Current Problems in Diagnostic Radiology 48 (2019) 75–96

Current Problems in Diagnostic Radiology

journal homepage: www.cpdrjournal.com

Computed Tomography Imaging of Non-Neoplastic and Neoplastic Benign Gastric Disease

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Gastric disease is a common finding in patients imaged in the emergency department, with radiologists encountering more and more benign gastric disease on CT. In this case based review, we discuss CT appearance of various benign gastric pathology including self-limiting conditions such as gastritis, different benign gastric neoplasms, as well as life threatening disorders such as perforation, obstruction, and hemorrhage.

Introduction

Ease of access and speed have established computed tomography (CT) as the study of choice for evaluating potential gastric disease in patients, especially in the emergency department compared to upper endoscopy, which is invasive, less readily available and more resource intensive.[1] For dedicated gastric imaging, water is used as an oral contrast agent. Water is well-tolerated and results in good gastric distention as well as excellent visualization of the enhancing gastric wall.[2]

In this case-based review, we will discuss CT imaging features of a variety of gastric disease with focus on benign neoplastic and non-neoplastic pathology.

Discussion

Inflammation

Inflammatory conditions of the stomach that can be diagnosed on CT range from gastritis and Menetrier's disease to peptic ulcer disease.

Gastritis includes a broad spectrum of entities that induce inflammation in the gastric mucosa. The integrity of the gastric mucosa is maintained by a variety of aggressive and defensive factors, the imbalance of which is considered the mechanism of injury. Although there are numerous etiologies of gastritis including infection, Crohn disease, alcohol abuse, and steroids, nonsteroidal anti-inflammatory drugs (NSAIDs) are thought to account for 50% of cases. On CT, the most common site of involvement is the antrum (Fig 1). Often the proximal half of the stomach or even the entire stomach can be involved. Thickened folds of the gastric wall, though nonspecific, are the best CT sign of gastritis.[3] The combination of mucosal hyperemia with submucosal edema results in the CT appearance described as mural stratification, which is most pronounced at arterial phase imaging.[1] At times, the inflammation can lead to circumferential wall thickening or a polypoid or lobulated morphology, which can be difficult to distinguish from malignancy, requiring biopsy for confirmation.[4]

Gastric or peptic ulcer disease (PUD) is thought to occur in approximately 10% of the adult population in the western world, most commonly from NSAIDs, *Helicobacter pylori* infection and cigarette smoking.[5] Uncomplicated peptic ulcer disease was initially though to be CT occult.[6] However, the advent of multidetector computed tomography with higher spatial and temporal resolution has improved detection of uncomplicated PUD. Disruption of the normal mucosal enhancement or focal luminal outpouching are reliable direct signs on CT (Fig 2). Low attenuation wall thickening, mucosal hyperenhancement and gastric fold thickening, though nonspecific findings, have been described with uncomplicated PUD. Among the complications of gastric ulcers, bleeding is most common with the left gastric artery along the lesser curvature frequently implicated as the bleeding source (Fig 3A and B). CT angiography plays an important role in initial diagnostic evaluation. Intraluminal contrast extravasation helps confirm and localize the site of bleeding prior tobefore intervention with angiography, endoscopy, or surgery (Fig 3C and D). CT has the added advantage of detecting extraluminal pathology that may be contributing to the gastric bleeding that cannot be seen with other tests like endoscopy.[7]

Perforation is potentially life threatening and necessitates prompt management. Presence of oral contrast outside the gastric lumen and pneumoperitoneum are telling signs of perforation (Fig 4) but may be absent in rare cases. The presence of extraluminal fluid, which may or may not communicate with the gastric lumen aids in the diagnosis in such scenarios.[7]

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https://doi.org/10.1067/j.cpradiol.2017.12.004
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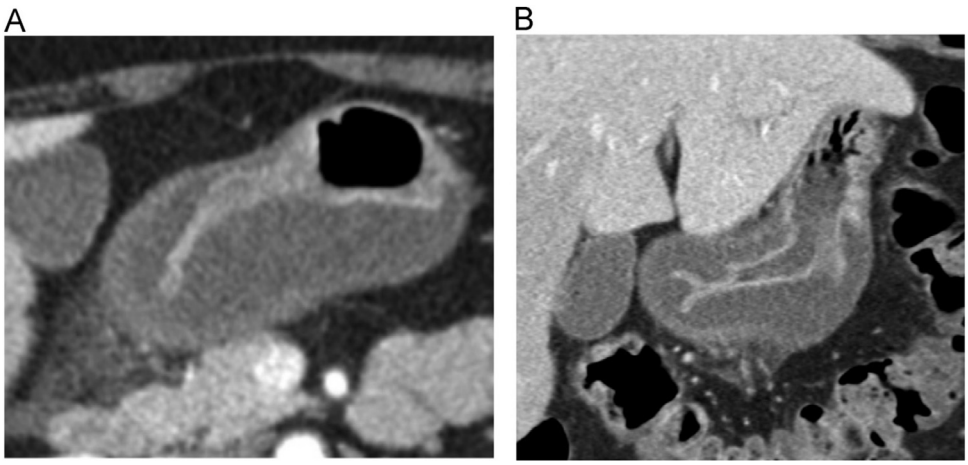

FIG 1. *Gastritis*. Axial (A) and coronal (B) CT images of the stomach demonstrates marked wall thickening involving distal body and antrum of the stomach. Note the mucosal hyperenhancement and submucosal hypoattenuation giving the mural stratification appearance.

Patients with ulcerous penetration without perforation usually have inflammatory changes in the surrounding fat and soft tissues including the liver (Fig 5) and pancreas.[6,7]

Benign fistula formation due to progressive gastric ulcer disease has become a rare occurrence due to advancement in the medical management of gastric ulcer disease. Gastrocolic fistula can occur with injudicious use of NSAIDS[8] and can be seen on CT as a tract communicating between the stomach and colon with opacification by oral or rectally administered contrast before the scan (Fig 6A). An enema or upper gastrointestinal (GI) fluoroscopic examination usually confirms the diagnosis (Fig 6B). Gastric ulcers can also rarely fistulize to the pericardium[9] (Fig 6C).

Zollinger-Ellison syndrome (ZES) is caused by a gastrin-secreting tumor leading to hypersecretion of gastric acid and often presents as a severe form of peptic ulcer disease. Almost 20%-60% cases are associated with multiple endocrine neoplasia type 1 (MEN1).[10] CT findings include markedly thickened rugal folds in addition to thickened folds in the esophagus, duodenum and jejunum (Fig 7). Multiple ulcers, particularly in the duodenum, a hypervascular pancreaticoduodenal tumor and potential liver metastases may be seen.[11]

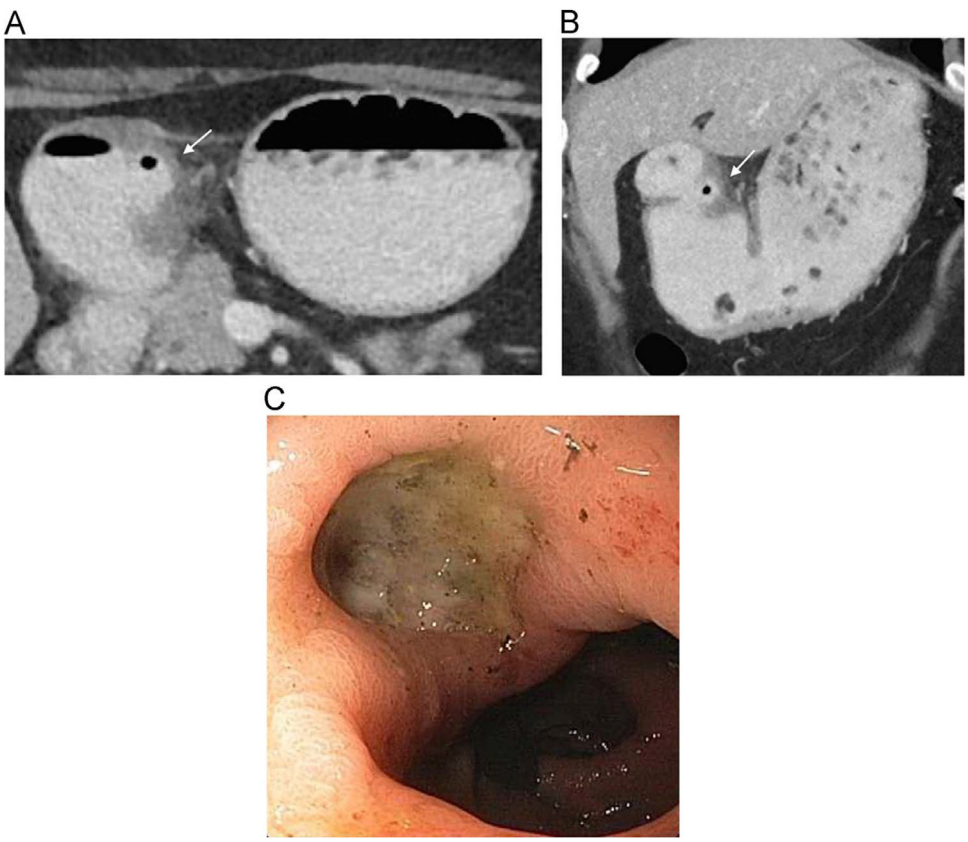

FIG 2. *Uncomplicated gastric ulcer*. Axial (A) and coronal (B) CT images of the stomach show a pre-pyloric ulcer confirmed at endoscopy (C).

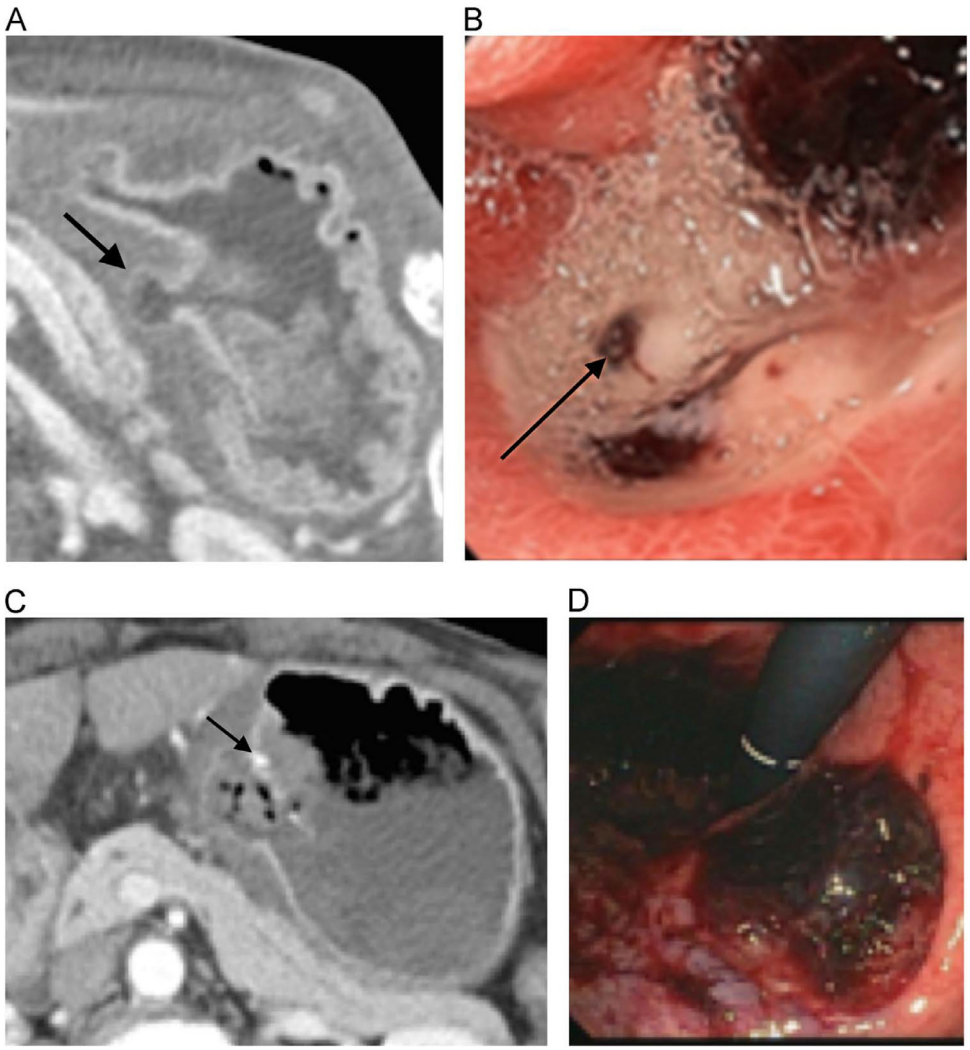

FIG 3. *Gastrointestinal bleeding.* Axial CT images (A) show high attenuating material in the gastric fundus and in close association with a lesser curvature ulcer. Subsequent endoscopy (B) shows a gastric ulcer (arrow) with clotted blood and stigmata of recent bleeding which was treated with epinephrine injection. Axial (C) CT images in a different patient show high attenuating material in the gastric fundus and a lesser curvature ulcer with active contrast extravasation (arrow) consistent with active arterial bleeding. Upper endoscopy (D) shows a large nonbleeding cratered ulcer with adherent clot, which was injected with epinephrine.

