Volvulus of the Gastrointestinal Tract: Appearances at Multimodality Imaging

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Volvulus of the gastrointestinal tract, a clinically relevant cause of acute or recurring abdominal pain in adults, remains a diagnostic dilemma for radiologists in a large number of cases. The clinical symptoms associated with volvulus are often nonspecific and include pain and nausea with vomiting. Yet referring clinicians often rely on radiologists to make the diagnosis; volvulus is rarely diagnosed clinically. Radiography, fluoroscopy, and computed tomography are the imaging methods most often used for this purpose. Prompt diagnosis is critical to avoid life-threatening complications such as bowel ischemia and infarction. Thus, it is useful for radiologists to be familiar with the various appearances of volvulus throughout the gastrointestinal tract.

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Introduction

Volvulus of the gastrointestinal tract, a clinically relevant cause of acute or recurring abdominal pain in adults, often poses a diagnostic dilemma for radiologists. The clinical symptoms associated with volvulus commonly are nonspecific and include pain, nausea, and vomiting. Because it is rarely diagnosed clinically, clinicians often consult radiologists for diagnostic evaluations; radiography, fluoroscopy, and computed tomography (CT) are the modalities most frequently employed. Prompt diagnosis is critical to avoid life-threatening complications of prolonged volvulus such as bowel ischemia and infarction. This article highlights the different clinical features and common imaging findings of volvulus throughout the gastrointestinal tract.

Gastric Volvulus

The stomach is a relatively uncommon site of volvulus. Patients with acute gastric volvulus typically present with epigastric pain, nausea, and vomiting. A useful clinical triad for identifying gastric volvulus, the Borchardt triad consists of sudden epigastric pain, intractable retching, and inability to pass a nasogastric tube into the stomach (1).

Gastric volvulus is usually divided into two main subtypes: organoaxial and mesenteroaxial. Organoaxial volvulus is far more common than mesenteroaxial volvulus and accounts for approximately two-thirds of cases of gastric volvulus. Both are surgical emergencies and warrant prompt diagnosis and treatment.

Organoaxial volvulus occurs when the stomach rotates along its long axis and becomes obstructed, with the greater curvature being displaced superiorly and the lesser curvature located more caudally in the abdomen (1–3). The antrum rotates anterosuperiorly, and the fundus rotates posteroinferiorly. In adults, organoaxial volvulus most commonly occurs in the setting of a post-traumatic or paraesophageal hernia that allows the stomach to move abnormally along its long axis (4). If the volvulus is severe or complete—meaning that the twist is greater than 180°—gastric outlet obstruction occurs, and the stomach becomes dilated and fills with fluid. If positive oral contrast material is administered, it is retained in the stomach. However, many patients have a less severe, incomplete or partial volvulus—a rotation of less than 180°. In these cases, ingested contrast material may pass through the stomach and into the duodenum. Patients with a redundant paraesophageal hernia are predisposed to developing a secondary rotation of the stomach along its long axis. These patients usually lack clinical symptoms of obstruction and exhibit no evidence of obstruction at imaging. In such cases, it is more accurate to describe the stomach as having an organoaxial position rather than an organoaxial volvulus, although an organoaxial position of the stomach predisposes it to future volvulus. It is unclear whether asymptomatic patients should be treated or followed up clinically. In general, the acuity and severity of symptoms dictate management. In children, a large Bochdalek hernia is a predisposing factor for gastric volvulus (Fig 1) (4).
gastric volvulus, with both organoaxial and mesenteroaxial components. Radiographic findings of gastric volvulus include herniation of a large portion of the stomach above the diaphragm, often with differential air-fluid levels (5). An upper gastrointestinal (GI) series may be performed to evaluate the rotation of the stomach, as well as to detect passage of ingested oral contrast material into the duodenum. Multi-detector row CT often is performed in the setting of epigastric pain and vomiting and can help confirm the rotation of the herniated stomach and the transition point (Figs 3–5).

