Date of origin: 1995
Last review date: 2005

American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Acute Chest Pain—Suspected Aortic Dissection**

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	9		Min
CT chest with contrast	9		Med
US echocardiography transesophageal	8	If skilled operator readily available.	None
MRI/MRA chest and abdomen	8		None
INV aortogram thoracic	5		IP
US echocardiography transthoracic	4		None
US chest intravascular aorta	3		None
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

ACUTE CHEST PAIN—SUSPECTED AORTIC DISSECTION

Expert Panel on Cardiovascular Imaging: Antoinette S. Gomes, MD[1]; Michael A. Bettmann, MD[2]; Thomas Casciani, MD[3]; Julius H. Grollman, MD[4]; Stephen R. Holtzman, MD[5]; Joseph F. Polak, MD, MPH[6]; David Sacks, MD[7]; Joseph Schoepf, MD[8]; William Stanford, MD[9]; Michael Jaff, MD[10]; Gregory L. Moneta, MD.[11]

Summary of Literature Review

Aortic dissection typically presents with excruciating, tearing, anterior, or interscapular chest pain that tends to migrate to other sites along the course of the dissection. Mortality is high in untreated aortic dissection, and in an analysis of 963 patients collected from six reported series, 50% of patients died within 48 hours, 70% within one week, and 90% within 3 months. Classification of aortic dissection is based upon the site of the intimal tear and the extent of the dissecting hematoma.

In DeBakey type I and type II dissection, the intimal tear is located in the ascending aorta, usually just a few centimeters above the aortic valve. In type I dissection, the hematoma extends for a variable distance beyond the ascending aorta, while in type II the dissecting hematoma is confined to the ascending aorta. In type III, the dissection originates in the descending aorta, usually just beyond the origin of the left subclavian artery and propagates antegrade into the descending aorta or, rarely, retrograde into the aortic arch and ascending aorta. Rarely, the intimal tear occurs in an unusual location such as the abdominal aorta.

In the more commonly used Stanford classification, type A refers to all dissections that involve the ascending aorta, and the reentry site may be located anywhere along the course of the aorta. All other dissections are classified as type B. In type B, the dissection is confined to the aorta distal to the left subclavian artery. Approximately 60% of dissections are type A and 40% type B. The detection and localization of a proximal entry or intimal flap are crucial because patients with a type A dissection of the aorta (equivalent to types I and II of the DeBakey classification) require surgical correction. Type B dissection of the descending thoracic aorta is often managed medically because of the higher operative mortality in this group. Reoperations are necessary in 7%-20% of patients with aortic dissection because of dissection-related complications.

Imaging studies in the evaluation of suspected thoracic dissection should be directed toward confirmation of the presence of dissection, determination of whether the dissection is type A or B, assessment of entry and reentry sites; identification of thrombus in the false lumen; assessment of aortic valve competency; detection of the presence or absence of aortic branch involvement, including involvement of the coronary ostia; and determination of the presence of extravasated blood into mediastinal, pleural, or pericardial spaces. In addition, imaging should help distinguish classic aortic dissection from other causes of "acute aortic syndrome" such as acute intramural hematoma and penetrating atherosclerotic ulcer.

Plain Films

As is recommended in all patients presenting with acute chest pain, a chest radiograph should be obtained in all patients suspected of having an aortic dissection. Occasionally, the findings in a single chest radiograph may raise a high level of suspicion for aortic dissection. In most cases, however**,** the plain film findings in aortic dissection are nonspecific, and all of the changes seen in aortic dissection may be secondary to other conditions. Comparison with previous films, however, may reveal changes in the aortic contour that are nearly pathognomonic for aortic dissection. Nonspecific findings on a chest radiograph, when studied in conjunction with the clinical history, can be significant and provide supporting evidence for dissection. Widening of the superior mediastinum may be present, but difficult to evaluate because most patients with suspected dissection are examined with portable radiography. Displacement of aortic wall calcification is a finding of limited value and may be misleading if the location of the calcification and the location of the lateral border of the aorta are not at the same body level. Calcification of a mural thrombus or thickening of the aortic wall secondary to atherosclerosis or aortitis may result in a false positive diagnosis. Almost 20% of patients with dissection may have negative chest x-ray findings apart from the very small percentage of cases in which the chest radiograph is diagnostic; its primary role is to rule out other pathology.

