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American College of Radiology
ACR Appropriateness Criteria®

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

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	9	Should be performed if readily available at the bedside and does not cause delay in obtaining a CT or MRI scan. Alternative causes of chest pain may be discovered. Not the definitive test for aortic dissection.	☢
CTA chest and abdomen with contrast	9	Recommended as the definitive test in most patients with suspicion of aortic dissection.	☢☢☢☢
MRA chest and abdomen without and with contrast	8	Alternative to CTA for: contraindication to CT (iodinated contrast), multiple prior chest CTA for similar symptoms, and in patients showing no signs of hemodynamic instability. Scanner availability and local expertise limit widespread use, as there is potential for delay in diagnosis. See statement regarding contrast in text under "Anticipated Exceptions."	O
US echocardiography transesophageal	8	If skilled operator readily available.	O
MRA chest and abdomen without contrast	7	Alternative to CTA for: contraindication to CT (iodinated contrast), multiple prior chest CTA for similar symptoms, and in patients showing no signs of hemodynamic instability. Scanner availability and local expertise limit widespread use, as there is potential for delay in diagnosis.	O
Aortography thoracic	5		☢☢☢
US echocardiography transthoracic resting	4		O
FDG-PET/CT skull base to mid-thigh	3	Not recommended as the initial test. May be useful for prognostication and for distinguishing acute from chronic dissection.	☢☢☢☢
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

ACUTE CHEST PAIN — SUSPECTED AORTIC DISSECTION

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Summary of Literature Review

Introduction/Background

Aortic dissection typically presents with sudden onset of excruciating, tearing, anterior, or interscapular chest pain that tends to migrate along the course of the dissection. Symptoms may be dominated by dissection-related side branch obstruction or malperfusion syndrome due to aortic obstruction by the flap. Timely diagnosis of ascending aortic dissection is crucial to permit prompt surgical management, as the early mortality rates are reported to be 1%-2% per hour after the onset of symptoms [1]. Mortality is high in untreated aortic dissection. The overall in-hospital mortality rate for acute aortic dissection is reported to be 27% [2]. Medical management alone of type A aortic dissections is associated with a mortality rate of nearly 20% by 24 hours after presentation, 30% by 48 hours, 40%-70% by day 7 [3], and 50% by 1 month [1]. The major cause of early death is aortic rupture [4]. The presence of a patent false lumen has been associated with an increased risk of mortality [5]. Classification of aortic dissection is based on the site of the intimal tear and the extent of the dissection. The clinical presentations of these various types of dissections may be quite similar.

Classification of Aortic Dissection

In DeBakey type I and type II dissection, the entrance intimal tear is located in the ascending aorta, usually just a few centimeters above the aortic valve. In type I dissection, the intimal flap extends for a variable distance beyond the aortic arch and into the descending aorta, while in type II the intimal flap is confined to the ascending aorta. Type III dissection originates in the descending aorta, usually just beyond the origin of the left subclavian artery, and propagates antegrade down the descending aorta. Rarely, the entrance intimal tear occurs in an unusual location such as the abdominal aorta [4].

The more commonly used Stanford classification comprises two categories. Type A refers to any dissection involving the ascending aorta, and therefore is equivalent to DeBakey type I and type II. Type B dissection is confined to the aorta distal to the left subclavian artery and may extend to the abdominal aorta. Stanford type B dissection is therefore equivalent to DeBakey type III. Approximately 60% of dissections are type A and 40% type B. Differentiation of the types of dissection is done by identifying the location of the intimal flap and is crucial because patients with a type A dissection of the aorta require surgical correction. Type B dissection is often managed medically unless the aorta is excessively dilated or there is mesenteric/limb ischemia [4].

Both the Stanford and DeBakey classifications are ambiguous with regard to dissections involving the descending aorta and aortic arch but sparing the ascending aorta proximal to the innominate artery. Such lesions are best described as Stanford type B or DeBakey type III with arch involvement to provide surgeons and cardiologists with the information needed to make appropriate management decisions. Reoperations are necessary in 7%-20% of patients with aortic dissection because of dissection-related complications [6].

