Mitral valve repair for degenerative mitral valve disease: surgical approach, patient selection and long-term outcomes

Gonçalo F Coutinho,[1,2] Manuel J Antunes[1,2]

[1]Cardiothoracic Surgery, University Hospital and Centre of Coimbra, Coimbra, Portugal
[2]Faculty of Medicine, University of Coimbra, Coimbra, Portugal

Correspondence to
Professor Manuel J Antunes, Cardiothoracic Surgery, University Hospital, 3000-075 Coimbra, Portugal; antunes.cct.chuc@sapo.pt

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ABSTRACT

Mitral valve repair (MVRepair) has become the procedure of choice to correct severe degenerative mitral regurgitation (MR), due to its documented superiority to valve replacement regarding long-term survival, freedom from valve-related adverse events and preservation of left ventricular (LV) function. The refinement of MVRepair techniques has rendered almost all valves (more than 95%) amenable to repair with a 15-year freedom from reoperation of 90%. The concept of 'centres of excellence for MVRepair' has emerged, encouraging referring doctors to select the most experienced institutions or individual surgeons to deal with the most complex cases, based on repair volume, appropriate peri-procedural imaging and data regarding expected outcomes (repair, mortality and durability of repair). Based on the good results, operating on asymptomatic patients with severe MR is now widely accepted, prophylactically avoiding the dire consequences of chronic MR, such as LV function deterioration/enlargement, and development of atrial fibrillation and pulmonary hypertension. In reference centres, where the repair rate is over 95% for all types of disease with <1% mortality, it has become standard practice in nearly 50%–60% of all patients submitted to MVRepair. Finally, recent advances in the surgical treatment with the purpose of reducing invasiveness and surgical trauma, through partial sternotomy or mini-thoracotomy (video-assisted with or without robotics), are now being increasingly performed in 20%–30% of centres, claiming comparable results to conventional surgery. In addition, transcatheter technology, particularly the MitraClip, is evolving and treading its way in the treatment of high-risk patients with severe MR, but the results are still short of ideal.

INTRODUCTION

Mitral valve repair (MVRepair) has become the gold standard for the correction of significant organic mitral regurgitation (MR), whenever is it is expected to be durable and associated with low morbidity and mortality and is recommended (class I) by current guidelines.[1,2] Its superiority, by comparison with mitral valve replacement (MVR), has been demonstrated by many groups.[3-11] The MIDA (Mitral regurgitation International DAtabase) investigators recently concluded that, among patients with degenerative MR with a flail leaflet, MVRepair was associated with lower operative mortality, better long-term survival and fewer valve-related complications compared with MVR.[12]

Since its introduction in the late 1960s, the evolution of the procedure has been remarkable. Early, Carpentier described, in a systematic fashion, the structural valve changes that ultimately lead to regurgitation and set up the universally embraced 'functional classification of Carpentier'.[13] This concept served as the framework of modern reconstructive mitral valve (MV) surgery, where all the components of the valve complex (annulus, leaflets, chordae tendineae and papillary muscles) were integrated and analysed, in order to provide not only a functional approach but also an anatomical approach. This is settled in three basic principles: to restore or preserve appropriate leaflet mobility; to ensure good leaflet coaptation; and to remodel and stabilise the annulus.

In this work, we review current concepts on surgical management, patient selection and long-term results of MVRepair, with the aim of setting the benchmark from where new technologies, such as transcatheter procedures, should be subjected to comparison.

RECONSTRUCTIVE VALVE SURGERY PARADIGM: FIRST BEGIN WITH AETIOLOGY

Primary (organic) MR and secondary (functional) MR represent distinct entities with regard to pathophysiology, clinical presentation, management and prognosis. Primary MR is a true valvular disease, where any change of one of the valve components may be responsible for regurgitation. In developing countries, rheumatic disease is still most prevalent, with nearly endemic proportions.[13] By contrast, the most frequent form of presentation in western countries is degenerative disease, usually classified as fibroelastic deficiency or myxomatous.

On the other hand, in secondary MR, the valve constituents are structurally normal, regurgitation resulting from geometric distortion of the subvalvular apparatus, secondary to left ventricular (LV) remodelling and dilatation, as a consequence of ischaemic disease or dilated cardiomyopathy. This pathology will not be further discussed in this work.