If a diagnosis is made and surgical repair is performed soon after the onset of symptoms, gastric ischemia usually can be avoided. However, if there is a delay in patient presentation, diagnosis, or intervention, gastric ischemia may result,
Figure 6. Perforated gastric volvulus in a 73-year-old man with abdominal pain. Scout radiograph (a) and coronal CT image (b) show gastric distention and pneumoperitoneum (arrows in a) due to a perforated gastric volvulus, the presence of which was confirmed at surgery. Perforation of a gastric volvulus is an uncommon complication that results from gastric ischemia. GC = greater curvature, LC = lesser curvature.

Figure 7. Midgut volvulus in an infant. (a) Upper GI image shows that the small bowel lies in the right side of the abdomen and does not cross the midline. (b) Lateral upper GI image shows the typical twisting corkscrew-like appearance of a volvulus of the proximal jejunum. (c) Lateral upper GI image obtained in a different patient also shows the classic corkscrew-like appearance.
which can lead to necrosis, perforation, mediastinitis, and peritonitis (Fig 6).

**Midgut Volvulus**

Midgut volvulus is a different clinical entity and is most common in children; 60%–80% of those affected present with bilious vomiting in the 1st month of life (6). However, as the use of CT in emergency departments increases, midgut volvulus is increasingly being recognized in adults.

Malrotation of the small bowel is the major predisposing factor for midgut volvulus. In a malrotation, there is abnormal fixation of the small bowel mesentery, which results in an abnormally short mesenteric root. This allows the small bowel to twist around its mesentery, causing obstruction and possibly ischemia of the bowel. Midgut volvulus often occurs early in life, and in such cases surgery is performed to repair the malrotation. However, volvulus also may occur in adulthood, and in some cases may manifest as chronic intermittent abdominal pain that resolves when the volvulus spontaneously reduces. If it does not spontaneously reduce, patients at any age may present with abdominal pain, nausea, and vomiting (1,7).

Conventional radiography usually yields nonspecific findings and is rarely helpful in making a diagnosis. On the other hand, fluoroscopic upper GI and small-bowel examinations may reveal the characteristic abnormal position of most of the small bowel in the right abdomen and the resultant abnormal location of the ligament of Treitz. These are usually the preferred imaging tests when midgut volvulus is suspected. On upper GI images, the ligament of Treitz normally is located at or to the left of the left L1 pedicle. In patients with malrotation, the ligament of Treitz is abnormally positioned, usually below and to the right of the left L1 pedicle. In the presence of a midgut volvulus, the twisted segment (usually a proximal segment) of small bowel has a characteristic corkscrew-like appearance on fluoroscopic images (Fig 7) (6).

Ultrasonography (US) is sometimes helpful in that an abnormal positional relationship between the superior mesenteric vein and artery may be appreciated, with the vein located to the left of the artery, which is the opposite of its usual orientation (6,8). However, US does not directly show the abnormal position of the bowel and is rarely used in this clinical setting.

Familiarity with the CT findings of midgut volvulus is important, because many patients present with nonspecific symptoms and are first evaluated with cross-sectional imaging. At CT, a swirling of vessels in the mesenteric root may be seen at the site of the volvulus (6,7,9). The abnormal relationship between the superior mesenteric artery and vein, an ectopic location of the majority of small bowel loops, and an abnormal position of the ligament of Treitz (which was described earlier) also may be seen (Fig 8).
Figure 9. Cecal volvulus in a 74-year-old woman with abdominal pain. Radiograph shows dilated air-filled cecum (arrow) in the left upper quadrant.

Figure 10. Cecal volvulus in an elderly woman with abdominal pain. (a) Coronal reformatted CT image shows dilated cecum (arrow) in the left upper quadrant of the abdomen. The cecum is displacing the contrast material–filled stomach superiorly, and there is obstruction of the small bowel. (b) Axial CT image shows that the dilated cecal loop (arrow) has twisted on its mesentery and is located ectopically in the upper abdomen.

Colonic Volvulus

Cecum
Cecal volvulus accounts for 25%–40% of all cases of colonic volvulus. Congenital anomalies of colonic fixation usually are present and include an abnormal fixation of the right colon to the retroperitoneum and abnormal motility of the right colon. Factors that result in dilatation of the right colon, such as pregnancy and recent colonoscopy, are less common and also may predispose patients to cecal volvulus (1,10).