Aortic intramural hematoma is considered a variant of classic dissection. The etiology is uncertain, but postulates include rupture of the vasa vasorum in the medial layer of the aorta. This may provoke a secondary tear and communication with the aortic lumen, converting to a dissection in 28%-47% of patients. Intramural hematomas may extend along the aorta, progress, regress, or reabsorb. The prevalence of intramural hematoma in patients with suspected aortic dissection is in the range of 21%-30% [1]. Involvement of the ascending aorta is generally considered an indication for urgent surgery because of similar potential complications of a dissection in the same location [7]. Penetrating aortic ulcer is another aortic condition properly considered separately from true aortic dissection with differing pathophysiology (the disruption in the aortic wall originates in an atherosclerotic plaque) and epidemiology (patients tend to be older, with extensive aortic atherosclerosis and a lesser degree of hypertension).

Overview of Imaging

Imaging studies in the evaluation of suspected thoracic aortic dissection should be directed toward confirming the presence of dissection; classifying the dissection as Stanford type A or B (and/or DeBakey types I, II, or III); identification of entry and reentry sites; patency of the false lumen; detecting the presence or absence of aortic

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branch involvement, including involvement of the coronary ostia; assessing aortic valve competency; and determining the presence or absence of extravasated blood in 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 aortic ulcer.

Radiography

A chest radiograph is recommended in all patients presenting with acute chest pain, including those suspected of having aortic dissection. Almost 20% of patients with dissection may have negative chest radiograph findings. Therefore, further imaging should be pursued despite a normal chest radiograph in cases of suspected aortic dissection. In most cases of dissection, the positive findings on a chest radiograph are nonspecific and, when studied in conjunction with the clinical history, can be significant and provide supporting evidence for dissection [8]. Widening of the superior mediastinum, among other signs of dissection, is seen in up to 61% of patients [9]. However, such a finding is difficult to evaluate with portable radiography. Displacement of aortic wall calcification is a finding of limited value and may be misleading. The primary role of chest radiography is to rule out other thoracic pathology.

Computed Tomography

Computed tomography (CT) with contrast injection is indicated in the diagnosis of aortic dissection. CT was the most common initial diagnostic test performed in patients enrolled in the International Registry of Acute Aortic Dissection [10]. It is minimally invasive, faster, safer, cheaper, and less resource-intensive than catheter aortography. Most 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 intimal flaps, aortic atherosclerotic plaque, branch vessel involvement, patency of the false lumen, extravascular pathologic conditions that may cause mediastinal widening or chest symptoms, and spatial relationships and status of adjacent organs and pericardial and pleural spaces. Precontrast images are recommended for identifying calcification and intramural hematoma [11].

A significant advantage of CT is that alternative causes of chest pain have been reported in up to 21% of cases scanned for suspected aortic dissection [12]. 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 among a thrombus-filled atherosclerotic aneurysm, thrombosed dissection, or intramural hematoma may be difficult. Other disadvantages of CT include the need for intravenous administration of iodinated contrast material and the use of ionizing radiation.