The lack of a universal nomenclature to define degenerative MV disease constitutes one important barrier to the interpretation of studies aimed at evaluating MVRepair results. Hence, the pathophysiological triad of MV disease developed by Carpentier gave an important insight into the genesis and cause of MR, enabling a methodological approach to the treatment. The **aetiology** (cause of the disease) leads to the appearance of **lesions** (consequence), which in turn causes **dysfunction** (effect). Carpentier's classification of valve dysfunction, with regard to leaflet motion (type I: normal motion; type II:

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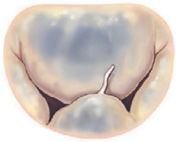
Characteristics	FD	Advanced FD	Forme fruste	Barlow's disease
				
Age at diagnosis	>60 years	>60 years	Variable	<60 years
History of MR	<5 years	<5 years	Variable	>10 year
Leaflet tissue	Normal/Translucent	++	++/+++	+++
Anterior leaflet tissue	+	+	++	+++
Posterior leaflet tissue	++	++	++/+++	+++
Segments affected	Single segment (P2)	Single segment (P2)	Multisegment	Multisegment
Chordae tendineae	Thin and ruptured	Thin and ruptured	Variable	Thickened and elongated
Annular dilatation	Ninguna (≤32 mm)	↑ (≤32 mm)	↑↑ (32-36 mm)	↑↑↑ (≥ 36 mm)
Calcification	None	+	+/++	+++

Figure 1 Spectrum of degenerative mitral valve disease (Reproduced, with permission, from Castillo *et al*[15]). + rarely found++frequently found +++ most frequently found.

excessive motion (prolapse); and type III: restricted motion), has now been widely accepted.[14]

This analysis has important prognostic implications, since the results of MVRepair (reparability and durability) are different among different aetiologies, type of valve dysfunction and lesions encountered (site of prolapse, presence of calcification, leaflet restriction, etc).

FIBROELASTIC DEFICIENCY VERSUS BARLOW'S DISEASE

There is a wide spectrum of degenerative disease, ranging from fibroelastic deficiency to Barlow's disease (figure 1).[15] The former is characterised by a normal amount of leaflet tissue in a normal-sized annulus. Leaflets are typically thin and chordae are flimsy. Regurgitation is typically caused by elongation/rupture of one or more chordae in a single prolapsing segment, most often P2. In the chronic setting, the prolapsing segment may become distended and thickened by a limited myxomatous process.

At the opposite end of the spectrum, Barlow's disease is marked by tissue excess, involving multiple segments of both leaflets in a large annulus. Leaflets are thickened and redundant, with elongated, mesh-like chordae which may or may not be ruptured.[16] There is an intermediate form designated '*forme fruste*', also characterised by excess tissue with myxomatous changes in generally more than one leaflet segment, but usually not in a large valve size. Echocardiographic evaluation is of great importance to discriminate the wide range of degenerative involvement (figure 2).

The repair of valves with fibroelastic deficiency is commonly straightforward because the abnormality is limited to P2 in 75% of patients. Treatment typically consists of resection of the abnormal segment or implantation of artificial chordae, and placement of a 'normal-sized' (30–32 mm) prosthetic ring. Repairing myxomatous valves, particularly Barlow's disease, is far more demanding, usually requiring a vast array of techniques, including leaflet resection, multiple neo-chordal implantation, papillary muscle shortening, commissural closure and use of large (≥34 mm) rings (figure 3).

'REPAIR-ALL' STRATEGY IN ALL CORNERS OF MITRAL VALVE PROLAPSE

For many years now, our philosophy has been that all degenerative MV are, by principle, amenable to repair, provided that a thorough and comprehensive pre-operatively and intra-operatively analysis of the whole valve apparatus is made. Accurate identification of all lesions responsible for valve dysfunction is of paramount importance because it allows appropriate selection of the surgical techniques (table 1).

