resection and primary anastomosis. Placement of SEMSs has a growing role as both a bridge to a single-stage resection and a primary palliative intervention [see Figure 14 and Mechanical Obstruction, Malignant Bowel Obstruction, Self-expanding metallic stents, above].

Bowel Obstruction without Previous Abdominal Operation

When partial SBO develops and resolves in a patient who has not previously undergone an abdominal operation, a diagnostic workup should be performed to identify the cause of the obstruction. Incarcerated inguinal, femoral, and umbilical hernias should be ruled out. There may be an underlying condition that is likely to cause recurrent obstruction (e.g., an internal hernia, malrotation, or malignancy). The first diagnostic test to be ordered should be a CT scan, followed by an upper GI barium study with follow-through views and a barium enema. If a pathologic lesion is identified, elective operation is indicated [see Figure 14]. An argument can be made that no additional diagnostic tests should be performed in these patients and that diagnostic laparoscopy should be performed instead to enable laparoscopic surgery in case a cause of obstruction is identified that can be treated with a minimally invasive procedure. If no cause of obstruction is found at laparoscopy, open laparotomy is performed.

Paraduodenal hernia, a congenital defect resulting from intestinal malrotation, is probably more common than was once thought. It accounts for approximately 50% of internal hernias. Patients with paraduodenal hernia may present with a catastrophic closed-loop obstruction; more often, however, they exhibit mild, nonspecific GI symptoms such as nausea, vomiting, esophageal reflux, and abdominal pain. Duodenogastric reflux and prominent bile gastritis in the absence of a previous operation or diabetic gastroparesis are indirect signs of a paraduodenal hernia. The diagnosis is established by means of either an upper GI contrast study with small bowel follow-through or CT scanning. When a paraduodenal hernia is identified, operative treatment is indicated. Such treatment is usually successful in alleviating symptoms and preventing strangulation obstruction.

Nonmechanical Obstruction

ILEUS

Ileus, or intestinal paralysis, is most common after abdominal operations but can also occur in response to any acute medical condition or metabolic derangement [see Table 1]. The pathophysiologic mechanisms that cause ileus are incompletely understood but appear to involve disruption of normal neurohumoral responses that result in elevated sympathetic nerve activity. Moreover, immunohistochemistry in rats has shown an increase in inflammatory mediators such as macrophages, mast cells, dendritic cells, and T cells as a result of surgical manipulation of the bowel, which, in addition to the sympathetic nervous system stimulation, leads to decreased circular muscle contractile activity. The intensity of the paralysis is directly proportional to the degree of trauma (e.g., physical manipulation, incision).

Ileus may be classified into two broad categories: postoperative ileus and ileus without antecedent abdominal operation [see Figure 16]. Postoperative ileus is manifested by atony of the stomach, small intestine, and colon and usually resolves spontaneously within a few days as normal bowel motility returns. Typically, the small bowel regains its motility within 24 hours of operation, followed 3 to 4 days later by the stomach and colon. Initial therapy of ileus is directed at identifying and correcting the presumed cause. If the patient experiences abdominal distention, abdominal pain, nausea, or vomiting, then NG decompression, placement of a Foley catheter, and IV rehydration are indicated. When ileus develops in patients who have not recently undergone an operation, a thorough history, a careful physical examination, and well-chosen laboratory tests are necessary to identify the possible causes. Serum electrolytes, including calcium and magnesium, should be routinely measured.

Perioperative measures to reduce postoperative ileus include early postoperative mobilization, avoidance of NG tube insertion when appropriate, prokinetic administration, early enteral feeding, judicious use of IV fluids, and minimization of narcotics (often with the assistance of thoracic epidural analgesia). Institution of these measures can be aided with the use of enhanced recovery protocols. Additionally, gum chewing has emerged as an effective perioperative intervention to alleviate ileus. A form of “sham feeding,” gum chewing improves intestinal motility through cephalic-vagal stimulation. A systematic review and meta-analysis demonstrated that gum chewing reduced length of stay by 1.1 days and shortened the time to first flatus by 14 hours when compared with control. As well as the adoption of gum chewing for patients with postoperative paralytic ileus, as an alternative to early feeding, eliminates the common complications associated with enteric feeding of recovering bowel, such as nausea and vomiting. Additionally, gum chewing can be tolerated sooner than even small amounts of food. Gum chewing appears to be a useful adjunct for reducing the duration of postoperative ileus to reduce cost and improve outcomes.
When ileus persists for what is, in one’s best clinical judgment, an inordinate length of time for the operation performed (typically, longer than 3 to 4 days), the possibility of partial mechanical obstruction or other surgical complication must be considered. Prolonged operative ileus (defined as no flatus for > 6 days) was independently associated with male gender, chronic obstructive pulmonary disease, and placement of an ileostomy in a study of colorectal surgery patients. CT distinguished ileus from obstruction in about 80% of patients.