Menetrier's disease, also known as hypoproteinemic hypertrophic gastropathy, is a rare condition characterized by massive foveolar hyperplasia in the stomach resulting in large gastric folds. It commonly presents with hypochlorhydria and hypoproteinemia.[12] On CT, diffusely enlarged rugal folds (Fig 8) primarily involve the gastric fundus and body with relative sparing of the antrum.[13]

Crohn's disease can involve any segment of the GI tract from the mouth to the anus. Approximately 0.5%-4% patients with *Crohn's disease* have clinically significant gastroduodenal disease, mostly with concomitant transmural disease involving small or large bowel.[14] On CT, the stomach usually appears thick walled with hypertrophied gastric rugae and mucosal ulcerations (Fig 9). Pyloric deformities and even fibrotic pyloric strictures can be seen causing gastric outlet obstruction. Gastric perforation and gastrocolic fistula are rare complications.

Gastric abscess also called phlegmonous or suppurative gastritis is a rare condition, which is characterized by a purulent inflammatory process involving the gastric wall. It can be diffuse, focal, or both. Pathogenesis is thought be either direct seeding of the gastric wall with bacteria secondary to a breach in the gastric mucosa or via hematogenous spread from a distant source of infection.[15] Predisposing conditions amongst many include alcoholism, foreign body or corrosive ingestion, recent gastric surgery, chronic peptic ulcer, gastric cancer, and human immunodeficiency virus.[16] On CT, the abscess will appear as an area of low attenuation with surrounding rim enhancement and associated inflammatory changes such as fat stranding and free fluid (Fig 10).

Vascular Conditions

Gastric varices are the most common cause of upper GI bleeding in cirrhotic patients. In patients without chronic liver disease, primary vascular etiologies are rare but recognized causes of upper GI bleeding. Recurrent unexplained GI bleeding should raise suspicion for vascular pathology.

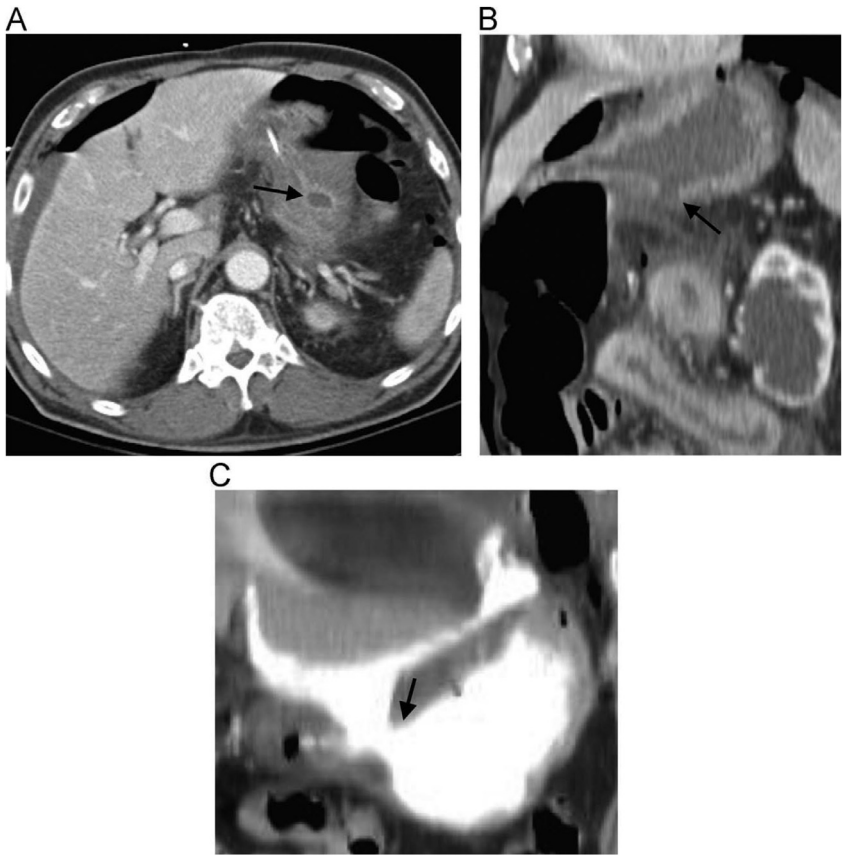

FIG 4. *Perforated gastric ulcer*. Axial (A) and sagittal (B) CT images show a defect along the inferior wall of the stomach (arrow) with free intraperitoneal air and ascites, findings that were confirmed at surgery. Coronal CT in a different patient (C) with oral contrast seen passing through a defect representing the site of perforation along the lesser curvature of the stomach and opacifying the lesser sac.

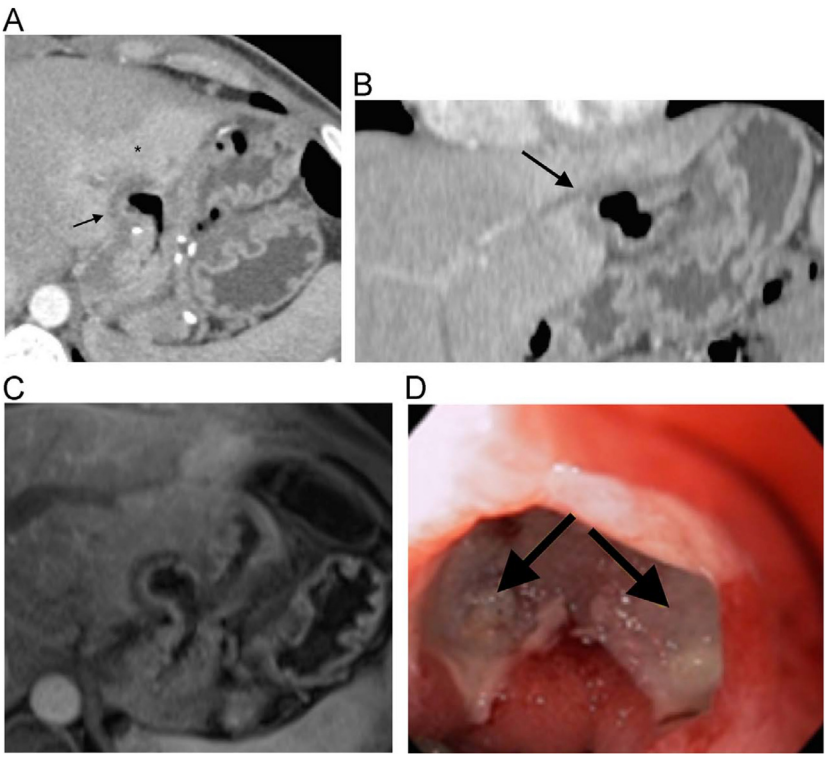

FIG 5. *Penetrating gastric ulcer*. Axial (A) and Coronal (B) CT and Axial T1 postcontrast MR (C) images show a gastric ulcer at the anastomotic line in a patient status post gastric bypass surgery with transient hepatic attenuation difference from a thrombosed left posterior portal vein branch (arrow). Upper endoscopy (D) confirms 2 gastric ulcers at the surgical anastomosis (arrows).

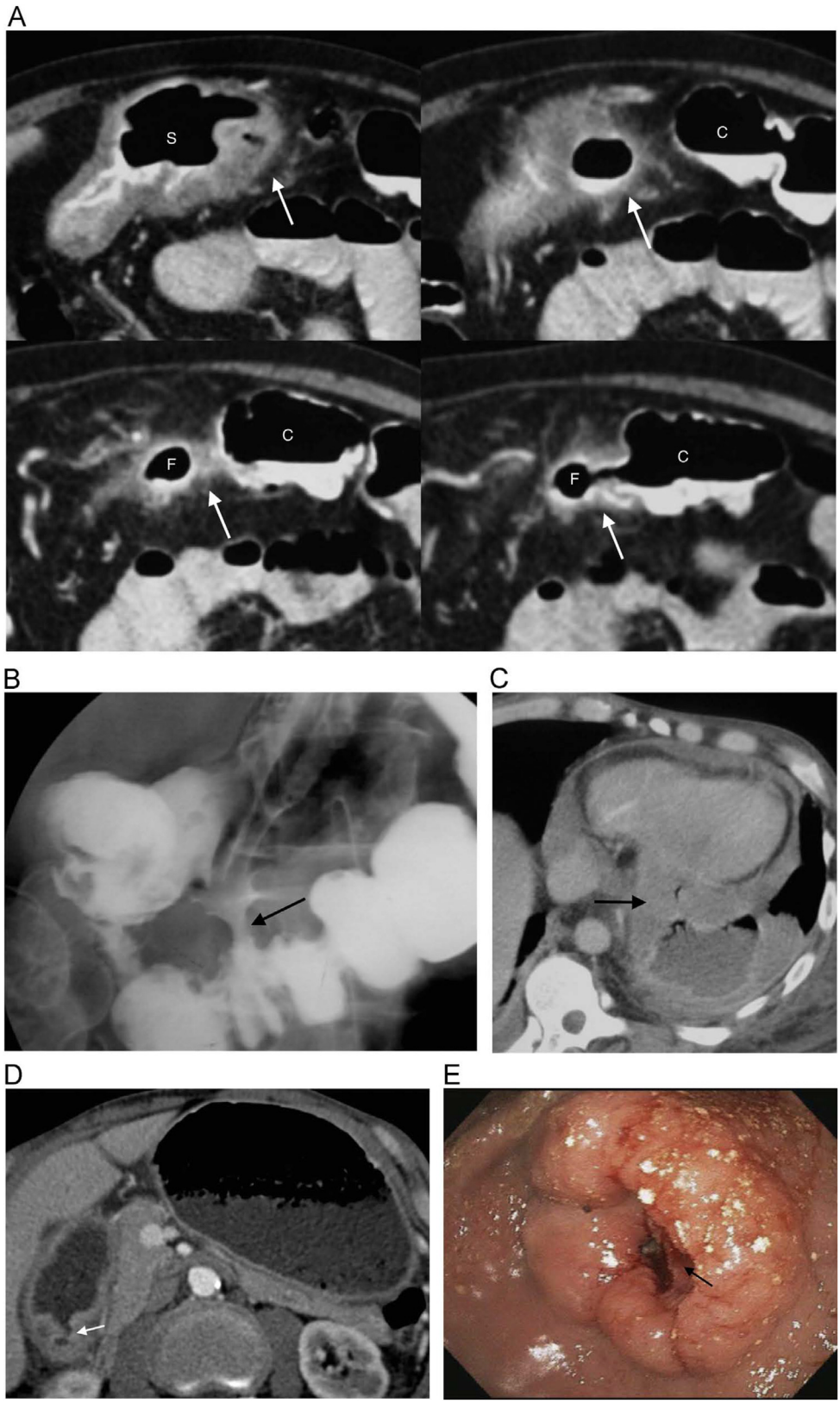

FIG 6. *Gastrocolic fistula.* Axial CT images (A) reveal a gastric ulcer along the inferior aspect of the greater curvature of the stomach (labeled S) with a fistula (labeled F-arrows) to the transverse colon (labeled C). Hypaque enema (B) confirms the presence of a gastrocolic fistula (arrow) with filling of the stomach. (C) *Gastropericardial fistula.* Axial CT image (C) shows a fistula (arrow) between the stomach and the pericardial sac, which is filled with blood in this patient with a hiatus hernia.

