Role of Mitral Valve Repair for Mitral Infective Endocarditis

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KEYWORDS

• Mitral valve infective endocarditis • Mitral valve repair • Autologous pericardium • Ring annuloplasty • Mitral valve replacement

KEY POINTS

- Systematic reviews and meta-analyses have demonstrated that mitral valve repair (MVrep), whenever feasible, yields better short- and long-term outcomes than mitral valve replacement in the treatment of mitral infective endocarditis (IE).
- The key factors determining reparability are the extent and location of tissue destruction by the endocarditic process and the quality of the remaining tissue after radical resection of infected tissue.
- MVrep, using a wide armamentarium of reparative procedures, has the potential to improve late outcomes in patients undergoing mitral valve surgery for mitral IE. Early repair-oriented surgery is recommended for mitral IE.

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

INTRODUCTION

Mitral valve replacement (MVR) using mechanical or bioprosthetic valves was the standard procedure for mitral valve infective endocarditis (IE) until the publication of the initial series on mitral valve repair (MVrep) for acute endocarditis by Dreyfus and colleagues[1] in 1990. They reported 40 patients undergoing MVrep for acute mitral IE using several reparative techniques including the pericardial patch technique as a leaflet substitute. The development of new techniques allowed them to increase their repair rate up to 80% without recurrence of endocarditis or reoperation for valvular insufficiency. Muehrcke reported 146 patients undergoing surgery for mitral IE.[2] MVrep was accomplished in 70% of the patients with lower hospital mortality and improved long-term survival.

Although only a limited number of studies focusing on MVrep for IE were available until 2000, clinical evidence suggesting improved outcomes with MVrep for mitral IE during the last 2 decades has increased. The principal concern is the impact of active infection on the feasibility and durability of repair. To avoid recurrence of infection, chordal reconstruction using chordal transport or annulus reinforcement without a prosthetic ring was advised in the early stages. Systematic reviews and meta-analyses have demonstrated that MVrep, whenever feasible, yields better short-term and long-term results than replacement in the treatment of mitral IE.[3,4] The feasibility of repair depends on the extent of destruction of the mitral valve and the surgeon's experience. The guidelines[5–7] recommend MVrep, whenever possible, for patients with mitral IE. The aim of this review was to summarize the history, reliable repair

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procedures, and clinical results of MVrep for mitral IE to ensure improved event-free survival rates after surgery.

METHODS

A search of the PubMed database was conducted for articles published from January 2000 to July 2020. Pertinent articles were selected using the following keywords: "mitral valve repair," "infective endocarditis," and "late results." Only articles in English and involving human subjects were included. Case reports, small case series with fewer than 30 cases of MVrep, or studies with missing surgical details were excluded. When more than one study had been published by a particular center, only the most recent study with the largest number of patients was included in this review.

RESULTS

Reports on Mitral Valve Repair for Infective Endocarditis in the 1990s

There were only 4 studies on MVrep for mitral IE from 1990 to 1999.[1,2,8,9] First, Dreyfus and colleagues reported a series of 40 patients with a mean follow-up of 30 months who had undergone MVrep for acute endocarditis in 1990. They stated that the organisms involved must not influence the surgical policy. The only factor limiting valve repair in IE, they believed, was the extent of the lesions. The entire anterior leaflet of the mitral valve was replaced with pericardium in 3 patients. A procedure of this kind was only possible when the infectious process did not involve the marginal chordae. Preservation of the marginal chordae is an important procedure. Barring such cases, chordal transposition was considered mandatory in all cases of ruptured chordae of the anterior leaflet. The repair rate was 80% using Carpentier's reconstructive techniques, including the use of pericardial patches.[10] They concluded that valve repair in acute endocarditis is possible and effective in most cases. Pagani and colleagues[8] reported a series of 22 patients with a mean follow-up of 20 months; there were no cases of recurrent endocarditis, no operative deaths, and only one late death. Muehrcke reported the Cleveland Clinic experiences of MVrep for bacterial endocarditis in 1997.[2] Between 1985 and 1995, 102 of 146 patients (70%) underwent MVrep for mitral IE. Every effort was made to avoid implanting any foreign material in patients with active endocarditis. In patients with acute endocarditis, prosthetic ring annuloplasty was performed in 38% of cases. They concluded that MVrep results in reduced hospital mortality and improved long-term survival. Lee and colleagues[9] reported 71 consecutive patients who underwent surgery for mitral IE. Endocarditis was divided into 3 stages: uncontrolled and active (n = 24), partially treated (n = 17), and healed (n = 30). The repair rates were 17%, 59%, and 63% for each stage, respectively. The total repair rate was 46%. They concluded that conservative surgery, preferably repair, should be performed, whenever feasible, for mitral IE to maintain left ventricular function. The total number of patients who underwent MVrep for mitral IE in these 4 studies was 197. The repair rate for mitral valve IE ranged between 46% and 80% at these highly experienced centers. The durability of repair was described as acceptable in these reports. However, the benefits of MVrep over MVR in mitral IE cases remained poorly established due to the overall lack of adequately sized and properly designed studies.