Aortography and Angiography

Aortography has long been considered the gold standard for diagnosis of aortic dissection. The sensitivity of aortography has been found to be 88% and the specificity

[1]Principal Author, UCLA School of Medicine, Los Angeles, Calif; [2]Panel Chair, Wake Forest University School of Medicine Radiology, Winston-Salem, NC; [3]Indiana University Hospital, Indianapolis, Ind; [4]Little Company of Mary Hospital, Torrance, Calif; [5]Radiology Associates of San Luis Obispo, San Luis Obispo, Calif; [6]New England Medical Center, Boston, Mass; [7]West Reading Radiology Associates, West Reading, Pa; [8]Medical University of South Carolina, Charleston, SC; [9]University of Iowa Hospital & Clinics, Iowa City, Iowa; [10]Massachusetts General Hospital, Boston, Mass, American College of Cardiology; [11]Oregon Health Sciences University, Portland, Ore, Society for Vascular Surgery.

Reprint requests to: Department of Quality & Safety, American College of Radiology, 1891 Preston White Drive, Reston, VA 20191-4397.

94%, with positive and negative predictive values of 96% and 84%, respectively.

The diagnostic accuracy of angiography approaches 98% in some series. Angiography is well tolerated by critically ill patients and has the advantage of allowing evaluation of the aortic valve and aortic branch vessel involvement. Currently, arterial digital subtraction angiography (IA-DSA) with a large field-of-view image intensifier and rapid filming is used most frequently. The high frame rates of arterial DSA facilitate identification of the intimal tear and the degree of aortic insufficiency. If large field-of-view DSA is unavailable, standard cut film radiography, which has higher resolution than intra-arterial DSA, may be used. Cineangiography has been used, but the field-of-view is usually limited. False negative arteriograms may occur when the false lumen is not opacified, when there is simultaneous opacification of the true and false lumen, and when the intimal flap is not seen.

Disadvantages of angiography are that it is invasive, iodinated contrast material is required, and there is typically a delay in implementing the procedure. Although angiography provides good visualization of the thoracic and abdominal branch vessels and flow patterns, it is now rarely used as the initial diagnostic procedure to detect aortic dissection. In recent years, it has been replaced by minimally invasive transthoracic echocardiography (TEE) and noninvasive computed tomography (CT) and magnetic resonance imaging (MRI).

Computed Tomography Scanning

CT with contrast injection is indicated in the diagnosis of aortic dissection. CT scanning was the most common initial diagnostic test performed in the patients enrolled in the International Registry of Acute Aortic Dissection. CT is less invasive, faster, safer, cheaper, and less resource intensive than catheter aortography. Most larger hospitals now have in-house CT technologists available 24 hours a day for emergency studies. CT angiography (CTA) affords high quality thin axial sections that demonstrate mural changes, extraluminal pathologic conditions, spatial relationships and status of adjacent organs, high contrast resolution, high sensitivity for detection of calcified lesions on precontrast images, and demonstration of extrinsic causes of vascular compromise. This allows exclusion of other causes of mediastinal widening, detection of intraluminal and periaortic thrombus, and diagnosis of pericardial and pleural effusions. Factors reducing the diagnostic accuracy of CTA are poor opacification of the aorta due to inadequate contrast injection or improper bolus timing, failure to identify the intimal flap because of motion artifacts, and misinterpretation of streak artifacts or motion artifacts as an intimal flap. When the false lumen does not opacify, differentiation from a thrombus filled atherosclerotic aneurysm or intramural hematoma may be difficult. Other limitations of CT include the need for administration of iodinated contrast material, inability to detect aortic insufficiency, and coronary artery involvement.