Numerous studies evaluating the efficacy of CT in diagnosing aortic dissection have demonstrated sensitivities of 90%-100%, but lower specificities ranging from 87% (lower than those of magnetic resonance angiography [MRA] or transesophageal echocardiography [TEE]) to 100% [13-16]. However these studies evaluated conventional CT, which has largely been supplanted by faster multidetector helical CT (MDCT) or less commonly electron beam CT (EBCT). More recent MDCT studies enrolling up to 57 patients have reported sensitivities and specificities of 100% [11]**.** The multidetector arrays in MDCT allow accurate imaging of a large anatomic area with high resolution and a short acquisition time. MDCT permits short volumetric acquisition, facilitating patient breath-holding and thereby eliminating ventilatory misregistration. Narrow collimation results in improved resolution with improved visualization of vascular structures as compared with conventional CT. Shorter imaging times also improve bolus tracking and image acquisition during peak contrast enhancement, resulting in improved visualization of vascular structures compared with conventional CT. CTA provides exquisite detail of the intimal flap and branch vessel involvement. Electrocardiographic (ECG) gating has proven particularly valuable for minimizing ascending aortic motion artifacts that can mimic dissection without significantly increasing imaging time [17-18]. In addition, ECG gating allows for qualitative assessment of aortic insufficiency and evaluation of coronary artery involvement.

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 a reasonable volume of contrast. Postprocessing of the volumetric data set using multiplanar reformatting and 3D volume rendering facilitates evaluation of the course of the intimal flap [19]. Recent studies show similar sensitivities for CTA, TEE, and magnetic resonance imaging (MRI) in detecting aortic dissection [10,12,16,20]. Evaluation of the relative accuracy of these modalities is confounded by the fact that technical improvements in CT, MRI, and TEE have outpaced our ability to perform necessary research trials. To date, there have been no large studies comparing MDCT, MRI, and TEE.

Triple-rule-out CT protocols are increasingly being used by several institutions where pulmonary and coronary arteries and aorta can be evaluated in a single examination [9]. Although details of protocols vary between institutions, the general technique involves intravenous administration of iodinated contrast, timing of which allows for assessment of both the pulmonary arteries and the aorta. The pulmonary arteries are evaluated on the initial nongated study, and the aorta, aortic root, and the coronary arteries are evaluated on the ECG-gated examination. Various techniques, such as prospective

ECG triggering and tube current modulation, can be used to reduce radiation exposure. It has been reported that triple-rule-out CT can safely eliminate further diagnostic testing in over 75% of patients in the appropriate patient population [21]. Compared to a dedicated CTA performed specifically for assessing aortic dissection, the major disadvantages of this protocol are increased contrast and radiation doses, thus limiting its applicability to a unique subset of patients whom pulmonary embolism, aortic dissection, and acute coronary syndrome cannot be reliably clinically differentiated based on patient symptomatology. Moreover, most triple-rule-out protocols exclude the noncontrast phase of a dedicated aortic CTA, thus rendering evaluation for intramural hematoma difficult. Most triple-rule-out protocols also exclude the abdominal aorta, and as descending dissections often extend to involve the abdominal aorta, the full extent of a descending aortic dissection may not be visualized. Continued clinical research is necessary to confirm appropriate utilization of this type of examination [22-23].

Although precontrast images are recommended for identifying calcification and intramural hematoma, such a sequence may not be necessary with the advent of dual-source dual-energy multidetector CT (DSDEMDCT or in short DECT) which can generate virtual noncontrast images. Decreasing the total number of sequences performed reduces the radiation burden on patients [24]. In addition, due to increased photoelectric absorption at 80 kVp, DECT may allow for a smaller volume of contrast material to be administered. To date, only limited data exist on DECT evaluation of surgically repaired abdominal aortas, and further studies are needed to assess the performance of DECT in the acute setting.

Magnetic Resonance Angiography

MRA allows the noninvasive visualization of the thoracic and abdominal aorta in multiple projections without the use of ionizing radiation. Patients can also be imaged without the use of contrast agents if they are contraindicated. A variety of pulse sequences are available. ECG-triggered black-blood or white-blood 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 [14]. Functional cardiac information such as aortic regurgitation and left ventricular function can be assessed. Newer gadolinium-contrast-enhanced 3D MRA (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 [25-26]. In addition to morphologic-characterization, MRA allows evaluation of complications of dissection, such as detection of luminal thrombosis or slow flow state, left ventricular dysfunction, and aortic regurgitation [27].

