CT Esophagography for Evaluation of Esophageal Perforation

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Abbreviation: PACS = picture archiving and communication system

RadioGraphics 2021; 41:447–461

https://doi.org/10.1148/rg.2021200132

Content Codes: CH CT ER GI

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SA-CME LEARNING OBJECTIVES

After completing this journal-based SA-CME activity, participants will be able to:

- Recognize appropriate uses of CT esophagography in clinical practice, as well as its advantages and disadvantages when compared with fluoroscopic evaluation.
- Describe the steps involved in performing CT esophagography.
- Develop an effective CT esophagography program with involvement of staff from multiple departments.

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Esophageal emergencies such as rupture or postoperative leak are uncommon but may be life threatening when they occur. Delay in their diagnosis and treatment may significantly increase morbidity and mortality. Causes of esophageal injury include iatrogenic (including esophagogastroduodenoscopy and stent placement), foreign body ingestion, blunt or penetrating trauma to the chest or abdomen, and forceful retching, also called Boerhaave syndrome. Although fluoroscopic esophagography remains the imaging study of choice according the American College of Radiology appropriateness criteria, CT esophagography has been shown to be at least equal to if not superior to fluoroscopic evaluation for esophageal injury. In addition, CT esophagography allows diagnosis of extraesophageal abnormalities, both as the cause of the patient's symptoms as well as incidental findings. CT esophagography also allows rapid diagnosis since the examination can be readily performed in most clinical settings and requires no direct radiologist supervision, requiring only properly trained technologists and a CT scanner. Multiple prior studies have shown the limited utility of fluoroscopic esophagography after a negative chest CT scan and the increase in accuracy after adding oral contrast agent to CT examinations, although there is considerable variability of CT esophagography protocols among institutions. Development of a CT esophagography program, utilizing a well-defined protocol with input from staff from the radiology, gastroenterology, emergency, and general surgery departments, can facilitate more rapid diagnosis and patient care, especially in overnight and emergency settings. The purpose of this article is to familiarize radiologists with CT esophagography techniques and imaging findings of emergent esophageal conditions.

Online supplemental material is available for this article.

Introduction

Esophageal injuries may be life threatening, requiring prompt diagnosis and treatment (1). Perforation usually occurs from acute chest trauma, violent retching (Boerhaave syndrome), or as a complication of endoscopy or surgery. Less common causes are esophageal tumor; ulcer; or accidental ingestion of a foreign object, acid, or chemicals. Most instances of esophageal perforation are iatrogenic (2,3). The mortality rate of esophageal perforation is between 10% and 20%, and anastomotic leakage after esophagectomy increases mortality by 11.9% (4,5).

TEACHING POINTS

- A typical CT esophagography examination includes imaging performed before the administration of oral contrast material, supine postcontrast imaging, and as necessary, prone postcontrast imaging. Intravenous contrast material may be added, depending on suspected comorbid conditions.
- CT esophagography is relatively sensitive and highly specific for the evaluation of acute esophageal injury, including penetrating trauma, postanastomotic leak, and esophageal rupture.
- CT esophagography has been shown to be at least equal to fluoroscopic esophagography for diagnosis of esophageal injury, with the key advantage of 24-hour and 7 days a week availability in most hospitals.
- In addition to evaluation of emergency department patients, CT esophagography may also be valuable in evaluating postoperative complications from gastric bypass, as clinical diagnosis may be difficult in this population.
- Development of a successful CT esophagography program involves education of both the radiology department and referring clinicians on appropriate uses, advantages, and disadvantages.

In the emergency setting, patients presenting with atypical chest pain and a clinical history suggestive of esophageal perforation (Boerhaave syndrome) create a diagnostic dilemma (Fig 1). Thoracic CT is commonly used in this patient population, allowing evaluation of multiple causes of chest pain. While the American College of Radiology (ACR) appropriateness criteria recommend fluoroscopic esophagography in the setting of suspected esophageal injury, this focused examination provides only limited evaluation of other causes of chest pain and requires more time and personnel to perform than CT (6).

Achieving rapid diagnosis through the fewest imaging examinations as possible allows timely treatment of esophageal injuries and is key to quality patient care, as delay in treatment of esophageal perforation is a significant predictor of mortality (4,5). Delay in operative treatment of 13 hours or more results in a threefold increase in mortality in patients with penetrating esophageal injuries (7). Perforations depicted more than 24 hours after onset result in survival rates of 20% or lower (8).

Traditionally, fluoroscopic esophagography and upper gastrointestinal examination with water-soluble contrast agent has been the imaging modality of choice when evaluating the esophagus and proximal gastrointestinal tract for perforation or postoperative leak (9,10). However, fluoroscopy has demonstrated false-negative results of 10%–38%, and fluoroscopic services may not be available, depending on the time and day of the week (11) (Figs 2, 3). In addition, calling in on-call technologists and radiologists takes time, which may delay diagnosis and increase both expense and morbidity. A well-designed CT esophagography protocol permits optimal visualization of dilute low-osmolar iodinated enteric contrast material. Low-osmolar contrast material has fewer associated risks compared with the risks of pneumonitis with diatrizoate meglumine-sodium solution (Gastrografin; Bracco) or the risks of mediastinitis or peritonitis with barium (12).

Many studies have demonstrated the utility of chest CT in the setting of suspected esophageal injury, with sensitivity superior to fluoroscopy and negative predictive value at least equal to fluoroscopy (13). Wei et al (14) also showed that the addition of oral contrast agent improved the positive predictive value of chest CT, although they

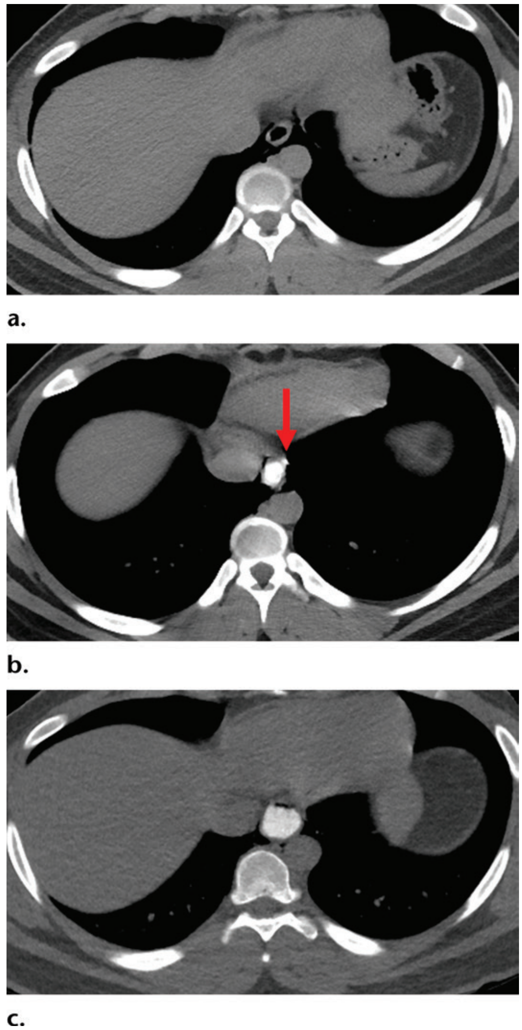
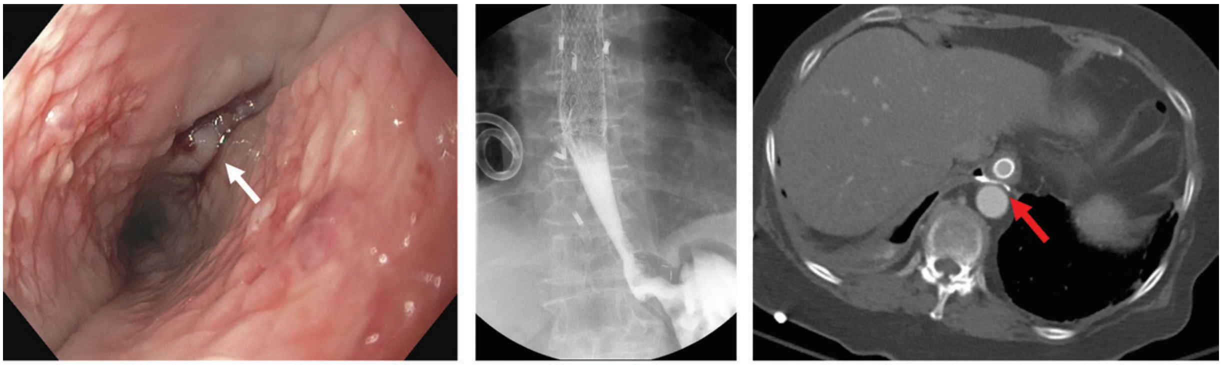
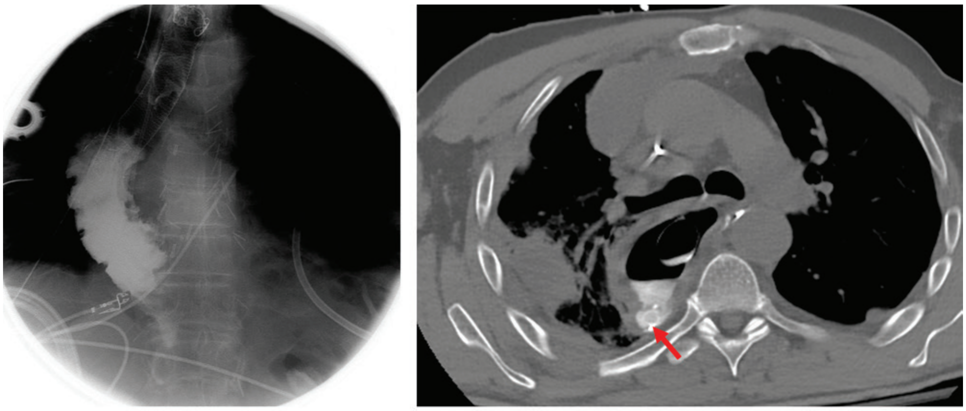


