Small-Bowel Obstruction: Optimizing Radiologic Investigation and Nonsurgical Management

Small-bowel obstruction is an old and common problem. Like most illnesses, its diagnosis and treatment continue to evolve. The radiologic approach to the investigation of small-bowel obstruction and the timing of surgical intervention have undergone considerable changes during the past decade. In this review, the authors analyze the recently described radiologic techniques used in the examination of patients with suspected mechanical small-bowel obstruction, revisit the controversy of the short versus long decompression tube, and provide insights on how to optimize the radiologic investigation and nonsurgical management of small-bowel obstruction.

Although conventional radiography is still requested as the initial method of radiologic examination, computed tomography (CT) is now frequently performed in the acute setting, both to answer questions relevant to the management of small-bowel obstruction and to identify other causes of acute abdominal pain (1). CT is of particular value in the acute setting because it can be performed immediately and depict other causes of an acute abdomen (2). Use of CT can establish the presence and cause of small-bowel obstruction as well as associated closed-loop obstruction or strangulation (3,4). In landmark studies (5,6), CT had a sensitivity of 90%–96%, specificity of 96%, and accuracy of 95% in the detection of intestinal obstruction. These early reports appeared to have focused on patients with relatively high-grade obstruction.

In a subsequent analysis that included patients with both low- and high-grade partial obstructions, the overall accuracy of CT was considerably lower, 66%; the sensitivity of CT was 63%, and its specificity was 78% (7). These authors found that CT had an acceptable sensitivity of 81% for detection of high-grade obstruction, but a sensitivity of only 48% for detection of low-grade obstruction. The results of that study confirmed the reliability of CT for the detection of higher grades of small-bowel obstruction and indicated the need for alternative methods of radiologic investigation in patients with lower grades of obstruction. These alternative methods include enteroclysis and, more recently, a combination of the elements of CT and enteroclysis—that is, CT enteroclysis (8). In spite of advances in imaging techniques, the diagnosis of low-grade small-bowel obstruction and the reliable exclusion of the presence of mechanical small-bowel obstruction as a cause of unexplained abdominal pain remain difficult.

An important aspect in the management of small-bowel obstruction is related to the use of intestinal tubes for decompression of the obstruction. A controversial issue involving such decompression is the current debate of whether the nasogastric (short) tube or nasointestinal (long) tube should be used (9). Advances in imaging techniques, refinements of previously described methods of radiologic examination, and the introduction of more versatile nasogastric/nasointestinal tubes continue to change the workup and treatment of patients with suspected small-bowel obstruction (1).

CLINICAL CONSIDERATIONS

Small-bowel obstruction is still associated with substantial mortality, about 5.5%, largely because of the feared complication of strangulation and the difficulty associated with its
preoperative recognition (10). This is the reason for the dictum, "Never let the sun rise or set on small-bowel obstruction." The timing of surgery has changed in recent years. Most patients currently receive a trial treatment of decompression and timely operative intervention for non-resolution unless there are clinical signs of strangulation (11).

Intestinal obstruction is responsible for approximately 20% of surgical admissions for acute abdominal conditions (12). The small bowel is the site of obstruction in 60%–80% of these cases. The pattern of major causes of small-bowel obstruction has changed during the past 5 decades. Nearly 50% of surgical cases are directly related to postoperative adhesions. In a surgical report, adhesions (49%), neoplasms (16%), and hernias (15%) collectively accounted for approximately 80% of all cases (13). In a report on patients with small-bowel obstruction after abdominal surgery for malignancy, 62% of patients had cancer-related obstruction and 38% had nonmalignant obstruction (14). These data indicate the need for accurate diagnosis of the cause of obstruction, because the surgical management is influenced by the underlying cause. For example, low-grade adhesive obstruction is frequently managed by a trial of decompression rather than by urgent surgical intervention, because this more conservative approach is considered to be safe under these circumstances (11).