As opposed to volvulus in other locations, colonic volvulus often has a characteristic appearance at conventional radiography, which may be sufficient for a diagnosis in a large percentage of patients. A dilated gas-filled viscus, usually located ectopically in the left upper quadrant or mid abdomen, is a radiographic feature of cecal volvulus. However, it is important to recognize that the cecum may be displaced anywhere in the abdomen (11). Proximal obstruction may or may
Figure 11. Cecal volvulus. Contrast-enhanced CT image shows dilated, fluid- and gas-filled cecum at the lower midline. Pneumatosis of the cecum (arrows) also is seen. The diagnosis was confirmed at exploratory surgery.

Figure 12. Cecal volvulus in an elderly patient with abdominal cramps. (a) CT image shows dilated fluid-filled cecum in the lower abdomen. The proximal small bowel also is dilated. (b) Image acquired in a contrast material enema study shows the classic beaklike appearance of the bowel at the twist (arrow).

not be present, depending on the acuity of the volvulus (Figs 9, 10) (1).

A diagnosis of cecal volvulus often is confirmed with a contrast material enema study or CT. During the enema, the distal colon usually is decompressed, and there is a beaklike tapering at the level of the volvulus. It usually is not possible for much contrast material to pass beyond the volvulus into the more dilated proximal colon and terminal ileum. For patients in whom cecal volvulus is suspected on the basis of radiographic findings, a contrast material enema study may help confirm the diagnosis. However, given the widespread availability of CT and the relative speed with which it can be performed compared with that of the enema study, most patients with suspected cecal volvulus proceed to CT if further imaging is required. At CT, the abnormally positioned cecum often appears in the upper mid and left abdomen and can be traced back to the level of the volvulus, which appears as an area of swirling of the bowel and its mesentery, a finding also known as the “whirl” sign (Figs 11–16) (12).

Cecal bascule, first described in the early 1900s, refers to abnormal location of the dilated cecum in the mid abdomen and results from upward folding of the cecum on itself, without associated twisting. Cecal bascule occurs when the cecum is loosely attached to its mesentery. Some
Figure 13. Cecal volvulus. (a) Topographic CT image shows a dilated air-filled viscus in the midline (arrow) and a small-bowel obstruction. (b) Contrast-enhanced CT image shows displacement of the dilated fluid-filled cecum in the right upper quadrant (arrow), with resultant small-bowel obstruction.

Figure 14. The whirl sign of cecal volvulus. (a) Contrast-enhanced CT image shows a dilated, stool-filled cecum in the left upper quadrant of the abdomen (arrow). (b) Contrast-enhanced CT image shows that the twist involves the ileum, which lies in the right lower quadrant (arrow). Note the whorled appearance of the mesenteric vessels within the twist. Mesenteric stranding and edema also are seen.

Figure 15. Infarcted cecal volvulus in a 20-year-old woman. Contrast-enhanced CT image shows a dilated cecum located high in the midline. Note the ring of gas in the cecal wall (arrows), a finding suggestive of pneumatosis. The diagnosis of an infarcted cecal volvulus was confirmed at exploratory surgery.
have argued that cecal bascule is a form of cecal adynamic ileus that may lead to perforation, depending on duration of symptoms (13).

Transverse Colon
The transverse colon is the rarest site of colonic volvulus (<5%–10% of cases), but it is associated with the highest mortality. It occurs in the setting of abnormal fixation of a long transverse colon. Conventional radiography is seldom helpful in diagnosing this entity. As in cases of cecal volvulus, a contrast material enema study shows the characteristic beaklike tapering of the colon at the level of the twist. However, because volvulus of the transverse colon is rare and not usually expected, the diagnosis is often made at CT, which shows bowel obstruction and the classic mesenteric twist (Fig 17).

Figure 16. Cecal volvulus. Axial (a) and coronal (b) reformatted CT images show the distended cecum in the left upper quadrant of the abdomen (* in a). The mesenteric twist, which in this case involves the terminal ileum, is most easily seen within the circled area in b.

