Mitral Valve Repair: An Echocardiographic Review: Part 2

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IMPROVED IMAGING and surgical techniques allow cardiac surgeons to repair mitral valves once considered unsuitable for this endeavor.[1–4] The demand for high-quality echocardiographic imaging has to match advancements in surgical technique to provide a roadmap for the surgical valve repair, and to assess the repair immediately after to determine if additional medical or surgical management is necessary (Figs 1 and 2) (Video clips 1 and 2).[1–3] With improved diagnostic imaging and surgical techniques, the durability of valve repair surgery now is described beyond 15 to 20 years.[4]

This is the second of a 2-part review providing a comprehensive presentation integrating the echocardiographic evaluation with mitral valve repair. While the first part described mitral valve anatomy, function, and dysfunction, the second part presents an array of mitral pathologies and the surgical repair techniques that apply. The review material is enhanced with 2- and 3-dimensional echocardiographic images and videos before and after the various repairs.

SURGICAL PROCEDURE

The indications for mitral valve repair evolve with advancements in the understanding of mitral anatomy and function, with the development of repair techniques and methods to preserve the mitral apparatus, and with the continued reporting of outcome benefits after restoring valve competence.[5–7] In recognizing these benefits, indications for valve repair now include asymptomatic patients as well as symptomatic patients. Class-1 indications include symptomatic patients with severe mitral regurgitation (MR) and primary valve dysfunction or asymptomatic patients with chronic severe MR in the presence of left ventricle (LV) dysfunction (left ventricular ejection fraction [LVEF] 30%-60%) and dilation (LV end-systolic diameter >40 mm). Class-IIa recommendations include asymptomatic patients with severe MR in the absence of LV dysfunction for which repair is highly feasible ($>90\%$). Valve surgery also is supported for asymptomatic patients with severe MR and new-onset atrial fibrillation, pulmonary hypertension (pulmonary artery systolic pressure >50 mmHg), or with New York Heart Association (NYHA) class of III-IV with severe LV dysfunction (LVEF $<30\%$ and/or LVESD >55mm). Valve repair for chronic severe secondary MR (ie, Type IIIb due to LV dysfunction) can be considered for patients who are NYHA class III-IV despite optimum therapy for heart failure.

The goals of mitral valve repair "are preservation or restoration of normal leaflet motion, creation of a large surface of coaptation, and stability of the entire annulus with remodeling annuloplasty."[8] Quantitatively, the repair of the regurgitant valve should restore competency (MR $<1+$), assure adequate patency (mean gradient ≤ 6 mmHg; Mitral Valve Area (MVA) ≤ 1.8 cm^2), and have durability (>10 years without significant MR and/or reoperation). Restoring the valve to normal function is not synonymous with restoring normal anatomy. The new anatomic baseline may appear to be either a normal functioning bileaflet valve, a normal functioning unicuspid valve, or what appears to be a figure-8 configuration (Fig 3) (Video clip 3).[9–11]

Regardless of the cause of MR, the repaired valve is heavily dependent on the function, mobility, and length of the anterior leaflet as the primary leaflet to cover the coaptation area.[12–15] In contrast, the role of the posterior leaflet has been described to buttress the coapting anterior leaflet.[9] As a result, anterior leaflet preservation and as-needed repair are important parts of all mitral valve repairs.[9,12–14] For patients in whom the anterior leaflet is relatively small (≤ 28 mm), preservation of and, if necessary, repair of the posterior leaflet might be part of the repair to provide an adequate surface with which the anterior leaflet can coapt.

For all repairs at the authors' institution, an annuloplasty ring is placed to reduce annular dimensions with the goals of increasing coaptation depth/zone, and preventing future annular dilation, thereby supporting additional repair techniques. The type, size, and shape of the annular ring vary per the initial pathology, and the accompanying repair technique employed.

Type-I Mitral Regurgitation

Type-I mitral regurgitation, due to annular dilation (normal leaflet mobility), is repaired with an annuloplasty ring. The primary purpose of the annuloplasty is to reduce annular area, prevent further annular dilation, and increase the coaptation zone. There are numerous types of annuloplasty techniques, including complete or partial, rigid, semi-rigid or selectively flexible, and flat or saddle-shaped rings and bands (Fig 4) (Video clip 4).[16] Earlier annuloplasty devices were designed to address annular dilation; therefore, they were rings that were rigid and fixed the mitral annulus in a flat end-systolic conformation.[8] Newer rings/bands not only reduce annular area but also recreate the nonplanar saddle shape of the annulus and attempt to restore annular dynamics. Restoration of nonplanarity reduces mechanical leaflet strain (or stress), which, in theory, increases the