The nasointestinal tube was once a mainstay in the management of small-bowel obstruction (15). Its efficacy in decompressing the dilated fluid-filled small intestine compared with that of the nasogastric tube was supported by the experiences of generations of general surgeons (9). The properly positioned nasointestinal tube had the inherent capability of providing suction closer to the point of obstruction compared with the nasogastric tube. The demise of the long tube was unfortunately prompted by the outlawing of metallic mercury as a toxic chemical and extremely hazardous waste in the 1991 Federal Register (15).

General surgeons tried several substitutes, but none worked. Because of the lack of a suitable substitute, the results of poorly controlled studies that purported to show that the nasogastric tube was just as effective as the nasointestinal tube were subsequently accepted by clinicians (9). In an editorial lamenting the demise of the long tube, Morgenstern wrote, "Finally in desperation, the concept took hold that gastric decompression served the purpose just as well and with much less trouble for all concerned" (9). Prior experimental and clinical study results, however, do not support this conclusion (16,17). Data in some articles show a growing support for long-tube decompression (18,19). In a prospective randomized study, 75% success with the long tube versus 51% with the short tube was found, and "the success of nonoperative therapy was influenced by decompression tube location as only 25% in whom the tube passed into the small bowel required operation" (19).

PATHOPHYSIOLOGIC FEATURES OF INTESTINAL OBSTRUCTION AND RATIONALE FOR NASOINTESTINAL DECOMPRESSION

The intestinal tract secretes up to 8.5 L of fluid every 24 hours, most of which is not removed if the decompression tube is positioned in the stomach, because the majority of this fluid is reabsorbed in the small intestine (20). In the presence of an intact pylorus, a nasogastric tube can provide effective decompression only if the pressure of backed-up small intestinal fluid and gas is sufficient to overcome the action of the pyloric sphincter. The results of several studies have shown that the efficacy of decompression is improved if the decompression tube tip is beyond the pylorus (17).

In a classic analysis of the mechanics underlying gastrointestinal tube decompression, it was demonstrated that kinks and trapped air between distended loops
of small bowel prevent the free transmission of negative pressure along the bowel toward the site of obstruction (16). In that study, it was also found that the effectiveness of intraluminal decompression varies inversely with the distance between the tip of the tube and the site of blockage. In proximal small-bowel obstruction, these hydrodynamic principles are relatively unimportant. However, small-bowel obstruction is much more commonly distal in location. In this situation, the efficacy of decompression is substantially reduced because of the considerable distance between the tube and the point of obstruction. The brunt of an intestinal obstruction is borne by the bowel immediately above the occlusion (20). This part of the gut becomes distended, its circulation is the most obviously prone to venous impairment, and, as a result, this segment has the greatest risk of becoming gangrenous and therefore perforating. This situation is aggravated because the distended bowel continues to secrete fluid and electrolytes at the same time that absorption is progressively impaired.

These pathophysiologic principles explain why nasointestinal rather than nasogastric intubation is considered the optimal method of decompressing the distended small bowel (Fig 1). In the past, nasointestinal decompression had been hindered by the difficulty in advancing long tubes beyond the pylorus and the failure to include a sump mechanism, which limited the efficacy of suction because of collapse of the bowel wall and plugging of suction ports (17). An added advantage to using a long tube is that as soon as the tube passes the pylorus and begins to decompress the small bowel, the colicky pain of obstruction is largely relieved. Because nasogastric tube decompression is limited to the stomach, the pain persists until the obstruction is relieved (21).

### RENAISSANCE OF LONG TUBES

In 1996, an estimated 700,000 nasogastric intubations were performed in emergency departments (EDs) throughout the United States; this procedure represents one of the most commonly carried out procedures in the ED or other hospital settings (22). Nasogastric intubation may result in considerable pain and discomfort and is not without substantial complications (23). In a study comparing commonly performed procedures in the ED, insertion of a nasogastric tube was found to be the most painful procedure (24). Discomfort can be reduced by topical nasal and pharyngeal anesthesia, conscious sedation, reducing the tube size, preventing reintubation by using a multifunctional tube, and appropriate training of the personnel performing intubation (25). It has been shown that a prior traumatic nasogastric intubation is the main reason for patient refusals to undergo enteroclysis examination (26).