Nationwide/"Real World" Cohort Report

Gammie and colleagues reported that 6627 patients underwent mitral valve surgery for mitral IE at 661 Society of Thoracic Surgeons (STS)-participating centers between 1994 and 2003.[11] The repair rate was 29.7% (active IE: 15.9%, treated IE: 40.9%). Although the repair rate for active IE improved from 35.8% to 46.6% during a decade, patients with active IE were less likely to undergo MVrep than those with treated IE. The in-hospital mortality significantly improved in the MVrep group even among the active IE group subjects. The authors supported MVrep, whenever technically feasible, in the setting of mitral IE. Toyoda and colleagues[12] reported real-world outcomes of surgery for native mitral IE. The study population comprised 1970 patients undergoing MVrep (n = 367, 18.6%) and MVR (n = 1603, 81.4%) in the states of New York and California between 1998 and 2010. The repair rates increased from 10.7% to 19.4% over the study period. The propensity-matched cohort included 798 patients: 266 in the MVrep group and 532 in the MVR group. The focus was on the association between mitral reoperation and the surgeon's case volume. MVrep performed for endocarditis by high-volume surgeons was 5 times less likely to require reoperation within 1 year than MVrep performed by low-volume surgeons (<25 cases per year). They concluded that survival rates were better, and the risk of recurrent infections was lower for MVrep than for MVR in active endocarditis patients; MVrep should be the surgery of choice when feasible. Lee and colleagues[13] conducted a nationwide cohort study comparing MVrep and

MVR for mitral IE between January 2000 and December 2013 in Taiwan. During the study period, 1999 patients underwent MV surgery for IE for the first time. The repair rate was 21.2% and the number of patients undergoing MVrep increased during the study period. A total of 352 propensity score–matched patients who underwent MVrep and MVR were eligible for the analysis. They concluded that MVrep for IE showed better perioperative and late outcomes than MVR. However, the beneficial effect of MVrep was not significant in low-volume hospitals.

Operative Techniques

Surgical principles are very important (**Box 1**). Exposure of acute mitral IE reveals leaflet perforations, vegetations of various sizes, and extension (**Fig. 1**). Owing to the possibility of recurrent infection in MVrep for mitral IE due to incomplete resection of the infected valvular tissue, all macroscopically involved tissues are largely resected without any concern for the possibility of repair. The surgical steps are listed in **Box 1**. The first step involves wide resection of the infected sites of the valve, including a strip of at least 2 mm of normal valvular tissue as described by Dreyfus.[1] The infected fragile chordae are also resected. The intact marginal chordae should be carefully preserved. The mitral annular abscess is examined along the posterior annulus. Reparative procedures for mitral IE have not changed significantly from those described in the series of Dreyfus in 1990, except chordal reconstruction with expanded polytetrafluoroethylene (ePTFE) sutures. In case of a mitral annular abscess, the abscess is opened and aggressively debrided, and the defect is corrected using a properly tailored autologous pericardial patch. The presence of a mitral annular abscess does not automatically imply valve replacement; annulus reconstruction must be required for performing either MVrep or MVR. After resecting a small area of infection of the posterior leaflet, placing a direct suture may be possible. In case of anterior leaflet perforation and commissure area infection, especially in the presence of acute infection, treated or untreated autologous pericardium may be used as a patch graft because of the fragility of the remaining leaflet tissue, which may be prone to tearing after a direct suture is placed (**Figs. 2** and **3**).

Box 1
Surgical steps of mitral valve repair for infective endocarditis

Step 1. Radical resection of infected tissue

Leaflet, chordae, annular abscess debridement

Step 2. Annulus reconstruction using pericardium (if required)

Step 3. Decision-making whether remaining leaflet tissue is sufficient (two-thirds free margin of AML/PML and one commissure: intact)

Step 4. Restore leaflet deficit using pericardium

Step 5. Chordal reconstruction by chordal transfer/ePTFE sutures

Step 6. Ring annuloplasty in the case of annular dilatation

Step 7. Assessment of mitral valve repair by intraoperative TEE

Abbreviations: AML/PML, anterior posterior mitral leaflet; ePTFE, expanded polytetrafluoroethylene; TEE, transesophageal echocardiography.