Figure 1. Boerhaave syndrome. **(a)** Axial CT image obtained without contrast material shows no evidence of perforation. **(b)** Axial CT esophagram obtained after administration of oral contrast material in the same patient shows a small focus of contrast material adjacent to the distal esophagus (arrow), a finding that highlights the importance of using oral contrast material. **(c)** Axial CT esophagram obtained at follow-up shows adequate distention and resolution of the leak.



a. b. c.

Figure 2. Esophageal leak in a patient with a history of pancreatic adenocarcinoma who was transferred from another facility for management of esophageal perforation after endoscopic US and fine-needle aspiration of a pancreatic mass. **(a)** Endoscopic image from an outside facility shows esophageal perforation (arrow). **(b)** Fluoroscopic esophagram shows a stent in the mid-distal esophagus and no contrast material leak. **(c)** Axial CT esophagram obtained with intravenous contrast agent shows a small leak (arrow) posterior to the esophagus (with stent). Intravenous contrast material was administered to aid in delineating the known pancreatic lesion.



a. b.

Figure 3. Enteropleural fistula in a patient who underwent recent esophagectomy and gastric pull-up and was evaluated for a suspected leak. **(a)** Initial fluoroscopic esophagram reveals no leak. **(b)** Axial CT esophagram obtained without intravenous contrast material at follow-up because of continued clinical concern shows contrast agent extending through a posterior defect and filling the adjacent chest tube (arrow), a finding consistent with an enteropleural fistula.

did not use a standardized oral contrast agent protocol. In addition, given the well-established role of CT in the diagnosis of acute chest conditions, CT esophagography has been developed to provide more accessible imaging evaluation of acute esophageal injuries such as traumatic hematomas, perforation, and postoperative leaks (10). CT esophagography has the additional benefits of a lower physical demand for patients who may be severely debilitated, as it does not require the patient to stand or even necessarily swallow contrast agent. Finally, this technique provides further benefits because it helps diagnose extraesophageal conditions (3,10) (Fig 4).

In a study by Awais et al (15), 79.7% of chest CT examinations performed for suspected esophageal injury demonstrated abnormal findings unrelated to the esophagus. An alternative diagnosis was evident in 94.9% of chest CT examinations without evidence of esophageal injury (Fig 5).

Multiple studies have also shown the limited utility of fluoroscopic esophagography in the setting of a negative chest CT scan, further supporting the adoption of CT esophagography, particularly in the emergency and trauma setting (13–15).

Creation of a CT esophagography program and defined protocol provides an effective tool for evaluation of esophageal injury, improving workflow and maintaining high diagnostic quality. This requires buy-in from radiologists, technologists, and referring clinicians through thoughtful protocol design and adequate training of all involved staff.

CT Esophagography Protocol

The protocol for CT esophagography varies by institution (Table 1). A typical CT esophagography examination includes imaging performed before the administration of oral contrast material,

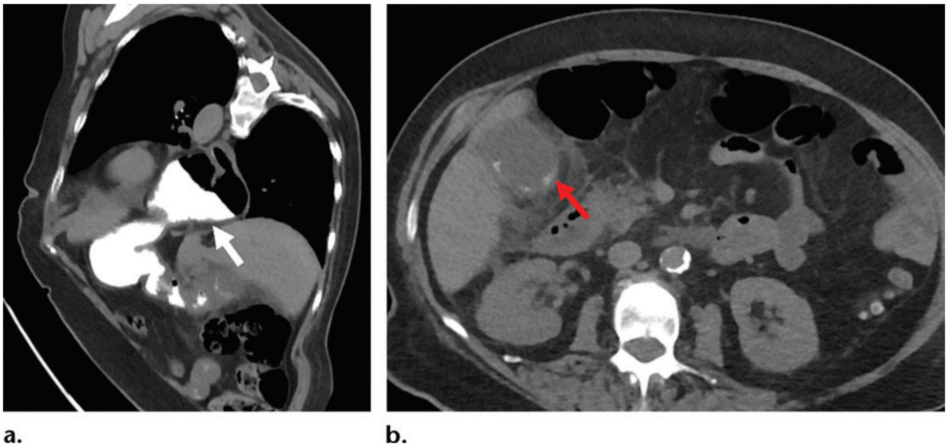


Figure 4. Acute cholecystitis in a patient with a history of a large hiatal hernia who presented with abdominal pain and concern for gastric obstruction from volvulus. Axial CT esophagram obtained with the patient semiprone **(a)** and axial CT esophagogram **(b)** show a large hiatal hernia (white arrow in **a**) but no gastric or esophageal obstruction or perforation. The patient's symptoms were caused by acute cholecystitis (red arrow in **b**).

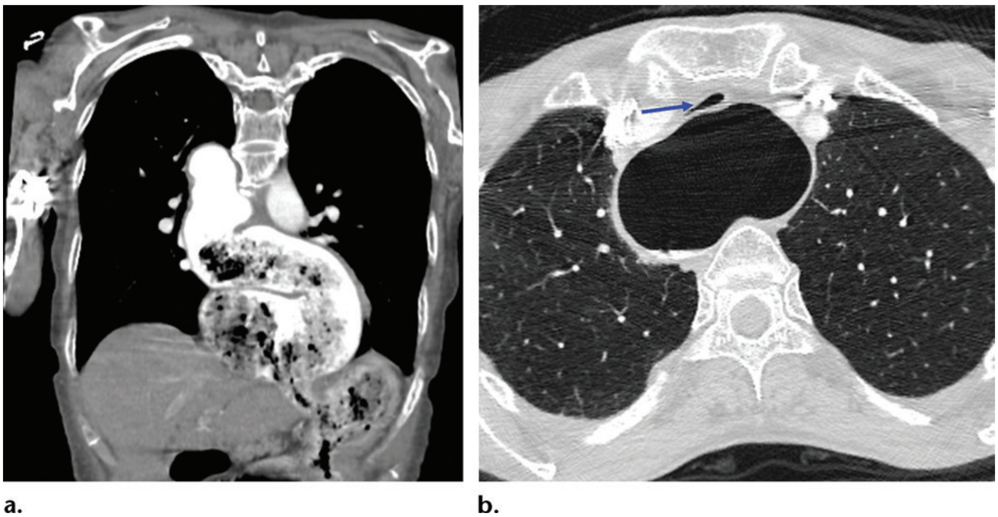


Figure 5. Achalasia in a patient who presented with nonspecific chest pain, dyspnea, and dysphagia. **(a)** Coronal oblique reformation from CT esophagography reveals achalasia. **(b)** Axial CT esophagram also demonstrates severe tracheal narrowing (arrow) secondary to the diffuse esophageal dilatation.

supine postcontrast imaging, and as necessary, prone postcontrast imaging. Intravenous contrast material may be added, depending on suspected comorbid conditions.

