CT Imaging of Acute Chest Pain

By Theodore J. Dubinsky, M.D.

The large differential diagnosis among patients who present to the emergency room with acute chest pain includes both thoracic and abdominal diseases. The differential diagnosis of acute chest pain also includes musculoskeletal abnormalities and neurologic conditions, which will not be discussed in this article.

The major thoracic differential considerations for acute chest pain include myocardial infarction, aortic dissection, pulmonary emboli, myocarditis, pericarditis, pneumonia, pneumothorax, superior vena cava thrombosis, and such congenital abnormalities of the cardiovascular system as coarctation of the aorta and other vascular abnormalities. Abdominal abnormalities always need to be considered in patients presenting with acute chest pain, and this includes patients with esophagitis, gastritis, duodenitis, peptic ulcer disease, Mallory-Weiss tears, cholecystitis, pancreatitis, and hepatitis. Multislice CT scanning has become an imaging modality of choice for the evaluation of these abdominal abnormalities.

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cardiac abnormalities can be diagnosed with CT. In particular, imaging of pulmonary emboli, acute dissection, and acute myocardial infarction is now possible and will only improve as 64-slice scanners allow all chest CTs to be gated.

**PNEUMONIA AND ITS COMPLICATIONS**

CT scanning has greater sensitivity for demonstrating the presence and extent of pneumonia than conventional radiographs. In fact, multislice CT is capable of demonstrating not only pneumonia, but also complications from pneumonia. Necrosis, abscess formation, and empyema, all well depicted by CT scanning, are necessary for triaging a patient to appropriate therapy such as percutaneous drainage or surgery. Various types of pneumonia appear differently on multislice CT, and none are more specific than the appearance of aspiration pneumonia or miliary TB. Multislice CT is one of the most common presentings, particularly in young patients arriving at the emergency department. Frequent chest radiographs suffice to demonstrate a large tension pneumothorax, necessitating treatment with a chest tube. In these cases, multislice CT scanning is probably not necessary. However, it is helpful in more complicated trauma or oncology patients and in patients with tuberculosis. A typical pneumothorax is well depicted by CT, and is the most common cause of pneumothorax in young adults. However, it is helpful in more complicated trauma or oncology patients and in patients with tuberculosis. A typical pneumothorax is well depicted by CT, and is the most common cause of pneumothorax in young adults. However, it may be associated with a pleural effusion and may require surgical intervention. On occasion, chest tube placement can be directed with CT scanning.

**ABDOMINAL ABNORMALITIES**

Abnormalities of the abdomen frequently present as acute chest pain. Esophageal perforations tend to be related to either penetrating or blunt trauma, and generally involve all the layers of the esophagus. They most often perforate toward the left, and therefore left-sided pneumothoraces and pleural effusions develop (Figure 3). Because these perforations tend to be fairly sharply margined, most of the gas within the esophagus tends to enter the pleural spaces, rather than expand within the mediastinum. This is distinct from Boerhaave’s syndrome, in which patients forcefully vomit against the closed glottis, resulting in increased intraluminal pressure within the esophagus creating a dissection of gas within the wall of the esophagus, which can dissect along the mucosa or through the submucosa. When severe enough, this can perforate the serosa to form pneumothoraces and left-sided pleural effusions such as seen with other forms of esophageal perforation. Generally, the gas trapped within the layers of the esophagus is not able to move out of the mediastinum; hence, its appearance on CT scan is highly characteristic for Boerhaave’s syndrome (Figure 4).

Most frequently, patients presenting with cholecystitis will have right upper quadrant pain, fever, and an elevated white blood cell count. However, on occasion, the pain can be atypical and localized to the chest. While ultrasound is the preferred modality for diagnosing cholecystitis, on occasion CT scanning, which reveals underlying cholecystitis, is performed on patients with acute upper gastric or chest pain. Complications from cholecystitis include abscess formation, necrosis, and perforation, and are well depicted with multislice CT scanning (Figure 5).

Patients with diabetes are susceptible to a somewhat rare form of cholecystitis, known as emphysematous cholecystitis. In these patients, clinical symptoms may be delayed, and since they are at risk for cardiac disease as well, differentiation of cholecystitis from other etiologies is important. In emphysematous cholecystitis, gas is present within the wall of the gallbladder secondary to the presence of gas-forming bacteria. On occasion, other body systems of patients with emphysematous cholecystitis will also be infected, particularly the kidneys and urinary tract.

Esophageal perforations frequently present with chest or abdominal pain, and on occasion fluid and pseudocyst formation may track along the retroperitoneum into the mediastinum. Multislice, multislice CT scanning can demonstrate the complications from pancreatitis, including infection, necrosis, and abscess formation.

