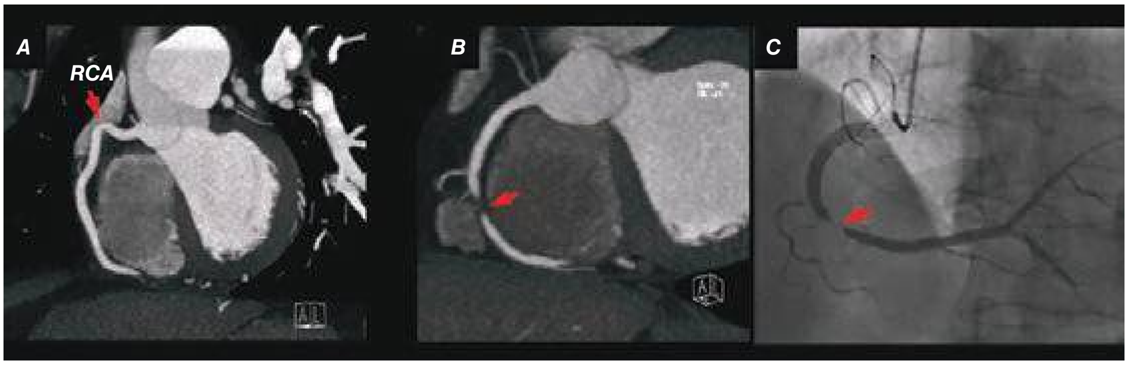


**FIGURE 270e-18 Representative coronary computed tomography angiographic (CTA) images of two patients presenting to the emergency department with chest pain and negative biomarkers.** The patient in ***A*** had angiographically normal coronary arteries; the panel shows a representative view of the right coronary artery (RCA). ***B*** and ***C*** show a corresponding significant stenosis in the mid portion of the RCA on both the CTA (***B***) and invasive angiographic view (***C***). *(Images courtesy of Dr. Quynh Truong, Massachusetts General Hospital, Boston, MA.)*



CMR can complement echocardiography when echocardiographic acoustic window is inadequate, quantifying blood flow data more precisely, or providing complimentary assessment of adjacent vascular structures relevant to the valvular condition.

Echocardiography can be used to assess both regurgitant and stenotic lesions of any of the cardiac valves. Typical indications for echocardiography to assess valvular heart disease include cardiac murmurs identified on physical examination, symptoms of breathlessness that may represent valvular heart disease, syncope or presyncope, and preoperative exams in patients undergoing bypass surgery. A standard echocardiographic examination should include qualitative and quantitative assessment of all valves regardless of indication and should serve as an adequate screening test for significant valvular disease.

**General Principles of Valvular Assessment** • *DIRECT VISUALIZATION OF VALVULAR STRUCTURES* Direct visualization of valve structures by two-dimensional echocardiography represents the first step in valvular evaluation. The morphology of valvular structures provides useful information regarding the etiology and severity of valvular disease. For example, two-dimensional imaging assessment of the aortic valve can identify the number of leaflets, determine whether the valve is bicuspid or tricuspid, and determine the severity of calcification and degree of leaflet excursion. Similarly, the classic appearance of a rheumatic mitral valve is extremely useful in determining the etiology of mitral stenosis, and mitral valve prolapse can be instantly identified without even the need for Doppler-based quantification.

*EVALUATION OF STENOTIC VALVES* As described earlier in the chapter, evaluation of stenotic valves generally includes estimation of the pressure gradient across the stenosis and determination of the valve area. Both of these measures have diagnostic and prognostic value. For example, when Doppler echocardiography is used to assess the maximal velocity across a stenotic aortic valve, this calculation will provide an accurate measure of the instantaneous gradient across the valve. This gradient will be higher than the mean gradient, as well as higher than that peak-to-peak gradient obtained at cardiac catheterization. This gradient is dependent on both the degree of stenosis and the contractile function of the left ventricle. Patients with significant left ventricular dysfunction may have severe aortic stenosis but will be unable to generate a high gradient across the valve because generated pressure within the left ventricle will be diminished.

Assessment of stenotic valves generally requires estimation of both the pressure gradient across the valve and the valve area. Pressure gradient is estimated through direct application of the Bernoulli principle, and the formula $p = 4v^2$ is usually sufficient to estimate the gradient across the valve. Several methods can be used to estimate valve areas, including the continuity principle based on the principle of conservation of mass. By this method, flow is estimated in two places. For example, for assessment of the aortic valve area, we measure the flow in the region of the left ventricular outflow tract and the cross-sectional area in this region, the product of which should be equal to the flow across the stenotic aortic valve and its cross-sectional area. Estimation of the mitral valve area in patients with suspected mitral stenosis can also be performed in a number of ways, including planimetry of the valve directly, estimation with continuity methods, or the most commonly used pressure half-time method, in which the stenosis severity is estimated by the time it takes for the pressure—estimated from velocity by the Bernoulli equation—to reach half of its original value during mitral inflow.

*EVALUATION OF REGURGITANT LESIONS* Regurgitant lesions are generally assessed by both visual assessment of the valve morphology and a variety of Doppler-based methods to assess the severity of regurgitation. The etiology of regurgitation can often be inferred from visual inspection. For example, prolapse of the mitral valve leaflets—and to a lesser extent, the aortic valve leaflets—can be easily visualized with two-dimensional echocardiography. In general, valvular regurgitation can be caused by abnormalities of the valve leaflets themselves or abnormalities of the annulus and supporting structures, and these can usually be distinguished visually on transthoracic echocardiography (see discussion below).

Quantification of valvular regurgitation is more difficult with echocardiography than quantification of valvular stenoses. Doppler-based methods are best suited to assess blood velocities rather than volumetric flow. The most widely used technique for assessing the severity of valvular regurgitation is color flow Doppler estimation, which is qualitative. More quantitative methods such as the proximal isovelocity surface area (PISA) method (see below) allow for more accurate assessment of regurgitation and provide estimation of the regurgitant fraction and effective regurgitant orifice area but are less widely used. Assessment of regurgitant lesions with CMR also has a number of advantages (see below).

**Assessment of Aortic Stenosis** Aortic stenosis, one of the most common forms of valvular heart disease, most often occurs because of gradual progression of valvular calcification in both normal and congenitally abnormal valves. Assessment of aortic stenosis is most commonly performed with echocardiography, although techniques for quantitative assessment of aortic stenosis with CMR have been developed and increasingly used over the past decade. Echocardiographic assessment generally begins with visual inspection of the valve, usually in the parasternal long-axis and short-axis views. This allows for assessment of valvular morphology, whether it is tricuspid, bicuspid, or some variant; degree of leaflet calcification; and leaflet excursion.

The normal aortic valve consists of three leaflets or cusps: the right coronary, the left coronary, and the noncoronary cusps. Abnormalities of cusp development are some of the most common congenital heart anomalies, the most common of which is bicuspid aortic valve, with two opening leaflets rather than three (Fig. 270e-19). The aortic valve can be visualized on echocardiography, although sometimes it can be difficult to distinguish true bicuspid aortic valve from variants, including the presence of a vestigial commissure (raphe). Bicuspid aortic