The key factors determining reparability are the extent and location of tissue destruction by the endocarditic process and the quality of the remaining tissue after radical resection of the infected tissue. Shang and colleagues suggested that MVrep should not be attempted when more than 50% to 60% of the posterior leaflet is absent or when more than 10% to 20% of the free edge of the anterior leaflet has been destroyed.[14] Similar to Dreyfus's observation in 1990, Shang and colleagues also noted that considerable destruction of the anterior leaflet did not necessarily mandate replacement because an autologous pericardial patch could reconstruct a large percentage of the body of the anterior leaflet. Defauw and colleagues reported that two-thirds of the free edge of the mitral valve and one commissure must be intact in order to attempt repair.[15] The repair rate in their study was 66% (of 149 patients) between 2000 and 2017.

Late results of pericardial patch grafting for anterior leaflet perforation indicate it to be a reliable procedure.[10,16–18] A relatively large autologous pericardial patch graft is sutured along the remnants of the anterior and posterior leaflets, resembling the sail of a yacht during systole. By placing the magic stitches at the commissure area, chordal reconstruction using ePTFE sutures is performed along the unsupported autologous pericardium at the anterior leaflet to achieve good coaptation of the anterior and posterior parts of the autologous pericardium (**Fig. 4**, Video 1). Chordal transfer from the posterior leaflet (flip-over technique) may also be effective. Chordal reconstruction using ePTFE sutures is a feasible technique for correcting the prolapse of the remnant leaflet. The combination of chordal

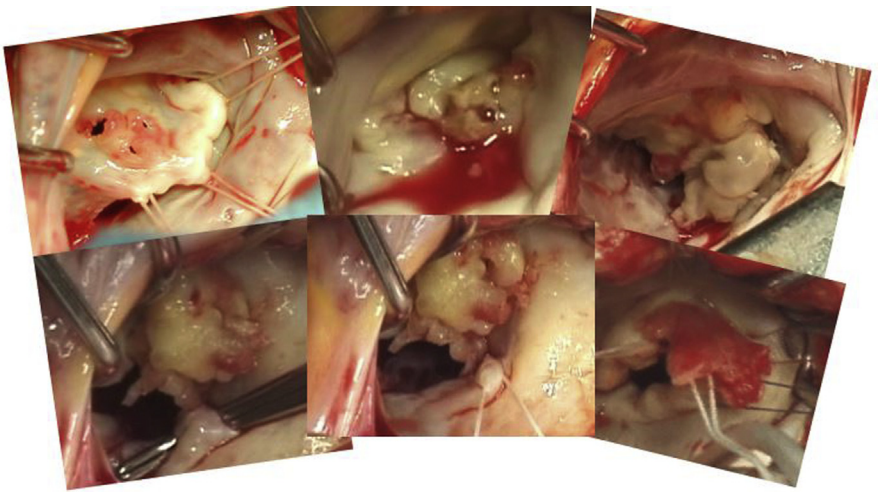

Fig. 1. Operative findings of mitral valve infective endocarditis.

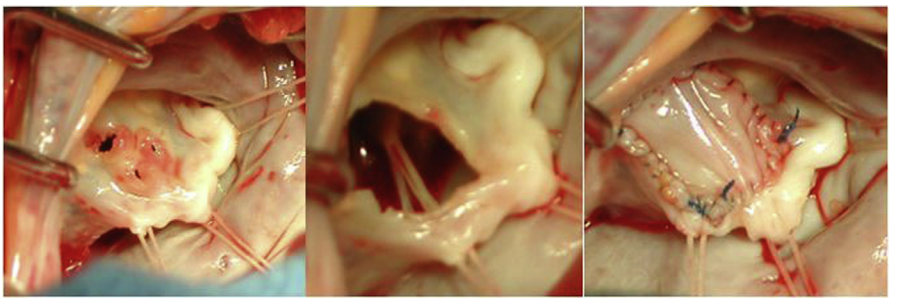

Fig. 2. Perforations of anterior mitral leaflet and patch closure using autologous pericardium.