Numerous studies evaluating the efficacy of CT scanning in diagnosing aortic dissection have demonstrated sensitivity of 90%-100%, but lower specificity ranging from 87% (lower than MRI or TEE) to 100%. However these studies compared conventional CT, which has largely been supplanted by fast multidetector array helical CT (MDCT) or less commonly electron beam CT (EBCT). Fast CT scanning (CT angiography) represents a significant advance in CT imaging. The use of multidetector arrays allows accurate imaging of a large anatomic area with high resolution and a short acquisition time. It permits breath-hold volumetric acquisitions, eliminating ventilatory misregistration. Narrow collimation results in improved through-plane resolution with improved visualization of vascular structures as compared with conventional CT. With shorter imaging times, better bolus tracking is accomplished and more images are obtained during peak contrast enhancement, resulting in improved visualization of vascular structures as compared with conventional CT. Fast CT angiography (CTA) provides exquisite detail on the intimal flap and branch vessel involvement. Motion artifacts in the ascending aorta mimicking dissection are much less of a clinical problem with MDCT, and the use of cardiac gating can eliminate potential artifacts in the aortic root. The rapid, large-volume acquisition that can be obtained with MDCT allows imaging of both the thoracic and abdominal components of the dissection and assessment of extension of the dissection into abdominal and pelvic branch vessels with one injection of contrast. Image post processing of the volumetric data using multiplanar reformatting and 3D volume rendering of the data set facilitate evaluation of the course of the intimal flap. Recent studies show similar sensitivities for CTA, TEE, and MRI in detecting aortic dissection. The relative accuracy of these modalities is confounded by the fact that technical improvements in CT, MR, and TEE have outpaced our ability to perform necessary trials. To date, there have been no large study comparisons of MDCT and MR or TEE.

Magnetic Resonance Imaging

MRI allows the noninvasive visualization of the thoracic and abdominal aorta in multiple projections without the use of contrast agents or ionizing radiation. A variety of pulse sequences are available. ECG-triggered spin echo images provide exquisite anatomic detail of the heart and aorta. Cine MRI and other fast gradient echo techniques allow visualization of flowing blood, facilitating the differentiation of slow flowing blood and clot, and determination of the presence of aortic insufficiency. The true and false lumen and intimal flap are readily identified. Functional information such as aortic regurgitation and left ventricular function can be assessed. Phase contrast techniques can be used for flow quantification. Both the sensitivity and specificity of MRI for the diagnosis of aortic dissection have recently been reported to be 100%. For identifying the site of entry, sensitivity was 85% and specificity 100%, and for identifying thrombus and the presence of a pericardial effusion, sensitivity and specificity were both 100%. Newer gadolinium contrast enhanced 3-dimensional MR angiography (CE-MRA) techniques permit rapid acquisition of MR angiograms of the thoracic and abdominal aorta and their branch vessels. These techniques allow coverage of large volumes with and without breath holding. The 3D data sets may be reconstructed. 3D CE-MRA permits easy identification of both the true and false lumen and enables identification of the type of dissection and assessment of patency of the false lumen. Excellent sensitivity (92%-96%) and specificity (100%) have been documented for CE-MRA in acute and chronic aortic dissection. Although MR has the potential to provide information about the coronary arteries, currently it cannot do so rapidly and routinely. Limitations of MRI/MRA are longer examination times compared with CT, and limited access to the patient. Further, patients with cardiac pacemakers, ferromagnetic aneurysm clips, and ocular or otologic implants cannot undergo MR imaging. Studies may be suboptimal in patients with cardiac arrhythmias, limited in unstable patients, and motion artifact in uncooperative patients can result in nondiagnostic images. MR is currently more expensive than other imaging techniques, and it may not be routinely available in emergencies or not compatible with life support equipment. MRI is, however, extremely well suited for the study of patients with stable or chronic dissection, and it may become the gold standard in defining the anatomy in such patients. Faster MR scanning techniques may extend its use in unstable patients.