MRI is considered a very accurate technique for diagnosing aortic dissection [14-16,20,25,28-29]. Both the sensitivity and specificity of MRI for diagnosing 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%. Excellent sensitivity (92%-98%) and specificity (100%) have been documented for CE-MRA in acute and chronic aortic dissection [9]. Limitations of MRI are longer examination times compared with MDCT, and more limited scanner availability on an emergency basis. Monitoring and treatment of very ill patients are also more difficult in the MRI environment compared with CT. Faster MRI techniques are being explored, and as the newer generations of faster scanners are developed, the feasibility of scanning these patients emergently is expected to improve [30]. Further, patients with cardiac pacemakers, ferromagnetic aneurysm clips, and other MRI-incompatible devices cannot undergo MRI, and contrast cannot be used in patients with severe renal insufficiency. Studies in uncooperative patients and patients who are unable to hold their breath can result in nondiagnostic images. The use of cardiac gating may be limited in the presence of cardiac arrhythmias.

Echocardiography

In the diagnosis of aortic dissection, echocardiography has the advantages of being widely available and suitable for use at the beside in hemodynamically unstable patients. Transthoracic echocardiography (TTE) has been found to have a sensitivity of 59%-85% and a specificity of 93%-96% [28-29,31-32]. It is useful in the diagnosis of dissection involving the ascending aorta and can diagnose the hemodynamic significance of pericardial effusions, the degree of aortic regurgitation, and left ventricular function [15]. TTE is of marginal value in diagnosing distal dissections because of the limited availability of ultrasound (US) windows [9]. Although the sensitivity of TTE in detecting descending aortic dissections was previously reported to be lower (31%-80%), more recently, harmonic imaging and the use of microbubble contrast enhancement have been shown to improve the sensitivity of TTE in detecting descending dissections to 84% [33].

Transesophageal echocardiography (TEE) overcomes many of the limitations of TTE and can image almost the entire thoracic aorta with limited visualization of the distal ascending aorta and arch vessels. TEE is also useful for detecting coronary artery involvement with the dissection. It has sensitivity similar to that of MRI and CT for detecting dissection.

Multiplanar TEE can accurately diagnose aortic dissection with sensitivity, specificity, and negative predictive values of up to 100% [29,32,34-35]. However, diagnostic problems may be encountered in the ascending aorta where reverberation artifacts can result in false positive diagnosis of dissection [36]. Principal limitations of TEE are its dependence on a high degree of operator skill, 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 include inability to visualize the distal extent of the dissection in the abdomen. Nonetheless, in most cases of acute dissection, TEE provides immediate, sufficient information to determine whether surgical intervention is indicated. Additionally, in hemodynamically unstable individuals, TEE can be safely performed with topical anesthetic alone. In descending aortic dissection, angiography, CT, and MRI are preferable, because they allow evaluation of branch vessel involvement and assessment of the distal extension of the dissection [37]. Given that TEE is semi-invasive and may cause a rise in systemic pressure from retching and gagging, thus requiring sedation, TTE is recommended by the European Association of Echocardiography as the initial imaging modality. However, given the low negative predictive value of TTE, further evaluation with TEE or CT will be required if the TTE examination is negative [38]. It is common in the United States that TEE or CT is the initial examination rather than TTE [39].

Intravascular US has been explored for evaluating aortic dissection [40-42]. However, it is an invasive procedure, and its use has been limited to intra-operation or postoperative evaluation of aortic dissection. Presently, intravascular US has no role in the immediate evaluation of suspected acute aortic syndrome.

Angiography

Angiography has historically been considered the gold standard for diagnosing aortic dissection. Its sensitivity has been found to be 88% and the specificity 94%, with positive and negative predictive values of 96% and 84%, respectively [43].

The diagnostic accuracy of digital subtraction angiography approaches 98% in some series. Angiography permits management of critically ill patients, and aortic regurgitation and aortic branch vessel involvement can be assessed. [44]. High frame rates facilitate identification of the intimal tear and the degree of aortic insufficiency. 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 displayed in profile.