Because the Salem sump nasogastric tube (Sherwood Medical, St Louis, Mo) cannot be used for enteroclysis and is too short to be advanced into the small bowel for nasoenteric decompression, patients who undergo enteroclysis for the evaluation of small-bowel obstruction experience the trauma of multiple intubations, especially if the nasogastric tube is to be reinserted after enteroclysis examination for further decompression. The multipurpose (ie, diagnostic and therapeutic) tube (MDEC-1400; Cook, Bloomington, Ind) was thus developed in 1992 to eliminate the need for multiple intubations (27). Another long tube, which is introduced endoscopically and used for the sole purpose of decompression, was described by Gowen et al (18). The results of their 12-year cohort study showed a success rate of 82% for long-tube decompression.

The multipurpose tube is a modification of the standard balloon enteroclysis catheter (28). It is a 14-F, 155-cm-long triple-lumen disposable catheter made of radiopaque polyvinyl chloride that was designed and adapted for use with suction devices currently used in hospitals (Fig 2). The small size of the tube and ease with which it can be advanced into the small bowel following initial gastric decompression have made this multipurpose tube a practical alternative to the currently used nasointestinal tubes both for decompression and subsequent diagnostic studies. The important addition of
a sumping port prevents intestinal debris from occluding the decompression side ports and collapse of the bowel wall against its side ports, and thereby permits effective decompression.

All the functions of a nasogastric tube can be carried out with this multipurpose tube in addition to its capability for nasoenteric decompression and diagnostic studies (28) (Fig 3). The complications reported with other nasointestinal tubes, such as perforation, have not been observed with this tube in 9 years experience. The availability of a long tube such as the triple-lumen multipurpose tube has once again provided the general surgeon the option for long-tube decompression of the obstructed small bowel.

REFINEMENTS IN SMALL-BOWEL IMAGING

In small-bowel obstruction, radiologic evaluation has several goals. It is carried out to confirm the diagnosis, distinguish between simple and strangulating obstruction, differentiate the various causes of obstruction, estimate the degree of obstruction, and exclude the possibility of colonic obstruction or paralytic ileus (1).

Conventional radiography remains the most common initial method of confirming clinical suspicion of mechanical small-bowel obstruction. Because of its poor sensitivity (Table 1) and inability to enable diagnosis of closed-loop obstruction or strangulation, abdominal radiography has been supplanted by CT in the emergency setting (1). The small-bowel follow-through examination as an elective method of investigation also has been largely replaced in many centers in Europe and North America by volume-challenged methods of investigation.

Experience accumulated mainly in the past 2 decades has shown that the intubation infusion method of examining the small intestine—that is, enteroclysis—has improved the preoperative diagnosis of patients with lower grades of obstruction (28–30). The complications reported with other nasointestinal tubes, such as perforation, have not been observed with this tube in 9 years experience. The availability of a long tube such as the triple-lumen multipurpose tube has once again provided the general surgeon the option for long-tube decompression of the obstructed small bowel.

**TABLE 1**

<table>
<thead>
<tr>
<th>Finding</th>
<th>Low-Grade SBO (%)</th>
<th>High-Grade SBO (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal (29/44) radiographic interpretation</td>
<td>21 (3/14)</td>
<td>...</td>
</tr>
<tr>
<td>Abnormal but nonspecific intestinal gas pattern</td>
<td>13 (7/53)</td>
<td>9 (5/53)</td>
</tr>
<tr>
<td>“Probable SBO” interpretation</td>
<td>37 (7/19)</td>
<td>16 (3/19)</td>
</tr>
<tr>
<td>“Definite SBO” interpretation†</td>
<td>26 (8/31)</td>
<td>23 (7/31)</td>
</tr>
</tbody>
</table>

Source.—Reference 29. Listed data are based on a total of 117 patients. The overall sensitivity of conventional radiography was 66% (29 of 44 patients). The numbers in parentheses are numbers of patients.