**PULMONARY EMBOLISM**

The most significant advance in multislice CT scanning in the past few years has been its use in diagnosing pulmonary embolism. A positive diagnosis of pulmonary embolism is present in the right lung, and a small amount of mass is present in the right main-stem bronchi. Figure 3. An esophageal perforation has resulted in a left pneumomediastinum, which has a chest tube in place. Only a minimal amount of air is present within the mediastinum adjacent to the esophageal cuff. Figure 4. Compared to a simple esophageal perforation, a pneumomediastinum is present in 100% of cases. A pulmonary embolus is present within the wall of the esophagus, which can produce spectrally selective collections of gas within the mediastinum. If the dissection extends within the esophageal serosa, pneumomediastinum and pleural effusion result. Figure 5. Necrotizing cholecystitis demonstrated on CT scan.

**AORTIC DISSECTION AND CARDIAC ABNORMALITIES**

Aortic dissection is one of the most common presentings, particularly in patients with acute chest pain. Sensitivity of multislice CT scanning for aortic dissection is probably not necessary, and is considered equivocal for pulmonary embolism by most of the literature. The ability to make multiphase reformations—and the ability to scan the entire aorta in one breath-hold—has produced nearly 100% sensitivity for demonstrating branch vessel involvement in aortic dissections. In particular, evaluation of the superior mesenteric artery and the celiac and renal arteries is an essential part of the evaluation of aortic dissections (Figure 8). Extension proximally into the carotid artery and great vessels of the head and neck is also essential for planning therapy.

The last few years have seen the complete evaluation of patients with acute chest pain revisited. Sensitivity and specificity of multislice CT scanning for potential pulmonary emboli in patients with normal pulmonary angiograms. Therefore, whether angiography remains an adequate reference standard for evaluating multislice CT scans that are considered equivocal for pulmonary embolism is questionable.
cardiac abnormalities can be diagnosed with CT. In particular, imaging of pulmonary emboli, aortic dissection, and acute myocardial infarction is now possible and will only improve as 64-slice scanners allow all chest CTs to be gated.

PNEUMONIA AND ITS COMPLICATIONS
CT scanning has greater sensitivity for diagnosing pneumonia in acute chest pain patients than conventional radiographs. In fact, multidetector CT is capable of demonstrating not only pneumonia, but also complications from pneumonia. Necrosis, abscess formation, and empyema, all well depicted by CT scanning, are necessary for triaging a patient to appropriate therapy such as percutaneous drainage or surgery. Various types of pneumonia appear differently on multidetector CT, and none are more specific than the appearance of diffuse lung injury. Because these perforations tend to be related to either perforating ulcers or a tear in the serosa to form pneumothoraces and left-sided pleural effusions such as seen with other forms of esophageal perforation. Generally, the gas trapped within the lungs may be difficult to move out of the mediastinum; hence, its appearance on CT scan is highly characteristic for Boerhaave’s syndrome (Figure 4).

Most frequently, patients presenting with cholecystitis will have right upper quadrant pain, fever, and an elevated white blood cell count. However, on occasion, the pain can be atypical and localized to the chest. While ultrasound is the preferred modality for diagnosing cholecystitis, on occasion CT scanning, which reveals underlying cholecystitis, is performed on patients with acute upper gastric or chest pain. Complications from cholecystitis, including perforation, necrosis, and perforation, are well depicted with multidetector CT scanning (Figure 5).

Patients with diabetes are susceptible to a somewhat rare form of cholecystitis known as emphysematous cholecystitis. In these patients, clinical symptoms may be mild or absent, and since they are at risk for cardiac disease as well, differentiation of cholecystitis from other etiologies is important. In emphysematous cholecystitis, gas is present within the wall of the gallbladder secondary to the presence of gas-forming bacteria. On occasion, other body systems of patients with emphysematous cholecystitis will also be infected, particularly the kidneys and urinary tract.

Patients with pancreatitis frequently present with chest or abdominal pain, and on occasion fluid and pseudocyst formation may track along the retroperitoneum into the mediastinum. Multidetector CT scanning can demonstrate the complications from pancreatitis, including infection, necrosis, and abscess formation.

PULMONARY EMBOLISM
The most significant advance in multidetector CT scanning in the past few years has been its use in diagnosing pulmonary embolism. Thin-slice multidetector CT allows resolution of small pulmonary arteries to the fourth and fifth order, and the speed with which these examinations can be performed allows them to be completed within a single breath-hold. This eliminates the motion artifact that, in the past, obscured visualization of the small pulmonary vessels. The speed of these scans allows imaging to be done while the contrast bolus is entirely within the pulmonary arterial system; the degree of opacification obtained within the pulmonary arteries is much greater than had been possible before. The diagnosis of large emboli that produce significant occlusion in the main pulmonary arteries, as well as acute right heart strain, is now reliable enough to make these studies a mainstay of initial evaluation of patients with suspected pulmonary embolism.

