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A BIWEEKLY REVIEW OF CLINICAL RADIOLOGIC PRACTICE

Imaging in the Evaluation of Esophageal Trauma Including Surgery

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After participating in this educational activity, the radiologist should be better able to describe an approach to the imaging evaluation of suspected esophageal perforation and identify key imaging features of native and neoesophageal rupture.

Category: Gastrointestinal
Modality: Multiple

Key Words: Esophageal Perforation, Esophageal Rupture, Boerhaave Syndrome, CT Esophagography, Fluoroscopic Esophagography, Esophagectomy, Postoperative Leak

Esophageal perforation and anastomotic leak of the postsurgical esophagus place patients at significant risk for morbidity and mortality, requiring prompt and accurate diagnosis through imaging. Plain radiographs may be obtained during the initial evaluation of symptoms but have low sensitivity and specificity for esophageal perforation. With clinical suspicion for perforation, CT with oral contrast should be obtained initially due to its high sensitivity, utility in surgical planning, and usefulness in evaluating underlying causes or other etiologies for symptoms. With a negative CT, perforation is ruled out and subsequent fluoroscopic esophagography is unnecessary. In patients with postsurgical anatomy such as esophagectomy, diagnosis is difficult and concurrent review of CT and fluoroscopy is more sensitive than either modality alone.

Esophageal perforation or rupture is a rare but potentially life-threatening condition with a variable clinical presentation and significant morbidity and mortality, especially with delay in diagnosis.[1-3] It is defined as a full-thickness tear of the esophagus and most commonly results from iatrogenic causes including endoscopy or intraoperative injury and less commonly from foreign body ingestion, trauma, caustic substance ingestion, malignancy, and after repeated and forceful vomiting, known as Boerhaave syndrome (Table 1).[2] Because of a relative anatomic weak point at the margin of esophageal muscle fibers, the distal left posterolateral wall is the point of rupture in most spontaneous perforations.[4,5] Symptoms may vary depending on the location of the perforation and include chest pain, dysphagia, epigastric, back, and shoulder pain, pain with neck movement, dyspnea, and crepitus resulting from subcutaneous emphysema (chest pain, vomiting, and subcutaneous emphysema are known as Mackler's triad).[2,6] In advanced presentations, systemic signs of fever, tachycardia, and hypotension may be present.

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Conditions that are associated with higher risk for perforation include esophageal malignancy, strictures, achalasia, gastroesophageal reflux disease, scleroderma, and hiatal hernias (Table 1).[2] Previous research has demonstrated the importance of timely diagnosis and treatment

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Table 1. Causes of and Risk Factors for Esophageal Perforation

Causes	Risk Factors
Iatrogenic (most common)—endoscopy, intraoperative injury	Gastroesophageal reflux disease
Spontaneous after severe vomiting (Boerhaave syndrome)	Malignancy
Foreign body ingestion	Esophageal stricture
Caustic substance ingestion	Achalasia
Malignancy	Hiatal hernia
Trauma (blunt or penetrating)	Scleroderma

in reducing mortality from perforations; however, accurate and early diagnosis remains challenging due to nonspecific presenting symptoms.[7-9] Given the increased mortality with delayed diagnosis, imaging studies performed in the emergency department should be high in both sensitivity and specificity. Traditionally, fluoroscopic esophagography has been used in the initial evaluation of suspected esophageal perforation, with CT esophagography performed to confirm leak and guide possible surgical management.[4,7] Studies have shown that CT esophagography has superior sensitivity and negative predictive value for esophageal perforations and is much less time, resource, and personnel intensive compared with fluoroscopy.[3,4,7,10]

The published literature is limited regarding the appearance of esophageal perforations in both the native and postsurgical, or neoesophagus, on different imaging modalities. The purpose of this article is to summarize the evaluation of esophageal injury, including the use of fluoroscopy compared with CT, and review the positive findings of both native and neoesophageal perforations in various imaging modalities (Tables 1–3). Our algorithm for the evaluation of patients with suspected pharyngeal and esophageal perforations is shown in Figure 1.