Echocardiography

In the diagnosis of aortic dissection, echocardiography has the advantage of being readily available and easily performed at the bedside. Transthoracic echocardiography (TTE) has been found to have a sensitivity of 59%-85% and a specificity of 93%-96%. It is useful in the diagnosis of dissection involving the ascending aorta, but is of limited value in diagnosing distal dissections. It is also limited by the availability of echocardiography windows. TEE overcomes many of these limitations and can image almost the entire thoracic aorta. TEE is also useful for detecting coronary artery involvement with the dissection, the hemodynamic significance of pericardial effusion, and the degree of aortic regurgitation and left ventricular function. TEE has sensitivity similar to MRI and CT for detecting dissection. With single plane units the sensitivity of TTE and TEE is lower than CT and MRI, mainly as a result of false positive findings in the ascending aorta. The sensitivity and specificity of monoplane and biplane TEE range from 97%-100% and specificity has ranged from 77%-100%. Multiplanar TEE can provide accurate diagnosis of aortic dissection with sensitivity of 99% and specificity of 98%. Several studies comparing TEE with aortography and CT found TEE superior. However, these studies were done with older generation CT scanners. The additional views provided by multiplanar TEE considerably reduce the blind spot of monoplanar TEE, leaving only a small portion between the ascending aorta and proximal aortic arch that is suboptimally shown. However, even with multiplane units, diagnostic problems are encountered in the ascending aorta where artifacts such as reverberation artifacts can result in false positive diagnosis of dissection. Principal limitations of TEE are its dependence on operator skills, and blind areas in the distal ascending aorta and proximal transverse arch which are obscured by the air-containing trachea and left main bronchus. Additional limitations are the inability to objectively document pathologic findings for comparison with follow-up studies and the inability to visualize the distal extent of the dissection in the abdomen. Nonetheless, in most cases of acute dissection, TEE provides immediate, sufficient information for the decision about whether to perform surgery, obviating the need for angiography, and is indicated. In descending aortic dissection, angiography, CT, and MRI/MRA are preferable, because they allow evaluation of branch vessel involvement and assessment of the distal extension of the aneurysm.

Summary

Current experience suggests that in skilled hands the accuracies of TEE, multidetector CT, and MRI/MRA will be nearly identical. Because patients with acute dissection are critically ill and potentially in need of emergency operation, the selection of a given modality will depend on clinical circumstances and availability. Fast CTA is likely to be more readily available on a 24-hour basis and can provide information on branch vessel involvement. It is also associated with less patient discomfort. Although it does not provide information regarding aortic insufficiency, this can be obtained with TTE or TEE while the operating room is being prepared. In selected centers where experienced cardiologists are readily available to perform state-of-the-art TEE in the emergency room, TEE may be the preferred first-line imaging because it can provide sufficient information to determine whether emergency surgery is needed. When information about branch vessel involvement is required by the surgeon and not provided by CTA (a rare occurrence with multidetector CT units), aortography may be useful. MRI may be sufficient to replace angiography in stable patients and those with chronic dissection or uncertain diagnoses. Faster imaging sequences may extend its use to unstable patients. Image post-processing of fast CT and MR data using multiplanar image reformatting and 3D volume rendering may provide additional information useful in treatment planning.