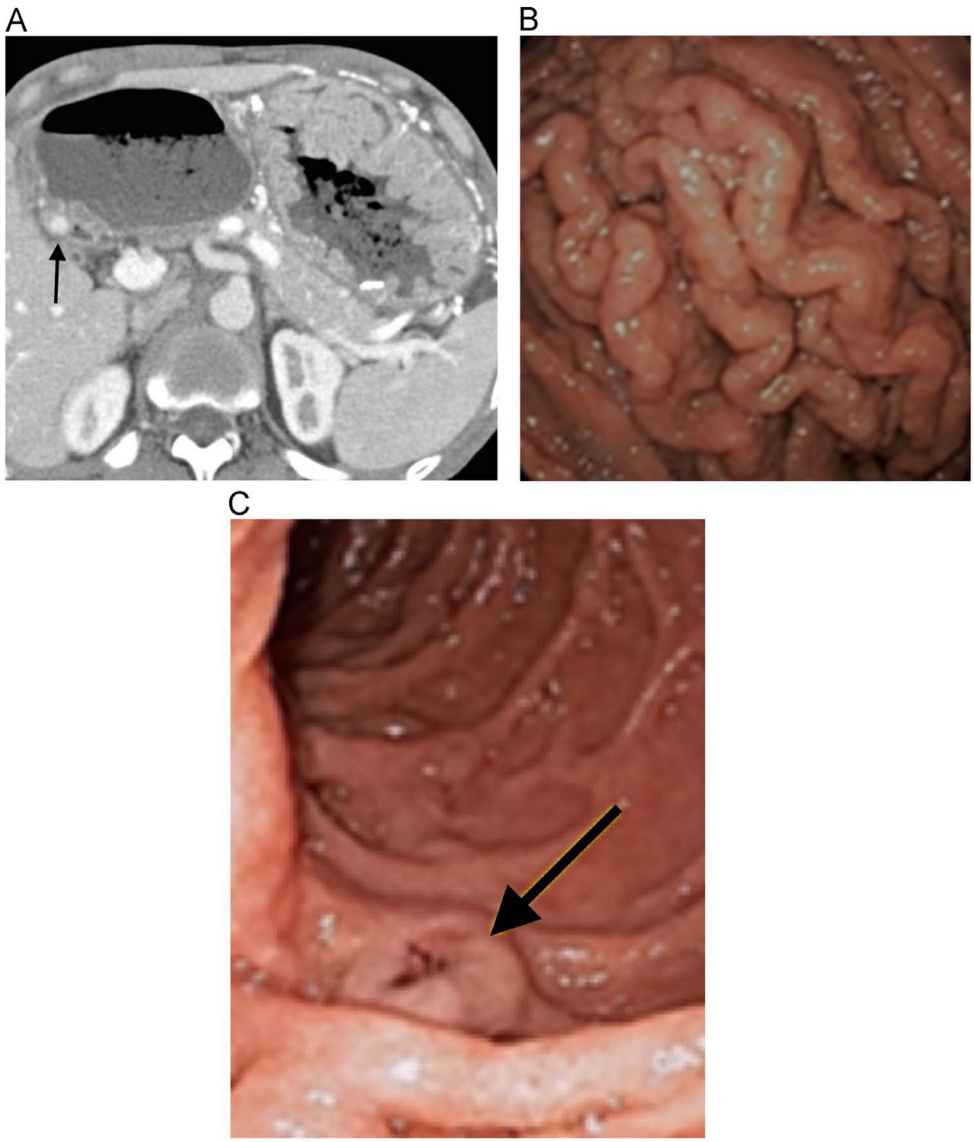

FIG 7. *Zollinger-Ellison syndrome*. Axial (A) and CT image shows markedly thickened gastric folds and a small hypervascular mass in the duodenal wall (arrow). Upper endoscopy (B and C) confirms diffuse gastric fold thickening as well as the duodenal mass (arrow) found to be a gastrinoma at surgery.

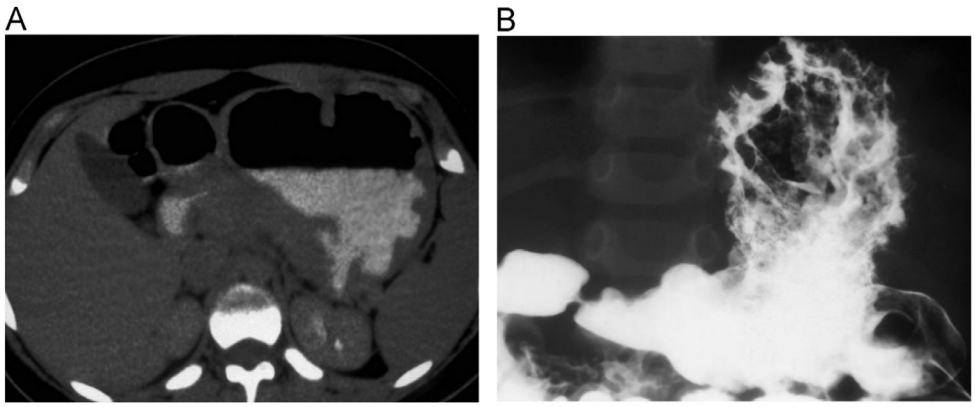

FIG 8. *Menetrier's disease*. Axial CT (A) and upper GI exam (B) demonstrate, thickened gastric folds in the gastric fundus and body with relative sparing of the gastric antrum, typical of Menetrier's disease.

FIG 9. Gastric Crohn's disease complicated by perforation. Axial CT image shows transmural inflammation suggested by marked gastric wall thickening with small volume perigastric fluid indicating perforation.

Gastric varices develop when there is flow reversal in the gastric fundal venous plexus. Portal hypertension is a progressive complication of hepatic cirrhosis and leads to 5%-33% of the patients developing gastric varices (Fig 11A and B). Splenic vein thrombosis secondary to pancreatitis can also cause localized portal hypertension leading to the development of gastric varices that drain via gastric veins (Fig 11C-E).[17] Although bleeding is a less frequent complication with gastric compared to esophageal varices, it is more severe and confers a higher mortality rate, due to the larger size and higher flow velocities of gastric varices.[18] On CT, gastric varices manifest as multiple dilated tubular contrast filled vessels coursing along the lesser curvature of the stomach, and in most cases contiguous with esophageal varices. In addition, CT can demonstrate communications of the varices, such as afferent and efferent veins, and other collateral vessels.[19]

Gastric arteriovenous malformation (AVM) is one of the rare etiologies that can lead to life-threatening upper gastrointestinal hemorrhage. AVMs are congenital high flow vascular lesions with abnormal communication between the arteries and veins. Sporadic gastric AVMs though scarce in the general population, have been commonly described in patients with Osler-Weber-Rendu disease (hereditary hemorrhagic telangiectasia). Although endoscopy is the study of choice for diagnosis, its been observed that for cases that are difficult to detect on upper endoscopy, CT angiography or a conventional celiac trunk angiogram prove highly useful.[20] On CT, the AVM appears as a tangle of vessels along the gastric wall with early opacification of the associated draining veins in the arterial phase (Fig 12). The AVM can recruit vessels from adjacent organs including the spleen, liver, and pancreas.

Gastric aneurysm or pseudoaneurysm is most commonly seen in the setting of complicated acute or chronic pancreatitis. Other etiologies may include trauma, recent intervention or surgery, or connective tissue disorders, for example, Loey's Dietz syndrome.[21-23] The left gastric artery is commonly involved. When the contrast bolus is timed with the arterial phase, the gastric aneurysm or pseudoaneurysm appears as a well-defined round or oval mass along the gastrohepatic ligament that enhances with the same intensity as the abdominal aorta (Fig 13). Sometimes, the aneurysm may be partially thrombosed and have an eccentric nonenhancing component.

Gastric antral vascular ectasia (GAVE), also called watermelon stomach, is an uncommon but noteworthy cause of upper GI bleeding in the elderly. The pathogenesis is not well-understood but GAVE is associated with a variety of renal, hepatic and cardiac disorders. On endoscopy, the pathognomonic appearance of GAVE is columns of red, tortuous and ectatic vessels in combination with the longitudinal folds of the gastric antrum giving the appearance of watermelon stripes.[24] CT findings include prominent and scalloped antral folds, which radiate to the pylorus. There is associated thickening of the gastric antrum[25] (Fig 14).

Gastric emphysema or gastric pneumatosis occurs secondary to disruption of the gastric mucosa leading to the dissection of air into the gastric wall. Conditions that predispose to gastric emphysema include increased intragastric pressure such as from gastric outlet obstruction, recent instrumentation (eg, postgastroscopy), and severe vomiting, or it may be idiopathic. These patients are usually asymptomatic and the clinical course is benign, with spontaneous resolution after the cause resolves.[26]

In comparison, *emphysematous gastritis* follows the colonization of the stomach wall by pathogenic gas-forming bacteria. It is hypothesized that an earlier gastric mucosal injury allows gas-forming organisms to gain access to deeper tissue layers. Alcohol and other toxic or corrosive agents, trauma, ulcer disease and necrotizing enterocolitis are a few etiologic considerations. Gastric infarction can progress to emphysematous gastritis once the dead mucosa sloughs away, providing a gateway to gas-forming organisms. The most common organisms involved include hemolytic streptococci, *Clostridia welchi*, *Escherichia coli*, and *Staphylococcus aureus*.[27] Patients present with a toxic clinical picture with a high mortality rate reaching 60%-80%.[28]

It is often difficult to differentiate the 2 entities radiologically. In both scenarios, on CT, the stomach is often distended with focal intramural gas or diffuse gas conforming to the stomach contour (Fig. 15 and 16). Other features may include gas in the portal venous system (Fig 15A). Thickened rugal folds when present suggest emphysematous gastritis rather than simple gastric emphysema. Occasionally, penetration of intraluminal contrast can be seen and may indicate the site of a mucosal defect.[29]

Trauma

Penetrating trauma is the most common cause of traumatic injury to the stomach. Identifying the injury tract is crucial in detecting gastric injury on CT as the stomach often deflates around the site of injury. Free intraperitoneal gas, intraluminal hematoma in the stomach, and injuries to surrounding structures like the spleen, left hemiliver and diaphragm should raise suspicion for gastric injury[1] (Fig 17).

Iatrogenic injury from procedures such as adjustable laparoscopic banding for weight control can lead to gastric complications such as band slippage, transmural band erosion, and infection. CT may show free or focal extraluminal gas (Fig 18) or a subphrenic abscess. Oral contrast material or air can be seen outlining the band.[1,30] Inflammatory fat stranding along the port site or tubing tract may indicate infection.[1]

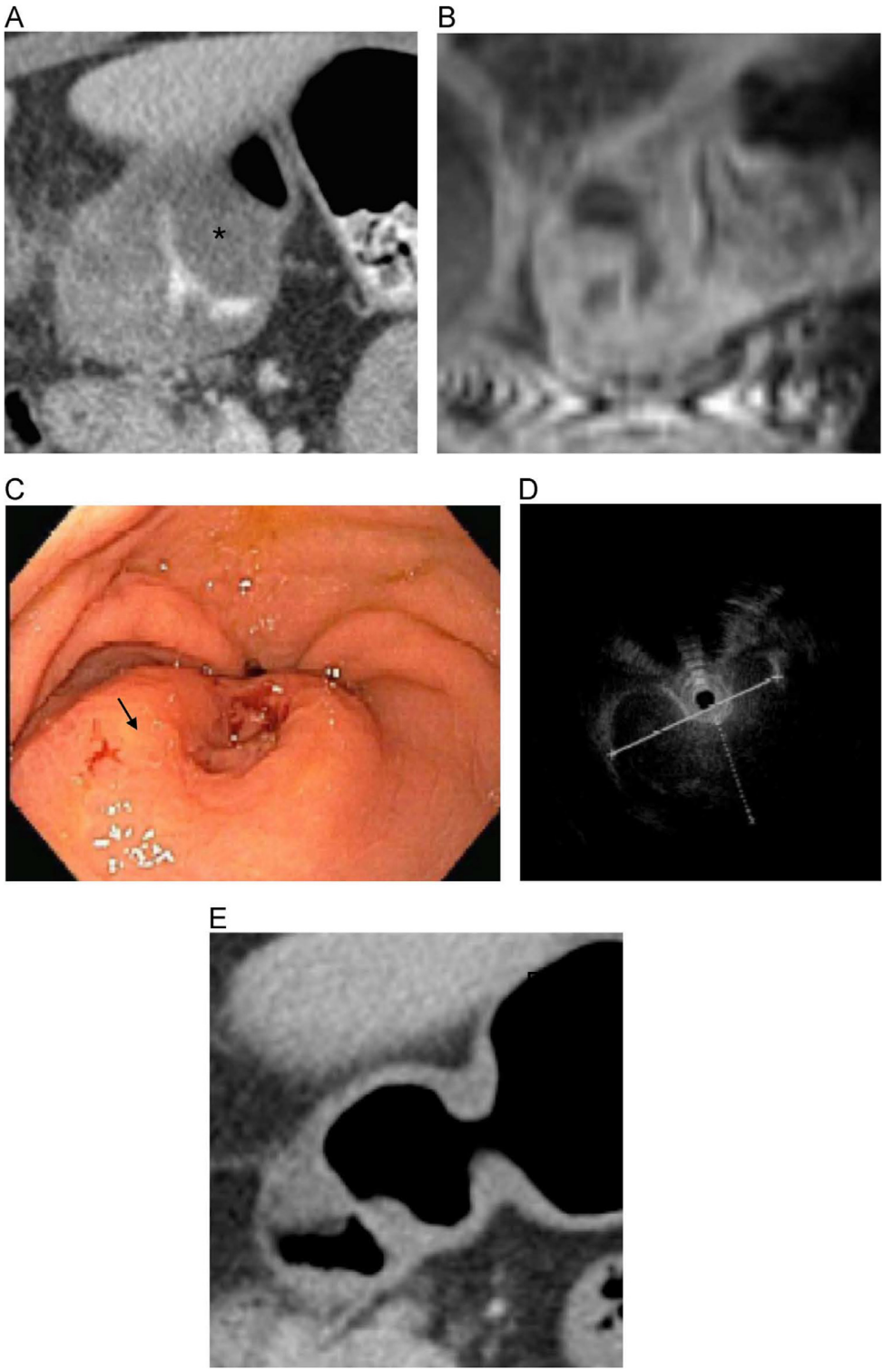

FIG 10. *Intramural gastric abscess* in a 47-year-old woman presenting with epigastric pain, nausea and vomiting. Axial (A) CT images show a region of low attenuation antral wall thickening with mild adjacent fat stranding. Axial MR T1 postcontrast image (B) demonstrates cystic spaces with enhancement of the antrum. Upper endoscopy (C) shows a submucosal, noncircumferential mass, partially obstructing the pyloric canal, which was confirmed to be an abscess on endoscopic ultrasound (D). FNA at the time yielded thick purulent aspirate. Follow up axial CT (E) after appropriate management shows resolution of abscess.