Recent reports show very high rates of MVRepair associated with low mortality in all types of lesions and valve complexity (table 2).[5,8,17–19] We and others have demonstrated that a nearly 100% repair rate of posterior leaflet prolapse (PMLP) can be expected, with long-term durability.[17,20–22] Here, recent experience has shifted towards the philosophy of 'respect rather than resect', using artificial chordae to correct the prolapse more

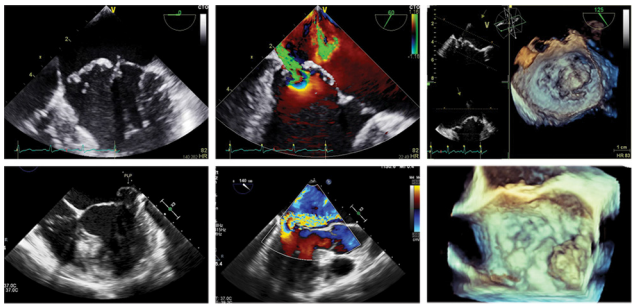


Figure 2 Upper panel: Transoesophageal echocardiogram of a severely myxomatous valve (Barlow's disease) with bileaflet prolapse and multiple regurgitant jets, and the corresponding three-dimensional (3D) image. Lower panel: Transoesophageal echocardiogram revealing a moderate myxomatous valve (*forme fruste*), with an evident posterior leaflet prolapse of the P2 segment and a regurgitant jet directed towards the inter-atrial septum, and the corresponding 3D image.

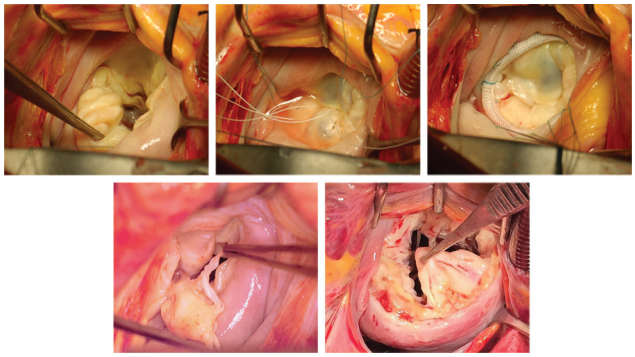


Figure 3 Upper panel: Intraoperative view, before, during and after repair, of a mitral valve with marked myxomatous involvement (Barlow's disease). Lower panel: Left—typical P2 prolapse with a ruptured chordae (fibroelastic deficiency with limited myxomatous involvement in the prolapsing segment), right—a myxomatous valve (second figure) with P1 and P2 prolapses due to elongated chordae and severe posterior annulus calcification (*forme fruste*).

often.[23] However, we still adapt our technique to the type of lesion, applying either resection (for large and bulky posterior leaflet segments) or non-resection techniques (in small leaflets).

Repair rates for anterior leaflet prolapse (AMLP) or bileaflet prolapse (BLP) are usually slightly lower than that for PMLP, but experienced centres report rates above 90%–95%, with low mortality (<1%).[17–19 24–26] There are several key points that deserve particular attention when repairing Barlow's valves: (1) reduce the height and volume of a large posterior leaflet by resection (with or without sliding plasty) or chordal implantation (lowering the free margin well into the ventricle) in order to avoid systolic anterior motion; (2) always use large rings (>34 mm); (3) favour artificial chordae, instead of the classical Carpentier shortening/transfer techniques to correct AMLP; (4) in BLP, start by correcting PMLP. We have found that the need for MVR in AMLP/BLP was influenced not only by anatomical issues but also by patient's characteristics and by the performing surgeon's experience (table 3).[24]

Recently, the concept of centres of excellence in MVRepair has evolved, to set the standards for best surgical practice in patients with severe MR.[27 28] These centres should meet several criteria, such as large MV surgery volume (centre and surgeon), appropriate peri-procedural imaging capabilities and willingness to provide data regarding expected outcomes based on the centre's recent experience, including repair, mortality and stroke rates, and repair durability.[28] However, we still believe that simpler cases (isolated P2 prolapse) are at the reach of any minimally experienced cardiac surgeon.

Our approach when dealing with severe MR due to flail leaflet is detailed in figure 4.