Table 2. Imaging Findings of Esophageal Perforation on Plain Radiograph, Fluoroscopy, and CT

Imaging Modality	Imaging Findings
Plain radiography	Pneumomediastinum—lucency visualized superolateral to heart, great vessels
	Air visualized along superior diaphragm
	Subcutaneous emphysema
	Pneumopericardium
Fluoroscopy	Extravasation of oral contrast
	Periesophageal air or fluid collections
CT	Pneumomediastinum
	Subcutaneous emphysema
	Extravasation of oral contrast
	Esophageal thickening
	Loculated air or fluid collections
	Pleural effusion
	Opacification of surgical drains by contrast in postsurgical patients

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Table 3. Benefits and Limitations of Plain Radiograph, Fluoroscopy, and CT in Evaluating Esophageal Perforation

Imaging Modality	Benefits	Limitations
Plain radiography	Quickly and easily obtained	Lower sensitivity
	Not resource intensive	Limited in identifying site of perforation
		Limited in assessing underlying cause of perforation
Fluoroscopy	Complementary to CT in evaluating postsurgical patients	Time and resource intensive
	Able to discern contained leaks from redundant stomach in postsurgical patients	Requires patient participation and exertion
		Requires radiologist experienced in fluoroscopy
		Does not evaluate nonesophageal causes of symptoms
		Risk of pulmonary edema with water-soluble contrast aspiration and mediastinitis with use of barium
CT	Sensitive for small-volume extraluminal air	In postsurgical patients, difficult to differentiate between signs of perforation and normal postoperative findings
	Less time and resource intensive than fluoroscopy	
	Able to identify site of perforation and aid in surgical planning	
	High sensitivity allows negative examination to rule out perforation	
	Able to assess underlying etiology or nonesophageal causes for symptoms	

Imaging of Esophageal Perforation

Plain Radiography

Owing to the speed and ease of acquisition, plain radiography may be the first imaging study obtained in the evaluation of possible esophageal perforation. Upright views of the chest and supine views of the abdomen may reveal lucency suggestive of extraluminal air or pneumomediastinum, and possible findings include air visualized as lucency superolateral to the heart, surrounding the great vessels, or along the superior diaphragm on an upright chest radiograph

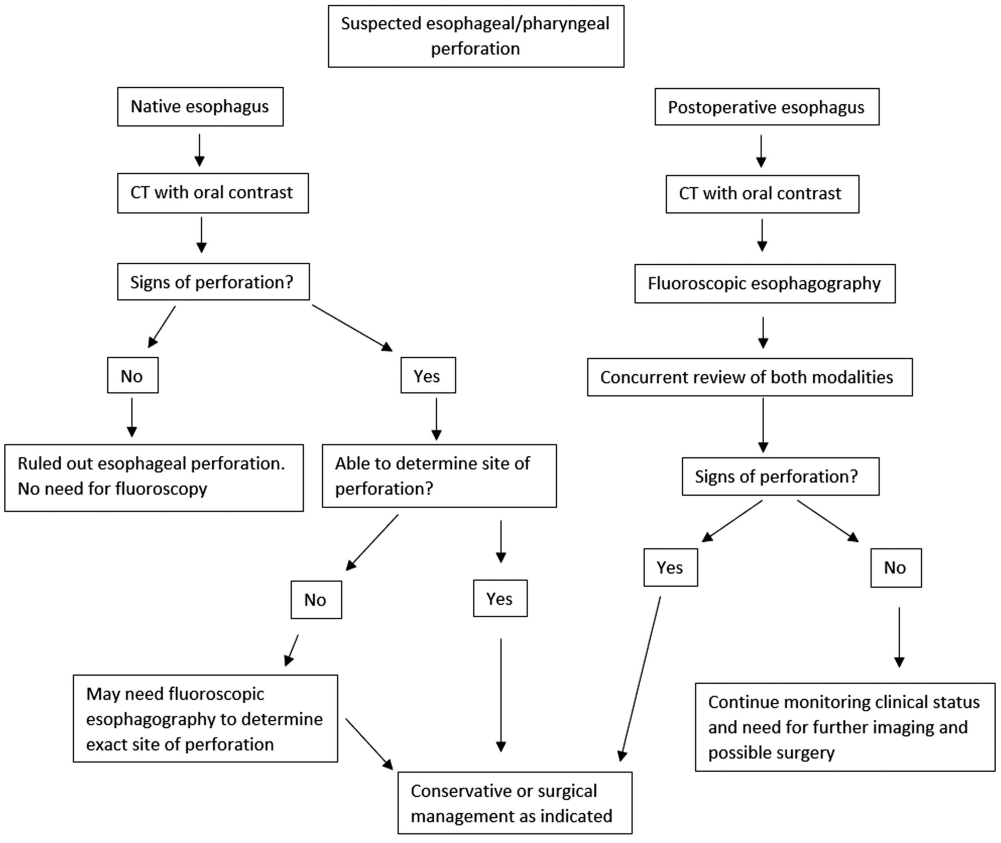

Figure 1. Imaging approach in patients with clinical suspicion for esophageal perforation.