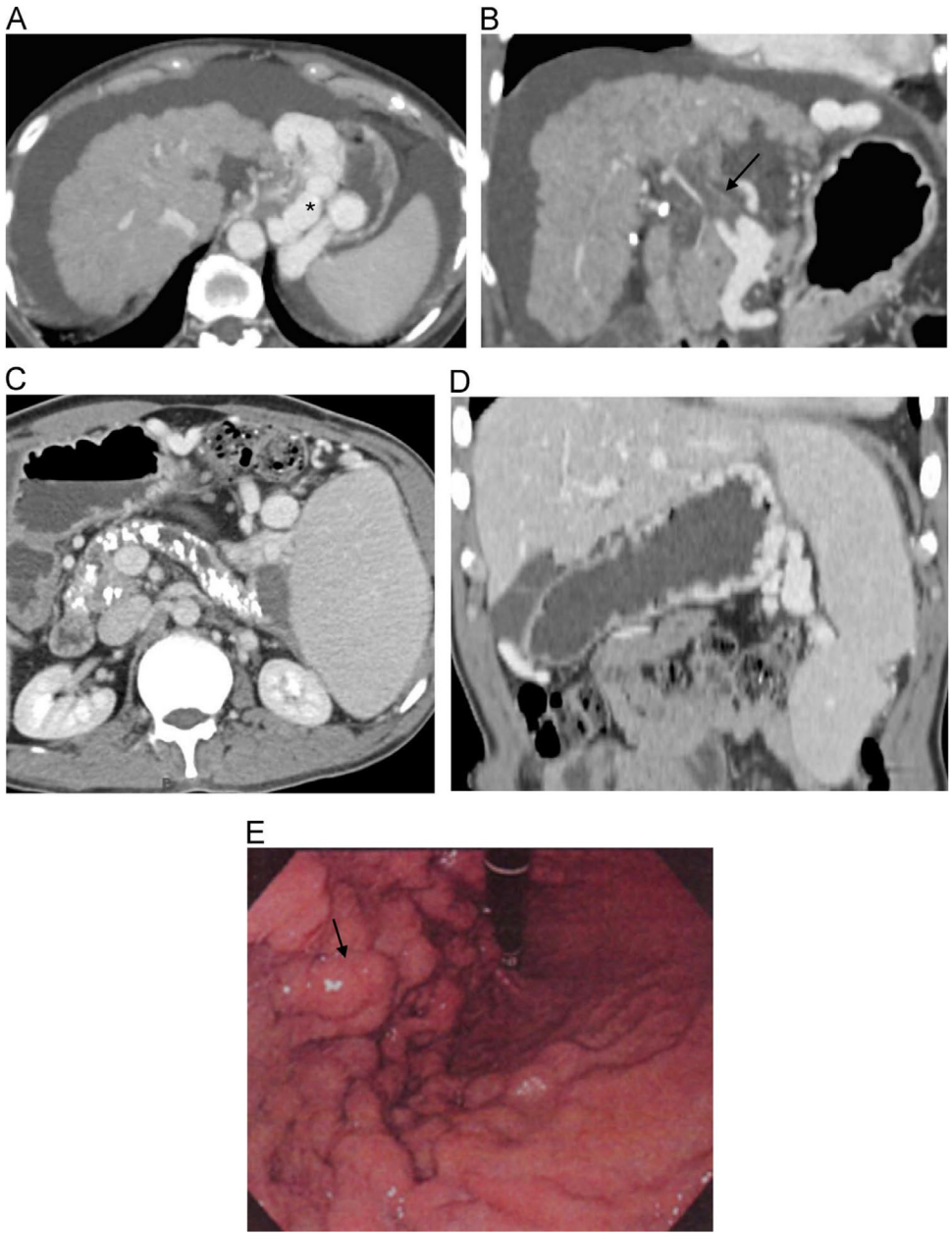

FIG 11. *Gastric varices.* Axial (A) and coronal (B) CT images in this patient with primary biliary cirrhosis show portal vein thrombosis (B, arrow) with resultant massively enlarged gastric varices. Axial (C) and coronal (D) CT images in a different patient with chronic pancreatitis show diffuse calcifications in the pancreas with dilated pancreatic duct and pseudocyst formation in the pancreatic tail. Isolated gastric varices have developed due to splenic vein thrombosis from chronic pancreatitis. Upper endoscopy (E) confirms presence of gastric varices.

Mechanical Conditions

Mechanical conditions involving the stomach usually result in gastric outlet obstruction. Extrinsic and intrinsic masses, intraluminal masses such as bezoars and gallstones and gastric volvulus can all result in obstruction or strangulation with potential life-threatening infarction.

Bezoar is an intraluminal mass consisting of accumulated ingested material. Trichobezoars (Rapunzel syndrome) and phytobezoars are the most frequent forms. Chronic ingestion of hair in psychiatric patients leads to formation of a trichobezoar. A phytobezoar on the other hand is composed of fruit or vegetable matter and commonly seen in patients with decreased gastric motility.[31] On CT, a bezoar has a characteristic appearance as an inhomogeneous mottled appearing mass[1,31] (Fig 19). Bezoars usually come to clinical attention when symptoms of gastric outlet obstruction develop, which is indicated by CT with concomitant gastric distention.

Gallstones may enter the stomach or the duodenum in patients with cholecystoduodenal or cholecystogastric fistulas. Bouveret's

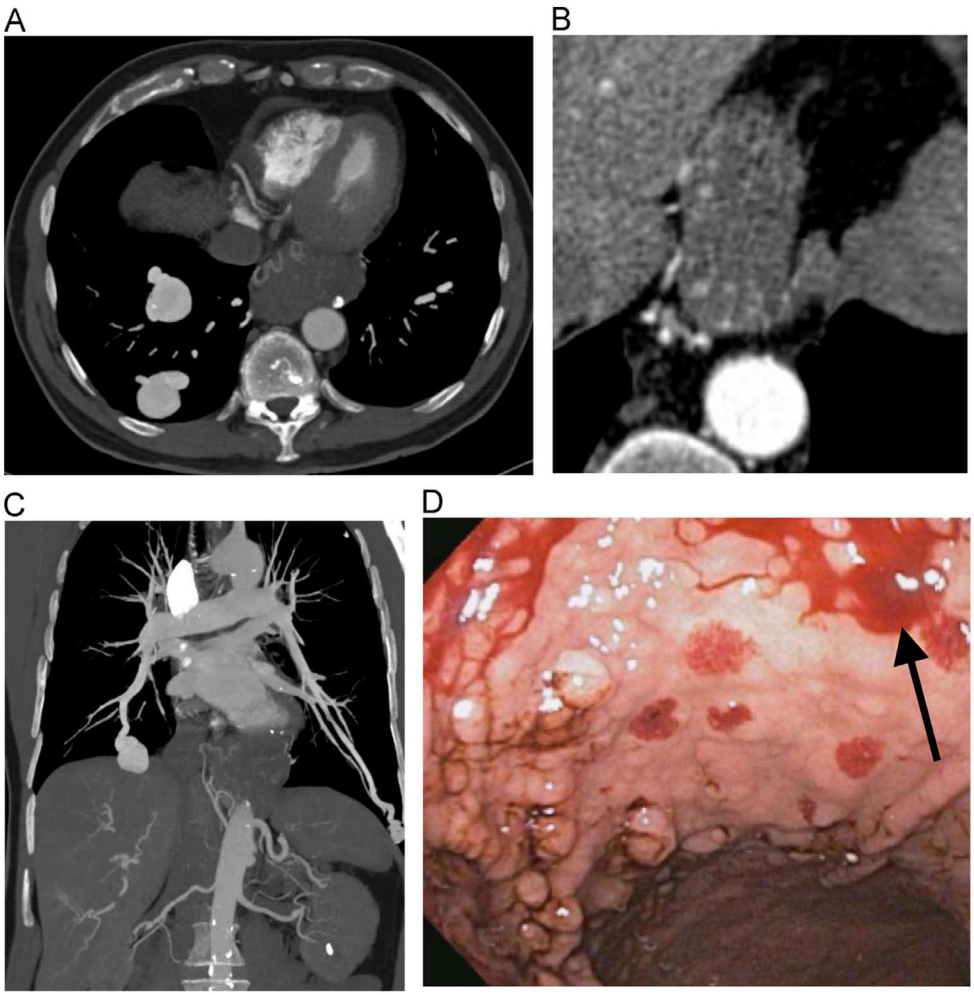

FIG 12. *Gastric arteriovenous malformation*. Axial CT images at the level of the lung bases (A and B) show a hiatal hernia with associated small tangle of vessels along the gastric wall consistent with an arteriovenous malformation in this 69-year-old patient with Osler-Weber-Rendu disease. Coronal maximum intensity projection(C) showing additional pulmonary, hepatic and pancreatic AVMs. Upper endoscopy (D) shows multiple areas of telangiectasia with one actively bleeding (arrow).

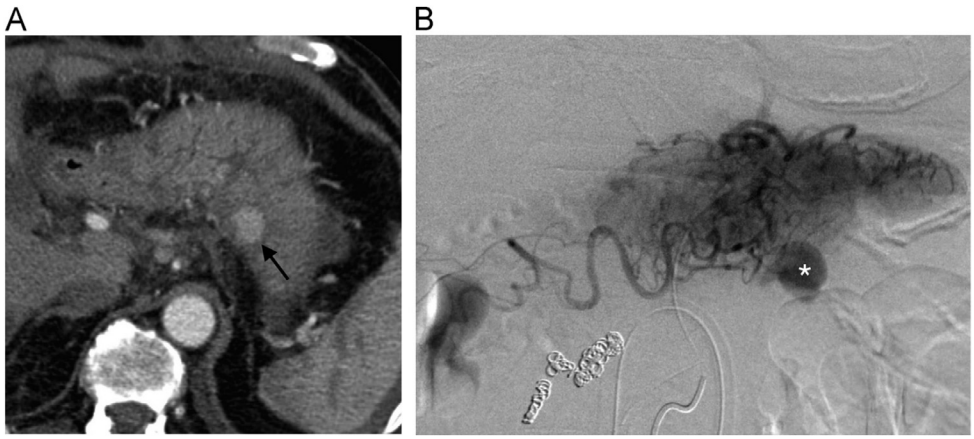

FIG 13. *Left gastric artery pseudoaneurysm*. Axial (A) CT image in a 52-year-old man with alcoholic pancreatitis shows a well-circumscribed area of arterial enhancement along the lesser curvature of the stomach (arrow). Superselective angiogram with digital subtraction (B) confirms a left gastric artery pseudoaneurysm.

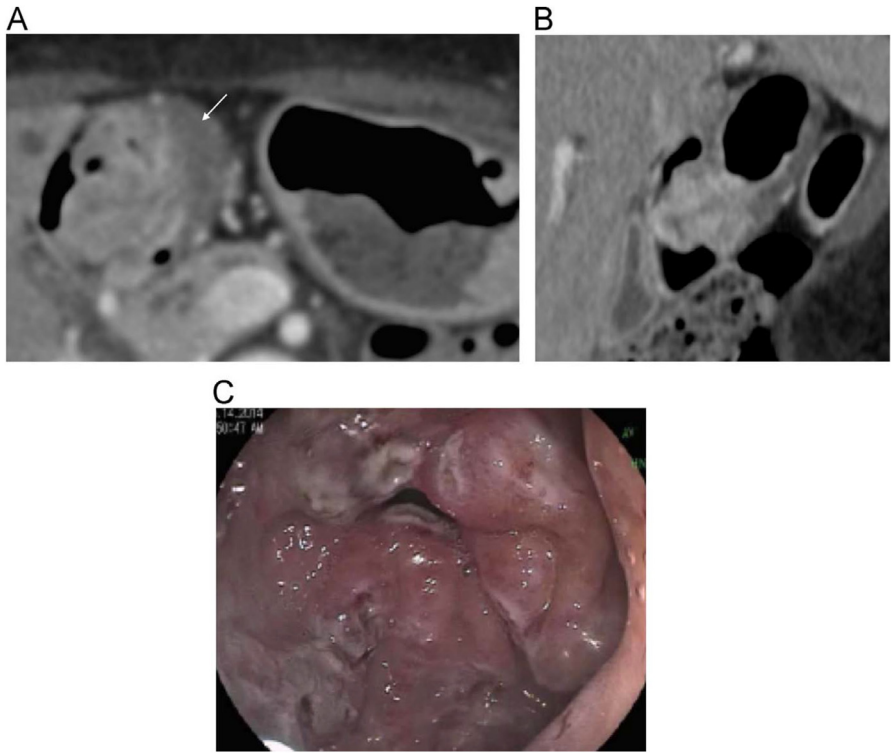

FIG 14. *Gastric antral vascular ectasia*. Axial (A) and sagittal (B) CT images of a 79-year-old female patient show gastric antral wall thickening, which is nonspecific. Upper endoscopy (C) shows ectatic vessels alternating with thickened antral folds giving the watermelon stripes appearance consistent with gastric antral vascular ectasia.