LONG-TERM SURVIVAL AND DURABILITY AFTER MVREPAIR

Several groups have published their long-term outcomes after MVRepair, and proved that the procedure is predictably associated with a survival similar to that of the age- and sex-matched general population (figure 5). This benefit has been observed even in elderly patients.[29] The best outcomes regarding durability of the repair are obtained with isolated PMLP, but the results are also gratifying with AMLP or BLP, particularly in young patients (figure 6). It is expected that more than 90% of patients submitted to MVRepair for PMLP will be free from reoperation after 15 years and this figure should be above 75%–80% in other types of prolapse.

Table 1 Lesions found in degenerative mitral valve disease and the surgical techniques used to correct them

Lesions	Surgical techniques	Probability of repair
Annular dilatation	Annuloplasty procedure: complete ring* partial ring/band† suture annuloplasty‡	>95%
PMLP	Artificial chordal implantation* Leaflet resection* Sliding plasty† Notch closure between segments† Chordal shortening/transposition‡	>98%
AMLP	Artificial chordal implantation* Chordal shortening/transposition† Suture plication (minor prolapse)† Leaflet resection‡	>95%
Commissural leaflet prolapse	Commissural closure ('magic stitch')* Papillary muscle shortening† Artificial chordal implantation† Chordal shortening/transposition‡	>95%
Leaflet restriction/small size	Patch augmentation† Leaflet thinning† Secondary chordal resection†	70%–80%
Annular calcification	Decalcification† Decalcification + patch reconstruction‡	70%–80%

The following options express the authors' opinions and trends according to their daily experience.
*Techniques frequently used to correct the corresponding lesions.
†Techniques occasionally used.
‡Techniques seldom used.
AMLP, anterior leaflet prolapse; PMLP, posterior leaflet prolapse.

However, it is essential to distinguish freedom from reoperation (crude analysis) from freedom from recurrent moderate-to-severe MR (accurate analysis). David *et al*[9] assessed the late outcomes of 840 patients with degenerative mitral disease, submitted to MVRepair over a 20-year period. The probability of reoperation was low (5.9%) and freedom from recurrent severe MR was 90.7%, but freedom from moderate or moderate-to-severe MR was significantly lower (69.2%). Recently, Suri *et al*[30] evaluated the effect of recurrent MR after MVRepair, and they found that it is associated with adverse LV remodelling and late death. Hence, long-standing competence of the MV should be the goal, and close follow-up should be established if recurrent MR is detected.

Table 3 summarises the outcomes according to the site of prolapse among different surgical groups.

CONTROVERSIES SURROUNDING MITRAL VALVE REPAIR

Asymptomatic patients

Early intervention in asymptomatic patients, before the onset of the nefarious consequences of chronic MR, was the natural course in the evolving experience of MVRepair and is now supported by the guidelines.[1,2] There are several logical assumptions that support this early surgery strategy.[31–34] First, the natural history of the disease has shown that, if left untreated, the death rate, namely sudden death, can reach 10%–20% per year, once symptoms occur.[6,35] Second, operating on a patient with significant symptoms (New York Heart Association; NYHA III/IV), or with LV dysfunction or dilatation, implies significantly higher operative mortality and reduced long-term survival.[4,36,37] Third, as demonstrated above, MVRepair is possible in the vast

Table 2 Mitral valve repair outcomes according to the site of prolapse among different surgical groups

Authors		n	Repair rate	Early mortality	Long term survival	Reoperation
PMLP	Castillo *et al*[21]	556	100%	0.8%	5 years – 97%	7 years – 97%
	David *et al*[11]	359	95%	0.6%	12 years – 75%	12 years – 96%
	Johnston *et al*[22]	3383	97%	0.1%	15 years – 76%	15 years – 97%
	Suri *et al*[7]	736	92%	0.7%	15 years – 58%	15 years – 95%?
	Correia *et al*[20]	492	98.4%	0.2%	15 years – 65%	15 years – 97%
AMLP/BLP	Castillo *et al*[18]	42/146	100%/99%	4.8%/0%	7 years – 86%/89%	7 years – 80%/92%
	David *et al*[11]	93/316	95%?	0.6%	12 years – 73%/78%	12 years – 88%/94%
	De Bonis *et al*[19]	139/-	Nd	0%	17 years – 72%	17 years – 90%
	Goldstone *et al*[17]	131	98.5%	0.2%	8 years – 92%	Nd
	Seeburger *et al*[26]	156/402	91%/90.3%	2.6%/2.2%	5 years – 87.3%	5 years – 95.6%
	Coutinho *et al*[24]	274/227	94.5%	1.2%	20 years – 43%	20 years – 88%