The high speed of multidetector CT scanning routinely allows diagnosis of a small subset of pulmonary emboli within the fourth to and fifth order pulmonary arteries (Figure 6). The ability to create maximum intensity projection (MIP) reconstructions allows differentiation of artifacts from true pulmonary emboli. In addition, these reconstructions allow the attending physician to confirm suspected diagnoses, particularly of small peripheral pulmonary emboli. Visualizing asymmetry in the size of the pulmonary arteries and cutoffs, particularly in IMIP images, also allows differentiation of chronic pulmonary emboli in patients who present with long-standing shortness of breath or vague chest pain (Figure 7). It is quite possible that in the future, reconstructed images will be evaluated when making a diagnosis of pulmonary embolism and axial images will be examined only when sensitivity for pulmonary embolus continues to get better with improved techniques in multidetector CT technology. Recently, sensitivities in the range of 70% to 90% for central pulmonary emboli and 30% to 50% for subsegmental emboli have been reported. However, these studies generally use angiography as the reference standard, and it has been well documented that it is the default that patients with normal pulmonary angiograms are identical to those of patients with normal CT pulmonary angiograms. Therefore, whether angiography remains an adequate reference standard for evaluating multidetector CT scans that are considered equivocal for pulmonary emboli is questionable.

AORTIC DISSECTION AND CARDIAC ABNORMALITIES
Aortic dissection is one of the most common causes of acute chest pain and an important differential diagnosis in patients with acute chest pain. Sensitivity of multidetector CT scan for aortic dissection can range from 80% to 100% in the literature. The ability to make multiplanar reformations—and the ability to scan the entire aorta in one breath-hold—has produced nearly 100% sensitivity for demonstrating branch vessel involvement in aortic dissections. In particular, evaluation of the superior mesenteric artery and the celiac artery and renal arteries? is an essential part of the evaluation of aortic dissections. Extension proximally into the carotid artery and great vessels of the head and neck is also essential for planning therapy. The last frontier in the complete evaluation of patients with acute chest pain is cardiac abnormalities, including myocardial infarction. The 10% to 40% of all myocardial infarctions that have normal or equivocal electrocardiograms in the emergency department provide an opportunity for the use of multidetector CT in the evaluation of these patients. Serum markers, including creatinine kinase with MB fractions and troponins, do not rise sufficiently to be detectable within the first 24 to 72 hours following myocardial infarction. Notably, the common presentation of acute cardiac infarctions present with atypical symptoms. While imaging of the myocardium with detection of a new wall motion abnormality, the heart must be seen during diastole in order to diagnose myocardial infarction. Unobstructed multidetector CT is prone to a great deal of motion artifact and, while imaging the myocardium, myocardial infarctions can be both overdosed and undersized.

The chest CT images shown in Figures 8 and 9 were obtained from a 58-year-old woman who presented with acute chest pain. Whether angiography remains an adequate reference standard for evaluating multidetector CT scans that are considered equivocal for pulmonary emboli is questionable.
diagonal branches of the coronary arteries of pigs and scanned using CT with three later times. Images were then compared with pathologic specimens and the results clearly showed that acute myocardial infarction and akiness of the involved walls could be demonstrated. Other cardiac abnormalities, including pericarditis, filling defects, masses and tumors within the heart, and valvular abnormalities, can all be diagnosed on un gated CT scanning. However, it is clear that gating will improve the ability of multislice CT scanning to demonstrate not only myocardial infaracts, but also functional ab nomalities, including wall motion and valvular abnormalities.

GATING

A comprehensive review of gated multislice CT scanning is beyond the scope of this article. At this time, using 16-slice scanners, it is not feasible to gate the entire chest during a pulmonary embolism or aortic dissection study. However, this is what will be nee ded for multislice CT scanning to exclude myocardial infarcts as well as aortic dissections and pulmonary emboli. When myocardial infarction is diagnosed, it may not be possible to gate the heart to recon struct the coronary anatomy, although until 64-slice CT scanning is readily available, this will remain impractical. But once a patient is diagnosed with potential myocardial infarction, evaluation of the coronary arteries may allow the appropriate triage of the patient to either angiographic therapy or consideration for surgical bypass.

Until multislice CT scanning can be used to evaluate the heart as part of a standard chest CT scan that also excludes pulmonary emboli and aortic dissection, it will be difficult for CT to overtake angiography as the standard of care for the evaluation and triage of patients with acute myocardial infarction who have EKG abnormalities. Obtaining human subjects’ approval to alter this diagnostic pathway will not be easy and therefore patients with atypical presentations for myocardial infarction who happen to be diagnosed while undergoing CT scanning for other reasons will have to serve as the study population to determine the feasibility of routinely using multislice CT scan to evaluate cardiac pain.

Eventually, it may be possible to consider CT scanning as the study of choice even in patients with EKG abnormalities who are at high risk for myocardial infarction. Improvements in both temporal and spatial resolution should allow the modality to be used for diagnosis of cardiac abnormalities, particularly coronary artery disease. In the future, CT scanning to exclude aortic dissection, pulmonary emboli, and myocardial infarction all in one study will probably become the standard of care for patients with acute chest pain.

Those patients shown to have acute myocardial infarctions could then have their coronary arteries reconstructed from the existing data. Hence, the issue in the future will not be whether a coronary artery CT angiogram should be ordered, but rather how to incorporate this information, which will be present anyway, in the treatment of patients.

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CT arteriography may be performed, but subclavian, axillary, and carotid artery stenosis. Vasc Med 2004;9(1):69.