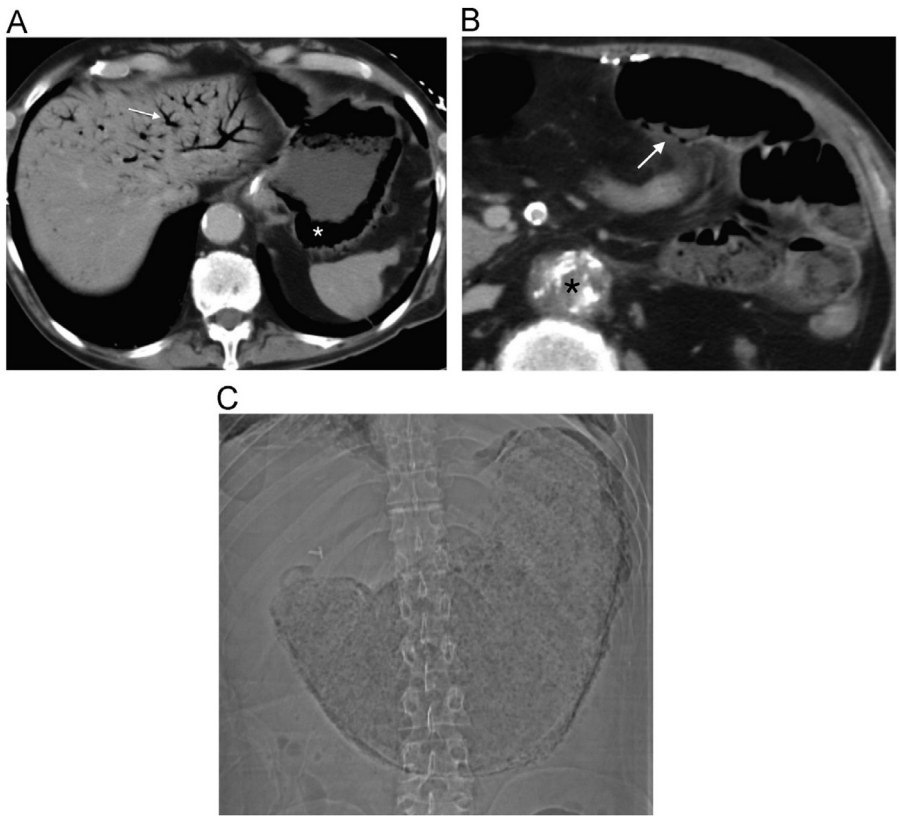

FIG 15. *Ischemic emphysematous gastritis*. Axial CT image shows portal venous gas and emphysematous gastritis (A). More caudal axial CT image shows intramural gas in small bowel loops and occlusive aortic disease (B). At surgery, there was necrosis of the stomach, proximal small bowel loops, and the sigmoid colon. CT topogram of a different patient with emphysematous gastritis (C) shows linear lucency formed by intramural gas conforming to the contour of the stomach. This patient required total gastrectomy with pathology showing transmural necrosis of the stomach.

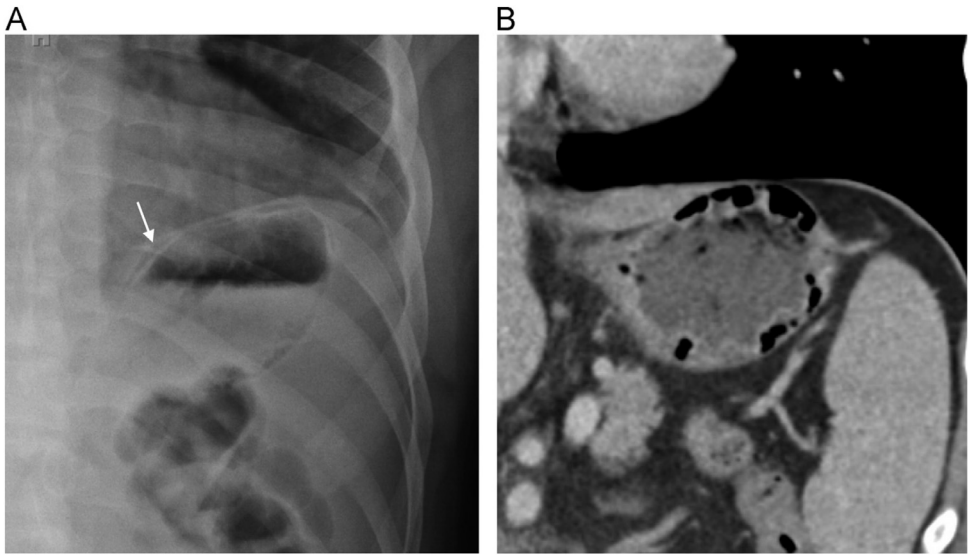

FIG 16. *Gastric emphysema*. Abdominal radiograph in a 32-year-old man with abdominal pain was concerning for free air. Coronal (B) CT image of the same patient demonstrates intramural gas in the gastric fundus. The patient required no further intervention and his pain resolved spontaneously.

syndrome is a very uncommon form of gallstone ileus, which occurs when a large gallstone erodes through a cholecystoduodenal fistula into the duodenal bulb and obstructs the gastric outlet[32] (Fig 20). CT findings include a dilated stomach, pneumobilia, gallstones in the gallbladder, and an ectopic gallstone or stones in the duodenum. An air-filled fistulous tract can sometimes be seen extending from the duodenum to the gallbladder.[33]

Gastric volvulus is a condition when the stomach twists more than180° upon itself, creating a closed loop obstruction associated with a large defect in the diaphragm that allows part or all of the stomach to herniate into the chest cavity.[34] Two main subtypes have been described depending upon the axis of rotation. Organoaxial volvulus is more common and occurs when the rotation occurs along the long axis of the stomach. The antrum is displaced anterosuperiorly and the fundus is displaced posteroinferiorly with the greater curvature lying superior to the lesser curvature. Rotation along the short axis of the stomach occurs less commonly and is called mesenteroaxial volvulus. The antrum is displaced above the gastroesophageal junction.[35] Post-traumatic diaphragmatic hernia and paraesophageal hernia are the 2 most common predisposing conditions to volvulus. CT findings of gastric volvulus include herniation of a large portion of the stomach above the diaphragm, often with differential air-filled levels and a transition point (Fig 21). The presence of obstruction is a key indicator of volvulus rather than simply an abnormal lie of the stomach. Orally administered contrast will fail to pass into the small bowel. Other findings that can be seen include gastric wall thickening and adjacent fluid and fat stranding.[1,35,36]

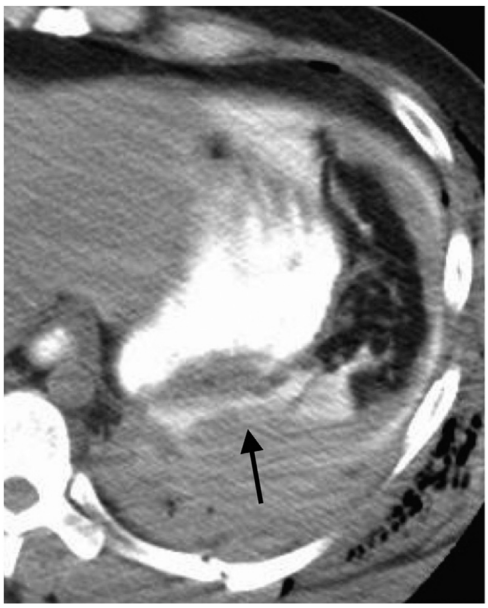

FIG 17. *Gastric perforation secondary to penetrating trauma*. Axial CT image after administration of oral contrast in a victim of gunshot trauma demonstrates extravasation of oral contrast posteriorly from the gastric fundus consistent with penetrating gastric injury. There was also a concomitant diaphragmatic injury at surgery.

Benign Gastric Tumors

Approximately 85%-90% of gastric tumors are benign.[37] Most of the benign gastric tumors are asymptomatic but can present with gastric outlet obstruction, unexplained weight loss, epigastric pain or bleeding.

Gastrointestinal stromal tumors (GISTs) comprise 40% of benign gastric tumors and arise from the interstitial cells of Cajal and 60%-70% of the GISTs occur in the stomach.[38] Benign GISTs can degenerate into aggressive tumors and metastasize so all GISTs are considered potentially malignant. They are identified on immunohistochemistry by the expression of KIT (CD117).[39] CT is considered more useful than endoscopy for assessing the size and extent of the tumor keeping in mind that GISTs can be extraluminal, intraluminal or both (Fig 22). Small tumors (<3 cm) appear as well-defined, homogenous, soft-tissue attenuation masses with variable degrees of enhancement. Larger GISTs tend to have irregular lobulated margins, varying degrees of

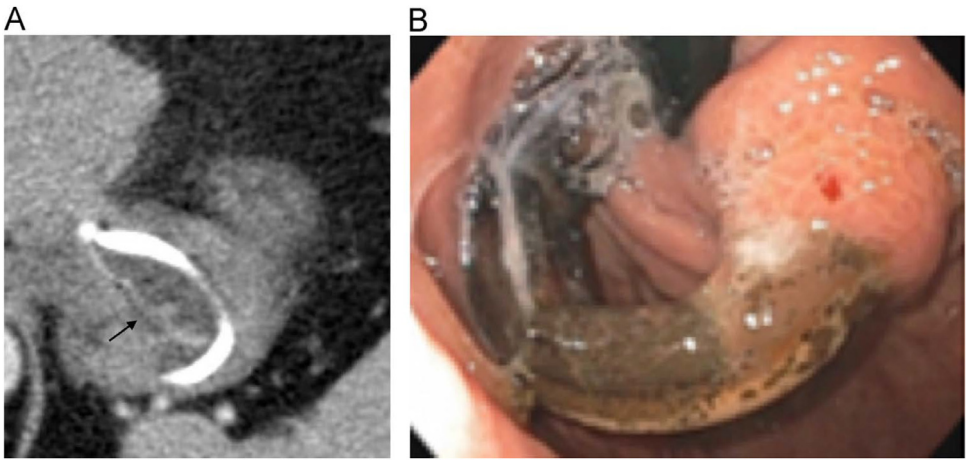

FIG 18. *Gastric perforation from laparoscopic banding.* Axial (A) CT image of this patient status post laparoscopic adjustable gastric banding shows erosion of the gastric band into the gastric lumen resulting in focal perforation, free intraperitoneal air, and perigastric fat stranding. Endoscopic examination (B) confirmed the intraluminal location of the gastric band.

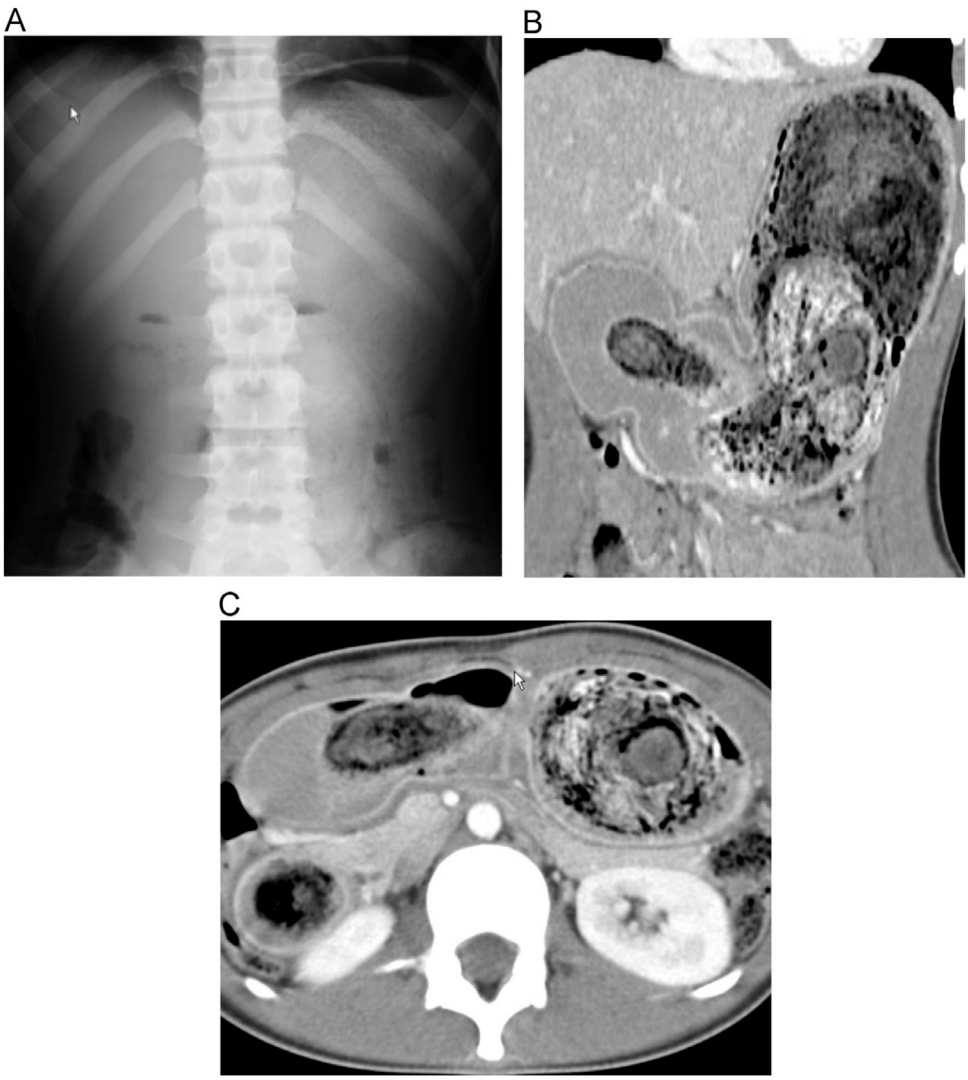

FIG 19. *Rapunzel syndrome*. Abdominal radiograph (A) in this young girl with abdominal pain shows marked gastric distension with a mottled, reticular pattern suggesting a bezoar. Coronal (B) and axial (C) CT images demonstrate a large, obstructing trichobezoar extending through the gastroduodenal junction and into the first and second portions of the duodenum.