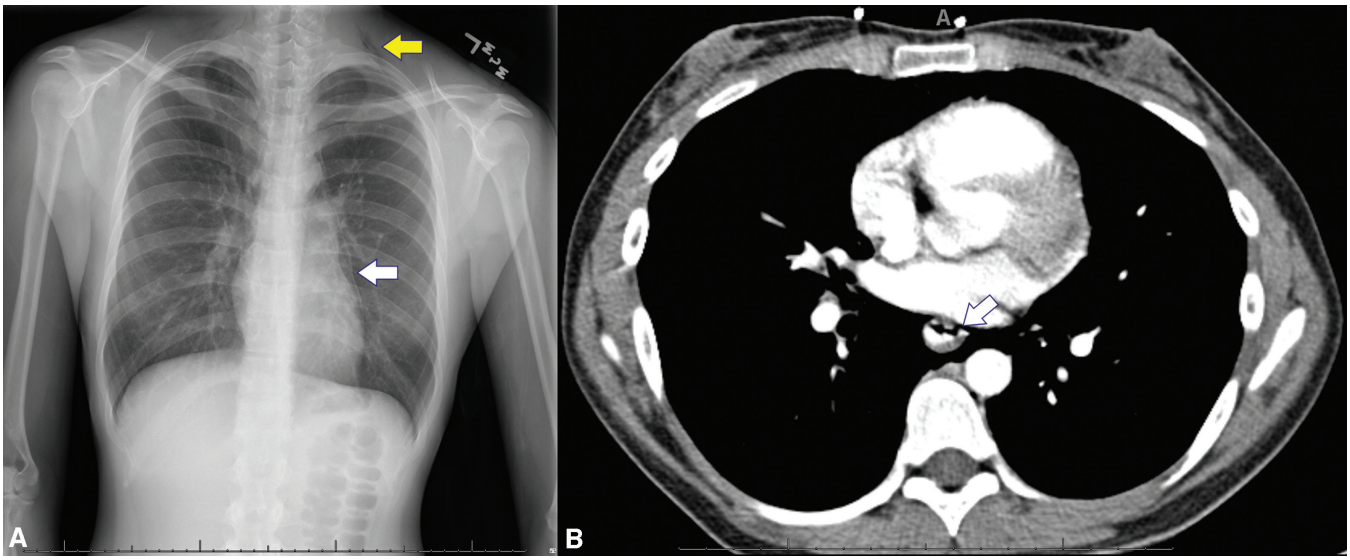

Figure 2. Chest radiograph and subsequent CT scan in a patient with a history of repeated vomiting after alcohol binge. *A*: Upright chest radiograph demonstrating pneumomediastinum with subcutaneous emphysema of the neck (*yellow arrow*) and pneumopericardium (*white arrow*). *B*: Axial CT image of the chest demonstrating a subtle area of focal disruption/tear (*arrow*) in the left anterolateral distal esophagus, which is consistent with Boerhaave syndrome.

(Figure 2 and Table 2).[11,12] Limitations of plain radiographs in evaluating hollow viscus perforation include its lower sensitivity, especially for smaller volumes of free air, limited utility in assessing the site of perforation, and limited ability to assess for an underlying cause (Table 3).[11,13]

Fluoroscopic Esophagography

Fluoroscopic esophagography has historically been used as the initial imaging modality for detection of esophageal perforation and is indicated per the American College of Radiology appropriateness criteria.[7,14,15] It is also used to assess for pharyngeal leak after trauma and sometimes obtained routinely in the postoperative period to evaluate for leak. Water-soluble oral contrast has a false-negative rate of up to 10% but is used before barium in the setting of possible perforation to reduce the risk of barium-induced mediastinitis.[2] If esophagography with water-soluble contrast is negative, then it should be repeated with barium due to its higher sensitivity for detecting perforation (Figure 3).[7,14,16] Imaging findings include extravasation of oral contrast or periesophageal air or fluid collections in the case of contained leak (Table 2). There are several notable drawbacks to the use of fluoroscopic esophagography in the evaluation of possible perforation: it requires the use of a fluoroscopy suite, is more time and resource intensive compared with CT, requires the patient to be able to swallow oral contrast and reposition themselves