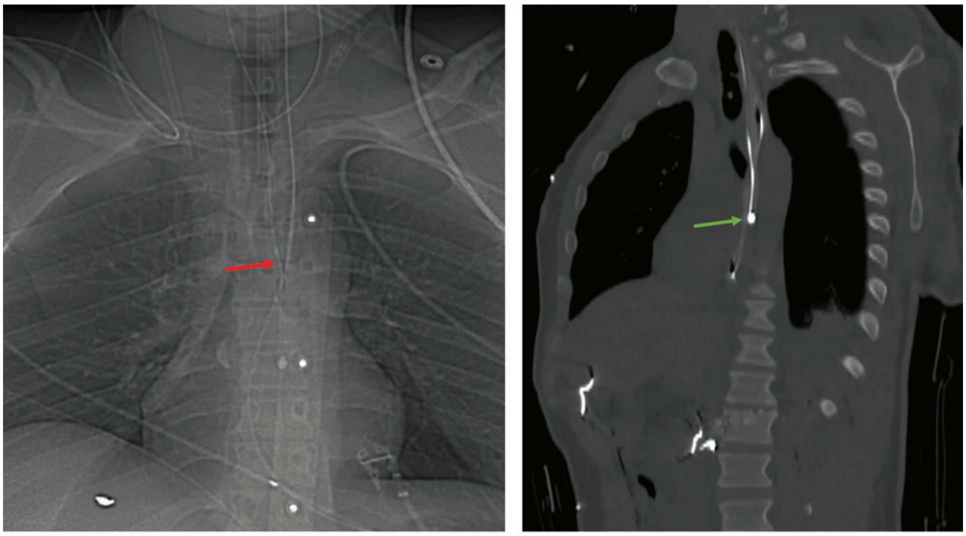
Three parameters must be decided before performing the examination. First, the ordering provider and radiologist must determine if intravenous contrast material should be given. Intravenous contrast material can be used to help diagnose extraesophageal pathologic conditions such as abscess, concomitant trauma, aortic dissection, pulmonary embolism, pneumonia, or other causes of acute chest pain (1,3). If there is not a concern for extraesophageal findings, then an examination without intravenous contrast material is adequate to help assess esophageal pathologic conditions.

The second parameter to determine is if the patient can drink oral contrast material. If a patient is unable to drink oral contrast material, a nasogastric tube may be placed above the level of the cricopharyngeal sphincter if the area of leak is unknown or proximal to the suspected leak if a location is known (10). The placement of the enteric tube with the tip above the level of the suspected leak is determined clinically or by using prior images. The patient's status does not need to be "nothing by mouth" for the examination. Third, the safety and feasibility of moving the patient into the prone position must be assessed in case the radiologist determines that adding prone imaging would improve the accuracy of the examination.

The oral contrast material is then prepared before performing imaging. At our institution, 16

Table 1: Comparison of CT Esophagography Protocols Reported from Various Centers

Study (Reference Number)	Intravenous Contrast Agent	Oral Contrast Agent	Effervescent Granules	No. of Patients	Sensitivity (%)	Specificity (%)
Fadoo et al (11)	Yes (without and with)	50 mL Omnipaque 300	Yes	11	100	100
Hogan et al (16)	No	250 mL Gastrografin at 2% concentration	No	38	88	100
Upponi et al (17)	No	5 mL iopamidol in 750 mL water with bolus of oral contrast material before CT	No	52	100	80
Suarez-Poveda et al (10)	Yes (without and with)	50 mL Omnipaque 300 at 10% concentration	No	64	78	94
Goense et al (18)	Yes	No	No	122	80	84
Strauss et al (19)	Yes	30 mL Omnipaque 300 in 150 mL water	No	97	73	94
Palacio et al (20)	Yes	15 mL iohexol in 100 mL water	No	17	59	87



a. b.

Figure 6. Use of an enteric tube for contrast material administration. **(a)** Anteroposterior scout CT image demonstrates enteric tube positioning (arrow). This finding was scan checked by the radiologist before contrast agent administration. **(b)** Coronal oblique CT esophagram demonstrates adequate orogastric tube placement (arrow) proximal to the suspected location of the distal esophageal leak.

ounces of premixed oral contrast material (Omnipaque 350, GE Healthcare) is added to a thickening agent. We use four packages of a thickener (Thick & Easy; Hormel Health Labs). The mixture is poured from one cup to another until fully dissolved. The mixture then sits for 5 minutes to allow additional thickening and is subsequently separated into two smaller cups. One cup of the mixture (8 oz) is used for the initial scan, and the other (8 oz) is held for possible repeat imaging.

The examination begins with frontal and lateral scout CT. This is part of standard CT protocols for determining scan coverage, although it can also help localize the tip of the nasogastric tube when one is needed to administer enteric contrast material (Fig 6). If the tube is malpositioned at scout imaging, it can be repositioned before oral contrast material administration by the ordering physician or nurse. Then a precontrast examination is performed from the angle of the mandible to the iliac crests. The precontrast examination permits identification of any radiopaque material such as surgical suture or calcification when compared with postcontrast images (Figs 7, 8) (Table 2).

After the precontrast imaging is performed, the patient sits up and drinks 4 oz of thickened oral contrast material (half of one premixed cup). Then the patient is asked to lie back down in the same location as for the precontrast imaging. The patient

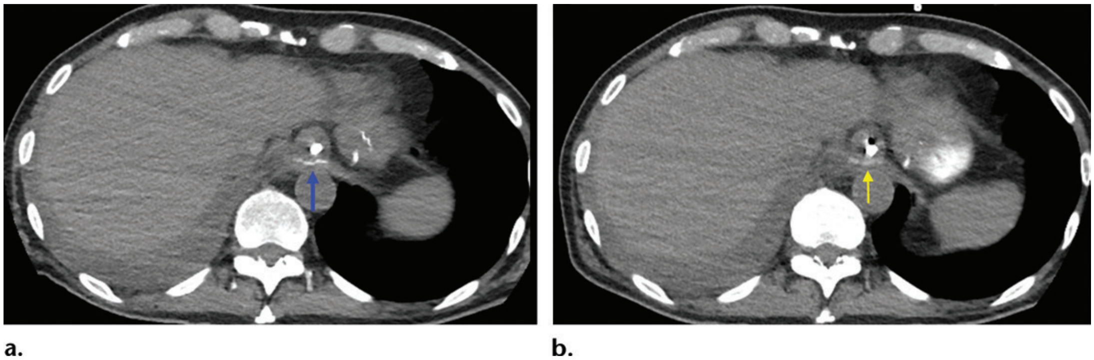


Figure 7. Benefit of precontrast images in avoiding misinterpretation of suture material in a patient with a complicated surgical history, including prior fundoplication with subsequent takedown. **(a)** Axial precontrast CT esophagram demonstrates suture material posterior to the esophagus (arrow). **(b)** Axial CT esophagram obtained after oral contrast material administration redemonstrates the suture material posterior to the esophagus (arrow), a finding that could be misinterpreted as a contrast agent leak without comparison precontrast images.

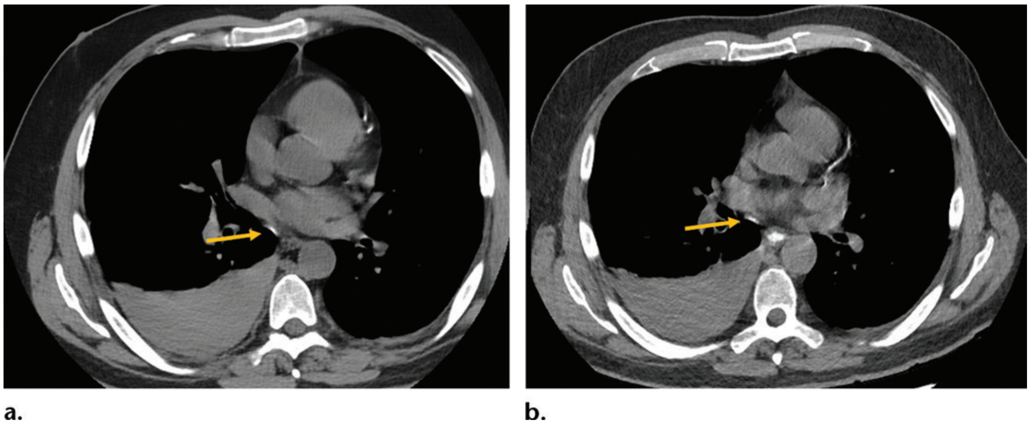


Figure 8. Benefit of precontrast images in excluding esophageal leak. **(a)** Axial precontrast CT esophagram shows increased attenuation to the right of the esophagus (arrow). **(b)** Axial CT esophagram obtained after enteric contrast administration shows persistent attenuation adjacent to the esophagus (arrow), which represents calcification within a lymph node. The precontrast images were valuable in excluding a leak at this location.

then turns their head and drinks the remaining contrast material (an additional 4 oz) with a straw. When enteric contrast material is administered with a nasogastric tube, all enteric contrast material may be given in the supine position.

