Identification and Quantification of Degenerative and Functional Mitral Regurgitation for Patient Selection for Transcatheter Mitral Valve Repair

Tiffany Chen, MD[a], Victor A. Ferrari, MD[b,c], Frank E. Silvestry, MD[d,*]

KEYWORDS

• Mitral regurgitation • Transcatheter mitral valve repair • Echocardiography
• Mitral valve prolapse • Cardiac imaging • MitraClip

KEY POINTS

- Mitral regurgitation (MR) can be due to valvular degeneration, secondary to ventricular remodeling, or a combination of the 2 mechanisms.
- Edge-to-edge leaflet repair is the only approved transcatheter mitral valve repair technique in the United States; novel approaches targeting different components of the mitral anatomy are emerging.
- Imaging with echocardiography establishes the cause of MR, determines anatomic feasibility of transcatheter repair, and grades the severity of MR.
- Feasibility of MitraClip edge-to-edge repair requires sufficient leaflet tissue for capture, leaflet motion that is not excessively restricted or redundant, and central MR origin.
- Quantification of MR involves integration of various echocardiographic (including 3-dimensional–derived) parameters and potentially advanced imaging with cardiac magnetic resonance to resolve discrepancies.

Video content accompanies this article at http://www.interventional.theclinics.com.

INTRODUCTION

Chronic mitral regurgitation (MR) is prevalent in the adult population and leads to significant morbidity and mortality.[1–5] Moderate or severe MR affects an estimated 1.7% of the adult population in the United States, more than 4-fold higher than aortic stenosis.[1] Although mitral valve surgery has been the mainstay of treatment of symptomatic severe degenerative mitral regurgitation (DMR), many patients at high or prohibitive

Disclosure Statement: F.E. Silvestry is a site sub-investigator for Edwards CardiaQ and CardioBand. No disclosures for the remaining authors.

[a] Department of Medicine, Cardiovascular Division, University of Pennsylvania, 11-134 South PCAM, 3400 Civic Center Boulevard, Philadelphia, PA 19104, USA; [b] Department of Medicine, Cardiovascular Division, University of Pennsylvania, 11-136 South PCAM, 3400 Civic Center Boulevard, Philadelphia, PA 19104, USA; [c] Department of Radiology, University of Pennsylvania, 11-136 South PCAM, 3400 Civic Center Boulevard, Philadelphia, PA, USA; [d] Department of Medicine, Cardiovascular Division, University of Pennsylvania, 11-133 South PCAM, 3400 Civic Center Boulevard, Philadelphia, PA 19104, USA
* Corresponding author.
E-mail address: fsilvest@pennmedicine.upenn.edu

Intervent Cardiol Clin 7 (2018) 387–404
https://doi.org/10.1016/j.iccl.2018.04.002

operative risk are now referred for consideration of percutaneous mitral valve repair. Imaging, primarily with echocardiography, plays a crucial role in the characterization and quantification of MR to determine candidacy for transcatheter mitral valve repair.

CAUSE AND PATHOPHYSIOLOGY OF MITRAL REGURGITATION

MR can result from several mechanisms, which are broadly characterized into either a primary abnormality of the valvular apparatus or a secondary dysfunction due to other cardiac disease.

Primary Mitral Regurgitation

The most common cause of primary MR is degenerative disease, whether due to fibroelastic deficiency (FED) or myxomatous infiltration (Barlow disease). The former is associated with focal leaflet involvement, whereas the latter manifests as myxoid degeneration of the valve with diffuse thickening and multisegment redundancy. FED is characterized by a lack of connective tissue resulting in leaflet and chordal thinning and eventual chordal rupture manifesting as prolapse or flail of a single leaflet segment. Barlow disease results in marked leaflet thickening, large redundant leaflets, chordal elongation or rupture, and annular dilatation. Patients with Barlow disease generally have complex valve pathologic condition and dysfunction, which is most often multisegmental. A forme fruste phenotype of Barlow disease may present with intermediate features. Mitral valve prolapse can ultimately progress to leaflet flail, which is nearly uniformly associated with severe MR and chordal rupture.[2,6,7]

Causes of primary mitral regurgitation
Fibroelastic deficiency
Myxomatous infiltration
Rheumatic disease
Infective or nonbacterial thrombotic endocarditis
Mitral annular calcification
Radiation heart disease
Congenital malformations

Functional Mitral Regurgitation

In contrast to primary MR, functional mitral regurgitation (FMR) is associated with relatively normal mitral leaflet structure and is typically attributed to myocardial pathologic condition. Left ventricular remodeling, whether due to ischemic injury or other cardiomyopathy, causes apical and outward displacement of the papillary muscle or muscles leading to restriction and tethering of the mitral valve leaflets.[8] MR results because of imbalance between the opposing tethering and closing forces that drive leaflet coaptation. Distortion of mitral annular geometry further perpetuates MR, as the normally saddle-shaped annulus dilates and flattens.[9,10] Less commonly, FMR may also result from isolated annular dilatation due to severe left atrial (LA) enlargement such as in chronic atrial fibrillation or restrictive cardiomyopathy.[11]

Carpentier Classification

Mitral valve dysfunction can also be categorized according to leaflet motion with the Carpentier classification system (Fig. 1), which originated as a framework for determining an approach to surgical repair.[12] Type I dysfunction is associated with normal leaflet motion, such as in atrial FMR or leaflet perforation. Type II describes excessive leaflet motion, which occurs with mitral valve prolapse and leaflet flail. Type III dysfunction refers to restricted leaflet motion and is subdivided into type IIIa (diastolic and systolic restriction) and type IIIb (systolic restriction). Rheumatic, carcinoid, radiation heart disease, and other inflammatory conditions that restrict mitral valve opening are classified as Carpentier type IIIa. FMR due to ventricular dilatation and ischemic MR causes type IIIb dysfunction (restricted mitral valve closure).

Hemodynamic Effects of Chronic Mitral Regurgitation

Regardless of the cause or mechanism, chronic MR creates an additional volume load on the left ventricle (LV), which responds with eccentric hypertrophy. In the compensated phase of chronic severe MR, total stroke volume increases proportional to the increased preload, thus allowing LV ejection fraction (LVEF) to remain greater than normal. As myocardial dysfunction, cell death, and myocardial fibrosis develop, ventricular stroke volume diminishes, and LVEF will decline. Other hemodynamic effects of chronic severe MR include increased LA pressure and consequent pulmonary venous hypertension. Associated LA remodeling and dilation may also result in eventual atrial fibrillation.

TRANSCATHETER MITRAL VALVE REPAIR

MR is more prevalent in the elderly, nearly 10% of Americans older than 75 years of age have