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CT Imaging of Acute Chest Pain

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LEARNING OBJECTIVES

Upon completion of this activity, participants should be able to:

- List the differential diagnoses of patients presenting to the emergency room with acute chest pain.
- Describe how CT scanning improves the evaluation of pneumonia and empyema.
- Review the contribution that multiplanar and curvilinear reformatting makes to diagnoses in acute chest pain.
- Recognize the role of CT in the evaluation of cardiac diseases

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The large differential diagnosis among patients who present to the emergency room with acute chest pain includes both thoracic and abdominal diseases.[1] 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 the imaging modality of choice for the evaluation of these abdominal abnormalities. Advances in multislice CT technology have significantly improved our ability to make specific diagnoses in these patients.

Multiplanar reformats and volumetric reconstructions have made multislice CT scanning the preferred evaluation for patients with pulmonary emboli[2] and aortic dissection.[3] However, as recently as 1999, reviews in the literature of patients with acute chest pain imaged in the emergency room did not include any cardiac abnormalities as part of the differential diagnosis.[4] This is because CT scanning was thought to have no ability to detect acute cardiac abnormalities. With the development of gating, thin-slice multislice CT, and software algorithms capable of performing curvilinear reformats of the coronary vessels, we are beginning to recognize that acute

Figure 1. CT scan demonstrates a small left pneumothorax that extends into the most superior portion of the major fissure, which also contains a small amount of fluid. Note the pulmonary laceration in the right lung in this trauma patient.


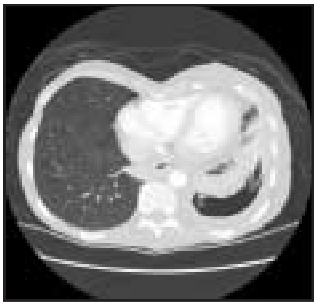

Figure 2. Bulla in the left upper lobe adjacent to the mediastinum. The presence of septae differentiate this lesion from a true pneumothorax. A pulmonary laceration is present in the right lung, and a small amount of mucus is present in the right mainstem bronchus. Figure 3. An esophageal perforation has resulted in a left hydropneumothorax, which has a chest tube in place. Only a minimal amount of air is present within the mediastinum adjacent to the esophagus itself. Figure 4. Compared to a simple esophageal perforation, Boerhaave's syndrome presents as a dissection of gas within the wall of the esophagus, which can produce spectacular collections of gas within the mediastinum. If the dissection exits the esophageal serosa, pneumothoraces and pleural effusions result. Figure 5. Necrotizing cholecystitis demonstrated on CT scan.

cardiac abnormalities can be diagnosed with CT. In particular, imaging of pulmonary emboli,[5] 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 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.

Pneumothorax is one of the most common presenting findings, particularly in young patients arriving at the emergency room with acute chest pain. Frequently 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 for findings of loculated pneumothoraces and those that extend anteriorly, perhaps into the major fissure, which are not readily amenable to therapy with chest tubes (Figure 1). Guidance for chest tube placement can be directed with CT scanning.

In patients with pneumothoraces that recur despite the presence of chest tubes, complications underlying the etiology of recurrent pneumothorax, including pulmonary lacerations and bronchopleural fistulae, can be well depicted with multislice CT scanning. Demonstrating the exact location of bronchopleural fistualae is important since preventing future recurrence of pneumothoraces requires surgery to remove this portion of the lung.

On rare occasions, abnormal gas can be seen within the interstitium of the lungs with or without an associated pneumothorax. Pulmonary interstitial emphysema, as it's known, is an unusual condition generally associated with positive pressure ventilation in patients with diffuse lung injury. However, in patients with trauma, small pneumothoraces will occasionally be associated with pulmonary interstitial emphysema. This was not well appreciated until thin-slice multislice CT became available. One of the major roles for CT scanning is to differentiate large bullae from true pneumothoraces and prevent the placement of chest tubes in patients who do not need them (Figure 2).

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 bowel. 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 marginated, most of the gas within the hollow viscus of the esophagus tends to enter the pleural spaces, rather than lie within the mediastinum.

This is distinct from Boerhaave's syndrome, in which patients forcefully vomit against the closed glottis. The increased intraluminal pressure within the esophagus creates a dissection of gas within the wall of the esophagus, which can dissect along the mucosa or through the submucosa. When severe enough, this gas can perforate the serosa to form pneumothoraces and left-sided pleural effusions such as are seen with other forms of esophageal perforation.[6] Generally, the gas trapped within the layers of esophagus is not able to move out of the mediastinum;[7] 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 hemorrhage, necrosis, and perforation, 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 quite atypical, 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. Multiphase, multislice CT scanning can demonstrate the complications from pancreatitis, including infarction, 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. Thin-slice multislice 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 smaller 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 CT scanning the study of choice in initial evaluation of patients with suspected pulmonary emboli.[8]

The high quality of multislice CT scanning routinely allows diagnosis of a small subset of pulmonary emboli within the fourth- 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 serve as adjunct information to confirm suspected diagnoses, particularly of small peripheral pulmonary emboli.