The postcontrast imaging is performed immediately after the patient finishes drinking the remaining oral contrast material. This examination includes the same anatomy as the precontrast examination, covering from the angle of the mandible to the iliac crest.

Our image acquisition is set up with a 5-second scan delay, which allows the CT technologist to press the in-room start button after the patient is finished drinking the contrast material. The 5-second delay allows enough time to exit the room before exposure.

If intravenous contrast material is given, it is injected when the patient has returned to the supine position concurrently with the remaining 4 oz of oral contrast agent. The injection protocol has a 40-second scan delay, although this may be adjusted depending on the desired contrast phase (pulmonary arteries, aorta, or delayed phase chest imaging). Imaging after intravenous contrast material administration is then performed and includes the same anatomy as the precontrast imaging.

After supine imaging, the technologist contacts the radiologist to determine if prone or repeat imaging is needed. Prone imaging is important in cases of suspected anterior esophageal perforation. If prone imaging is needed, the steps are repeated with the patient prone (see Table 2 for protocol parameters). At times, the initial scan needs to be repeated because of motion or lack of adequate esophageal distention (Fig 9). Prone imaging may be relatively contraindicated or difficult in some patients (eg, intubated patients), in which case, the threshold to repeat supine imaging to achieve adequate distention of the esophagus is lowered. This is at the discretion of the radiologist, and the decision should be made on the basis of the suspected area of leak, find-

Table 2: Sample CT Esophagography Protocol from Our Center

Primary Reconstruction										
Scan Mode	Pitch	Detector Rows	Coverage (mm/rotation)	Start Location	End Location	Interval (mm)	Field of View	Tube Voltage (kVp)	Window Width	Window Level
Helical 0.7-sec rotation	1.531:1	128	122.48	Angle of mandible	Iliac crest	2.5	Large body (50 cm)	120	450	50

Secondary Reconstruction								
Reconstruction Name	Start Location	End Location	Thickness (mm)	Interval (mm)	Window Width	Window Level	Reformations
Thin-section axial	Angle of the mandible	Iliac crest	0.625	0.625	450	50	Sagittal and coronal*
Chest-only thin-section data	Angle of the mandible	CP angles	0.625	0.625	1500	–500	Coronal MIP and MinIP†
Lung	Angle of the mandible	CP angles	1.25	1.25	450	50	Axial

Note.—CP = costophrenic.
*Sagittal and coronal 2.5-mm contiguous reformations sent to the PACS.
†MIP (maximum intensity projection) and MinIP (minimum intensity projection) images are created with an 8-mm thickness at a 4-mm interval.

ings at initial supine imaging, and the patient's clinical condition.

Postprocessing may vary by institution. Axial images are sent to the picture archiving and communication system (PACS) for the precontrast and postcontrast images. Thin-section axial images using 0.625-mm detector collimation with a pitch of 1.53 are preferred for more accurate depiction of small leaks. Additional sagittal and coronal reformations are created from the postcontrast images. Axial images of the chest using a sharp kernel are created for better visualization of the lungs, in addition to maximum intensity and minimum intensity projection images of the postcontrast chest. Sagittal and coronal reformations of the precontrast images are available at the request of the radiologist.

Accuracy of CT Esophagography

CT esophagography is relatively sensitive and highly specific for the evaluation of acute esophageal injury, including penetrating trauma, postanastomotic leak, and esophageal rupture. The accuracy of CT esophagography is at least equal to if not superior to that of fluoroscopic esophagography (14). CT esophagography has a sensitivity of 59%–100% and a specificity of 80%–100% in assessing leak (Table 1) (10,11,16–20). Data from early studies were predominantly obtained from examinations of postoperative patients, although more recent studies have shown the utility of CT esophagography in the acute setting, including trauma and forceful retching. Most studies of CT esophagography did not use a standardized protocol for oral contrast material administration, which likely would have improved diagnostic yield.

CT Esophagography Benefits and Limitations

CT esophagography can increase access and decrease time to diagnosis, especially in patients who present after hours or on the weekend. CT esophagography has been shown to be at least equal to fluoroscopic esophagography for diagnosis of esophageal injury, with the key advantage of 24-hour and 7 days a week availability in most hospitals. CT examinations are performed 24 hours a day, 365 days a year at most emergency departments and hospitals and do not require direct radiologist supervision in the examination room (21). Fluoroscopic studies performed outside of normal business hours often require on-call staff, including a technologist and radiologist who may not be on site, as well as an open fluoroscopy suite (11). CT esophagography can be performed any time of the day if a trained CT technologist is available. This is beneficial for busy or remote departments that may not have