Disadvantages of angiography are that it is invasive, iodinated contrast material is required, and there is typically a delay in initiating the procedure. Although angiography provides good visualization of the thoracic and abdominal branch vessels and flow patterns, it is now rarely used in the evaluation and management of aortic dissection except where definitive coronary evaluation is required. In recent years, it has been replaced by minimally invasive TEE and noninvasive CT and MRI [1].

^{18}F-Flourodeoxyglucose Positron Emission Tomography/Computed Tomography

^{18}F-Flourodeoxyglucose positron emission tomography (FDG-PET)/CT has recently been explored for evaluation of aortic dissection and has been shown to be of value in distinguishing acute from chronic dissection [45-47]. In addition, several studies have also shown that elevated FDG uptake of mean standardized uptake value (SUV) in the region of the dissection flap is predictive of poor outcome [45-46]. Specifically, a mean SUV of 3.029 has been reported to be of significant predictive power with a sensitivity of 75%, specificity of 70%, positive predictive value of 50%, negative predictive value of 87.5%, and accuracy of 71% [45].

Several studies reported that increased FDG avidity in the atherosclerotic vascular wall correlated with dense infiltrations of macrophages and the number of macrophages in the plaque [40,48-49]. These results support the hypothesis that the uptake of FDG is predictive of elevated concentrations of macrophages and serves as a marker of atherosclerotic inflammation within the aortic wall. Several studies demonstrated a relationship between the degree of inflammation and vascular complications or the outcome of acute aortic dissection [50-51].

A significant disadvantage of FDG-PET/CT is the prolonged scan time, thus obviating its applicability in the acute setting. In addition, as the available data are limited to small studies, this modality has limited value until results from larger studies become available. Potentially, FDG-PET/CT may play a role in prognosticating the outcome in individuals diagnosed with aortic dissection, and in individuals diagnosed with aortic dissection. Further investigation is warranted.

Summary

- 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.
- Current experience suggests that the accuracies of TEE with a skilled operator and reader, of MDCT, and of MRI are very similar.
- CTA is likely to be more rapidly available on a 24-hour basis and is associated with less patient discomfort. It can provide information on branch vessel involvement and ancillary significant findings and has the advantage of evaluating the aorta and branch vessels in their entirety. Although it does not provide information regarding aortic insufficiency, this information can be obtained with TTE or TEE, if needed, while the operating room is being prepared.
- In selected centers where experienced cardiologists are readily available to perform TEE in the emergency room or in instances where hemodynamic or other clinical factors preclude CTA, TEE may be

the preferred first-line imaging study 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 MDCT units), angiography may be useful. Coronary angiography may still be required if definitive preoperative coronary evaluation is needed and was suboptimally assessed on the prior MDCT, MRI, or TTE examination.
- MRA may be sufficient to replace angiography in stable patients and those with chronic dissection or uncertain diagnoses. In selected centers, MRA may readily be offered as the first line of imaging on an emergent basis. Faster imaging sequences may extend its use to less stable patients.
- Image postprocessing of CT and MRI data using multiplanar image reformatting and 3D volume rendering may provide additional useful information for treatment planning.

Anticipated Exceptions

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (ie, <30 mL/min/1.73m^2), and almost never in other patients. There is growing literature regarding NSF. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the type and amount in patients with estimated GFR rates <30 mL/min/1.73m^2. For more information, please see the ACR *Manual on Contrast Media* [52].

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document.

Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢☢	0.1-1 mSv	0.03-0.3 mSv
☢☢☢	1-10 mSv	0.3- 3 mSv
☢☢☢☢	10-30 mSv	3-10 mSv
☢☢☢☢☢	30-100 mSv	10-30 mSv

*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies".

Supporting Document(s)

- ACR Appropriateness Criteria® Overview
- Procedure Information
- Evidence Table

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