Ischemic mitral regurgitation: current trends and treatment

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Purpose of review
Ischemic mitral regurgitation (MR) is a common finding in patients with coronary artery disease. In this review, we summarize the current literature describing the treatment of ischemic mitral regurgitation.

Recent findings
Recent publications have focused on describing outcomes following the treatment of ischemic mitral regurgitation based on the specific mechanism of regurgitation. New therapies such as remodeling rings and percutaneous approaches, along with insights into mitral valve replacement, have advanced the treatment of ischemic mitral regurgitation.

Summary
Mitral valve surgery and concomitant coronary artery bypass grafting represent the most effective strategy for the treatment of severe symptomatic ischemic mitral regurgitation. Overall, the survival of patients with ischemic mitral regurgitation is poor. Advances in mitral valve repair may improve long-term durability of surgery, whereas evolving percutaneous therapies may be a treatment option for patients with functional mitral regurgitation who are not surgical candidates.

Keywords
ischemic mitral regurgitation, mitral valve repair, mitral valve replacement

INTRODUCTION

Ischemic mitral regurgitation is a mechanical complication of coronary artery disease and may be either acute or chronic. Acute ischemic mitral regurgitation is rare and occurs as a result of papillary muscle rupture or elongation. These patients typically present in extremis, and surgical correction is associated with increased perioperative risk [1]. Most commonly, ischemic mitral regurgitation is due to chronic left ventricle (LV) remodeling following myocardial infarction. The resulting papillary muscle displacement leads to tethering of the mitral valve leaflets and mitral regurgitation [1–2].

The presence of ischemic mitral regurgitation following myocardial infarction is associated with a 5-year mortality of 62% [1]. The presence of even mild mitral regurgitation is associated with an increased cardiovascular mortality [1–2]. The increasing prevalence of coronary artery disease has resulted in a rise in the number of patients with ischemic mitral regurgitation requiring surgery. Despite advances in medical and surgical treatment, longitudinal data have shown poor survival for patients with ischemic mitral regurgitation compared with patients who present with mitral regurgitation due to other causes. Nevertheless, new technologies and recent studies have provided new insights into this challenging surgical problem.

In this review of ischemic mitral regurgitation, we summarize the current understanding in regards to the pathophysiology and management of ischemic mitral regurgitation.

PATHOPHYSIOLOGY OF ISCHEMIC MITRAL REGURGITATION

Patients with ischemic mitral regurgitation present differently based on their underlying mitral disorder. Most commonly, the initial insult in patients with chronic ischemic mitral regurgitation is remodeling

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KEY POINTS

- Surgical correction of moderate chronic ischemic mitral regurgitation at the time of CABG is likely associated with a benefit in postoperative functional status.
- Overall, the long-term survival of patients with chronic ischemic mitral regurgitation is worse than that of patients with mitral regurgitation because of other etiologies.
- Mitral valve repair of chronic ischemic mitral regurgitation can be performed with favorable results, especially with advances in remodeling rigid rings.
- Mitral valve replacement of chronic ischemic mitral regurgitation is a viable alternative in certain patients.

of the LV following ischemia. The LV becomes more spherical in shape and the associated annular and subvalvular changes result in mitral regurgitation. Papillary muscle displacement occurs away from the anterior annulus and posterolaterally. The resulting tethering of the secondary chordae is seen echocardiographically as the 'sea-gull' deformation of the leaflet body [3▪▪,4]. Isolated annular dilation may also be observed, but it is typically associated with basal infarction [3▪▪]. Ischemic mitral regurgitation also occurs because of ventricular dyssynchrony, which increases mitral leaflet tethering. Cardiac resynchronization therapy has been shown to improve LV systolic and diastolic function, and decrease mitral regurgitation in medically managed patients [5]. Systolic papillary muscle dyssynchrony is also associated with the recurrence of mitral regurgitation following mitral valve repair [6]. Once ischemic mitral regurgitation occurs, it progresses as changes in LV size and shape increase LV wall stress, which results in worsening function and further papillary muscle displacement and leaflet tethering [2,3▪▪,4,5,6]. Acute ischemic mitral regurgitation is rare, and occurs with either papillary muscle rupture or chordal elongation [1–2].