References

1. DeBakey ME, McCollum CH, Crawford ES, et al. Dissection and dissecting aneurysms of the aorta: twenty-year follow-up of five hundred twenty-seven patients treated surgically. *Surgery* 1982; 92(6):1118-1134.
2. Erbel R, Oelert H, Meyer J, et al. Effect of medical and surgical therapy on aortic dissection evaluated by transesophageal echocardiography. *Circulation* 1993; 87(5):1604-1615.
3. Svensson LG, Crawford ES, Hess KR, Coselli JS, Safi HJ. Dissection of the aorta and dissecting aortic aneurysms: improving early and long-term surgical results. *Circulation* 1990; 82(5 Suppl):IV24-38.
4. Crawford ES. The diagnosis and management of aortic dissection. *JAMA* 1990; 264(19):2537-2541.
5. Eyler WR, Clark MD. Dissecting aneurysms of the aorta: roentgen manifestations including a comparison with other types of aneurysms. *Radiology* 1965; 85(6):1047-1057.
6. Erbel R, Daniel W, Visser C, et al. Echocardiography in diagnosis of aortic dissection. *Lancet* 1989; 1(8636):457-460.
7. Yamaguchi T, Guthaner DF, Wexler L. Natural history of the false channel of type A aortic dissection after surgical repair: CT study. *Radiology* 1989; 170(3):743-747.
8. Andresen J, Baekgaard N, Allermand H. Evaluation of patients with thoracic aortic dissection by intraarterial digital subtraction angiography. *Vasa* 1992; 21(2):167-170.
9. Nienaber CA, Von Kodolitsch Y, Nicolas V, et al. The diagnosis of thoracic aortic dissection by noninvasive imaging procedures. *N Engl J Med* 1993; 328(1):1-9.
10. Stanford W, Rooholamini SA, Galvin JR. Ultrafast computed tomography in the diagnosis of aortic aneurysms and dissections. *J Thorac Imaging* 1990; 5(4):32-39.
11. Cigarroa JE, Isselbacher EM, DeSanctis RW, Eagle KA. Diagnostic imaging in the evaluation of suspected aortic dissection. *New Engl J Med* 1993; 328(1):35-43.
12. Costello P, Ecker CP, Tello R, Hartnell GG. Assessment of the thoracic aorta by spiral CT. *AJR* 1992; 158(5):1127-1130.
13. Rubin GD. Helical CT angiography of the thoracic aorta. *J Thorac Imaging* 1997; 12(2):128-149.
14. American College of Surgeons, Committee on Trauma. Resources for optimal care of the injured patient. *Bulletin of the American College of Surgeons*; 1990; 75:30.
15. Kersting-Sommerhoff BA, Higgins CB, White RD, et al. Aortic dissection: sensitivity and specificity of MR imaging. *Radiology* 1988; 166(3):651-655.
16. Prince MR, Narasimhan DL, Jacoby WT, et al. Three-dimensional gadolinium enhanced MR angiography of the thoracic aorta. *AJR* 1996; 166(6):1387-1397.
17. Barron DJ, Livesey SA, Brown IW, Delaney et al. Twenty-year follow-up of acute type A dissection: the incidence and extent of distal aortic disease using magnetic resonance imaging. *J Card Surg* 1997; 12(3):147-159.
18. Krinsky G, Reuss PM. MR angiography of the thoracic aorta. *Magn Reson Imaging Clin N Am* 1998; 6(2)293-320.
19. Laissy JP, Blanc F, Soyer P, et al. Thoracic aortic dissection: diagnosis with transesophageal echocardiography versus MR imaging. *Radiology* 1995; 194(2):331-336.
20. Nienaber CA, Spielmann RP, von Kodolitsch Y, et al. Diagnosis of thoracic aortic dissection: magnetic resonance imaging versus transesophageal echocardiography. *Circulation* 1992; 85(2):434-447.
21. Granato JE, Dee P, Gibson RS. Utility of two-dimensional echocardiography in suspected ascending aortic dissection. *Am J Cardiol* 1985; 56:123-129.
22. Ballal RS, Nanda NC, Gatewood R, et al. Usefulness of transesophageal echocardiography in assessment of aortic dissection. *Circulation* 1991; 84(5):1903-1914.
23. Omoto R, Kyo S, Matsumura M, et al. Evaluation of biplane color Doppler transesophageal echocardiography in 200 consecutive patients. *Circulation* 1992; 85(4):1237-1247.
24. Adachi H, Omoto R, Kyo S, et al. Emergency surgical intervention of acute aortic dissection with the rapid diagnosis by transesophageal echocardiography. *Circulation* 1991; 84(5 suppl):III 14-19.
25. Chan KL. Impact of transesophageal echocardiography on the treatment of patients with aortic dissection. *Chest* 1992; 101(2):406-410.
26. Keren A, Kim CB, Hu BS, et al. Accuracy of biplane and multiplane transesophageal echocardiography in diagnosis of typical acute aortic dissection and intramural hematoma. *J Am Coll Cardiol* 1996; 28(3):627-636.
27. Sommer T, Fehske W, Holzknecht N, et al. Aortic dissection: a comparative study of diagnosis with spiral CT, multiplanar transesophageal echocardiography, and MR imaging. *Radiology* 1996; 199(2):347-352
28. Willens HJ, Kessler KM. Transesophageal echocardiography in the diagnosis of diseases of the thoracic aorta: part 1. Aortic dissection, aortic intramural hematoma, and penetrating atherosclerotic ulcer of the aorta. *Chest* 1999; 116(6):1772-1779.
29. Rubin GD. MDCT imaging of the aorta and peripheral vessels. *Eur J Radiol* 2003; 45 Suppl 1:S42-S49. Review.
30. Moore AG, Eagle KA, Bruckman D, et al. Choice of computed tomography, transesophageal echocardiography, magnetic resonance imaging, and aortography in acute aortic dissection: International Registry of Acute Aortic Dissection (IRAD). *Am J Cardiol* 2002; 89(10):1235-1238.