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STATE-OF-THE-ART PAPER

Surgical Approaches to Mitral Regurgitation

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Surgical approaches to correct mitral regurgitation (MR) have evolved over 50 years and form much of the basis for percutaneous approaches to the mitral valve. Surgical mitral repairs have been more durable with use of annuloplasty, but recurrent regurgitation not resulting in reoperation can occur. The mitral leaflets may be resected or augmented, with recent trends to preserve leaflet coaptation surfaces if possible. Mitral chords tend to be replaced or transferred instead of being shortened. Mitral replacement still has a role when more durable and reliable than repair. Surgical incisions have varied from full sternotomy down to percutaneous access only, with less invasiveness usually requiring a trade-off versus effectiveness or ease of application. Less invasive options in treating MR may encourage higher-risk patients to seek anatomic therapy, whether surgical or percutaneous. Rapidly evolving technology will continue to be a dominant driver of surgical approaches to MR, with increasing overlap and interaction with percutaneous approaches. (J Am Coll Cardiol 2012;60:1315–22) © 2012 by the American College of Cardiology Foundation

A successful surgical approach to mitral regurgitation (MR) was first reported as early as 1951 by Bailey et al. (1). Since that time, surgical and percutaneous interventions to treat MR have evolved tremendously. At present, percutaneous means to repair the mitral valve (MV) or even replacing the MV appears to be on the horizon and promises to dramatically alter the treatment and selection of patients with MR. The purpose of this review is to summarize current surgical practice in treating MR, and to suggest where treatment for MR might be heading in the near future.

A Brief History

Bailey et al. (1) first approached MR through a left thoracotomy, and the mitral annulus was narrowed by external constriction of the base of the heart in an approach not unlike recent attempts to perform mitral annuloplasty through the coronary sinus. Lillehei et al. (2) performed the first direct suture annuloplasty of the MV in 1957 using cardiopulmonary bypass (CPB), and Starr and Edwards (3) first replaced the mitral valve using a commercially successful device in 1960. Today, surgery for MR is performed in 40,000 patients each year in the United States. One should be aware that, in this age of rapidly advancing percutaneous technology that is used both by surgeons and nonsurgical interventionists, the term "surgical" could, in fact, be considered an anachronism.

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Anatomic Approaches to the Mitral Valve

The MV sits between the left atrium and the left ventricle, and can therefore be approached from either of those 2 chambers. At present, nearly all surgical access to the MV is through the left atrium. Rarely, the MV is approached through the left ventricle or the aortic root.

The left ventricular apex has previously been used to perform closed mitral commissurotomy. More recently, a transapical approach has been used to replace the MV using a percutaneous, stented aortic valve device in a patient with failed biological mitral prosthesis (4). Mitral chordae have also been replaced through a transapical approach (5). A transventricular approach to MV repair has been described in patients having left ventriculotomy performed for left ventricular aneurysm (6,7). The transventricular approach at the time of ventricular aneurysm repair is best suited for simple replacement or commissural annuloplasty.

Surgical Incisions to Access the Mitral Valve

To access the anatomic approaches to MR listed above, several skin incisions have been used, including sternotomy, thoracotomy, or percutaneous access. With wide use of CPB in the 1960s, median sternotomy replaced right thoracotomy as the primary surgical approach to treat MR due to reliability, speed, and excellent access to most of the heart. The skin incision for full sternotomy can be made as small as 8 cm and can be a cosmetic inframammary incision in women. Disadvantages to median sternotomy include blood loss, slow sternal healing, potential for sternal nonunion, and morbidity and mortality from deep sternal infection, which may affect 1% to 2% of cases.

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Abbreviations and Acronyms

CPB = cardiopulmonary bypass
LV = left ventricular
MV = mitral valve
MR = mitral regurgitation

Because of patient demand, marketing forces, and improved technology, the percentage of MV operations done with minimally invasive incisions other than sternotomy have steadily increased to 20% of all mitral operations in 2008 (8). Although large, controlled studies are lacking, minimally invasive approaches to the MV have been associated with faster recovery, less blood loss, and less infection (9). Disadvantages can include increased operative difficulty, increased procedure and pump times, limited access to the rest of the heart, potentially more equipment costs, and possibly more stroke due to greater use of femoral arterial cannulation for CPB (8,10).