SURGICAL MANAGEMENT OF CHRONIC ISCHEMIC MITRAL REGURGITATION

Surgical planning typically involves answering three important questions:

(1) Should concomitant mitral valve surgery be performed at the time of surgical revascularization?
(2) If the mitral valve is to be addressed surgically, should the valve be repaired or replaced?
(3) If the mitral valve is repaired, what type of repair should be employed and how durable is the outcome?

WHEN SHOULD ISCHEMIC MITRAL REGURGITATION BE SURGICALLY CORRECTED?

Current treatment guidelines recommend concomitant mitral valve surgery with revascularization in patients with severe mitral regurgitation undergoing coronary artery bypass grafting (CABG) [7]. In elderly patients or those with multiple comorbidities, moderate mitral regurgitation is sometimes not surgically corrected because of the increase in perioperative risk [8–9]. However, moderate mitral regurgitation may progress in 30–77% of patients who undergo surgical revascularization alone [10–11]. The long-term survival benefit of mitral valve surgery concomitant to CABG in these patients is the subject of debate [8–12].

In a randomized comparison involving 75 patients (CABG plus mitral valve repair in 34 and CABG alone in 39) with moderate mitral regurgitation and a LV ejection fraction less than 30%, mitral annuloplasty with CABG was superior to CABG alone [13▪▪]. The study was stopped early after review of interim data. At 1 year, there was a greater improvement in the primary end point of peak oxygen consumption in the CABG plus mitral repair group compared with the isolated CABG group (3.3 ml/kg/min versus 0.8 ml/kg/min; $P = 0.001$). Patients who underwent CABG and concomitant mitral repair also had a greater reduction in postoperative left ventricular end-systolic volume index, mitral regurgitation volume and plasma B-type natriuretic peptide levels [13▪▪]. However, 30-day and 1-year mortality was similar between groups [13▪▪]. Another randomized study also found that mitral valve surgery concomitant to CABG improved postoperative New York Heart Association (NYHA) functional class and LV dimensions in patients with moderate ischemic mitral regurgitation [14].

MITRAL VALVE REPLACEMENT VERSUS MITRAL VALVE REPAIR IN PATIENTS WITH CHRONIC ISCHEMIC MITRAL REGURGITATION

In patients undergoing mitral surgery for ischemic mitral regurgitation, is it preferable to repair or replace the valve? There is no randomized study to date which answers this question. Retrospective studies have included mixed cohorts of patients with limited long-term follow-up.

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The seminal study by Bolling *et al.* [15] set the stage for down-sizing ring annuloplasty as the treatment of functional mitral regurgitation. In that study, patients who underwent mitral valve repair had improvement in their NYHA functional class, and follow-up echocardiography showed improved LV function. Since then, retrospective data have confirmed that mitral valve repair of ischemic mitral regurgitation is associated with better early and late survival [16–18,19▪▪].

On the contrary, the survival of patients with ischemic mitral regurgitation is poor, and recurrent mitral regurgitation may occur in an important proportion of patients following mitral valve repair. In fact, mitral regurgitation may occur in 28% of individuals 6 months following mitral repair [20]. In a propensity matched analysis of 120 patients, we found no difference in 5-year survival among patients who underwent repair or replacement of chronic ischemic mitral regurgitation [21]. Although there was no difference between groups in regards to the development of recurrent 3+ or 4+ mitral regurgitation, patients who underwent valve repair were more likely to have recurrent moderate mitral regurgitation [21]. Similar findings were observed in a recent study involving 1006 patients with chronic ischemic mitral regurgitation and impaired LV function defined as a LV ejection fraction less than 40% [22▪▪]. From this large cohort, 244 propensity-matched pairs were identified. There was no difference between groups in early mortality or survival at 8 years. A competing-risks regression showed that mitral valve repair was a strong predictor of subsequent mitral valve re-operation [22▪▪].