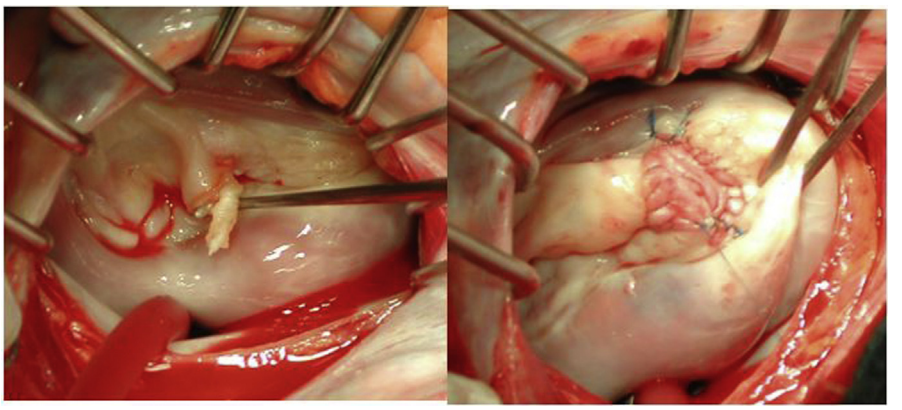

Fig. 3. Infective endocarditis at commissure area and repair using autologous pericardium.

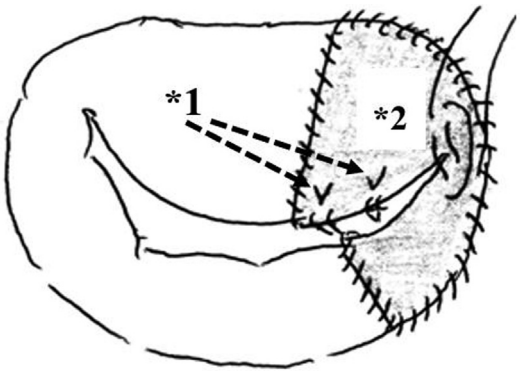

Fig. 4. Leaflet reconstruction using autologous pericardium and ePTFE suture (*1: chordal reconstruction using ePTFE. *2: magic stitch to make a good coaptation).

reconstruction and anterior leaflet patching is a complex procedure and requires an experienced surgeon. Redundancy of the autologous pericardium at the anterior leaflet is mandatory. In such cases, a prosthetic ring is required to create a good coaptation area.

To reduce the chances of early redo surgery for residual or recurrent mitral regurgitation (MR), immediate assessment of this complex MVrep using intraoperative transesophageal echocardiography is mandatory. In our practice, a second pump run is always indicated in cases of residual MR of the mild grade or more. The second pump run incidence was 8.8%, and rerepair was accomplished in all our cases.[19] Freedom from reoperation at 5 years was 90% in active mitral IE and 99% in healed mitral IE cases.

Reports from a Single Institute (2000–2020)

The number of patients who underwent MVrep for mitral IE ranged from 34 to 155 (**Table 1**). The case volumes in each institution during an average of 14 years are quite limited. The repair rate varied from 33% to 86% based on the surgeon's discretion. Iung and colleagues reported that the surgical techniques used in their study were highly specialized and could not be widely extrapolated.[20] The procedures included leaflet resection, transposition of chordae, chordal shortening, pericardial patch repair, partial homograft insertion, and prosthetic ring annuloplasty. However, they reported that the good results obtained using MVrep should lead to its diffusion, as has previously been the case with degenerative causes. Ruttmann and colleagues compared the surgical results between MVrep (n = 34) and MVR (n = 34) for mitral IE without performing randomization.[21] They used leaflet reconstruction with treated autologous pericardium, annular reconstruction with autologous pericardium, chordal transposition, rotation paracommissural sliding plasty, and ring annuloplasty. They observed that asking a surgeon to perform a procedure that he or she is not convinced about or lacks a high level of experience in may be unethical. Therefore, randomized trials are unlikely to be feasible regarding the choice of these 2 surgical techniques. They concluded that MVrep offers excellent early and late results in terms of event-free survival after surgery. Doukas and colleagues reported the use of MVrep (n = 36) for active culture-positive mitral IE.[22] They concluded that MVrep for active mitral IE was associated with low operative mortality and provided satisfactory freedom from recurrent infections and repeat

Table 1
Reports of mitral valve repair for mitral infective endocarditis (2000–2020)