AMLP, anterior leaflet prolapse; BLP, bileaflet prolapse; N, number of patients; Nd, not documented; PMLP, posterior leaflet prolapse.

majority of patients and it seems that the repair rate in asymptomatic patients is higher than in those presenting with the classical triggers for surgery, probably due to structural valve changes induced by chronic MR.

We therefore hypothesise that early surgery can, at least, prevent some degree of leaflet degeneration caused by chronic MR, but there are authors that favour a more conservative approach ('watchful waiting'), to intervene only when symptoms or LV dysfunction occurs.[38]

In our experience, the overall repair rate in asymptomatic patients with severe degenerative MR and preserved LV function, including all types of prolapse, was 98.2% with a 30-day mortality of 0.8%.[34] Interestingly, in the subgroup of patients with AMLP/BLP, the repair rate increased from 94.8% to 98.4% in asymptomatic or mildly symptomatic patients.[24] Moreover, these patients had increased late survival in comparison to those with pre-operative NYHA class III/IV symptoms, and similar survival to the age- and sex-matched population (figure 6).

Therefore, as the guidelines recommend,[1] asymptomatic patients with severe MR should be offered surgery if MVRepair is likely (>95%) with low mortality (<1%), and, when possible, patients should be referred to centres/surgeons with large experience.

Atrial fibrillation

Atrial fibrillation (AF) is present in 30%–50% of patients undergoing MV surgery and has been identified as a prognostic marker of poorer outcome. Even after successful MVRepair or MVR, a non-negligible percentage of patients will remain in AF. Grigioni *et al*[39] analysed the occurrence of AF in patients with degenerative MR under conservative management and in sinus rhythm at diagnosis, and they found that the incidence at 5 and 10 years was 18±3% and 48±6%, respectively, with a linearised rate of 5.0±0.7% per year, and it was associated to increased cardiac mortality and morbidity.

We have recently evaluated the impact of pre-operative AF and of pulmonary hypertension (PHT) in the long-term outcomes of asymptomatic patients with severe degenerative MR (preserved LV function) after MVRepair. Patients with AF/PHT had poorer long-term survival and event-free survival even after successful surgery. The durability of MV repair was also compromised in these patients, which probably indicates that they should have been operated on earlier.[40] On the other hand, the Mayo Clinic group found that post-operative AF occurred after surgery for MR in 24% of patients previously in sinus rhythm and was associated with increased subsequent morbidity. Left atrial enlargement was a powerful predictor of post-operative AF.[41]

In recent years, there has been a trend to perform surgical ablation of AF during MV surgery. Recent data from the STS Database showed that 32.2% of patients presented to MV surgery have AF and concomitant AF ablation in this setting is performed in 61.5% of patients.[42] Rates of post-ablation freedom from AF of 80% or higher have been described. Gillinov and associates[43] have recently evaluated the safety and effectiveness of surgical AF ablation during mitral surgery. They randomly assigned 260 patients with persistent or long-standing AF who required MV surgery to undergo either surgical ablation or no ablation (control). The addition of ablation to MV surgery significantly increased the rate of freedom from AF at 1 year (63.2% vs 29.4%), with similar early mortality in the two groups, but implantation of a permanent pacemaker was increased after ablation.

Table 3 Factors predisposing to mitral valve replacement rather than repair in anterior or bileaflet prolapse[28]

Variables	HR	95% CI	p Value
Age (per year)	1.098	1.037 to 1.163	0.001
Previous cardiac surgery	4.083	1.489 to 9.046	0.002
LV dysfunction (EF <45%)	5.504	1.209 to 25.064	0.027
Mitral calcification	3.703	2.093 to 6.552	0.001
Retraction/tethering of PL	2.341	0.075 to 5.169	0.018
AMLP (≥2 segments)/Barlow's	3.983	2.966 to 7.163	0.002
Surgeon*	1.525	1.047 to 2.222	0.028

*The surgeon variable was transformed into a dichotomous variable, with the most experienced surgeon in comparison with other surgeons.
AMLP, anterior mitral leaflet prolapse; EF, ejection fraction; LV, left ventricle; PL, posterior leaflet.