† The sensitivity of a “definite SBO” interpretation was 13% (4/31) for the detection of complete SBO.
The need for volume challenge in diagnosing small-bowel obstruction. (a) Unremarkable conventional transverse CT scan obtained in a 58-year-old woman with undiagnosed recurrent abdominal pain and vomiting. Note the artifacts (arrow) from a bicortical screw and plate transfixing the thoracolumbar spine. (b) CT enteroclysis through the multipurpose tube performed by using 15% water-soluble contrast material in the same patient 4 days following a comparison barium meal (arrow) causing low-grade partial mechanical obstruction. Small-bowel window display was acquired by using a width of 1,200 HU and a center of 204 HU. The segment distal to the adhesive band was fixed to the posterior parietal peritoneum at surgery. (c) Conventional transverse abdominal CT scan obtained in a 50-year-old woman with elevated blood urea nitrogen and creatinine levels and congestive heart failure with unexplained recurrent abdominal pain and vomiting. The patient underwent prior gastric surgery for ulcer, inadvertent enterotomy, and transverse ostomy. The small bowel was noted to be distended with gas and fluid. The precise point of obstruction and cause were not apparent. (d) CT enteroclysis performed in the same patient, following 12 hours of intermittent mechanical suction, by using the multipurpose tube (width, 1,200 HU; center, 204 HU) shows multiple points of high-grade partial adhesive band obstruction (arrows). The multifocal site is suspected on the basis of the dilated loop distal to a transition point (area of caliber change). Also note the interloop adhesions (arrowheads). Continued intermittent mechanical long-tube suction relieved the abdominal pain and vomiting. Surgery performed for recurrent symptoms confirmed the presence of multiple sites of dense adhesive band obstruction.

Figure 4. The need for volume challenge in diagnosing small-bowel obstruction. (a) Unremarkable conventional transverse CT scan obtained in a 58-year-old woman with undiagnosed recurrent abdominal pain and vomiting. Note the artifacts (arrow) from a bicortical screw and plate transfixing the thoracolumbar spine. (b) CT enteroclysis through the multipurpose tube performed by using 15% water-soluble contrast material in the same patient 4 days following a comparison barium meal (arrow) causing low-grade partial mechanical obstruction. Small-bowel window display was acquired by using a width of 1,200 HU and a center of 204 HU. The segment distal to the adhesive band was fixed to the posterior parietal peritoneum at surgery. (c) Conventional transverse abdominal CT scan obtained in a 50-year-old woman with elevated blood urea nitrogen and creatinine levels and congestive heart failure with unexplained recurrent abdominal pain and vomiting. The patient underwent prior gastric surgery for ulcer, inadvertent enterotomy, and transverse ostomy. The small bowel was noted to be distended with gas and fluid. The precise point of obstruction and cause were not apparent. (d) CT enteroclysis performed in the same patient, following 12 hours of intermittent mechanical suction, by using the multipurpose tube with 15% water-soluble contrast material and a small-bowel window display (width, 1,200 HU; center, 204 HU) shows multiple points of high-grade partial adhesive band obstruction (arrows). The multifocal site is suspected on the basis of the dilated loop distal to a transition point (area of caliber change). Also note the interloop adhesions (arrowheads). Continued intermittent mechanical long-tube suction relieved the abdominal pain and vomiting. Surgery performed for recurrent symptoms confirmed the presence of multiple sites of dense adhesive band obstruction.

The stimulus for the initial reported experience with CT enteroclysis in North America was to overcome the poor reliability of conventional CT in patients with low-grade small-bowel obstruction (32). Early experience with CT enteroclysis suggests that it is more reliable than conventional CT in patients with small-bowel obstruction and a history of prior malignancy (33) (Table 2). CT enteroclysis can both depict the cause of small-bowel obstruction by virtue of its cross-sectional display and show the severity of the obstruction by virtue of the enteric infusion of liquid. These observations are of practical importance in the examination and treatment of these patients (Fig 6). In addition, initial experience suggests that CT enteroclysis is an excellent method for showing the various types and anatomic location of adhesions. These findings, combined with prompt nasogastric and nasointestinal decompression, may have implications for laparoscopic surgery. Laparoscopic surgery is difficult to perform in patients with an acutely distended small bowel (34).