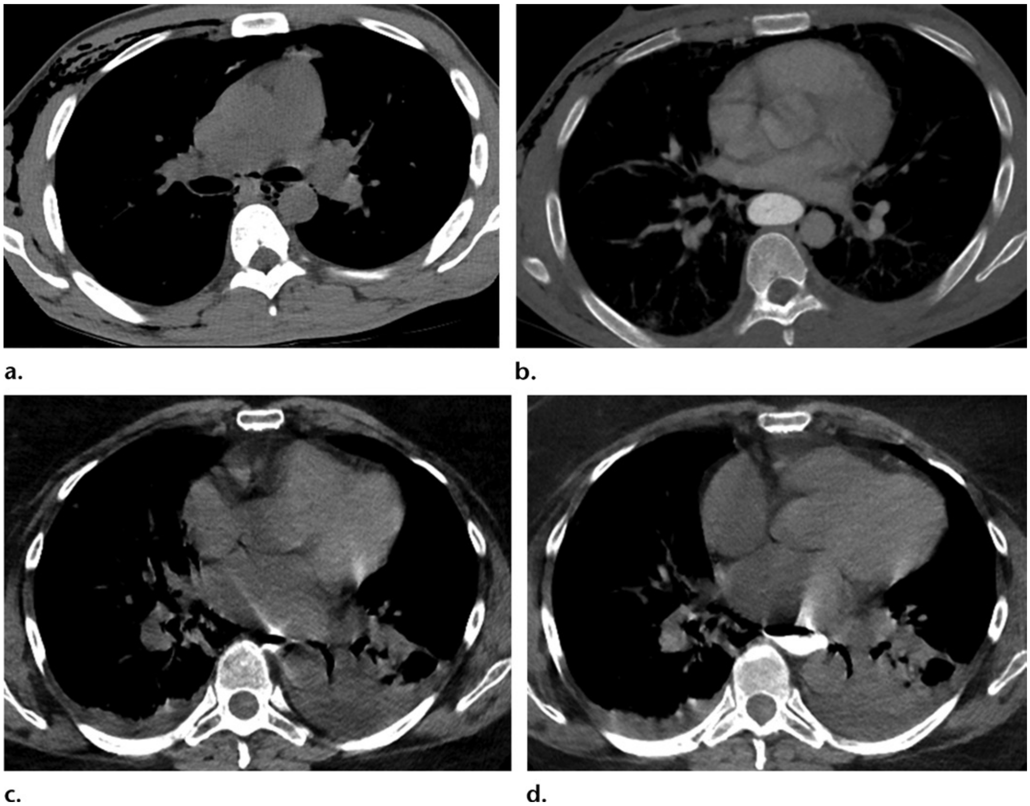


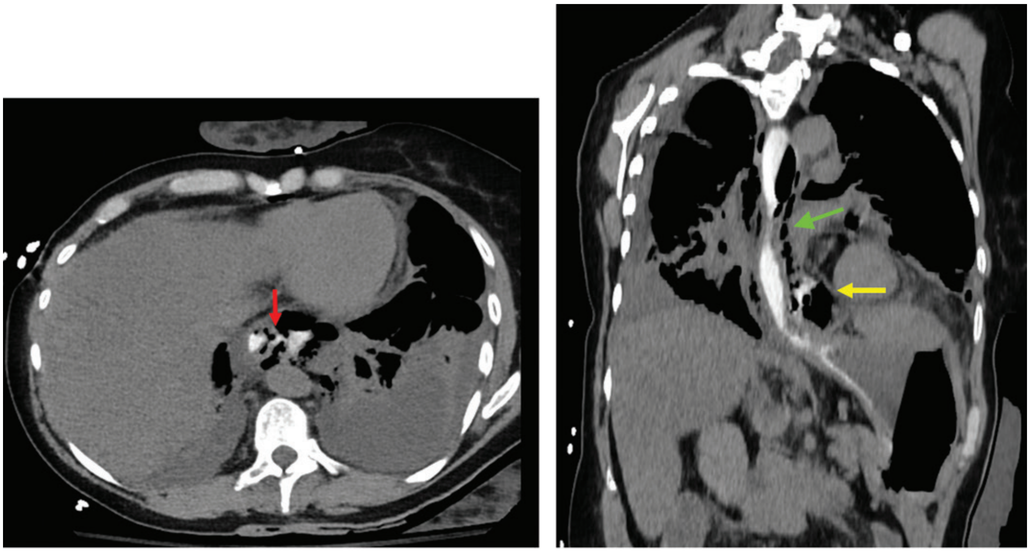
Figure 9. Adequate and inadequate esophageal distention. **(a)** Axial precontrast CT esophagram demonstrates the anatomy before contrast material administration. **(b)** Postcontrast CT esophagram shows adequate esophageal distention. **(c)** Axial postcontrast CT esophagram in a different patient demonstrates inadequate distention. **(d)** Axial CT esophagram obtained after administration of a repeat dose of contrast material in the same patient as in **c** demonstrates adequate distention.

the staffing or time availability to perform a fluoroscopic study. Fluoroscopic esophagography also has a relatively high rate of false-negative examinations, with 10%–12% of perforations missed with barium contrast material and 22%–50% missed with water-soluble contrast material (14).

The hallmark finding of esophageal injury or leak is extraluminal contrast material. In the absence of oral contrast material administration, periesophageal air collections are the next most useful finding for depicting pathologic conditions (8) (Figs 10, 11). CT is superior to fluoroscopic esophagography for the depiction of periesophageal collections (Figs 12, 13). In addition, CT may help assess the presence of periesophageal inflammation and may demonstrate intramural esophageal air, suggesting nontransmural tears (Mallory-Weiss tears), which are likely to be fluoroscopically occult (14,22).

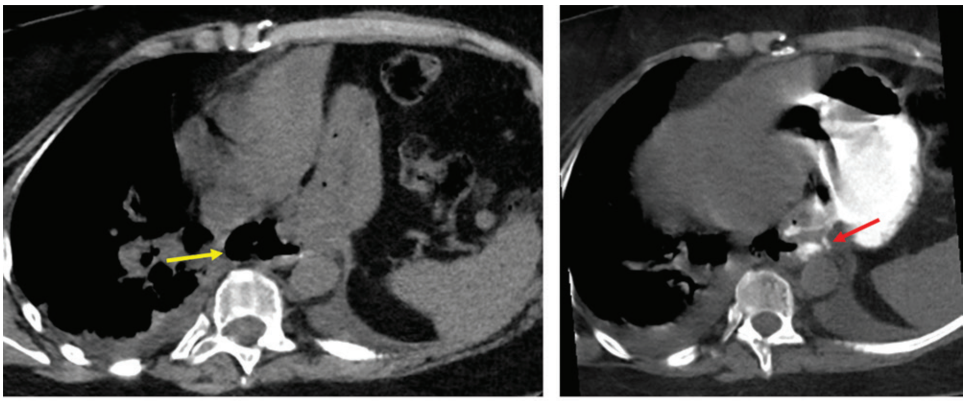
Patients with acute esophageal pathologic conditions are often critically ill (11,16,18) (Fig 14). A postoperative leak after gastrointestinal surgery may be associated with mediastinitis, sepsis, and peritonitis (3,21,23,24). CT esophagography requires only minimal physical exertion for the patient to drink enteric contrast material, compared with fluoroscopic esophagography, which requires the patient to stand and change positions (3). If the patient cannot swallow, physical demand may be reduced further by instilling enteric contrast material through a nasogastric tube that has been positioned above the level of a suspected or known tear or if that is unknown, above the cricopharyngeal sphincter (10). Patients with trauma may have concurrent cervical spine instability, which may preclude adequate fluoroscopic esophagography, further supporting the use of CT esophagography (25). Often, CT can also reveal decisive criteria for diagnosis of Boerhaave syndrome such as periesophageal air tracks, esophageal wall thickening, mediastinal fluid, and esophagopleural fistula (8) (Fig 15).

Fluoroscopic studies are operator dependent and require an experienced radiologist to perform and interpret the study, whereas performance and interpretation of CT esophagography is more consistent (26,27). Therefore, CT may improve depiction of subtle esophageal injuries, particularly when radiologists with more extensive fluoroscopic experience are not available. In our experience, identifying small leaks can be extremely difficult with fluoroscopy, especially in patients with obesity or those with limited mobility.



a. b.

Figure 10. Esophageal perforation in a patient with a history of pancreatic cancer who was evaluated for acute epigastric pain after vomiting. **(a)** Axial CT esophagogram shows an anterolateral esophageal perforation (arrow), which is compatible with Boerhaave syndrome. **(b)** Oblique coronal reformation from CT esophagography shows a contrast agent–containing amorphous fluid collection (yellow arrow) and diffuse paraesophageal air (green arrow), which are findings consistent with perforation.



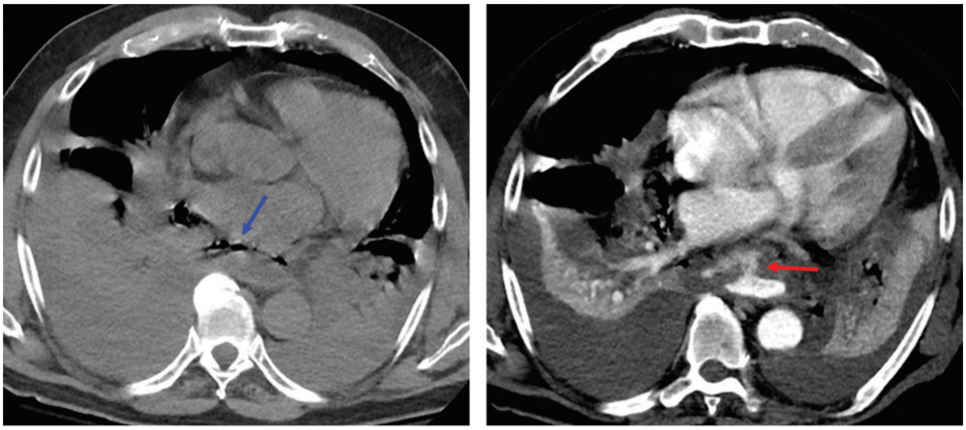
a. b.

Figure 11. Leak at the gastroesophageal junction in a patient with acute-onset epigastric pain. **(a)** Axial CT esophagram shows pneumomediastinum and paraesophageal air (arrow) that were identified at nonenhanced abdominal CT (not shown). **(b)** Axial postcontrast CT esophagram shows a leak at the posterior gastroesophageal junction (arrow).

The use of intravenous contrast agent does not improve depiction of esophageal pathologic conditions but has an added value in the diagnosis of other acute conditions such as pulmonary embolism, trauma, infection, or aortic dissection (1,10) (Figs 16, 17). Not all institutions use intravenous contrast agent for CT esophagography, supporting the diagnostic value of an examination with oral contrast material only in patients with renal failure or severe allergy (16,17). In the postoperative setting, CT esophagography aids in the depiction of extraesophageal findings, which may be missed with fluoroscopic studies (Figs 18–21). These include abscess, ileus, small-bowel obstruction, and more distal small-bowel injuries or leaks (3). In addition to evaluation of emergency department patients, CT esophagography may also be valuable in evaluating postoperative complications from gastric bypass, as clinical diagnosis may be difficult in this population (Figs 22, 23). Bingham et al (3) showed that CT was superior to fluoroscopic upper gastrointestinal examination to help evaluate leaks in patients who have undergone bariatric surgery.