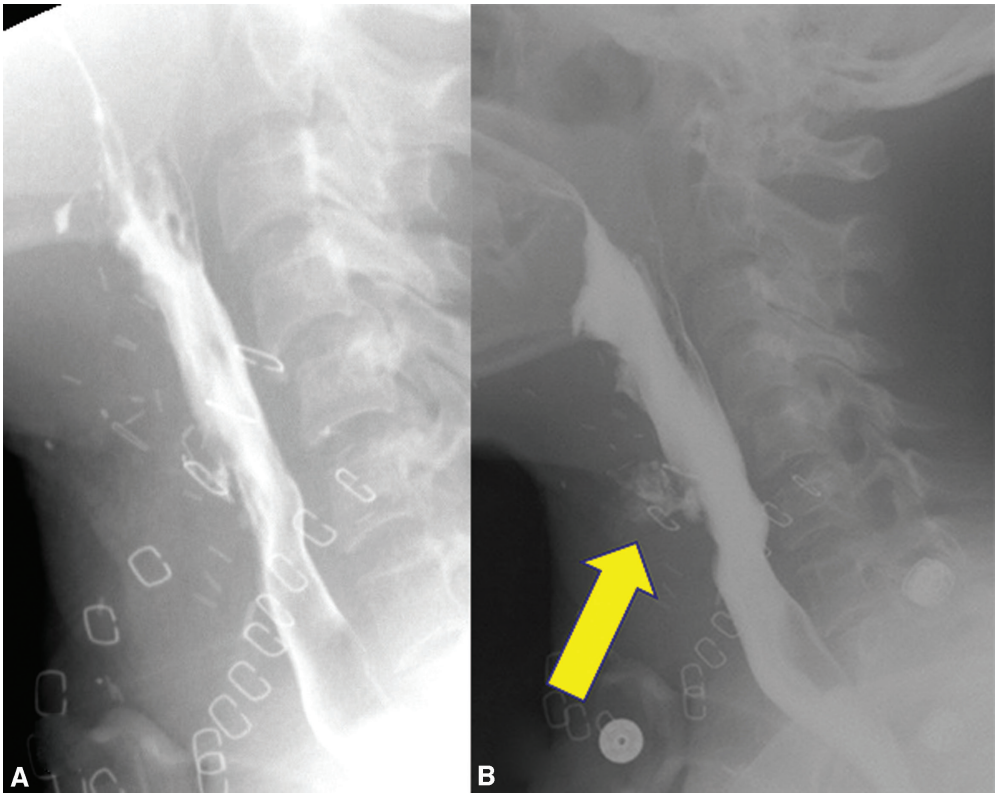

Figure 3. Postoperative leak not shown by water-soluble contrast. *A*: Esophagogram with water-soluble contrast in the postsurgical patient without evidence of leak. *B*: Subsequent barium esophagogram of the same patient showing extravasation of contrast (*arrow*) confirming postoperative leak.

Figure 4. CT and esophagogram of a patient 5 weeks after Ivor-Lewis esophagectomy representative of a false-negative esophagogram. *A*: Coronal CT scan shows extravasation of oral contrast medium (*arrows*) confirming perforation. *B*: Fluoroscopic esophagogram in the same patient is without evidence of contrast extravasation or other signs of perforation and thus a false negative.

during the examination, is more operator-dependent requiring a radiologist experienced in fluoroscopy, and does not reveal nonesophageal causes for the patient's symptoms.[4,7] Additionally, aspiration of water-soluble contrast poses a risk for pneumonitis and pulmonary edema leading to significant morbidity and mortality (Table 3).[4,7] If esophagography with barium is performed before CT, residual barium may cause streak artifacts on CT, whereas the diluted oral contrast used for CT does not interfere with subsequent fluoroscopy.

If esophagography with water-soluble contrast is negative, then it should be repeated with barium due to its higher sensitivity for detecting perforation.