SURGICAL APPROACHES IN MITRAL VALVE REPLACEMENT

Contemporary mitral valve replacement is performed with lower perioperative mortality than even a decade ago [7]. Although historically performed with complete resection of the mitral leaflets, and chordae, mitral replacement is now performed with preservation of the subvalvular apparatus, thereby improving postoperative LV function [1–2]. This may, in part, explain the lack of survival benefit of repair versus replacement in certain study cohorts.

SURGICAL APPROACHES IN MITRAL VALVE REPAIR

Successful surgical correction of ischemic mitral regurgitation depends upon proper assessment of the etiology.

Annular repair – mitral annuloplasty system

Down-sizing ring annuloplasty is the primary approach in managing patients with annular dilatation [15]. Rigid rings may provide better long-term results than flexible rings [23].

Newer remodeling rings may further improve long-term durability of valve repair in these patients [24]. The McCarthy-Adams IMR Etlogix (Edwards Lifesciences, Irvine, California, USA) has been shown to reduce the mitral tethering area and tenting height with 95% and 89% survival free from recurrent mitral regurgitation ≥2+ at 15 and 25 months, respectively [24]. However, long-term data regarding the performance of these annuloplasty systems are still pending.

Leaflet repair

There are two techniques of mitral leaflet repair, that is, the edge-to-edge repair and posterior mitral leaflet augmentation.

Edge-to-edge repair

The edge-to-edge repair is a well-tolerated and effective treatment option for the repair of ischemic mitral regurgitation due to annular dilatation and posterior leaflet tethering [19▪▪]. Durability of the edge-to-edge repair, however, is influenced by the concomitant use of an annuloplasty system and is worse for patients with mitral annular calcification [25].

Posterior mitral leaflet augmentation

In patients with extensive posterior leaflet restriction, patch augmentation of the posterior leaflet has been shown to improve leaflet coaptation [26]. Favorable early results have been shown using this approach [26].

Subvalvular repair approaches

Different repair techniques that address the subvalvular apparatus are described, which are chordal cutting, papillary muscle sling and posterior papillary muscle relocation.

Chordal cutting

Leaflet tethering is an important factor in the development of ischemic mitral regurgitation. Division of secondary chords may increase anterior leaflet mobility as measured by a reduction in the distance between the free edge of the anterior mitral valve leaflet and the posterior left ventricular wall [27]. This approach decreases the incidence of late recurrent mitral regurgitation without

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negatively impacting postoperative LV function [27].

Papillary muscle sling

This approach involves placement of an intraventricular polytetrafluoroethylene sling that encircles the papillary muscles at their base [28]. Tightening the sling decreases the distance between the papillary muscles and effectively reduces mitral regurgitation [28].

Posterior papillary muscle relocation

In this technique, a suture is placed from the posterior papillary muscle toward the mitral annulus, adjacent to the right fibrous trigone [29]. Although effective, long-term data regarding outcomes are not available [29].

PREDICTORS OF RECURRENT MITRAL REGURGITATION FOLLOWING REPAIR

Echocardiographic factors associated with repair failure include posterior leaflet angle more than 45 degrees, distal anterior leaflet angle more than 25 degrees, tenting height more than 10 mm, and tenting area more than 2.5 cm^2 [30–31]. The size of the left ventricle may also have prognostic importance, with an end-diastolic dimension more than 65 mm associated with poor reverse remodeling following CABG even in the presence of viable myocardium [32].

PERCUTANEOUS APPROACHES FOR MITRAL VALVE REPAIR OF ISCHEMIC MITRAL REGURGITATION

Although a variety of percutaneous therapies addressing mitral regurgitation have been developed, the MitraClip (Abbott Laboratories, Abbott Park, Illinois, USA) has emerged as a clinically well-tolerated and effective method for percutaneous mitral valve repair [33].

CONCLUSION

The management of ischemic mitral regurgitation continues to evolve. Understanding the mechanism of mitral regurgitation is critical in determining the optimal treatment strategy. Advances in the mitral valve repair techniques and replacement have resulted in better early and late results following the surgical treatment of ischemic mitral regurgitation.

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Conflicts of interest

There are no conflicts of interest.

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- ■ of special interest
- ■■ of outstanding interest

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