Visualizing asymmetry in the size of the pulmonary arteries and cutoffs,

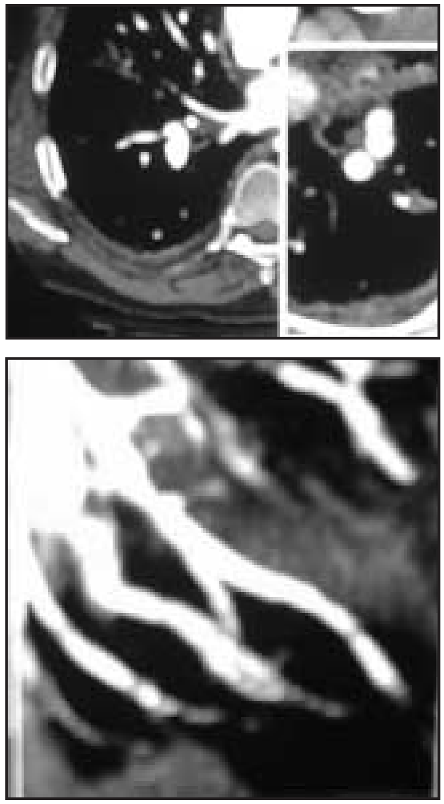

Figure 6 A and B. A small subsegmental pulmonary embolus well demonstrated by multislice CT. Coronal oblique reconstructions of the data show multiple small emboli in the peripheral pulmonary vasculature.

particularly in MIP images, also allows diagnosis 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 emboli and axial images will be examined only when necessary.

Sensitivity to pulmonary embolus continues to get better with improvements in multislice 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 outcomes in 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 multislice CT scans that are considered equivocal for pulmonary emboli is questionable.

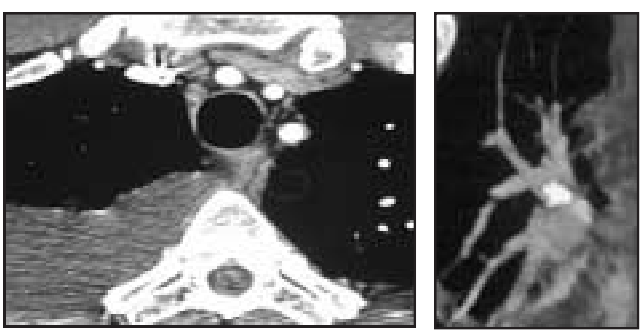

Figure 7. Axial CT image showing a paucity of vessels in the right upper lobe. The corresponding coronal oblique reconstructions and angiogram demonstrate cutoff of the right upper lobe vasculature.

AORTIC DISSECTION AND CARDIAC ABNORMALITIES

Aortic dissection is one of the most common presenting abnormalities in patients with acute chest pain. Sensitivity of multislice CT scanning for aortic dissection ranges from 80% to 100% in the literature.[9] 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 axis[10] and renal arteries[11] 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 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 EKGs on presentation provides an opportunity for the use of multislice CT in the evaluation of these patients. Serologic abnormalities, including creatinine kinase with MB fractions and troponins, do not rise sufficiently to be detected for at least 24 to 72 hours following myocardial infarction.

Nearly half of all myocardial infarctions present with atypical symptoms. While imaging of the myocardium does not necessarily require gating, the heart must be seen during diastole in order to diagnose myocardial infarctions.[12] Ungated multislice CT is prone to a great deal of motion artifact and, should imaging occur during systole, myocardial infarctions can be both overdiagnosed and obscured.

Two recent publications have indicated that myocardial infarctions can be demonstrated on ungated multislice CT images.[13,14] Sixty-nine patients undergoing CT scanning for potential pulmonary emboli were included in a retrospective study in which 18 patients were discovered to have had myocardial infarcts. Fourteen of these had abnormal serology and 11 had abnormal EKGs, yet all 18 had abnormalities on CT scanning. In a second study, researchers occluded the left anterior descending or second diagonal branches of the coronary arteries of pigs and scanned the animals using CT three hours later. Images were then compared with pathologic specimens and the results clearly showed that acute myocardial infarction and akinesis 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 ungated CT scanning. However, it is clear that gating will improve the ability of multislice CT scanning to demonstrate not only myocardial infarcts, but also functional abnormalities, including wall motion and valvular abnormalities.

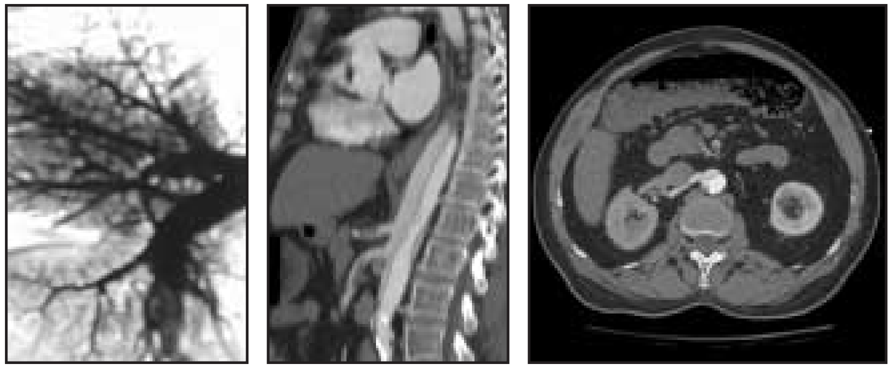

Figure 8. Sagittal reformat demonstrates a large aortic dissection that extends into the celiac axis and SMA. Axial image shows that the right renal artery originates in the false lumen of the dissection and the right kidney has subsequently infarcted.

GATING

A complete 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 would be necessary for multislice CT scanning to exclude myocardial infarctions as well as aortic dissections and pulmonary emboli. When myocardial infarction *is* diagnosed, it might be possible to reconstruct 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 might 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 the heart.

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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Reviews Scheduled: Mar 2006 and Mar 2007

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