Computed Tomography

CT esophagography offers multiple benefits over both plain radiographs and fluoroscopic esophagography (Table 3) and typically includes imaging after low-osmolar iodinated oral contrast, with IV contrast used as indicated. It is the most sensitive imaging modality for detection of small-volume extraluminal air and thin collimation images and reformats allow for accurate evaluation at the site of perforation, which is useful for surgical planning (Figure 4).[11,17] Sensitivity of CT for esophageal perforation or postanastomotic leak is 59% to 100% whereas specificity is 80% to 100%.[4,18-20] Additionally, CT is less time and resource intensive than fluoroscopy. Although fluoroscopy requires the patient to possibly stand and reposition themselves for image acquisition, CT is less physically demanding, which is a significant benefit in critically-ill individuals or those with limited mobility or trauma.[4] Fluoroscopy is also more operator dependent and less consistent compared with the images obtained with CT, necessitating radiologists with extensive fluoroscopy experience for detection of small leaks. Findings of esophageal perforation on CT include pneumomediastinum, extravasation of oral contrast media, esophageal thickening with surrounding fluid, loculated fluid or air collections, pleural effusions (distal perforations are associated with left-sided effusions, whereas mid-esophageal perforations are associated with right-sided effusions), and in postsurgical patients, direct opacification of surgical drains by contrast (Figure 5).[6,11,13,16,17]

Considerations in the Postoperative Patient

Evaluation for esophageal perforation or anastomotic leak in the postoperative or neoesophagus (e.g., esophagectomy) presents a diagnostic challenge, given varying anatomy from different surgical techniques and the presence of redundant stomach at the site of anastomosis. Although extraluminal air or fluid suggests esophageal perforation in the native esophagus, these may be normal postoperative findings after esophagectomy, thus leading to false-positive diagnosis of conduit leak on CT (Figure 6).[19,21] Opacification of surgical drains with oral contrast on CT is a key finding of conduit leak in these patients (Figure 5 and Table 2).[19] The appearance of side-to-side anastomosis is similar to a contained conduit leak and may also result in false positives on fluoroscopic esophagography.[19,21]

In the native esophagus, CT esophagography should always be performed first because, if negative, fluoroscopic esophagography is not needed.

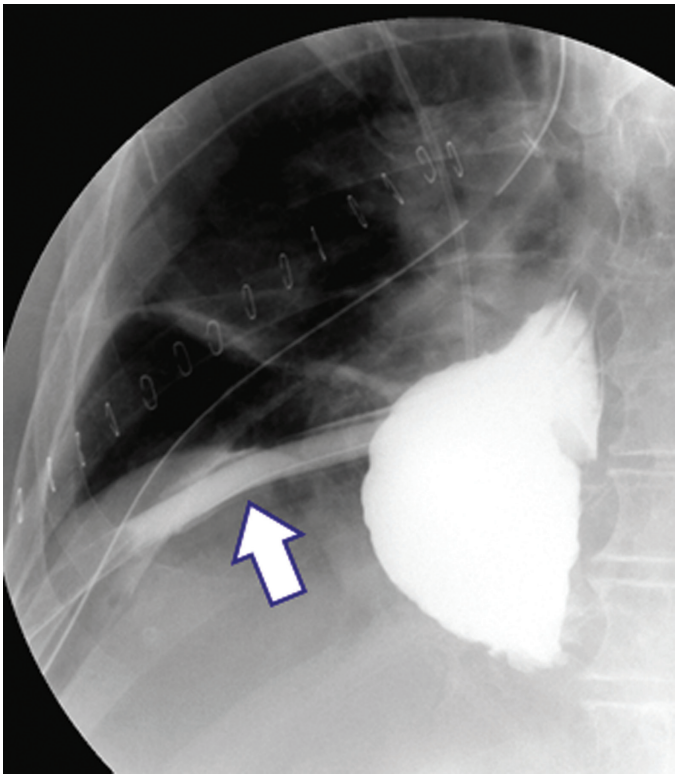

Figure 5. Esophagogram obtained from a patient 1 week after Ivor-Lewis esophagectomy for gastroesophageal adenocarcinoma demonstrating contrast filling predominantly within the right lower perihilar chest tube (*arrow*) suggesting conduit leak.

