Computed Tomography Angiography of the Thoracic Aorta

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KEYWORDS

• Thoracic aorta • Computed tomography • Angiography • Aneurysm • Dissection • Acute aortic syndrome

KEY POINTS

- Electrocardiogram gating should be considered for evaluation of the aortic root and ascending aorta and is required for accurate evaluation of the aortic valve and annulus.
- Acute aortic syndrome should be evaluated for important additional findings, such as extension to the coronary arteries or aortic valve, occlusion of major branches, or evidence of aortic rupture, because these factors can influence patient management.
- Familiarity with the normal postoperative appearance of the aorta will prevent misdiagnoses such as mistaking elephant trunk for dissection or surgical pledget for pseudoaneurysm.

Video of prosthetic aortic valve endocarditis with sinus of valsalva pseudoaneurysm; normal aortic motion throughout the cardiac cycle; aortic isthmic traumatic pseudoaneurysm; and aortic root anatomy and orientation for preprocedural evaluation of transcatheter aortic valve replacement accompanies this article http://www.radiologic.theclinics.com/

INTRODUCTION

The aorta is the largest artery in the human body, pumping up to 200 million liters of blood through the body in an average lifetime. Thoracic aortic disease presentation ranges from asymptomatic (as in an aneurysm incidentally detected on imaging) to severe acute chest pain (as in acute aortic dissection). The recent increased prevalence of aortic disease in Western countries is a result of increased clinical awareness and longer life spans. Multidetector-row computed tomography (MDCT) of the aorta can be used to diagnose various acute and chronic conditions of the aorta, including aortic aneurysms, aortic dissections, intramural hematomas, penetrating atherosclerotic ulcers, traumatic injuries, inflammatory disorders, and congenital abnormalities.

In the early 1990s, single-detector spiral computed tomography (CT) was introduced into routine clinical imaging, allowing excellent visual assessment of vessels from any angle as opposed to catheter-based projectional angiography.[1–3] However, single-detector spiral CT had limitations,

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such as long breath holds, motion artifacts from slow gantry rotation time, and limited coverage in z-dimension.[1–3] In the late 1990s, MDCT was introduced. MDCT significantly improved image quality with improved through-plane resolution, faster gantry rotation, increased coverage along the z-axis, and increased table speed.[4]

Modern 64 detector-row and newer-generation CT scanners can evaluate the entire aorta, including its smaller branches, with one short breath hold. Compared with catheter angiography, extravascular structures are also well assessed with MDCT.[4] MDCT provides superior image quality by acquiring isotropic subcentimeter voxels, which allow 2-dimensional and 3-dimensional reconstructions in any orientation.[5]

This article reviews the spectrum of MDCT imaging findings in thoracic aortic diseases. Although discussion focuses on the thoracic aorta, initial examination of the aorta should include the entire aorta and iliac arteries; aortic diseases, such as aneurysm or dissection, frequently affect the whole aorta or may affect multiple regions of the aorta.

COMPUTED TOMOGRAPHY IMAGING PROTOCOL

Dose Reduction

Many patients undergoing evaluation of the aorta will require serial imaging follow-up over many years for monitoring of aneurysm size, extent of dissection, and postprocedural complications as outlined in the following sections. Several radiation dose reduction techniques have been introduced and should be used in this patient population when possible. Dual-energy CT has several potential advantages, including virtual noncontrast imaging, precluding the need for a separate precontrast acquisition, calcium subtraction, and iodine mapping for improved detection of extraluminal contrast. Iterative reconstruction algorithms allow for radiation dose reduction by improving signal-to-noise ratio at lower tube current levels. Tube current modulation and body mass index–based tube potential selection can further decrease radiation dose.

Noncontrast Computed Tomography

Inclusion of a noncontrast CT scan is imperative in aortic imaging for suspected acute aortic syndrome because aortic intramural hematomas are more evident without intra-arterial contrast. Calcification is best evaluated on noncontrast imaging because of high tissue contrast between calcium and unenhanced tissue. Moderate density calcification can be subtle on contrast-enhanced images because the density may be similar to enhanced tissue, even in very extensive cases, such as coral reef aorta, which can obstruct the distal thoracic aorta. Radiation dose is often reduced during this phase by increasing collimation, decreasing kilovolts peak, or increasing the noise index with concomitant reduction in effective milliampere-seconds (mAs).

Computed Tomography Angiography

Nongated thoracic aortic CT angiography is usually performed with a pitch of 1.0 to 1.5, a collimation of 0.5 to 1.0 mm, and reconstruction of 1.0- to 1.5-mm slices with spacing of 0.75 to 1.0 mm. The kilovolts peak is usually set at 120 kVp. A lower kilovolts peak (70–100 kVp) may be used in thin patients. Automated tube current modulation should be used when available, in conjunction with automatic tube potential selection (a relatively new technique not widely available).

With automatic tube current modulation, the tube current is automatically reduced when scanning regions of lower attenuation and increased for areas of higher attenuation.[6] A desired noise index is entered, defined as the standard deviation of Hounsfield units in the center of an image using soft tissue kernel reconstruction. A threshold-based bolus-tracking algorithm with a region of interest in the ascending aorta is typically used.

Contrast is injected at rates of 3 to 5 mL/s, and the overall contrast volume should be approximately the injection rate (in milliliters per second) multiplied by the scan duration in seconds plus 5 to 10 seconds; typical contrast volumes range from 60 to 120 mL. Adding 5 to 10 seconds to the contrast injection duration is necessary to compensate for the difference in position between the tracking position in the ascending aorta and the top of the chest. A small field of view can be selected to optimize spatial resolution. However, a full field-of-view series should be reconstructed to detect incidental findings. Initial examination of the thoracic aorta should include the abdominal aorta and iliac arteries because thoracic aortic pathology commonly involves these vessels.

Electrocardiogram (ECG) gating is not required for routine aortic angiography; but cardiac motion can result in significant artifact in the aortic root and ascending aorta, which can decrease the accuracy of measurement or even mimic aortic dissection. In cases whereby aortic root abnormality is suspected, such as prosthetic valve endocarditis, ECG gating can accurately evaluate for valve dehiscence, vegetations, para-valvular abscess, and pseudoaneurysm. **Fig. 1** and Video 1 demonstrate prosthetic valve endocarditis of