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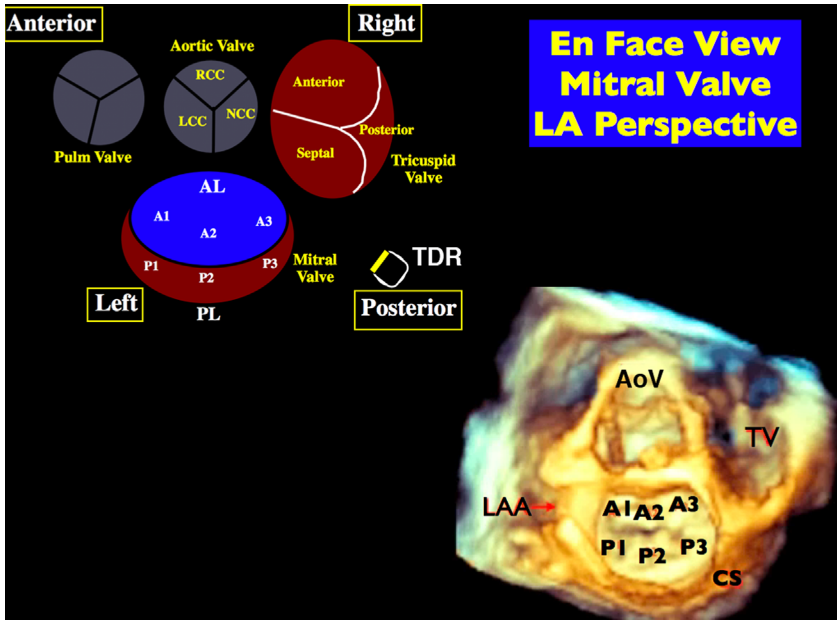

Fig 1. The top left of the figure shows a schematic with the mitral valve in the en face view and the surrounding valves to show a flat (2-dimensional) relationship among the valves. The transducer (TDR) is placed to resemble where the esophagus really is. The image shown in the right lower corner is an en face 3-dimensional view of the mitral valve and the surrounding tissues. A1, A2, A3, scallops of anterior leaflet; AL, anterior leaflet; AoV, aortic valve; CS, coronary sinus; LA, left atrium; LAA, left atrial appendage; LV, left ventricle; P1, P2, P3, scallops of the posterior leaflet; PL, posterior leaflet; Pulm Valve, pulmonary valve; RCC, LCC, NCC, right, left, and noncoronary cusps; TDR, transducer; TV, tricuspid valve.

durability of the repair.[17–24] However, depending on the extent of prerepair annular dilation and flattening, restoration of normal geometry and annular dynamics may not be possible.[25] Clinical data show that, overall, a rigid and flat ring provides a more durable repair and reduces MR recurrence to a greater extent than a flexible ring.[8,26–30]

Accurate sizing of an annuloplasty device is crucial in achieving the most optimal annular dimensions to prevent

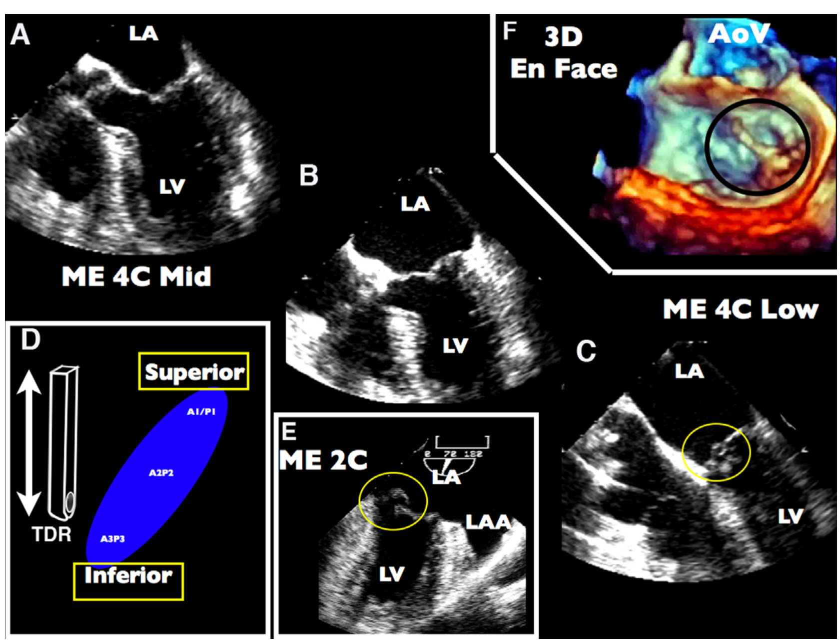

Fig 2. (Associated with Video clip 2). From multiple views, a flail of the posterior (P3) portion of the posterior leaflet with a torn chord is seen. The images show how the mitral valve also exists in a vertical plane as imagined in the schematic in panel D. Images A, B, and C were obtained by advancing the transesophageal echocardiography (TEE) probe from the mid esophageal (ME) 4 chamber (4C) level to a lower esophageal level, the last of which shows the P3 defect (yellow circle). The lesion is further highlighted in the ME 2-chamber view in panel E (yellow circle) and in the 3-dimensional (3D) en face views in panel F, the latter of which shows the defect and the torn chord (black circle). A1, A2, A3, scallops of anterior leaflet; AL, anterior leaflet; AoV, aortic valve; LA, left atrium; LAA, left atrial appendage; LV, left ventricle; P1, P2, P3, scallops of the posterior leaflet; PL, posterior leaflet; TDR, transducer.