Although CT esophagography has superior sensitivity and specificity to fluoroscopy for diagnosing esophageal perforation in the native esophagus, fluoroscopy and CT are complementary in the postoperative patient with concurrent review of both modalities resulting in greater sensitivity and specificity.[10,19,21] This is exemplified in Figure 6 where CT obtained post-esophagectomy is concerning for contained leak but fluoroscopic examination shows contrast is not fixed in that area, suggesting the CT findings are a result of redundant stomach.[10]

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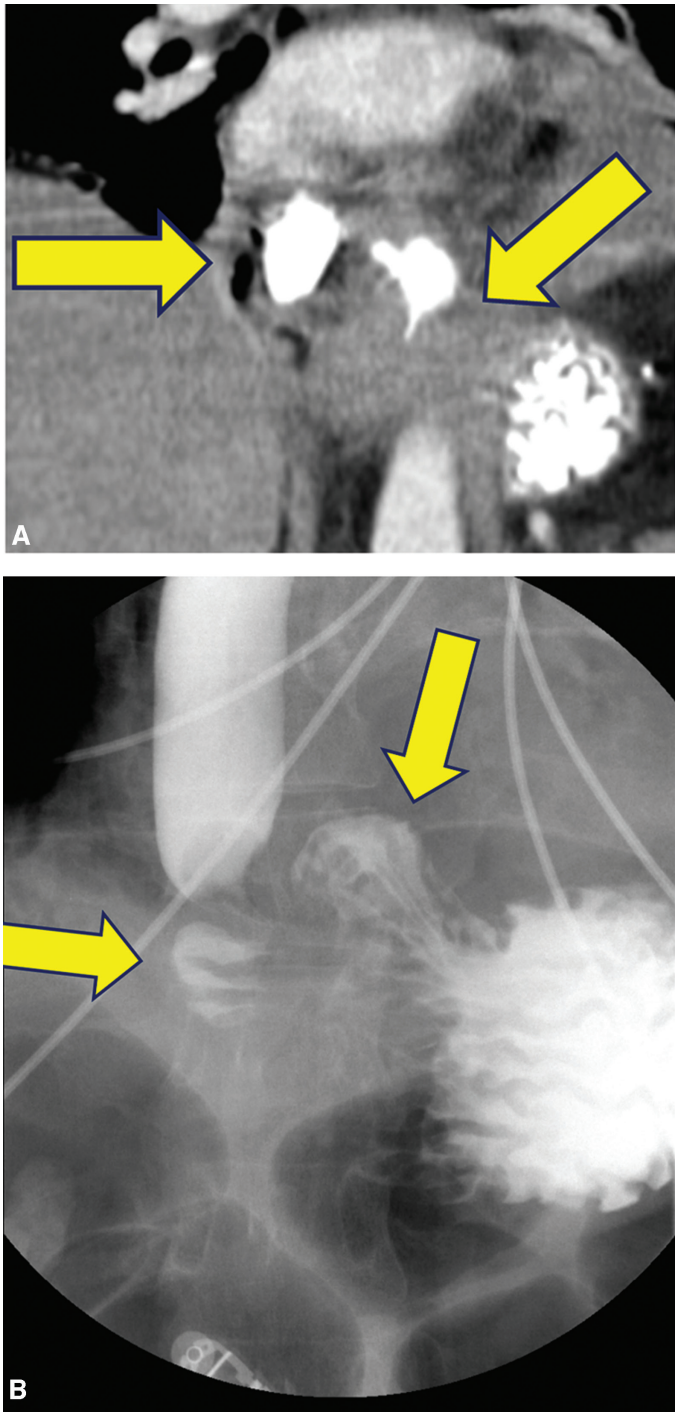

Figure 6. CT and esophagogram from a patient with a history of fundoplication representative of a false-positive CT. *A*: Coronal CT image with oral contrast shows apparent extravasation of contrast with loculated air collections (*arrows*) suggestive of perforation. *B*: Fluoroscopic esophagogram demonstrating blind-ending stomach pouches (*arrows*) in the postsurgical patient without evidence of perforation.

Treatment

Esophageal perforation and postoperative leaks can lead to mediastinitis and sepsis, which are the most common severe complications and result in severe postoperative morbidity and mortality. These complications may require immediate drainage by either surgery or image-guided drainage. The approach depends upon the location and accessibility. In some patients, leaks may be managed non-operatively by endoscopic stent placement. Endoscopically placed fibrin glue has also been used in some centers.[22] Other nonoperative management for patients with mild symptoms and no signs of sepsis includes broad-spectrum antibiotics and parenteral nutrition with the patient having nothing by mouth until the leak has sealed.[2]