Enteroclysis is still avoided by many surgeons because it entails the use of barium, which is associated with the prevalent but unfounded fear that the retained barium will convert a partial obstruction into a complete obstruction. Perhaps CT enteroclysis will enable physicians to overcome this reluctance to request additional imaging, because it does not involve the use of barium as a contrast material. The advantages of CT enteroclysis should apply to volume-challenged magnetic resonance imaging of the small bowel, with the added benefits of increased soft-tissue contrast and multiplanar capabilities.

**DISCOMFORT OF INTUBATION AND PATIENT SELECTION**

Nasogastric intubation is one of the more common procedures performed in EDs and other health care settings. This procedure almost invariably produces pain and gagging. In one case series (24), 115 patients who underwent decompression with enteroclysis in which a preexisting nasogastric tube was being replaced were examined. All of these patients preferred the long tube because of less discomfort during intubation. The smaller caliber of the multipurpose tube and the tapered tip are design features that may account for reduced pain and discomfort compared with those associated with the standard 16- or 18-F Salem sump nasogastric tube (27).

Although the higher cost of the multipurpose tube may appear to be an objection to its use, the lack of familiarity with the device of emergency physicians and general surgeons appears to account for its lack of widespread use. The beginning realization of emergency physicians of the trauma of nasogastric intubation and the need to replace the nasogastric tube with other tubes if another small-bowel procedure is required should result in more acceptance of the multipurpose tube (25). The need for emergency physicians or surgeons to anticipate which patients may require further radiologic evaluation will spare patients reintubation and make the initial use of the multipurpose tube cost-effective. Such inter-
ventions may be necessary in patients who have small-bowel obstruction with a history of Crohn disease, abdominal malignancy, or prior abdominal surgery.

THE NEED FOR GREATER INVOLVEMENT BY RADIOLOGISTS

The need for more involvement by radiologists both in the diagnosis and management of small-bowel obstruction has recently been emphasized (35). This is now more realistic because of the increasing presence of radiologists in the ED. Emergency radiologists can exert considerable influence in the diagnostic investigation and management of small-bowel obstruction. They can prevent multiple intubations in patients who need intestinal decompression and/or small-bowel imaging. This can be achieved in the ED by the initial placement of the multipurpose tube instead of the conventional nasogastric tube. This requires informing emergency physicians and general surgeons as to the merits of this multipurpose tube, which can then be introduced by appropriately trained personnel while the patient is still in the ED.

Radiologists should be prepared to assist emergency personnel in placing the multipurpose tube to ensure that it is positioned properly and is performing adequate decompression. Initial decompression of the stomach, from 4–12 hours, should always be carried out. Subsequent advancement of the multipurpose tube into the proximal jejunum for small-bowel decompression is done under fluoroscopic guidance by the radiologist (Fig 3). It should be emphasized that long-tube decompression should not be attempted without first ensuring that the stomach is free of fluid and that gastric peristalsis is present. If this is not done, gastroesophageal reflux, and even aspiration, may occur. This consideration is important because secretions formed in the stomach can accumulate. If gastric peristalsis is present, the secretions formed will be emptied into the proximal small bowel and effectively drained by the nasointestinal tube.

SELECTION OF IMAGING PROCEDURES

In the emergent situation, CT with intravenous contrast material is the method of choice when conventional abdominal radiography depicts distended small bowel and further imaging is required (1). CT usually enables one to confirm the diagnosis of small-bowel obstruction, often demonstrates its cause, and differentiates between small- and large-bowel obstruction. The most substantial contribution of CT is its ability to enable diagnosis of closed-loop obstruction before strangulation ensues (1,3,4). The ability of CT to depict strangulation and its high negative predictive value in the diagnosis of closed-loop obstruction and strangulation will help resolve the controversy about whether urgent operation or longer nonsurgical measures are appropriate in patients with adhesive small-bowel obstruction (36–40).

