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STATE-OF-THE-ART PAPER

The Role of Imaging in Aortic Dissection and Related Syndromes

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Aortic aneurysm and acute aortic syndrome are not uncommon conditions. Management of acute aortic dissection and related syndromes requires a multidisciplinary approach with input from the patient, clinician, imager, surgeon, and anesthesiologist. This requires an integrated evaluation of pathophysiology, anatomy, and severity to enable appropriate therapy. This review includes discussion of essential anatomy of the aortic valve and the aorta that determines the candidacy for surgical repair. It also includes discussion of various imaging modalities, particularly echocardiography, cardiac computed tomography, and cardiac magnetic resonance angiography. The relative benefits and demerits of each of these techniques are reviewed. This paper is intended to help guide management decisions for patients with acute aortic dissection and related syndromes. (J Am Coll Cardiol Img 2014;7:406–24) © 2014 by the American College of Cardiology Foundation

The human thoracic aorta, a complex geometric organ confounded by asymmetry and obliquity, consists of the ascending, arch, and descending aorta (1). The ascending aorta has 2 portions: 1) the lower portion or the aortic root, which extends from the level of the aortic valve to the sinotubular junction and includes the annulus and sinuses of Valsalva; and 2) the upper portion, which extends from the sinotubular junction to the aortic arch. The aortic root provides support to the aortic valve leaflets, allowing complete excursion of the valves during systole, and to the sinuses of Valsalva from wherein originate the coronary arteries. The aortic annulus is the junction of the proximal ascending aorta with the left ventricular outflow tract and is usually resistant to dilation because of its fibrous nature. The annulus measures 13 ± 1.0 mm/m^2. Most dissections of the ascending aorta and intramural hematomas begin within a few centimeters of the aortic valve (Fig. 1). As the ascending aorta is not truly or totally vertical, obtaining accurate images or measurements of the aortic diameter requires diligence. The normal aorta dilates by about 6 mm/m^2 at the level of the sinuses and then

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tapers to within 2 to 3 mm of the annular size at the sinotubular junction. During imaging it is important to not only determine the size of the aorta but also the shape, particularly the loss of the normal "waist" of the aorta at the sinotubular junction. Loss of this normal indentation is a predictor of future aortic events. The dimensions of the ascending aorta, arch, and descending thoracic aorta are determined by body surface area and size and are similar but for the slight tapering of the descending thoracic aorta. The aortic arch gives rise to arch vessels, including the innominate artery, left common carotid artery, and left subclavian artery. The sharp curve of the aortic arch results in an oblong rather than circular contour on axial images, making it difficult to accurately measure the aortic diameter. The descending aorta begins just distal to the origin of the left subclavian artery at a point termed the *aortic isthmus*. The isthmus is particularly vulnerable to deceleration forces during trauma because this location is the point where the relatively mobile ascending aorta and arch become relatively fixed to the thoracic cage. As a result, most descending aortic dissections and intramural hematomas have their origin just distal to the left subclavian artery (Fig. 1). During its course, the descending thoracic aorta gives rise to paired intercostal arteries from the posterior wall at each level of the spine. The descending aorta continues downward to become the abdominal aorta at the level of the diaphragm and 12th thoracic vertebra. At this point, it often takes a sharp curve in older persons, making axial images more oblong in contour rather than circular and resulting in misleading measurements of the true aortic diameter at this point.

Aortic dissection is found in approximately 80% to 90% of the acute aortic syndromes, whereas others will manifest with acute intramural hematoma or penetrating atherosclerotic ulcer (Fig. 2). Aortic dissection occurs with an annual incidence of 10 to 30 per million individuals. There are 2 major classification schemes of aortic dissection based on the location of the dissection—the Stanford classification and DeBakey classification (Fig. 3). Depending on the involvement of the ascending aorta, the Stanford classification divides dissections into types A and B. Stanford type A dissection involves the ascending aorta, with or without extension to the descending aorta, and the Stanford type B dissection does not involve the ascending aorta. The DeBakey classification categorizes dissections into types I, II, and III. DeBakey type I originates in the ascending aorta and extends at least to the aortic arch and often to the descending aorta, frequently all the way down to the iliac arteries. DeBakey type II is when the dissection is limited to the ascending aorta. DeBakey type III originates in the descending aorta usually just distal to the origin of the left subclavian artery. It is categorized as IIIa when it is limited to above the diaphragm and IIIb when it extends below the diaphragm. Very occasionally, a type III dissection may extend proximally into the aortic arch and ascending aorta. An intramural hematoma is a hemorrhage into the medial layer and can propagate longitudinally or circumferentially; however, it does not rupture into the lumen. The presenting symptoms and signs are similar to an aortic dissection. Over 60% of the hematomas are located in the descending aorta and are often accompanied by other features of aortic dissection. Penetrating aortic ulcer (PAU) is a crater-like outpouching in the aortic wall with jagged edges and is usually accompanied by significant atheroma. Both hematomas and PAUs can break through the adventitia to form pseudoaneurysm or rupture into the mediastinum.

Both chronic and acute aortic syndromes are challenges for primary care physicians and cardiac specialists (1,2). Longitudinal progression of chronic aortic diseases and appropriate timing of open or endovascular surgery are usually derived from serial noninvasive imaging studies. Rapid imaging is necessary for the timely diagnosis of a potentially life-threatening condition. Given that the presentation is atypical, that the diagnosis of dissection is often either missed or made too late, and that the morbidity and mortality are time-dependent, imaging is an important step in the early diagnosis and treatment of any aortic disorder. An ideal imaging modality will precisely, safely, and rapidly confirm suspected acute or chronic aortic pathology with quantitative information on aneurysm formation and progression, as well as on tear location, extent, and type of dissection, including evaluation for imminent complications. Today, invasive angiography has been replaced by noninvasive imaging strategies with multislice computed tomography (CT) and magnetic resonance imaging (MRI) for both chronic and acute pathologies; under emergency conditions, acute aortic syndromes can be imaged and confirmed at the bedside by transesophageal echocardiography (TEE), particularly to identify ascending aortic pathology such as type A aortic dissection. According to the International Registry of Acute Aortic Dissection (IRAD), as early as in 2002, CT

ABBREVIATIONS AND ACRONYMS

CT = computed tomography
ECG = electrocardiography
IMH = intramural hematoma
MDCT = multidetector computed tomography
MRI = magnetic resonance imaging
PAU = penetrating aortic ulcer
TEE = transesophageal echocardiography
TTE = transthoracic echocardiography
3D = 3-dimensional