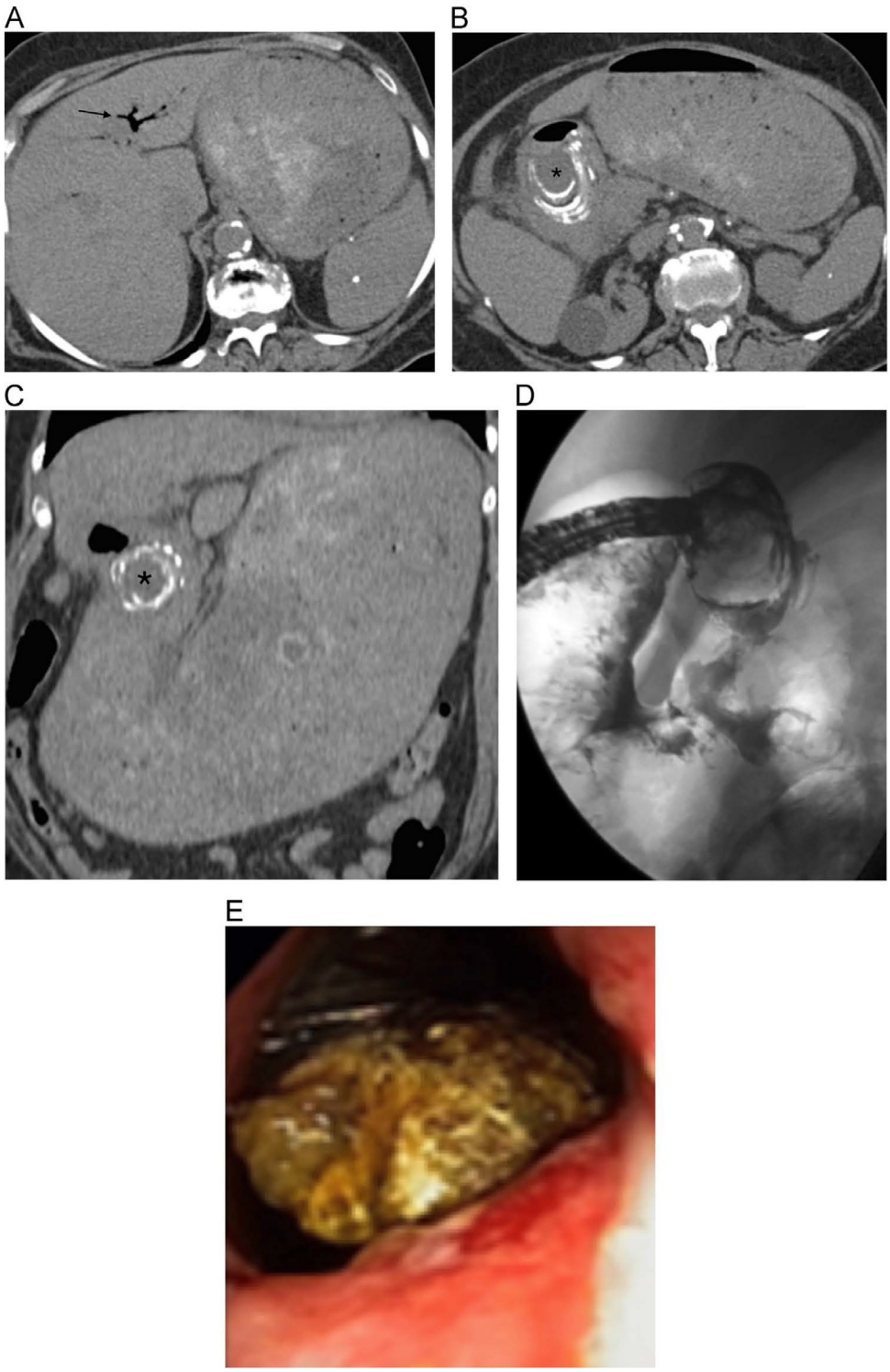

FIG 20. *Bouveret's syndrome*. Axial (A and B) and coronal (C) CT images in an elderly woman with abdominal pain demonstrate pneumobilia (A) and a stone impacted in the second portion of the duodenum (B and C) resulting in gastric outlet obstruction. ERCP and endoscopy confirmed these findings with an impacted stone in the duodenal bulb (D and E), which was broken up with endoscopic lithotripsy and removed. A choledochoduodenal fistula was also present.

necrosis, hemorrhage, cavitation, mucosal ulceration, and heterogeneous enhancement.[38] Necrosis in the tumor can lead to fistula formation with the gastric lumen with an air-fluid level or oral contrast medium in the cavity of the tumor. Sometimes tumor vessels can be seen. Calcification is rarely seen in GISTs.[40] Carney's triad is a form of multiple endocrine neoplasia describing an association of GISTs with paragangliomas and pulmonary chondromas. Unilateral or bilateral usually nonfunctioning adrenocortical adenomas can also be seen in this condition.[41]

Gastric lipoma is rare and accounts for fewer than 1% of all gastric tumors.[42] These are submucosal tumors that are mostly asymptomatic and discovered incidentally. The antrum and pylorus are the most common location and therefore when large enough, these can present with gastric outlet obstruction, abdominal pain, and bleeding

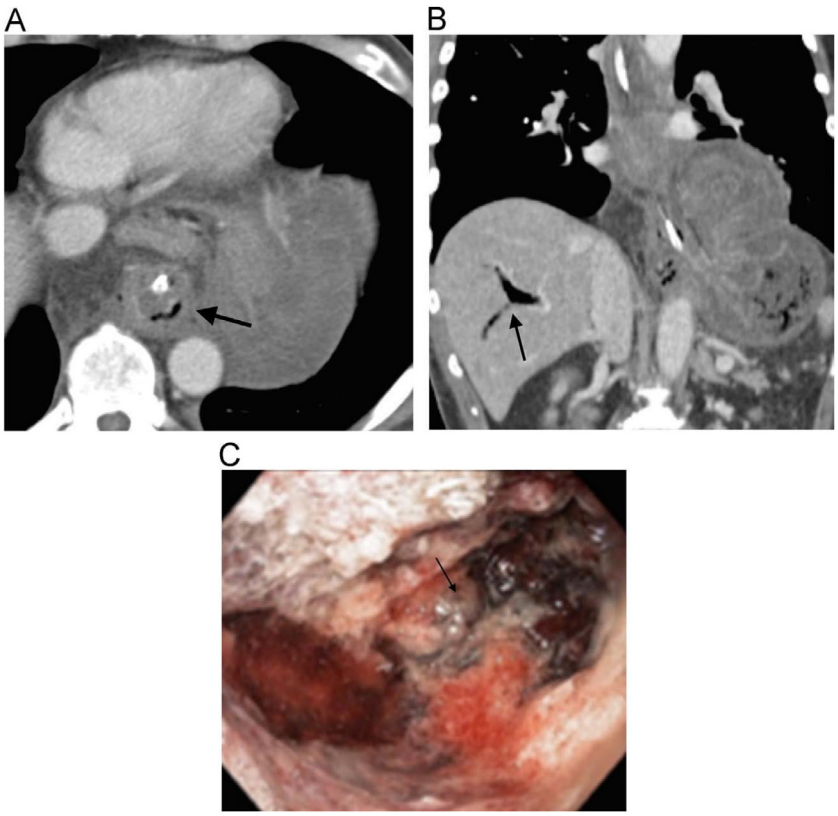

FIG 21. *Gastric volvulus*. Axial (A) and coronal (B) CT images in this patient with abdominal pain and emesis demonstrate an obstructed stomach herniated into the thorax with the gastric antrum (A, arrow) at the level of the gastroesophageal junction consistent with a gastric volvulus. Portal venous gas (B, arrow) is also present and correlates with the upper endoscopy (C) findings of friable, greyish plaques consistent with necrosis.

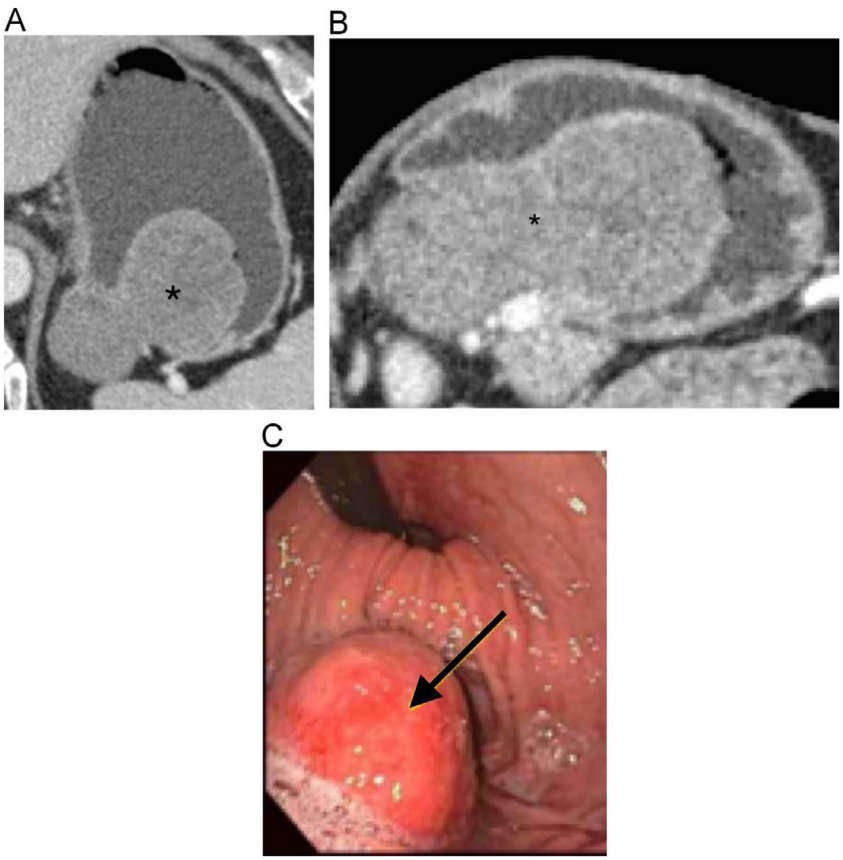

FIG 22. *Gastrointestinal stromal tumor (GIST)*. Axial (A) and coronal (B) CT images demonstrate a dumbbell shaped enhancing mass centered in the posterior gastric fundal wall. Endoscopy (C) shows this mass is partially ulcerated and at surgery, it was found to be a GIST.

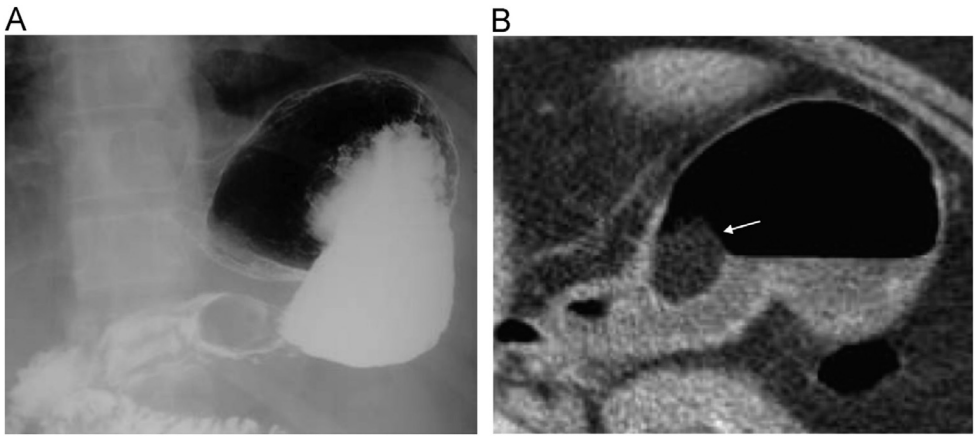

FIG 23. *Gastric lipoma*. Upper GI examination (A) shows an oval filling defect in the gastric antrum. Axial CT image (B) demonstrates fat attenuation in this intramural mass consistent with a lipoma.