Conclusion

Esophageal perforations are rare but may result in serious complications, including sepsis and death. Early and accurate diagnosis through imaging is vital in reducing morbidity and

mortality and guiding management. CT esophagography is more sensitive but less specific than fluoroscopic esophagography in the evaluation of patients with a suspected esophageal perforation and is also less time and resource intensive, leading to more prompt diagnosis. Findings on CT include extravasation of contrast, loculated fluid collections, and direct opacification of surgical drains by contrast. In the native esophagus, CT esophagography should always be performed first because, if negative, fluoroscopic esophagography is not needed.[3,4,7,23] In the postoperative patient, concurrent review of both modalities is complementary. When esophagography is indicated, water-soluble contrast should be used first and, if negative, followed with a barium study given the potential for false negatives with water-soluble contrast. An algorithm is presented for the imaging management of patients with clinical findings suggesting a pharyngeal or esophageal leak.

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1. Mackler's triad refers to clinical symptoms suggestive of esophageal rupture and includes
- **A.** ptosis, miosis, and anhidrosis.
- **B.** vomiting, chest pain, and subcutaneous emphysema.
- **C.** hypotension, flank pain, and pulsatile abdominal mass.
- **D.** right upper quadrant pain, fever, and jaundice.

2. Which one of the following imaging modalities is *most* sensitive for detecting esophageal rupture?
- **A.** ultrasound
- **B.** plain radiograph
- **C.** fluoroscopy
- **D.** CT

3. Most spontaneous esophageal ruptures arise from the
- **A.** distal left posterolateral wall.
- **B.** distal right posterolateral wall.
- **C.** proximal left posterolateral wall.
- **D.** proximal right posterolateral wall.

4. A patient with no history of abdominal surgery presents to the emergency department with clinical suspicion for esophageal rupture. CT esophagography is negative for perforation. Which one of the following subsequent imaging studies is *most* appropriate to rule out perforation?
- **A.** fluoroscopic esophagography
- **B.** ultrasound
- **C.** plain radiography
- **D.** no further imaging is needed

5. Which one of the following imaging findings on CT is *most* suggestive of postesophagectomy conduit leak?
- **A.** extraluminal air
- **B.** extraluminal fluid
- **C.** loculated fluid and air collections
- **D.** contrast in surgical drain

6. Fluoroscopic esophagography with water-soluble contrast is negative in a patient with clinical suspicion for esophageal perforation. Which one of the following is the *best* next step in diagnosis?
- **A.** monitor clinical status
- **B.** obtain upright chest radiograph
- **C.** repeat esophagogram with barium
- **D.** no further imaging is necessary

7. In which one of the following scenarios is obtaining an esophagogram *most* appropriate?
- **A.** after CT in a postsurgical patient with suspected perforation
- **B.** as the first study obtained in the emergency department with suspected perforation
- **C.** routinely in the postsurgical patient to evaluate for leak
- **D.** after chest radiograph in a patient with chest pain and vomiting

8. A full-thickness tear of the esophagus from forceful retching is known as
- **A.** Boerhaave syndrome.
- **B.** Brugada syndrome.
- **C.** Mallory-Weiss syndrome.
- **D.** Mirizzi syndrome.

9. In the postsurgical patient, which one of the following imaging findings is *most* suggestive of a redundant loop of stomach, as opposed to contained leak, on fluoroscopy?
- **A.** extraluminal air
- **B.** free-moving extraluminal contrast
- **C.** fixed extraluminal contrast
- **D.** periesophageal air/fluid collections

10. A 23-year-old man presents with vomiting, midthoracic back pain, and shortness of breath several hours after endoscopy. Figure 7 shows the esophagogram with water-soluble contrast obtained and shown below. Which one of the following is the *most* likely diagnosis?
- **A.** squamous cell carcinoma
- **B.** free esophageal perforation
- **C.** reflux esophagitis ulcer
- **D.** intramural perforation

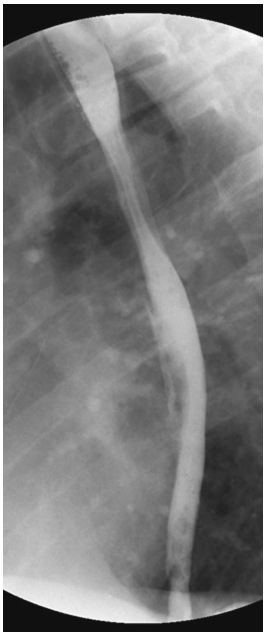

Figure 7.