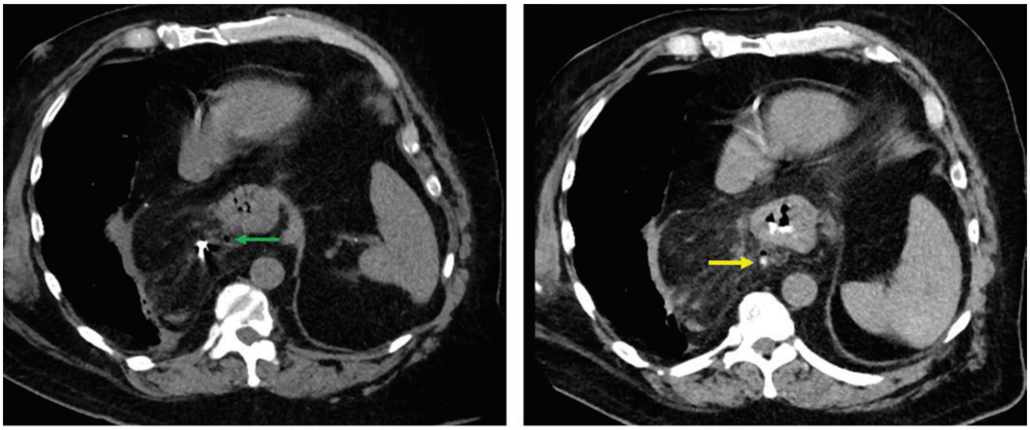
Finally, should treatment be required, oral contrast material (Gastrografin or barium) may interfere with or prevent endoscopic intervention (14) (Fig 24).

The most significant limitation of CT esophagography is poor demonstration of mucosal detail



a. b.

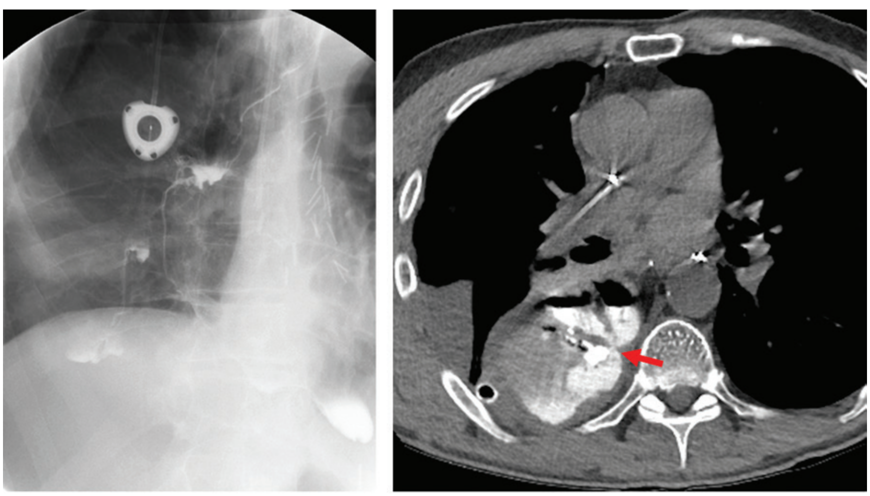
Figure 12. Esophageal perforation in a patient with shortness of breath and central chest pain. CT images obtained as part of the pulmonary embolism protocol showed pneumomediastinum and bilateral pleural effusions (not shown). **(a)** Axial precontrast CT esophagram shows pneumomediastinum (arrow) and bilateral pleural effusions. **(b)** Axial CT esophagram obtained after the administration of oral and intravenous contrast materials shows a large anterior esophageal perforation (arrow).



a. b.

Figure 13. Stomach perforation in a patient with sudden-onset epigastric pain and a history of hiatal hernia. **(a)** Axial CT image obtained at presentation demonstrates a small focus of air outside the hernia (arrow). **(b)** Axial CT esophagram shows extraluminal contrast material, a finding that helps confirm a small perforation in the posterior intrathoracic stomach (arrow).

Figure 14. Esophageal leak in a patient who recently underwent esophagectomy and gastric pull-up. **(a)** Fluoroscopic esophagram shows leakage of contrast material from the esophagectomy site. The exact site of the leak was unable to be ascertained during fluoroscopic esophagography as the patient was critically ill and difficult to reposition. **(b)** Axial CT esophagram obtained without intravenous contrast agent clearly demonstrates the posterior defect in the esophagectomy site (arrow), allowing surgical planning.



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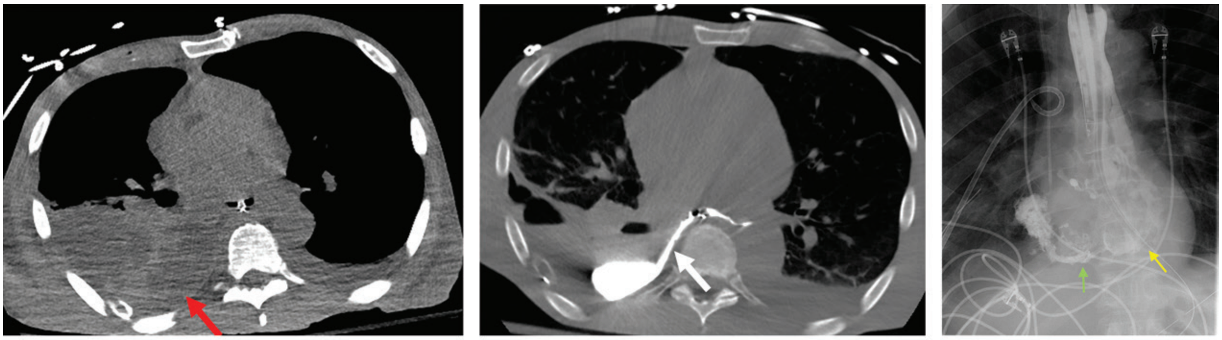
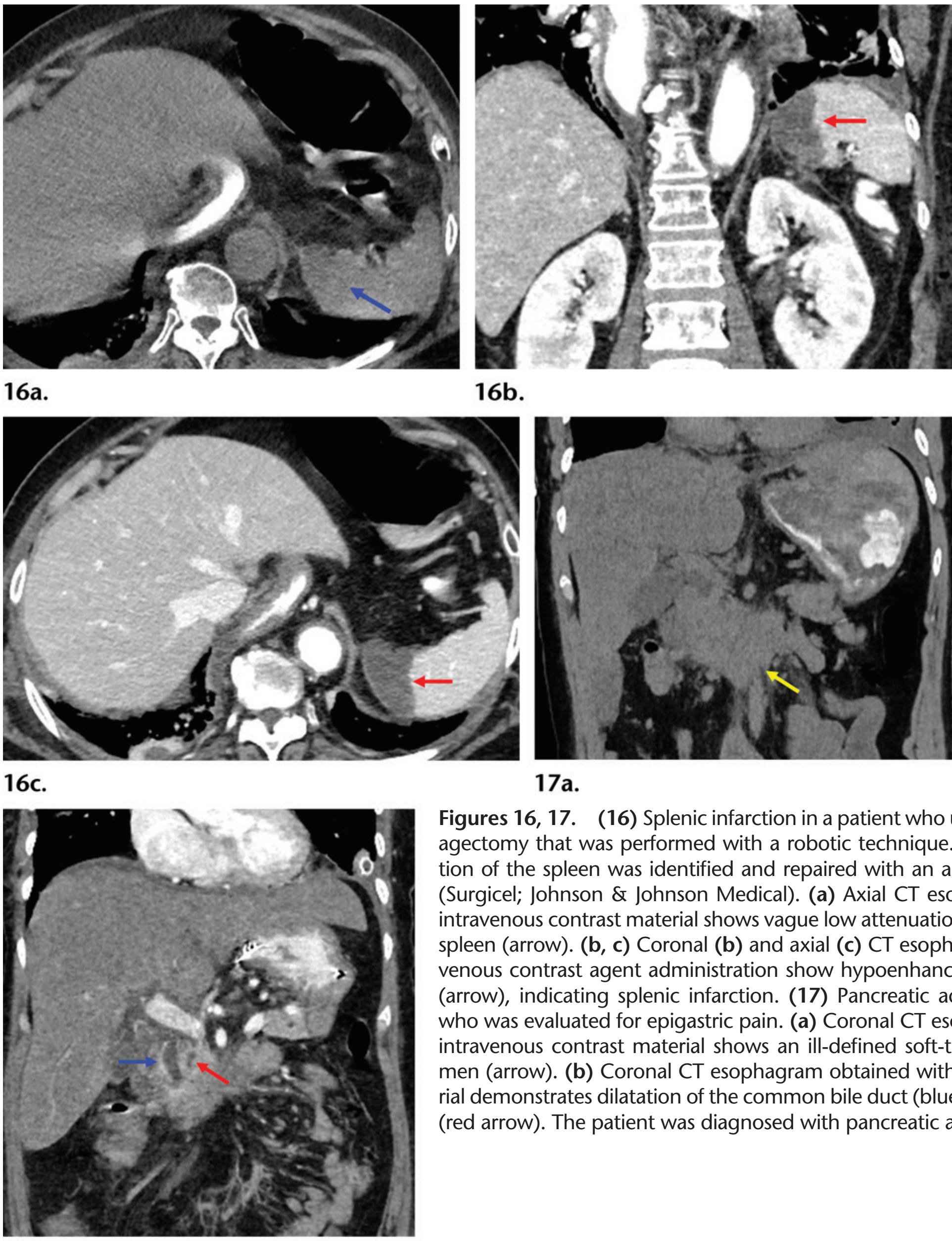


a. b. c.