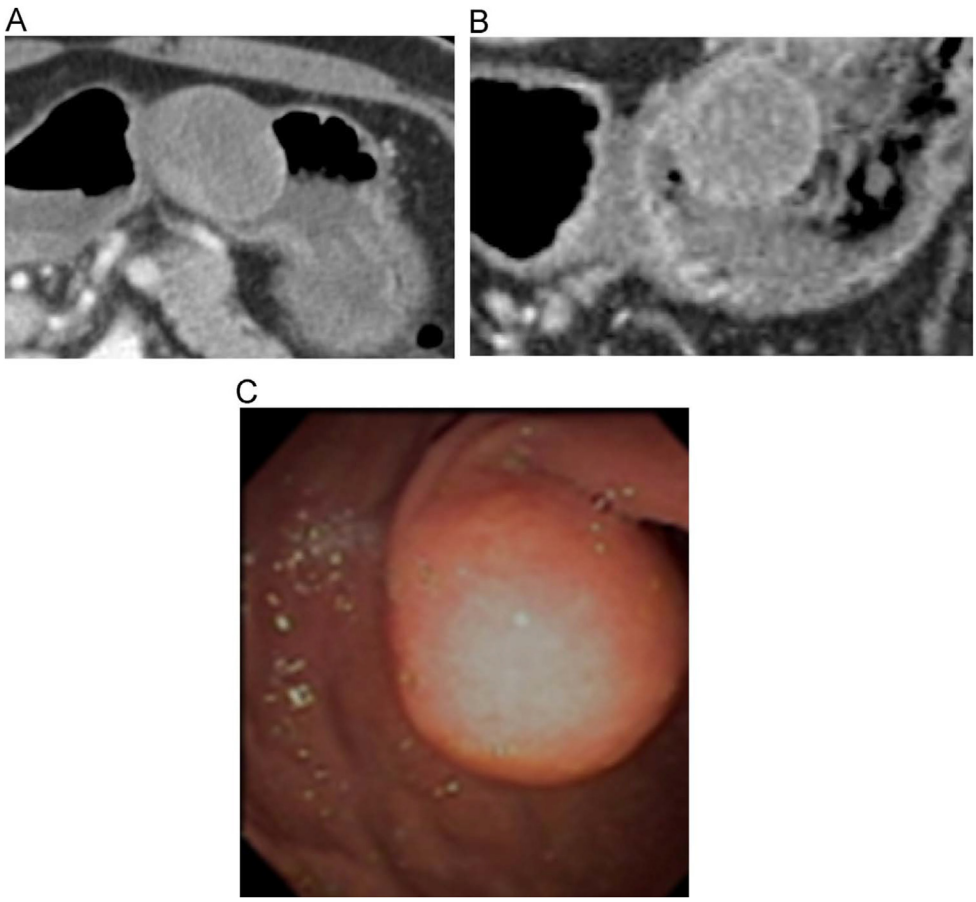

FIG 24. *Gastric schwannoma*. Axial (A) and coronal CT images (B) demonstrate an enhancing mass arising from the lesser curvature of the stomach. Upper endoscopy (C) confirms these findings. At surgery, this was found to be a schwannoma.

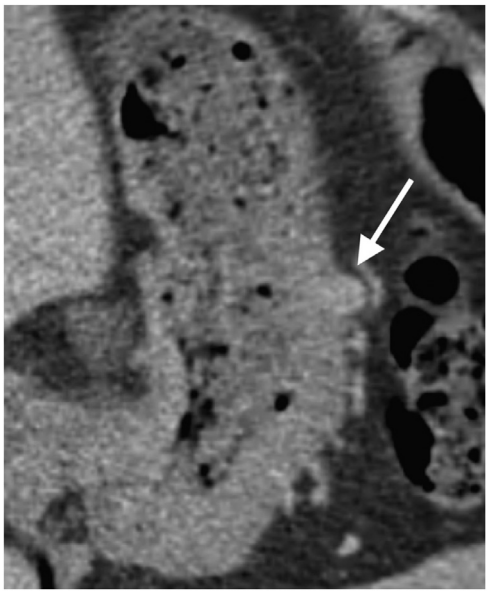

FIG 25. *Glomus tumor of the stomach.* Axial CT image show a round, enhancing, exophytic mass along the greater curvature of the stomach (arrow). Laparoscopic wedge resection was done with pathology confirming a glomus tumor.

if the tumor ulcerates.[43] CT is considered diagnostic as the tumor has a classic appearance due to presence of mature fat cells. Findings include a well-defined round or oval mass with fat attenuation (CT attenuation of −60 to −120 Hounsfield units) (Fig 23).[44]

Neurogenic tumors such as schwannomas and neurofibromas are rare in the gastrointestinal tract. As with GIST, for GI schwannomas, the stomach is the most common location with the gastric schwannomas representing approximately 4% of all benign gastric neoplasms.[45] On CT, a gastric schwannoma usually occurs along the lesser curvature and commonly presents as an ovoid, submucosal mass (Fig 24) with well-circumscribed margins and exophytic, endophytic or mixed growth pattern. On noncontrast examinations, homogeneous attenuation is present with necrosis, calcification, and ulceration being infrequent. One characteristic finding that is seen on dynamic CT is homogenous progressive enhancement of the tumor.[46]

Vascular tumors of the stomach are rare and account for less than 2% of all benign gastric tumors. *Gastric glomus tumors* are rare and almost always benign. These are hypervascular tumors and usually intramural or submucosal in location.[47] On CT, a glomus tumor usually appears as a solitary, well-defined, round or oval, hyperenhancing mass, most common along the antrum (Fig 25). These can ulcerate and then present with upper gastrointestinal bleeding.[37]

Gastric leiomyoma are rare but benign tumors predominantly occurring at the gastric cardia. On CT, these appear as homogenous, low attenuation masses with an endoluminal growth pattern (Fig 26). Large tumors can ulcerate centrally.[48]

Gastric polyps can by hyperplastic, fundic gland or adenomatous. Hyperplastic polyps are more common accounting for up to 75% cases and are usually coupled with *H. pylori* associated chronic gastritis. On multidetector computed tomography, hyperplastic polyps appear as multiple, round, sessile masses with smooth surface, usually 5-10 mm in size usually seen along the gastric body or fundus (Fig 27). Between 1% and 20% of the hyperplastic polyps are believed to harbor foci of dysplasia. Risk of malignancy increases with size greater than 1 cm.[49]

Fundic gland polyps are mostly sporadic and common in the western world where proton pump inhibitor use is common and *H. pylori* is less prevalent. These can be seen in association with polyposis syndromes such as familial adenomatous polyposis. The sporadic form has virtually no malignant potential, but in rare cases may show dysplasia. Those associated with familial adenomatous polyposis have a 30%-50% rate of low-grade dysplasia and rarely progress to cancer.[50] On CT, as the name indicates, these polyps are concentrated in the gastric fundus and cardia as sessile or pedunculated endoluminal defects (Fig 28).

Adenomatous polyps are usually solitary and rare in occurrence accounting for approximately 6%-10% of the gastric polyps. On CT, when present, adenomatous polyps are larger with size up to 2 cm. These can be pedunculated with lobulated contour and commonly occur in the region of the antrum (Fig 29).[3] Around 8%-59% of the gastric adenomas are associated with a synchronous gastric cancer.[51]

Cronkhite-Canada syndrome (CCS) is a noninherited, likely autoimmune disease characterized by gastrointestinal hamartomatous polyposis, hyperpigmentation, alopecia, and diarrhea.[52] It can extensively involve the stomach with large lobular folds forming a mass-like configuration on CT (Fig 30).[53]

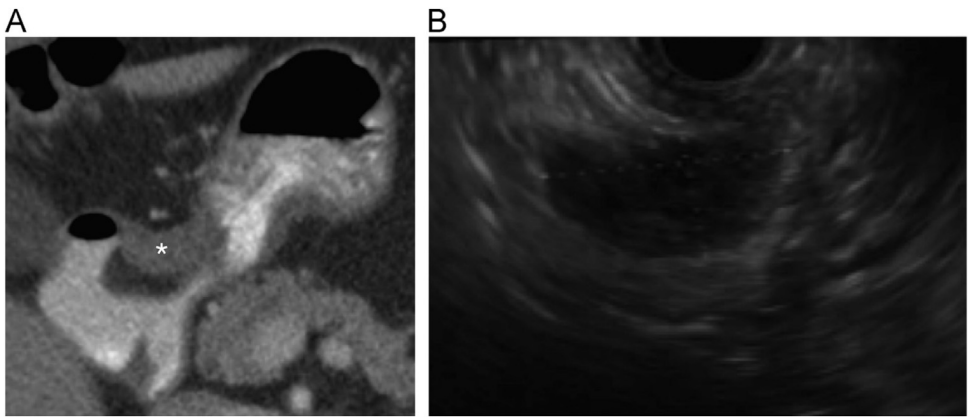

FIG 26. *Gastric leiomyoma.* Axial (A) CT images of a 67-year-old woman show an endophytic gastric antral mass. Endoscopic ultrasound (B) confirms a submucosal mass in the antrum, which was proven to be a leiomyoma on biopsy.

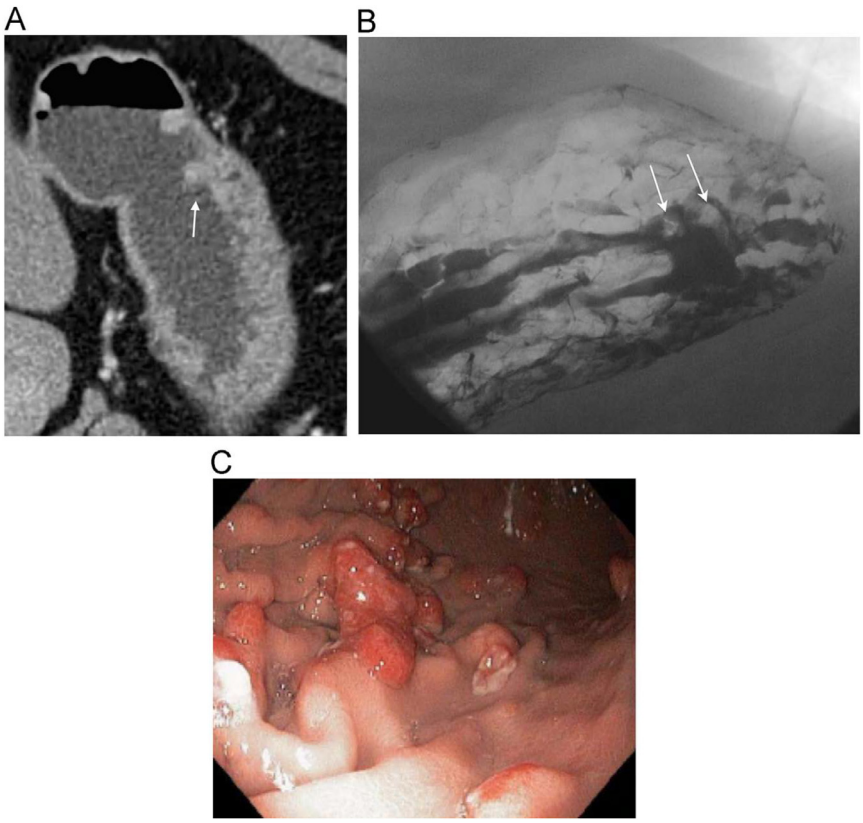

FIG 27. *Hyperplastic gastric polyps*. Axial (A) CT image of a 54-year-old woman with intractable epigastric pain. Multiple endoluminal pedunculated masses are seen in the gastric body. An upper GI barium study (B) shows multiple filling defects in the gastric body. On endoscopy (C) and biopsy, these filling defects were confirmed to be hyperplastic polyps, one of which showed high-grade hyperplasia.

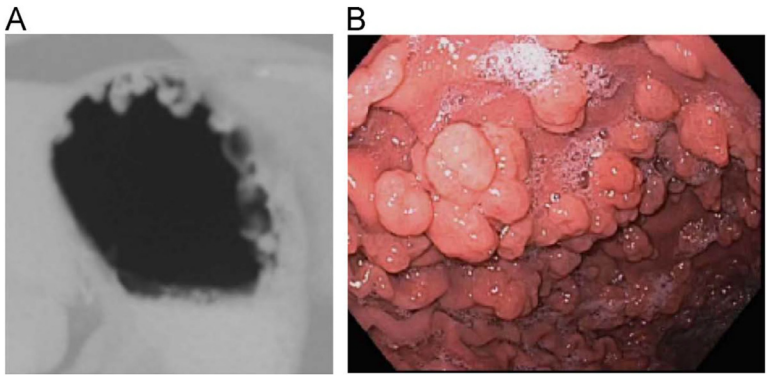

FIG 28. *Fundic gland polyps*. Axial (A) CT image of the stomach in an asymptomatic 47-year-old woman shows multiple endoluminal defects along the gastric fundus best seen on lung window. Endoscopy confirmed sessile polyps along the fundus (B).

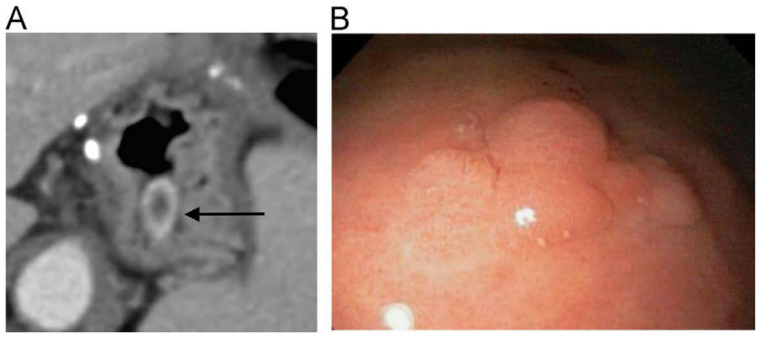

FIG 29. *Gastric adenoma*. Axial CT image (A) shows an enhancing mass in the gastric body with central area of low attenuation (arrow). Endoscopy (B) shows a polypoid mass, which proved to be an adenomatous polyp with high-grade dysplasia on biopsy.