Study (Year)	No of Repair	(Acute/ Healed)	Repair Rate (%)	Mean Age	Hsp Mortality (%)	Survival
Iung et al,[20] 2004	63	(25/38)	81	50 ± 17	3.2	93 + 4% (7 y)
Ruttmann et al,[21] 2005	34	(34/-)	50	52 ± 17	11.8	85% (5 y)
Doukas et al,[22] 2006	36	(36/-)	46	53	2.8	93% (5 y)
Shang et al,[14] 2009	56	(36/20)	63	48	5.3	91% (5 y)
Shimokawa et al,[23] 2009	78	(14/64)	86	50 ± 15	0	90 ± 5% (10 y)
Jung et al,[24] 2011	41	(41/-)	40	34 ± 17	0	98% (5 y)
Perrotta et al,[25] 2018	76	(NA)	54	60	1	77 ± 6% (10 y)
Tepsuwan et al,[26] 2019	38	(38/-)	33	44 ± 16	2.6	72% (10 y)
Solari et al,[27] 2019	155	(155/-)	81	60 ± 14	11.6	65 ± 5% (10 y)
Defauw et al,[15] 2020	97	(NA)	66	57 ± 13	12.4	66.5% (10 y)
Okada et al,[19] 2020	147	(49/98)	86	50 ± 18	0.7	89 ± 4% (10 y)

operations as well as improved survival. Shang and colleagues reported early surgical therapy and the aggressive use of repair for mitral IE.[14] They also concluded that MVrep for mitral IE offered a long-term survival advantage over MVR. Shimokawa and colleagues reported 78 cases of MVrep for mitral IE (active n = 14, healed n = 64).[23] They observed that MVrep for mitral IE was associated with low operative mortality and morbidity, and its long-term durability was comparable to that of repair for degenerative MR. Jung and colleagues analyzed MVrep (n = 41) and MVR (n = 61) for active mitral IE without performing randomization[24] and found no significant difference in the long-term survival and event-free survival between the 2 groups. Perrotta and Tepsuwan reported that MVrep for mitral IE is associated with excellent midterm and long-term results in selected patients.[25,26] Solari and colleagues described the use of repair-oriented surgery for active mitral IE.[27] They applied a wide armamentarium of repair techniques including autologous pericardium repair, tricuspid autograft, and mitral homograft as a leaflet. Early surgery and repair-oriented surgery for mitral IE were recommended. Solari and colleagues compared the clinical results of MVrep with patch and MVrep without patch. They concluded that patients could benefit from complex MVrep even if patch material was necessary for valve repair. We used treated autologous pericardium as a leaflet substrate, ePTFE sutures (CV-5) for chordal reconstruction, and a prosthetic ring if required.[19] Our basic concept in mitral IE repair involves radical resection of the infected tissue and functional reconstruction of the mitral valve without residual MR. We do not hesitate to use a second pump run to minimize residual MR after MVrep for mitral IE. In these 11 reports, freedom from redo surgery for recurrent MR rates or reinfection after MVrep rates ranged from very high to acceptable.

DISCUSSION

This review found that MVrep, using a wide armamentarium of reparative procedures, has the potential to improve late outcomes in patients undergoing mitral valve surgery for mitral IE. Early repair-oriented surgery is recommended for mitral IE to prevent worsening heart failure and continuing valve destruction due to the infection.

The advantages of MVrep over replacement are well established in terms of preservation of left ventricular function, low perioperative mortality, and freedom from valve-related events after surgery for severe degenerative MR. However, no randomized clinical trials comparing MVrep and MVR have been conducted, even among patients with degenerative MR. The accumulation of retrospective observational studies and spread of knowledge of repair techniques at academic conferences have gained the attitude of the heart valve team.

The single-institutional series on MVrep for mitral IE in the 1990s by Carpentier's group and the Cleveland Clinic Foundation stimulated us to consider the possibility of MVrep for mitral IE to obtain better surgical results. Early in the 1990s, Prof. Carpentier taught me that the surgeon should try to repair the affected valve in mitral IE soon after identification of the organism before the destruction of the mitral apparatus occurs. Our initial experience of successful repairs for mitral IE in terms of postoperative care and freedom from valve-related events had a great impact on our team members. Our experience with treated autologous pericardium in MVrep for rheumatic MR since 1991 has been very helpful in valve repair for mitral IE cases.[17]

Dreyfus noted that the only limiting factor in MVrep is the extent of the lesions. Although he reported that determining whether enough mitral valve tissue was available after radical resection of the infected tissue was easy, the reparability rates differ depending on the surgeon's skill and experience. The intactness of two-thirds of the free edge of the mitral valve and of one commissure is the anatomic criterion by Defauw and colleagues that is generally accepted.[15] After radical resection of the infected tissue, the leaflet tissue deficit is restored using treated or fresh autologous pericardium. Extension of the leaflet using treated or fresh autologous pericardium is not a challenging procedure but rather a standard procedure to increase the good coaptation area in patients with insufficient leaflet tissue.[10,17] Autologous pericardium is a good substrate to expand the reparability in complex mitral valve disease, including mitral valve IE.