Figure 15. Necrotizing esophagitis and esophagopleural fistula. **(a, b)** Axial CT esophagrams obtained without intravenous contrast agent in a patient with necrotizing esophagitis show an esophagopleural fistula (white arrow in **b**) and a right lung abscess (red arrow in **a**). **(c)** Fluoroscopic esophagram shows irregularity of the distal esophagus (yellow arrow) and an esophagopleural fistula (green arrow). The additional extent of contrast material into the left mediastinum that indicates bilateral wall perforation was not appreciated at fluoroscopic examination.



16a. **16b.**

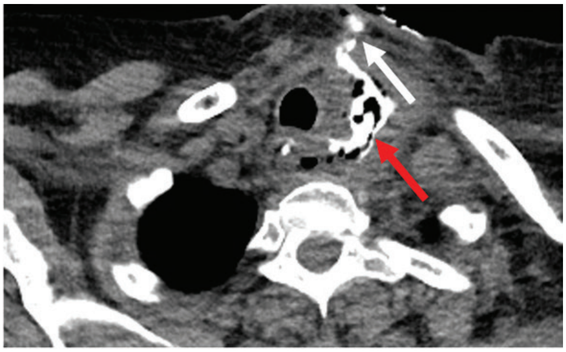
16c. **17a.**

17b.

Figures 16, 17. **(16)** Splenic infarction in a patient who underwent Ivor Lewis esophagectomy that was performed with a robotic technique. During surgery, deserolization of the spleen was identified and repaired with an absorbable hemostatic agent (Surgicel; Johnson & Johnson Medical). **(a)** Axial CT esophagram obtained without intravenous contrast material shows vague low attenuation in the medial aspect of the spleen (arrow). **(b, c)** Coronal **(b)** and axial **(c)** CT esophagrams obtained after intravenous contrast agent administration show hypoenhancement of the medial spleen (arrow), indicating splenic infarction. **(17)** Pancreatic adenocarcinoma in a patient who was evaluated for epigastric pain. **(a)** Coronal CT esophagram obtained without intravenous contrast material shows an ill-defined soft-tissue mass in the midabdomen (arrow). **(b)** Coronal CT esophagram obtained with intravenous contrast material demonstrates dilatation of the common bile duct (blue arrow) and pancreatic duct (red arrow). The patient was diagnosed with pancreatic adenocarcinoma.

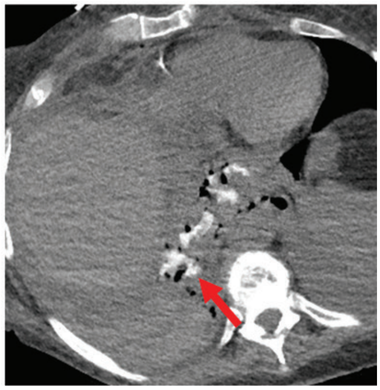
Figures 18-20. **(18)** Dehiscence of an anastomosis with a skin fistula after transhiatal esophagectomy. **(a)** Axial precontrast CT esophagram shows an anterolateral soft-tissue defect and disrupted suture material (arrow). **(b)** Axial CT esophagram obtained after oral contrast material administration confirms dehiscence of the proximal anastomosis (red arrow) and a fistula to the skin (white arrow). The contrast material leak and fistula were not evident at fluoroscopic esophagography that was performed on the same day (not shown). **(19)** Esophageal leak. **(a)** Fluoroscopic CT esophagram obtained after Heller myotomy was negative for leak. After diet advancement, the patient became progressively hypoxic, and a chest radiograph (not shown) revealed large right pleural effusion. **(b, c)** CT esophagrams obtained without intravenous contrast material help confirm an esophageal leak above the level of the gastroesophageal junction, with a gas-fluid collection in the right pleural space (arrow). **(20)** Long-segment esophageal stricture in a patient with a history of esophageal rings requiring dilation who presented with food impaction and concern for esophageal rupture. **(a)** Fluoroscopic esophagram suggests a stricture (arrow). However, the patient was unable to swallow additional contrast agent while standing. CT esophagography was recommended to help evaluate for leak. **(b)** Sagittal maximum intensity projection (MIP) reformation from CT esophagography demonstrates a long-segment esophageal stricture (bracket). No leak was evident. **(c)** Sagittal reconstruction from CT esophagography also shows the long-segment esophageal stricture (bracket).

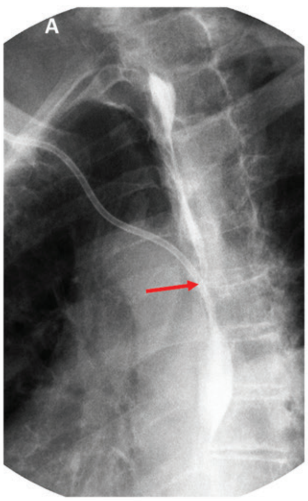

18a.


18b.

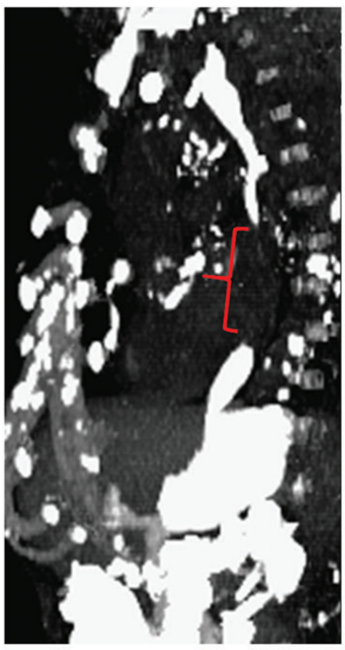

19a.

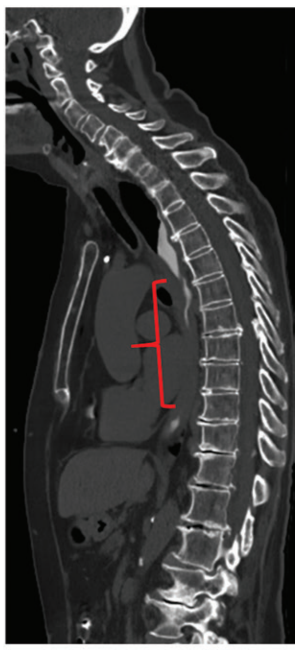

19b.

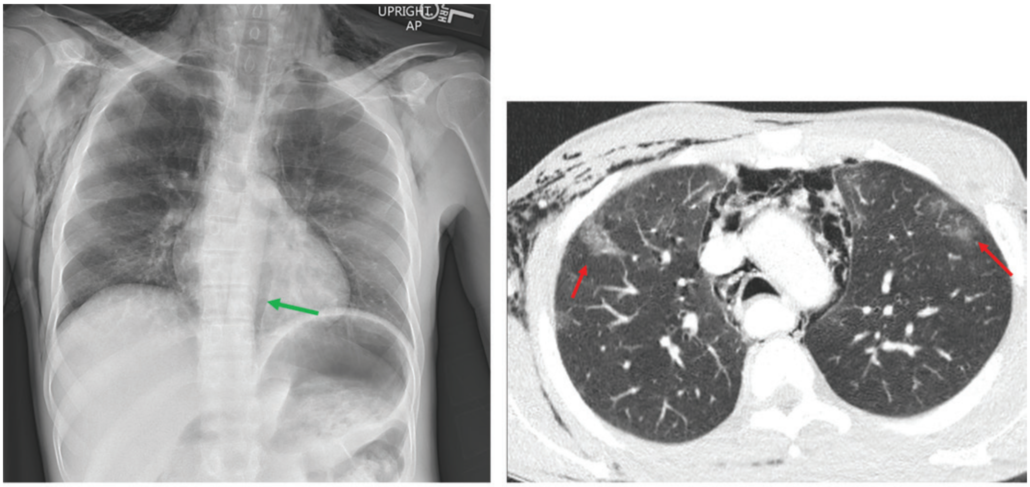

19c.



20a.