Tricuspid valve repair

Functional tricuspid regurgitation (FTR) is commonly associated to left-sided heart valve disease. Persistent PHT leads to increased right ventricular (RV) afterload, which ultimately results in ventricular enlargement and geometric distortion, and tricuspid annular dilatation and flattening, leading to tricuspid regurgitation (TR). Until recently, the tricuspid valve (TV) was the 'forgotten valve', not entered in the surgical algorithm, due to the erroneous concept that it played a passive role in the evolution of the disease. It was then thought that FTR would disappear after correction of the mitral or aortic pathology. However, experience has shown that this does not always happen and TR may actually increase when the primary left-sided valve disease

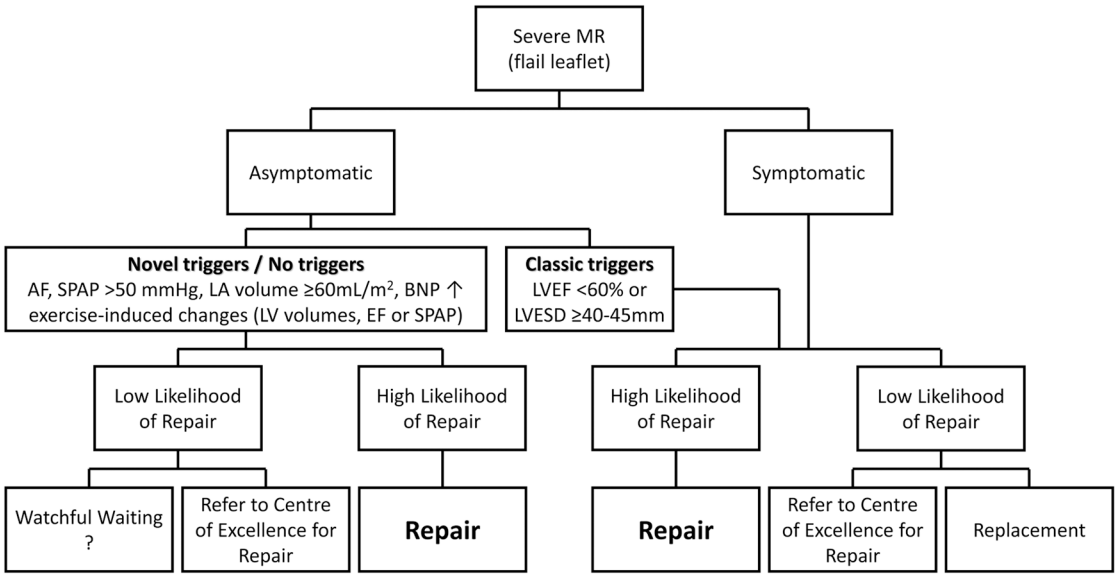


Figure 4 Decision-making process regarding the optimal surgical timing and approach to severe mitral regurgitation of degenerative aetiology. EF, ejection fraction; LV, left ventricle; MR, mitral regurgitation; AF, atrial fibrillation; SPAP, systolic pulmonary artery pressure; LA, left atrium; BNP, brain natriuretic peptide; LV, left ventricle; LVEF, left ventricle ejection fraction; LVESD, left ventricle end-systolic diameter; High likelihood of repair is usually associated with: posterior leaflet prolapse or isolated segmental prolapse, especially in the central segments (A2 or P2); absence of calcification; and non-severe myxomatous involvement. Low likelihood of repair is usually associated with: multiple segmental prolapses with multiple regurgitant jets; presence of severe myxomatous involvement (Barlow's disease); and bileaflet prolapse; marked calcification.

is not completely resolved during surgery, as in the case of a less than perfect valve repair. Furthermore, isolated severe TR is now increasingly observed in patients with normal left heart valve function after either mitral valvuloplasty or replacement. This is an important issue because reoperation carries high hospital mortality, particularly in the presence of RV dysfunction.