Chordal reconstruction involves chordal transfer or using ePTFE sutures to create a competent valve. Although surgeons still hesitate to use prosthetic materials such as prosthetic rings and ePTFE sutures for chordal reconstruction in patients with early-stage active mitral IE, reinfection rates are very low after implantation of prosthetic materials. A wide armamentarium of repair techniques is available even in the setting of active mitral IE.

As the number of patients who require surgical treatment of mitral IE is very limited, systemic reviews and meta-analyses have attempted to compare the clinical results of MVrep and MVR in the setting of mitral IE. Feringa and colleagues compared the clinical outcomes of MVrep (n = 470) and MVR (n = 724) based on 24 studies

published between January 1980 and May 2005.[3] They concluded that MVrep is associated with good clinical in-hospital and long-term results among patients undergoing surgery for mitral IE. Harkey and colleagues also analyzed MVrep (n = 2906) and MVR (n = 6072) based on 14 studies published between 1997 and 2014.[4] They demonstrated that MVrep was associated with better clinical results than MVR in terms of freedom from reoperation, reinfection, and midterm mortality. The repaired mitral valve is durable and resistant to infection in the setting of either acute or healed endocarditis. According to the reports of experienced centers, MVrep for mitral IE demonstrated improved event-free survival.

Byrne and colleagues reported the STS Clinical Practice Guideline for surgical management of endocarditis.[5] If the infectious disease is limited to the valvular tissue, MVrep is the preferred surgical option based on the evidence of single-institution reports published between 2004 and 2007.[20–22,28,29] They reported the advantages of MVrep over MVR, such as better preservation of left ventricular function and a reduced rate of prosthetic valve-related complications. The current American Association for Thoracic Surgery and European Society of Cardiology/European Association for Cardio-Thoracic Surgery (ESC/EACTS) guidelines also recommend valve repair whenever possible, particularly when IE affects the mitral valve without causing significant destruction. The ESC/EACTS guidelines state that intraoperative assessment of the valve after debridement is of paramount importance to evaluate whether the remaining tissue is of sufficient quality to achieve a durable repair. The need for a patch to achieve a competent valve is not associated with worse results in terms of recurrence of IE or MR when performed by experienced surgeons. Successful MVrep can be achieved in up to 80% of patients by experienced teams, but such results may not be duplicated in nonspecialist centers.

Bolling commented on the marked variability in the frequency of MVrep, and the median number of mitral valve surgeries per year was 5 (range, 1–166), according to the STS database.[30] One of the characteristics that decreased the repair rate was the presence of active endocarditis. Stahel and colleagues analyzed the role of the surgeon's experience in predicting the probability of a successful MVrep.[31] They pointed out that a preoperative assessment of 7 variables including endocarditis can accurately predict the risk of MVrep failure. As Antunes noted, it is widely accepted that MVrep, whenever possible, yields better short-term and long-term results than replacement, even for infected native valves.[32,33] Surgeons should therefore become acquainted with and master the multiple techniques that have proved useful in this setting. The solution to realizing the potential of MVrep in IE may be education and exposure.

SUMMARY

MVrep, using a wide armamentarium of reparative procedures, has the potential to improve late outcomes in patients undergoing mitral valve surgery for mitral IE. Early repair-oriented surgery is recommended for mitral IE.

CLINICS CARE POINTS

- Guidelines currently recommend MVrep whenever possible for patients with mitral IE in terms of short- and long-term clinical results.
- In general, two-thirds free edge of mitral valve and one commissure need to remain intact in order to attempt repair.
- MVrep using a wide armamentarium of reparative procedures including autologous pericardium as a leaflet substitute, ePTFE for chordal reconstruction, and a prosthetic ring has a possibility to expand reparability of mitral IE.
- Intraoperative transesophageal echocardiography is mandatory to assess immediate operative results to reduce early redo operation for this kind of complex repair.

DISCLOSURE

None.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found online at https://doi.org/10.1016/j.ccl.2021.01.005.

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