The influence of CT in the management of small-bowel obstruction in the acute setting has been well documented (41–43). Nasogastric intubation should be avoided unless the patient is vomiting. If intubation has already been performed, suction

<table>
<thead>
<tr>
<th>TABLE 2</th>
<th>CT Enteroclysis versus Conventional CT in Evaluating Small-Bowel Obstruction in Patients with Known Malignancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modality</td>
<td>Sensitivity</td>
</tr>
<tr>
<td>CT enteroclysis</td>
<td>7/7 (100)</td>
</tr>
<tr>
<td>Conventional CT</td>
<td>4/7 (57)</td>
</tr>
</tbody>
</table>

Source.—Reference 33. Listed data are based on a total of 36 patients. The numbers in parentheses are percentages.
should be commenced only after the CT examination. If the general surgeon’s examination results and conventional abdominal radiographs indicate a diagnosis of small-bowel obstruction and a trial of long-tube decompression is desired, a multipurpose tube can be introduced into the stomach, decompression can be performed for 4–12 hours, and the multipurpose tube can then be advanced into the jejunum under fluoroscopic guidance for subsequent small-bowel decompression. CT enteroclysis can then be performed after initiation of decompression. Following CT enteroclysis, the multipurpose tube can be kept in the jejunum if the stomach is decompressed and gastric peristalsis is present; otherwise, the tube should be withdrawn into the stomach.

If emergent CT is unremarkable or equivocal for small-bowel obstruction and nasogastric intubation is desired clinically, the multipurpose tube should be positioned in the stomach. CT enteroclysis appears to be the method of choice in this situation and can be performed after advancing the tube, under fluoroscopic guidance, into the jejunum. In patients with a prior history of abdominal malignancy or Crohn disease, CT enteroclysis should be the primary method of investigation if it can be done expeditiously. When questions relevant to management are not answered by using CT enteroclysis, barium enteroclysis can be used as a problem-solving modality. In departments where the performance of CT enteroclysis is not logistically practical, barium enteroclysis should remain the method of examination (1). On the basis of this review, our current proposed algorithm for the examination of patients with suspected intestinal obstruction is shown in Figure 7.

CONCLUSION

Patients with high-grade small-bowel obstruction and other causes of the acute abdomen are currently given accurate diagnoses by using conventional CT in the emergency setting. The possibility of low-grade mechanical small-bowel obstruction should be considered in any case of undiagnosed acute abdominal pain. The long tube, whose temporary demise has been lamented by experienced surgeons, has reemerged as a multipurpose diagnostic/decompression catheter. The initial use of the multipurpose tube prevents the possibility of reintubation without compromising nasogastric decompression if a diagnostic radiologic procedure or trial of long-tube decompression is required. The smaller size of the tube and its softer material decrease the discomfort and gagging associated with the use of conventional nasogastric tubes. We believe that these advantages offset the lower price of the conventional nasogastric tube. Patients with partial small-bowel obstruction secondary to adhesive disease will usually undergo a trial of nonoperative management; those with a history of inflammatory bowel disease, radiation injury, or history of malignancy will usually require additional diagnostic evaluation (44). Emergency physicians and surgeons can prevent the unnecessary discomfort and complications secondary to multiple transnasal intubations and optimize the radiologic examination and nonsurgical treatment of patients with small-bowel obstruction. Active collaboration between radiologists, emergency physicians, and general surgeons is necessary to optimize the diagnostic evaluation and management of this common and potentially dangerous problem.

References

8. Bender GN, Maglinte DDT, Kloppel VR, Timmons JH. CT enteroclysis: is it another superfluous diagnostic procedure or does it have a role in the investigation of