Hence, current guidelines recommend a more aggressive approach with regard to performing TV surgery whenever there is significant annular dilatation (>40 mm or 21 mm/m^2), even when there is only mild-to-moderate TR.[1] The procedure does not usually increase operative risk. Since in FTR the valve is structurally normal, correction is relatively straightforward by annuloplasty alone. Most reports attribute superiority to rigid annuloplasty rings over suture-based or flexible-band annuloplasty for the treatment of FTR. However, due to a favourable past experience with a modified DeVega annuloplasty in well over a thousand patients, we still use this approach in the majority of cases, reserving use of rings for organic TV disease.[44]

Desai *et al*[45] recently assessed the behaviour of FTR in 1833 patients with degenerative MR who underwent MVRepair. Notably, TR grade and RV function improved after surgery in all patients undergoing MVRepair alone, but the improvement was temporary and, by 3 years, both parameters returned to preoperative levels. By contrast, concomitant annuloplasty in patients with moderate-to-severe TR durably eliminated regurgitation and RV function improved up to 3 years.

FUTURE TRENDS IN MITRAL VALVE REPAIR SURGERY

Recently, there have been major technological developments in the management of valvular heart disease, which have enabled cardiologists and surgeons to go a step further in the treatment

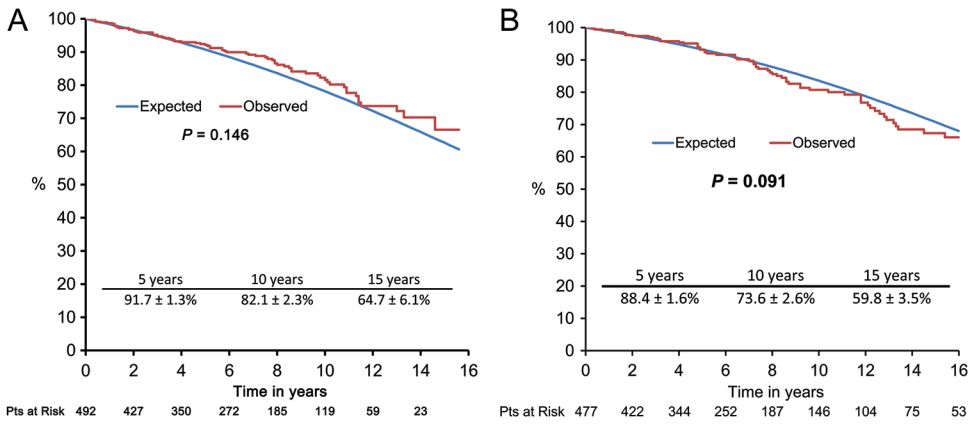


Figure 5 Long-term survival after mitral valve repair comparing patients with (A) posterior leaflet or (B) anterior/bileaflet prolapse with the general population (age and sex matched) in our experience.[24,28]