Partial superior sternotomy has been the most popular minimally invasive approach to the MV since the work of Gillinov and Cosgrove (11). Before median sternotomy, mitral operation for regurgitation was performed through right thoracotomy by Lillehei et al. in 1956 (2). Many series now describe smaller right thoracotomies termed "mini" thoracotomy or "port access" (12,13), with an incision length somewhere between full thoracotomy (20 cm) and an endoscopic port (0.5 cm to 1.5 cm).

Transapical access to the MV can be obtained through a small left anterior thoracotomy and has been reported for valve-in-valve redo mitral replacement using the Sapien (Edwards Lifesciences, Irvine, California) percutaneous valve device (4). Inferior partial sternotomy, right parasternal incision, and left thoracotomy have all seen limited use due to worse exposure or more chest trauma than other approaches.

To patients and to most surgeons, the term "totally endoscopic" has generally implied no incision larger than the port for a 0.5 to 1.5 cm endoscope. However, in cardiac surgical circles, "totally endoscopic" has also been used to describe a right minithoracotomy in the 4 cm to 8 cm range with no rib spreading (14). To avoid confusion of terminology, Chitwood et al. (15) proposed a classification system whereby minimally invasive approaches are categorized, as in Table 1, on the basis of whether the surgeon uses direct vision, thoracoscopic visualization, or robotics for any portion of the surgery. Totally endoscopic MV surgery with no chest incision >1.5 cm generally requires robotic assistance and groin incision for femoral arterial and venous access.

Table 1 Levels of Minimally Invasive Mitral Surgery*

Direct vision mini-incision (10 to 12 cm)
Video-assisted microincision (4 to 6 cm)
Video directed or robotic assisted (3 to 4 cm)
Robotic telemanipulation (1 cm)
Percutaneous

*Modified from Chitwood and Rodriguez (15).

Robotic assistance for MV surgery as currently practiced first became available in 2000 and has been championed by Mohr, Chitwood, and others (16). The current daVinci robot (Intuitive Surgical, Sunnyvale, California) is a remotely controlled servo where 1 or 2 operating surgeons sit at a console away from the patient and manipulate 2 to 4 servo-controlled arms. The robotic arms offer scaling where the instruments move smaller distances than the operator's hands, tremor reduction, stereoscopic vision, and ×10 magnification. An additional bedside surgeon is needed to load the various robotic arms, pass sutures in and out of the wound, cut, tie, and perform manipulation not done by the robotic arms. The greatest merit to robotic assistance comes when surgical incisions are sufficiently small to prevent facile operating directly through the minithoracotomy (generally 4 cm or less) (Table 1). Disadvantages of a robotic approach include equipment cost and complexity, size and bulk of current technology, and difficulty with knot tying.

Percutaneous Access to the Mitral Valve

The only well-documented percutaneous approach to MR in the United States today is the MitraClip (Abbott Laboratories, Abbott Park, Illinois), which remains in trial in the United States (17). This is a 13-mm clip that is applied to attach the anterior and posterior mitral leaflets together, similar to the surgical edge-to-edge surgical repair technique (see following discussion). The MitraClip is placed from the femoral vein and through the interatrial septum.

Initial results of the North American EVEREST (Efficacy of Vasopressin Antagonism in Heart Failure: Outcome Study With Tolvaptan) trial and the European experience show that MitraClip can reduce MR, reduce left ventricular volume, and improve quality of life and heart failure symptoms at 1 to 2 years (17). Limitations of the MitraClip include the requirement of a localized regurgitant jet, technical challenges of the transseptal approach, and lack of results beyond 2 to 3 years.

Concern has been voiced that MitraClip placement without ring annuloplasty may duplicate surgical reports of higher recurrent MR due to lack of an annuloplasty ring (11). Conversely, Maisano et al. (18) reported a series of patients with surgical edge-to-edge repair without ring with freedom from reoperation or >2+ MR of 80% at 12 years. Many of these patients had annular calcification, which may have effectively served as an annuloplasty.

An additional concern voiced is that MitraClip placement may increase the likelihood of needing subsequent replacement instead of repair. This concern is supported by data from the EVEREST trial and from Germany, where replacement rates were higher than expected in patients requiring surgery after MitraClip placement (19,20). Nonetheless, more data will be needed, as these are small series with short term follow-up and a relatively inexperienced