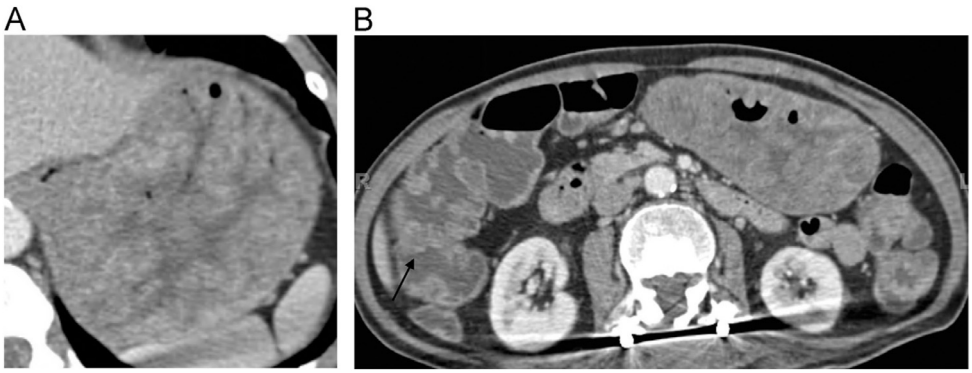

FIG 30. *Cronkhite-Canada syndrome*. Axial CT images (A and B) demonstrate extensive lobular folds in the gastric fundus and body giving a mass-like appearance. Polyps are also seen in the colon (B, arrow).

Duplication cysts of the stomach are uncommon congenital abnormalities comprising only 5%-7% of all intestinal duplications.[54] Proximity of the cyst to the GI tract, layer of smooth muscle in the wall, and an epithelial lining resembling some part of the GI tract are considered diagnostic for duplication cysts. Ectopic gastric or pancreatic tissue can be present which can lead to bleeding or perforation.[55] CT findings include a thin walled cystic lesion in or adjacent to the wall of the stomach (Fig 31). The thin wall of the cyst may show enhancement. If hemorrhage or ectopic tissue is present, these cysts may appear more complex requiring tissue diagnosis.

Gastric diverticulum is a congenital or acquired focal outpouching of the gastric wall most commonly arising from the fundus and projecting posteriorly. On CT, a gastric diverticulum appears as a well-defined saccular collection of fluid or gas or both which communicates with the gastric cavity and fills with orally administered contrast. Gastric cardia diverticula can be confused anatomically with a left adrenal mass (Fig 32).[56]

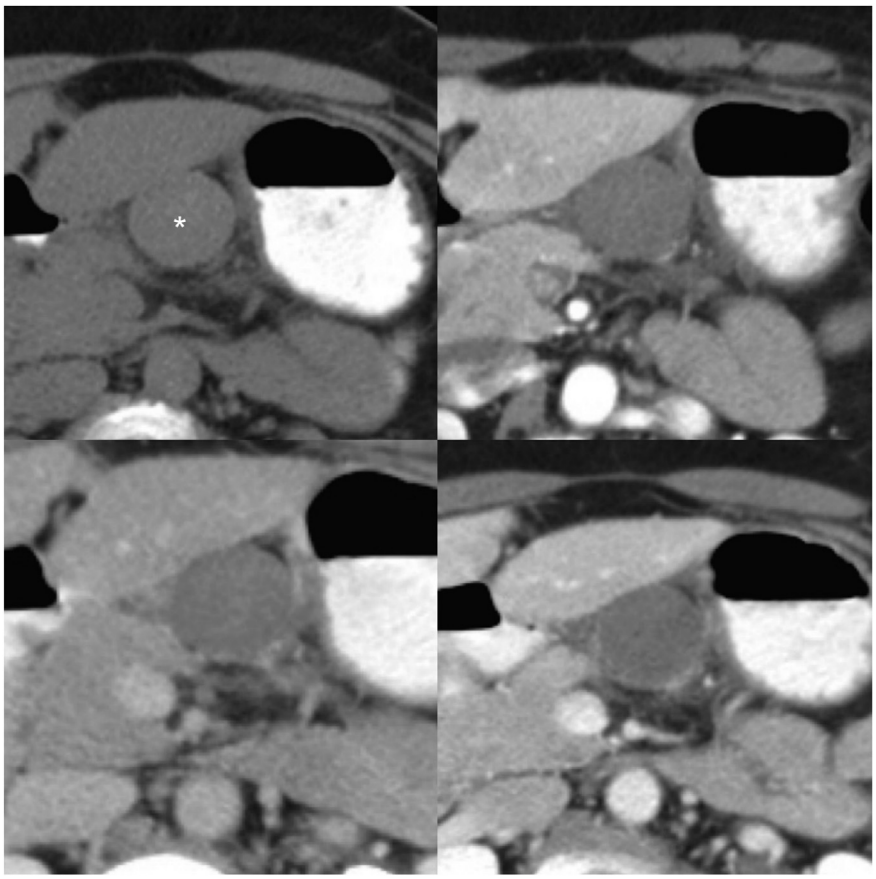

FIG 31. *Gastric duplication cyst*. Axial CT images in the clockwise direction, noncontrast phase, arterial phase, portal venous phase and delayed phase, show an isoattenuating round mass along the lesser curvature of the stomach. The mass has a thin imperceptible wall with no enhancement on contrast enhanced imaging consistent with a cyst.

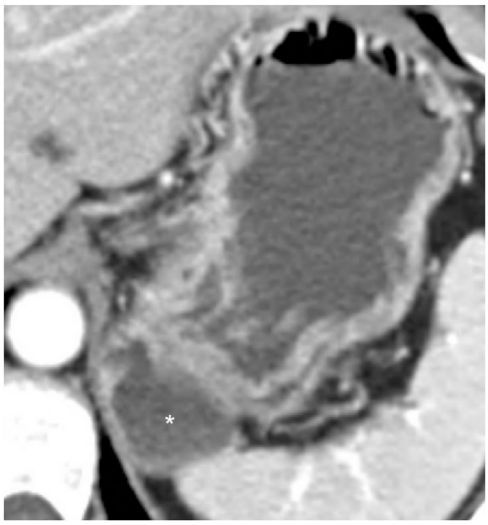

FIG 32. *Gastric diverticulum*. Axial CT image (A) demonstrating a fluid filled structure posterior to the stomach adjacent to the fundus. This can easily be mistaken as a cystic left adrenal mass. Reformatted coronal CT image (B) of the same lesion demonstrating a communicating tract (arrow) with the gastric cavity consistent with a gastric diverticulum.

Ectopic pancreatic rest, also known as a myoepithelial hamartoma, is a congenital anomaly. Most common location is the stomach, followed by duodenum and proximal jejunum. In the stomach, these appear as submucosal masses, commonly along the greater curvature of the antrum close to the pylorus and demonstrate enhancement intensity similar to that of the pancreas (Fig 33). However, due to the mass-like appearance, these can easily be mistaken as a primary gastric neoplasm such as GIST. These are usually asymptomatic but can present with epigastric pain or upper GI bleeding.[57]

Gastric splenosis refers to the autotransplantation of splenic tissue usually at the gastric fundus as a result of splenic trauma or surgery. It is an uncommon secondary tumor of the stomach and difficult to distinguish from other gastric tumors especially GISTs. These can be asymptomatic or present with abdominal pain and upper GI bleeding.[58] A prior history of trauma and splenectomy is useful. On CT, if the splenosis is large enough, a tigroid pattern of arterial enhancement can be seen but small tumors usually enhance homogenously, similar in intensity as the spleen. Diagnosis can be suggested on CT and confirmed with heat-damaged RBC tagged nuclear scan (Fig 34).

Conclusion

A wide variety of benign gastric disease ranging from inflammatory conditions to neoplasms can be encountered on CT. These can be innocuous incidental findings or have life-threatening clinical implications related to bleeding, obstruction, or perforation, thereby

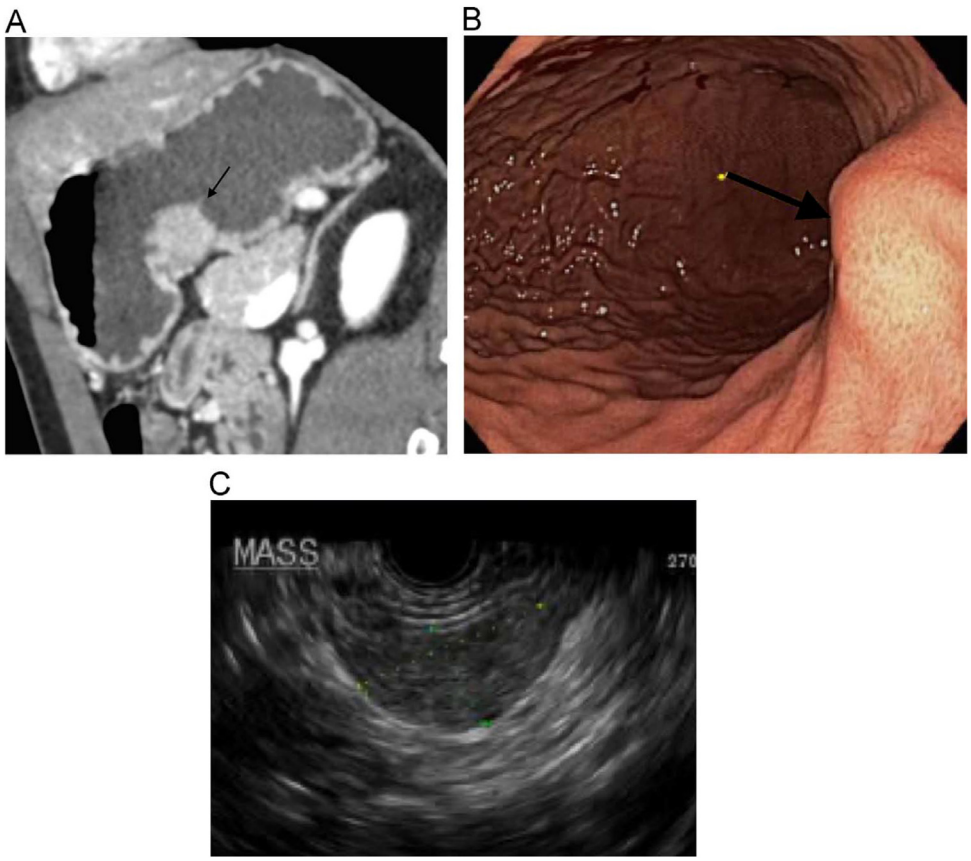

FIG 33. *Ectopic pancreatic rest in the stomach*. Sagittal (A) CT image of the stomach in a 30-year-old male patient with unexplained weight loss shows an enhancing submucosal mass along the lesser curvature. Note the enhancement of the mass is similar to the pancreatic parenchyma. Endoscopy (B) also shows a submucosal mass without stigmata of bleeding or ulceration. EUS-guided FNA (C) confirmed normal pancreatic tissue.

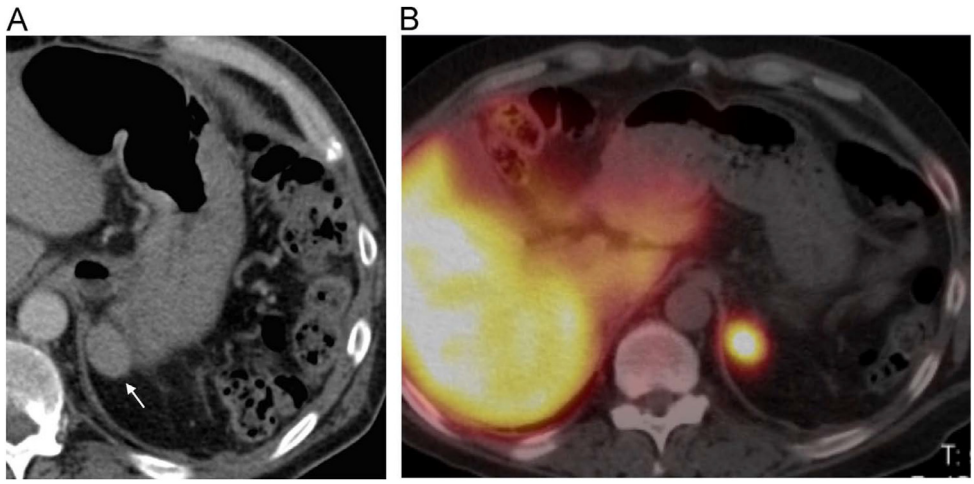

FIG 34. *Splenosis at the gastric fundus*. Axial (A) CT image of a 58-year-old man with known pancreatic neuroendocrine tumor status post distal pancreaticosplenectomy one-year prior, shows an enhancing perigastric soft-tissue nodule abutting the gastric fundus. Note the absent spleen in the left upper quadrant. Heat-damaged RBC scan (B) demonstrates avid uptake of radiotracer in the nodule confirming the presence of splenic tissue.

necessitating familiarity with the radiological appearance on CT to direct appropriate management.

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