Figure 17. Transverse colon volvulus in a 57-year-old woman with a 7-year history of intermittent abdominal pain and a 30-year history of laxative use. (a, b) CT images (b is slightly more caudal than a) show a whirl sign adjacent to the transverse colon (arrow). (c) Image acquired during an enema shows classic beaklike narrowing of the transverse colon at the volvulus (arrow).
Sigmoid Colon

The sigmoid is the most common site of colonic volvulus and accounts for 60%–75% of all cases of colonic volvulus. It is generally considered to be an acquired condition because its prevalence increases among those with chronic constipation and sigmoid colonic redundancy due to a high-fiber diet, pregnancy, hospitalization or institutionalization, or Chagas disease (1,10,14). In developed countries, sigmoid volvulus is a common cause of large-bowel obstruction in the absence of neoplasm and diverticular disease. However, in developing countries, sigmoid volvulus causes a majority of bowel obstructions and is presumably caused by relatively high-fiber diets. It is also the most common cause of bowel obstruction during pregnancy.

Because patients usually present with nonspecific abdominal pain and symptoms of obstruction, conventional radiography often is performed as part of the initial work-up. Radiographic findings that may be diagnostic of sigmoid volvulus include a large air-filled bowel loop, which rep-
Figure 20. Sigmoid volvulus in a 46-year-old woman with abdominal pain. (a) Radiograph shows an air-filled, dilated viscus (arrow) arising from the pelvis. (b) Coronal CT image shows the whirl sign in the sigmoid mesocolon (arrow). A contrast material enema study helped confirm the diagnosis.

Figure 21. Sigmoid volvulus. Coronal CT images obtained with soft-tissue (a) and lung (b) window settings show the whirl sign (arrow in a) and the classic beak sign (arrow in b) at the level of the twist. The diagnosis was confirmed at endoscopy.

represents the sigmoid colon, arising from the pelvis and extending cranially beyond the level of the transverse colon (the “northern exposure” sign) (Figs 18–23) (10,15). Other useful radiographic features include the “coffee bean” sign, which refers to the coffee bean–like shape that the dilated sigmoid colon may assume (10,16). Similarly, the “closed-loop” and “three-line” or “white-stripe”
Figure 22. Sigmoid volvulus. (a) Radiograph shows a dilated sigmoid colon arising from the pelvis, with its apex in the right upper quadrant of the abdomen (arrow). (b) Coronal CT image shows the characteristic whirl sign at the level of the volvulus (arrow).

Figure 23. Sigmoid volvulus. (a) Radiograph shows a dilated viscus arising from the pelvis and ascending above the transverse colon. (b) CT image shows the site of the twist (arrow).
signs describe the U-shaped closed-loop appearance of the colon, which is dilated between the two points of obstruction at the site of the volvulus; and the obliquely oriented vertical white lines that represent the opposed walls of the dilated bowel loop (the center line) and the outer walls of the bowel loop on either side (11,17).

In cases in which the diagnosis is uncertain, a water-soluble contrast material enema study or CT may be performed. In an enema study, a beak-shaped area often is seen at the level of the distal aspect of the twist in the sigmoid, beyond which no contrast material passes. In addition to providing diagnostic information, the enema may help achieve reduction of the volvulus. At CT, the abnormal position of the sigmoid colon and swirling of the mesentery at the level of the volvulus are visible. As with cases of volvulus involving other sites in the GI tract, coronal and sagittal reformations may be useful for locating the mesenteric swirl and evaluating the orientation of the rotated bowel segment.

Summary
Volvulus may involve any portion of the GI tract from the stomach to the colon and is an important cause of acute or recurring abdominal pain. Because a delay in diagnosis can have devastating consequences, including bowel ischemia and infarction, prompt diagnosis is essential. The clinical symptoms of volvulus often are nonspecific, and radiologists often are consulted for diagnostic evaluations. This article describes the various radiologic imaging appearances of volvulus throughout the GI tract, emphasizing strategies for achieving an accurate diagnosis.

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