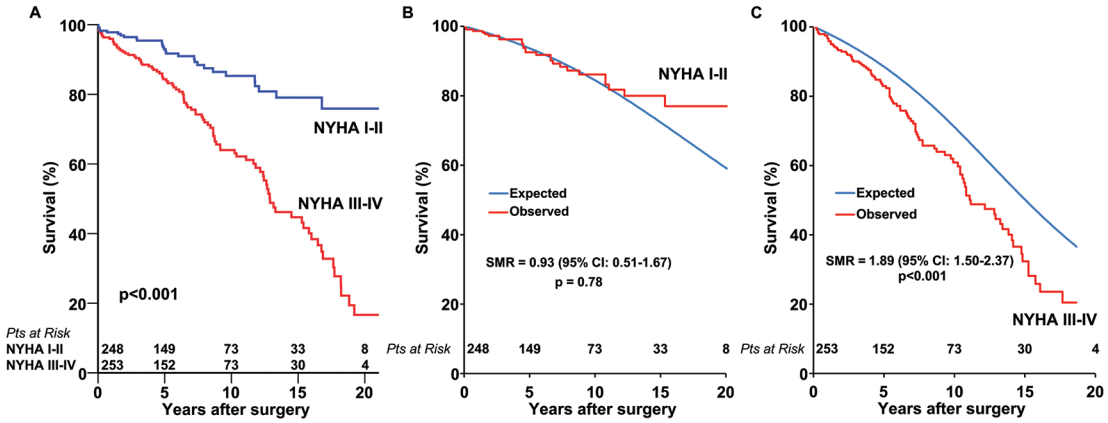


Figure 6 (A) Comparison between patients in New York Heart Association (NYHA) class III–IV with those in NYHA class I–II. (B) Comparison between patients in NYHA class II–III with the age-matched and sex-matched general population. (C) Comparison between patients in NYHA class III–IV with the age-matched and sex-matched general population.[28] SMR, standardised mortality ratio.

of high-risk patients, in addition to decreasing invasiveness of the procedures. The MV has not been an exception and percutaneous treatment of severe MR has evolved alongside with surgical treatment.

With regard to surgery, the access for minimally invasive MV surgery (MIMVS) can be subdivided into two groups: partial sternotomy and right thoracotomy, including the open and video-assisted methods, with or without robotic assistance. Thus, MIMVS does not refer to a single procedure but rather to a group of methods aimed at decreasing surgical trauma, by minimising the size of the incisions and avoiding full sternotomy.

In a recent meta-analysis, Sündermann *et al*[46] showed equivalent excellent short-term and mid-term outcomes with MIMVS, by comparison to conventional surgery, with regard to stroke, mortality, MVRepair rate and durability of the repair. MIMVS has also been associated with reduced bleeding and blood transfusion, ventilation time and intensive care stay, as well as with elimination of sternum-related morbidity and more rapid resumption of normal activity.[47] Moreover, Iribarne *et al*[48] have reported that MIMVS was associated with lower hospital costs. These excellent results have propelled the dissemination among the surgical community, highlighted in a recent report from the STS, revealing an increase in the proportion of MIMVS from 10% in 2004 to 20% in 2008. Nevertheless, it remains to be proven that MIMVS is at the reach of all surgical groups and of all surgeons.

Although robotic-assisted MIMVS has become the least invasive approach, totally endoscopic and without thoracotomy or significant rib spreading, it is associated with high capital investment, resulting in higher per-case operative costs. Still, approximately 10% of all MIMVS procedures in the USA are already performed using this method. The advantages reported are the superb three-dimensional visualisation of the valvular and subvalvular apparatus and the precise movements given by the EndoWrist, which permits complex surgical manoeuvres with high degree of dexterity.[47]

Finally, along came the transcatheter techniques. Since the feasibility Everest Phase I Clinical Trial, in 2005, the MitraClip technology has 'forced' the entry into the MR treatment arena, and its use for inoperable or high-risk patients with degenerative MR has been approved by the Food and Drug Administration. However, there are several key issues that require further attention before this procedure becomes accepted in a large scale. Most importantly, it is founded on the edge-to-edge operation developed by Alfieri in the early 1990s, not consensual within the surgical community because the procedure only yields functional and not anatomical correction. Of note, the Alfieri group have recently evaluated their long-term results (18 years) with the technique and verified that the isolated procedure, without annuloplasty, was not satisfactory, hence stressed the need for a reliable annuloplasty to improve long-term outcomes.[49]

However, several methods of percutaneous mitral annuloplasty have, so far, yielded less than optimal results. The early failure of repair is exceedingly higher in the MitraClip patients and the need for MV surgery or reoperation increased by five-fold, and 58% of these patients had significant MR at 4 years compared to 18% in the surgical group in one recent study.[50]

CONCLUSIONS

The contemporary results of transcatheter MVRepair are still far from optimal, especially in degenerative MR where surgical techniques have demonstrated incomparably better results until this date. In this pathology, valve replacement is exceptionally required. Improved surgical techniques, with particular emphasis on chordal substitution, have played a fundamental role in achieving these results. The techniques are very reproducible and at the reach of the majority of centres and surgeons. Therefore, for the foreseeable future, percutaneous therapy of MR will be limited to patients who would otherwise not be eligible for surgery.

Contributors Both authors contributed equaly to this work.

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