Intragastric administration of a water-soluble contrast agent has shown great potential in the treatment of ileus. In one study, administration of 120 mL of WSCM via an NG tube to 40 adults with postoperative ileus led to restored intestinal motility within 6 hours in all 40, allowing them to resume oral alimentation within 24 hours. A phase IV prospective, randomized clinical trial is currently under way to study the efficacy of WSCM on postsurgical ileus. Also in the expanding repertoire of pharmacologic modalities is a prokinetic ghrelin agonist, TZP-101 (ulimorelin). This agent, when administered beginning 1 hour after operation and continued

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**Figure 16** An algorithm outlining an approach to the management of ileus. CT = computed tomography; IV = intravenous; NG = nasogastric; PO = by mouth; WSCM = water-soluble contrast medium.
daily until the first bowel movement, was independently, prospectively associated with accelerated return of GI function and an increased proportion of patients recovering bowel function within 72 hours. Alvimopan, a selective mu-opioid receptor antagonist, is well tolerated and has been shown to accelerate GI recovery and the time to writing of the discharge order (by 16 hours over placebo). Further investigation into pharmacologic treatment and prevention is likely to yield synergistic, cost-saving strategies to prevent and reduce the severity and duration of postoperative ileus.

**Pseudo-obstruction**

Pseudo-obstruction [see Figure 17] can exist in the small bowel or colon and can be either acute or chronic. Acute colonic pseudo-obstruction, also known as Ogilvie syndrome, is the most common form. Colonic pseudo-obstruction occurs most commonly in hospitalized patients in the postoperative period or in response to a nonsurgical acute illness (e.g., pneumonia, myocardial infarction, hypoxia, shock, intestinal ischemia, or electrolyte imbalance). The pathophysiologic mechanisms underlying idiopathic pseudo-obstruction appear to be related to an imbalance in the parasympathetic and sympathetic influences on colonic motility.

The presenting symptoms of acute colonic pseudo-obstruction are massive dilatation of the colon seen on a plain abdominal radiograph (with the cecum more dilated than the distal colon), crampy pain, nausea, and vomiting. If peritoneal irritation or systemic toxicity is present, immediate laparotomy is indicated; if not, treatment begins with conservative methods and proceeds in a stepwise fashion. Conservative modalities include NG decompression, placement of a rectal tube, tap-water enemas, correction of any underlying metabolic disturbances, and avoidance of narcotic and anticholinergic medications. With conservative management, acute colonic pseudo-obstruction resolves within 4 days in more than 80% of cases. In unalleviated cases, colonoscopy was previously the method of choice for decompression. However, it is now recommended that acute colonic pseudo-obstruction that does not resolve within 24 to 48 hours be treated pharmacologically. IV administration of 2.5 mg neostigmine, an acetylcholineesterase inhibitor, over 2 to 3 minutes, leads to prompt resolution of acute colonic pseudo-obstruction within minutes in nearly all cases. Although other prokinetic agents (IV erythromycin, cisapride, metoclopramide) are reportedly effective, neostigmine has emerged as the only option backed by a randomized, controlled trial. When using neostigmine, serious GI, cardiovascular, and respiratory side effects can occur, including bronchospasm, bradycardia, and hypotension, potentially leading to syncope. Therefore, the patient’s vital signs and electrocardiogram should be monitored, with medical support immediately available during the infusion. Now that this previously difficult and potentially lethal problem can readily be treated pharmacologically, colonoscopic decompression and surgical intervention should be reserved for cases in which pharmacologic measures fail.

Chronic intestinal pseudo-obstruction is a rare acquired disorder that is caused by various diseases involving GI smooth muscle, the enteric nervous system, or the extrinsic autonomic nerve supply to the gut. These disorders are treated with an NPO regimen, home TPN, and octreotide. Patients with chronic intestinal pseudo-obstruction should be followed closely for the development of nutritional deficiencies. Surgical approaches are sometimes helpful, but often the condition is progressive, such that removal of a defunctional segment of bowel may not provide long-term relief. Bowel transplantation has been attempted, with varying degrees of success.