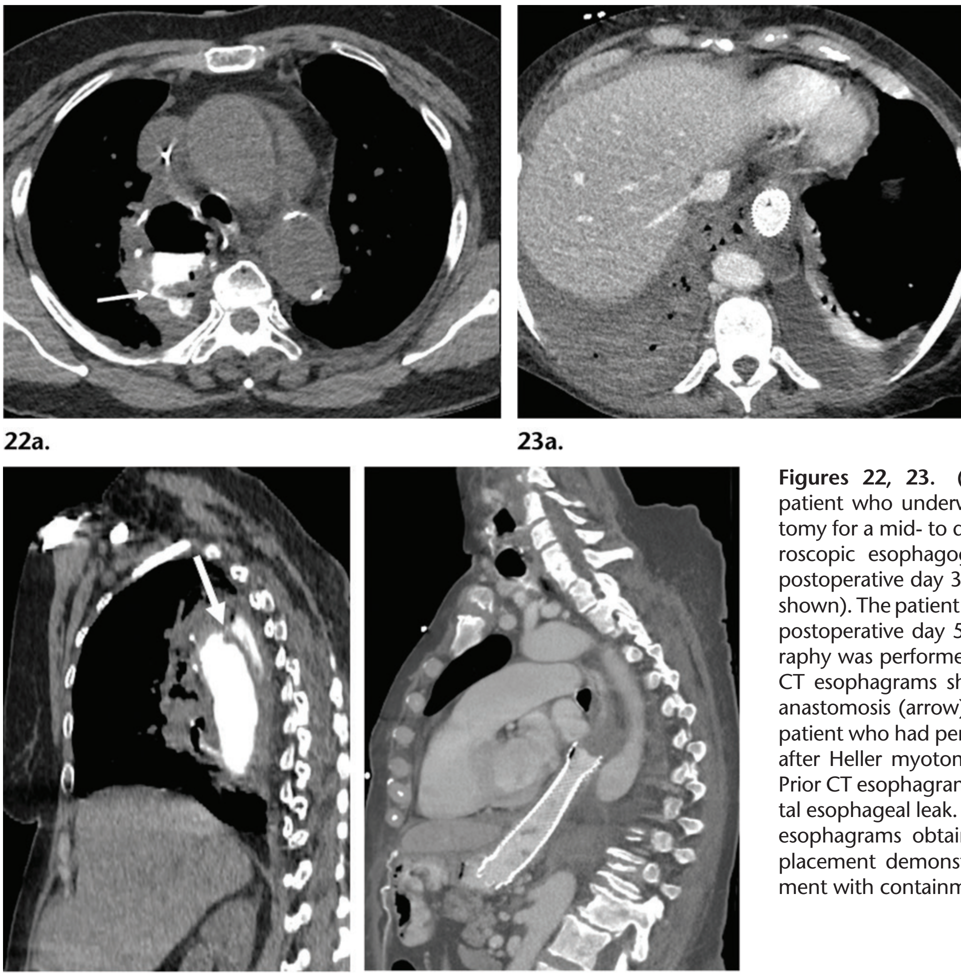

20b.


20c.



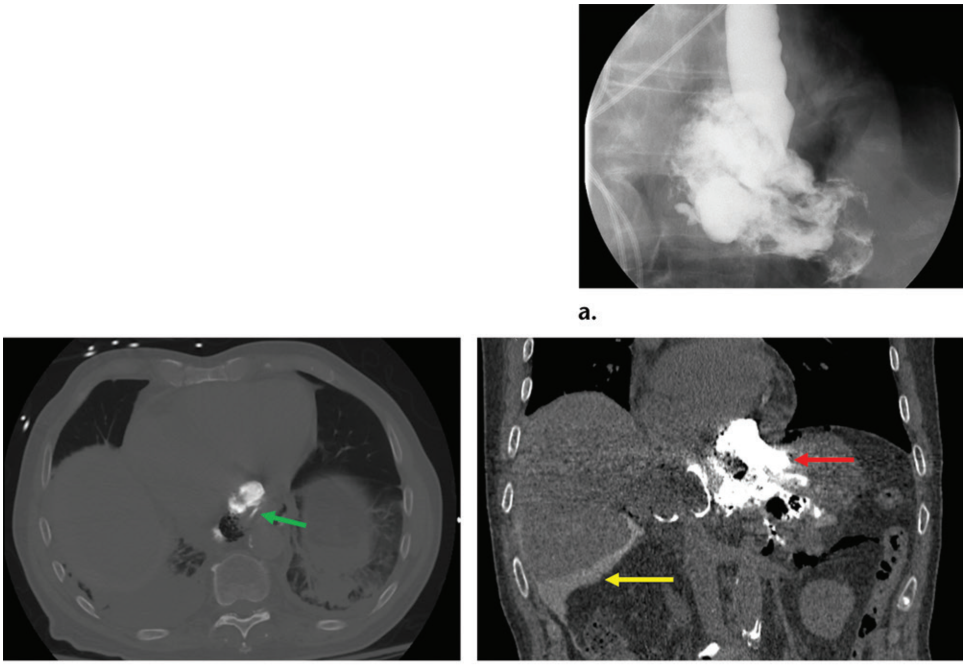
a. b.

Figure 21. Findings of COVID-19 in a patient with chest pain. **(a)** Anteroposterior chest radiograph acquired in the emergency department shows pneumomediastinum (arrow) and chest wall gas. **(b)** Axial CT esophagram is negative for leak, although evaluation of the lung parenchyma demonstrates peripheral ground-glass opacities (arrows). The patient was subsequently diagnosed with COVID-19.



22a. 23a. 22b. 23b.

Figures 22, 23. (22) Esophageal leak in a patient who underwent Ivor Lewis esophagectomy for a mid- to distal esophageal mass. Fluoroscopic esophagography was performed on postoperative day 3 with negative findings (not shown). The patient developed fever and pain on postoperative day 5, for which CT esophagography was performed. Axial **(a)** and sagittal **(b)** CT esophagrams show a posterior leak at the anastomosis (arrow). **(23)** Esophageal leak in a patient who had persistent surgical drain output after Heller myotomy and hiatal hernia repair. Prior CT esophagrams (see Fig 19) showed a distal esophageal leak. Axial **(a)** and sagittal **(b)** CT esophagrams obtained after endoscopic stent placement demonstrate adequate stent placement with containment of the leak.



a. b. c.

Figure 24. CT esophagography for better anatomic localization of a leak. **(a)** Fluoroscopic esophagram shows gross contrast material leak from the distal esophagus and gastroesophageal junction. The patient rapidly drank a large bolus of contrast material, which resulted in a large contrast material leak, making anatomic localization difficult. **(b)** Axial CT esophagram depicts an anterior esophageal leak (arrow), which was difficult to confirm with fluoroscopy. **(c)** Coronal oblique reformation from CT esophagography delineates the contrast material collection in the lesser sac (red arrow), which was difficult to interpret at fluoroscopy. Contrast agent is seen extending along the liver (yellow arrow), a finding that was not appreciated at fluoroscopy.

compared with a fluoroscopic double-contrast examination. However, most acute evaluations are performed as a single-contrast examination with water-soluble contrast agent, which also provides limited mucosal detail.

Building a CT Esophagography Program

Development of a successful CT esophagography program involves education of both the radiology department staff and referring clinicians on appropriate uses, advantages, and disadvantages. This requires a multidisciplinary approach, with radiology, gastroenterology, emergency medicine, cardiothoracic surgery, and general surgery staff facilitating communication and education across all departments involved in the ordering and interpretation of these examinations. Defining the appropriate indications for CT esophagography and using flowcharts for performing the examination can greatly improve utilization and the consistency of the examinations (Figs E1–E4).

As with most departmental quality improvement projects, development of a successful CT esophagography program requires buy-in from all concerned parties. The use of fluoroscopy is well established, so demonstrating easier patient access, faster turnaround time, and the improved clinical accuracy of CT esophagography in patient care and diagnosis may be necessary to recognize this new protocol as a viable alternative.

Conclusion

CT esophagography has been shown to be at least equal to fluoroscopic esophagography if not superior to it in many instances and is readily available in most clinical settings. In addition, this service may be provided in the absence of direct on-site radiologist supervision, allowing timely and accurate diagnosis of esophageal perforation. This may improve patient care and reduce morbidity and mortality associated with postoperative complications and acute chest trauma. To this end, creation of a successful CT esophagography program requires a multidisciplinary approach involving communication and education among all staff involved, including creation of a reproducible CT esophagography protocol.

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