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Review Article

Role of computed tomography in the evaluation of acute chest pain

Thomas H. Urbania, MD*, Michael D. Hope, MD, Shannon D. Huffaker, MS, Gautham P. Reddy, MD MPH

University of California Medical Center, Department of Radiology and Biomedical Imaging, 505 Parnassus Avenue, Box 0628, San Francisco, CA 94143-0628, USA

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Abstract. Chest pain is common and the initial clinical presentation is often nonspecific. The emergency physician faces the challenge of correctly identifying those patients with a life-threatening cause of chest pain while avoiding unnecessary hospital admissions. Three important life-threatening causes of chest pain are aortic dissection, pulmonary embolism, and acute coronary syndrome. Simple clinical tools should be applied to exclude these diagnoses and avoid CT whenever possible. A normal serum d-dimer measurement can safely exclude pulmonary embolism and aortic dissection, although elevated d-dimer levels are common and nonspecific. Promising markers for early myocardial ischemia have been described and should be developed further. CT provides a first-line imaging tool for aortic dissection and pulmonary embolism based on its wide availability, speed, and high level of diagnostic performance. Improvements in CT scanner technology now enable in-depth data on the coronary arteries. Although angiographic information is limited in its relation to physiologic lesion significance, coronary CT is used to safely diagnose or exclude coronary disease as a source of chest pain in emergency department patients. "Triple rule-out" protocols designed to simultaneously assess the aorta, pulmonary arteries, and coronary arteries are a compromise between dedicated protocols for each diagnosis. The diagnostic value and appropriate clinical use of these protocols remain to be shown by randomized, controlled, outcomes-based trials.

Introduction

Chest pain is a common and challenging clinical problem. Five percent of all patients presenting to the emergency department (ED) report chest pain and 70% of these patients will be admitted to the hospital with a per-patient cost of $1040.[1,2] Yet, only 10%–15% will have an acute myocardial infarction (MI).[3] The principal challenge facing the ED physician is to identify the subset of patients with life-threatening causes of chest pain. Inappropriately discharging a patient with a life-threatening cause of chest pain can have grave consequences for the patient and is a major source of malpractice claims.[4] However, unnecessarily admitting patients is costly and carries risks of further invasive procedures and hospital-acquired illness.

Computed tomography (CT) has become a central diagnostic tool in medicine. Increased availability and improved technology have led to dramatic increases in CT utilization, especially in the ED. From 2000 to 2005, increases in CT scans have substantially outpaced increases

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* Corresponding author.
E-mail address: Thomas.urbania@radiology.ucsf.edu

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in patient volume. For example, at one center, a 226% increase in chest CT was accompanied by only a 13% rise in patient volume.[5] This increase underscores the need for studies to show improved patient outcomes from the use of CT.

The purpose of this article is to explore the role of CT in the evaluation of acute chest pain. The discussion focuses on 3 life-threatening causes of chest pain: aortic dissection, pulmonary embolism (PE), and acute coronary syndrome (ACS). Defining the role of CT requires a review of the initial clinical approach to these diagnoses, the diagnostic accuracy of CT for each, and the strengths and limitations of CT with respect to alternative methods. Current evidence about the use of cardiovascular CT (CCT) in the ED is specifically reviewed. "Triple rule-out" protocols and the challenges facing use of CT for acute chest pain are considered.

Acute aortic dissection

Initial clinical evaluation

The most reliable characteristic features of acute aortic dissection are tearing aortic pain with immediate onset, unequal extremity pulses or blood pressures, and mediastinal widening on chest radiograph. This combination of findings may identify 83%–100% of cases, but 4%–7% of patients with aortic dissection may have none of these findings.[6,7] With an estimated 1%–2% per hour mortality within the first 24 hours after onset and an 80% rate of untreated mortality at 2 weeks,[8] failing to diagnose 4%–7% of aortic dissections after a "low-risk" clinical designation will result in an unacceptable rate of mortality. Adding plasma d-dimer measurement to the clinical assessment allows for confident exclusion of aortic dissection in the ED.[9] Elevated d-dimer, a breakdown product of cross-linked fibrin, is a highly sensitive but nonspecific marker for aortic dissection, present in virtually all cases.[9,10]

Imaging

Any patient with suspected aortic dissection needs imaging with either CT, magnetic resonance imaging, or transesophageal echocardiography. In a meta-analysis of 16 studies involving 1139 patients, magnetic resonance imaging, transesophageal echocardiography, and CT were 98%, 98%, and 100% sensitive, respectively, and 98%, 95%, and 98% specific for aortic dissection, respectively.[11] In the acute setting, specific advantages of CT include its wide availability and short acquisition times.

CT accurately depicts aortic pathology. In a study correlating CT and surgical findings, accuracy for detection of Stanford type A dissection or intramural hematoma was 100%.[12] In another study, CT identified 67 (99%) of 68 acute aortic disorders, including dissection, intramural hematoma, penetrating aortic ulcer, new or enlarging aneurysm, or acute aortic rupture[13] (Fig. 1).

Detailed characterization of a dissection and associated complications are unique strengths of CT. In the era of endovascular repair, distinction of the true from the false lumen has become important for therapeutic planning.[14] The true lumen is often smaller, located anteromedially, and shows brisk arterial enhancement. The false lumen shows relatively lower enhancement or may be thrombosed.[15,16] It may contain linear low attenuation "cobwebs," representing residual ribbons of the aortic media. The "beak sign," specific to the false lumen, is a wedge of hematoma protruding from the false lumen. Rupture or extension of a dissection into branch arteries is also readily identified by CT.[15,17]

Pulmonary embolism

Initial clinical evaluation

Historically, conventional pulmonary angiography (CPA) has been the "gold standard" for the diagnosis of PE. Given the cost and risk of this procedure, much effort has gone into developing clinical predictive tools to determine which patients warrant angiography. Although ventilation-perfusion nuclear scintigraphy offers a safer, noninvasive diagnostic option, the clinically determined pretest probability of PE is integral to interpreting this examination.[18] Clinical scoring systems such as the Wells and Geneva scores can be used to risk stratify patients suspected of having PE, but they are insufficient to exclude the diagnosis alone. In the original description of the derivation of the Geneva score, 10.3% of low-probability patients were ultimately diagnosed with PE.[19,20]

Strong evidence supports the use of plasma d-dimer measurement in the evaluation of patients with suspected PE. A negative result can obviate the need for further workup and may exclude PE in 17%–33% of patients.[21,22] A systematic review of studies that used d-dimer in the evaluation of PE concluded that a rapid enzyme-linked immunoabsorbent assay (ELISA) d-dimer assay, available in minutes, could exclude pulmonary embolism independent of pretest clinical probability.[23]

Imaging

Imaging methods complement clinical tools for the optimal identification of PE. Diagnostic imaging strategies include ventilation-perfusion scanning, lower extremity sonography, CT pulmonary angiography (CTPA), and CPA. Among these methods, CTPA has become the first-line tool for evaluation of PE in the acute setting.

Consensus on the diagnostic accuracy of CTPA for PE is limited. Analyses from the early part of this decade draw largely on data collected before the widespread dissemination