**Recurrence and Prevention of Small Bowel Obstruction**

The largest series to date of over 32,000 patients with adhesive SBO indicated that nonoperative therapy leads to resolution of obstruction in approximately three quarters of patients; however, resolution was followed by recurrence of obstruction within 5 years of the index admission in approximately 20% of cases. Of note, patients initially managed nonoperatively have a slightly higher recurrence rate requiring readmission than those managed operatively during their index admission (20% versus 16%) and a shorter median time to recurrence (194 days versus 354 days). Even high-grade to complete obstructions may be managed nonoperatively, but there is an increased incidence of recurrent obstruction requiring hospitalization when compared with operative management (24% versus 9%), with nearly half of all recurrences in the nonoperative group occurring within 2 years. However, approximately one fifth of all patients undergoing initial laparotomy for SBO will have recurrence within 10 years. Because of the significant risk of SBO posed by adhesions and the considerable risk of recurrence with both operative and nonoperative therapy, a great deal of effort has gone into adhesion prevention.

Multiple Cochrane reviews have examined the evidence on adhesion prevention with placement of bioreabsorbable membranes beneath fascial closures (typically composed of sodium hyaluronate and carboxymethylcellulose, i.e., Seprafilm, or oxidized regenerated cellulose, i.e., Interceed) and instillation of fluid agents (solutions containing dextran, icodextrin, and hyaluronic acid) in both gynecologic and nongynecologic surgery. Although products containing hyaluronic acid and cellulose significantly reduced the severity and density of postoperative adhesions, long-term studies are required to determine whether the use of these products will result in fewer adhesion-related admissions. In the only prospective long-term study, the incidence of obstruction-related readmissions following the Hartmann procedure was not statistically different between groups in which Seprafilm was placed versus those without it (0 versus 2). Unfortunately, the study only enrolled 35 patients for long-term follow-up and was underpowered to detect such a difference. Therefore, a well-designed, appropriately powered, long-term, prospective examination of adhesion prevention and its relation to real-world prevention of adhesive bowel obstruction is still required. Also, logic would dictate that smaller incisions needed for laparoscopic surgery would result in fewer adhesions to the abdominal wall and reduce the risk of subsequent bowel obstruction; however, no study examining adhesion-related readmissions following laparoscopic versus open procedures of a similar type has been conducted.
Figure 17  An algorithm outlining an approach to the management of pseudo-obstruction. IV = intravenous; NG = nasogastric; NPO = nothing by mouth; TPN = total parenteral nutrition.
Cost Considerations

Cost considerations are exerting an ever-growing influence on surgical care in general and on the decision whether to operate in particular. A large percentage of the high total cost of caring for patients with ileus or mechanical intestinal obstruction is accounted for by the cost associated with hospitalization or the need for laparotomy. Bed stay for these admissions represents the equivalent of almost one surgical bed per year and at least 2 days of operating room time.112

Strategies for reducing the overall cost of managing patients with bowel obstruction have taken several forms: the development of diagnostic and therapeutic methods that lead to more rapid diagnosis and resolution of ileus and partial SBO; the development of techniques for rapid identification of patients with complete or closed-loop obstruction and early reversible strangulation, which should permit earlier operative intervention and thereby reduce the incidence of complications; the development of therapeutic approaches that prevent postoperative ileus, including the use of selective postoperative inhibition of GI opioid receptors,113 the use of a well-defined postoperative care program, including continuous thoracic epidural analgesia and enforced early mobilization and enteral nutrition,114 gum chewing,19 and avoiding positive salt and water balance14; and the development of proven methods for preventing intra-abdominal adhesions, which can significantly reduce the overall incidence of adhesive bowel obstruction.

From a management viewpoint, if a specific diagnostic test, medication, or approach (e.g., laparoscopy) costs less than a day of hospitalization does, it immediately becomes cost-effective if it reduces complications and shortens length of stay by 1 day. Intragastric administration of a water-soluble contrast agent to diagnose and relieve small bowel ileus or partial adhesive obstruction is an example of an innovative, cost-effective diagnostic and therapeutic strategy with the support of high-level evidence. CT has emerged as an effective aid for earlier definitive management decisions and to prevent unrecognized gangrenous obstruction. Laparoscopic adhesiolysis is safe and leads to earlier hospital discharge. On the basis of the collective experience reported in a substantial number of studies (see above), a logical proposal for cost-effective management of patients with bowel obstruction is to perform abdominal CT immediately after initial resuscitation and then to perform laparoscopic surgery on those patients in whom the contrast agent does not arrive in the right colon within 24 hours [see Figure 1]. However, prospective, randomized clinical trials are needed to evaluate the cost-effectiveness of this and other new management strategies.

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References


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Figures 8, 9, 10, 11, and 12  Courtesy of Lawrence Holder, MD.
Figure 15  Marcia Krammerer