Transcatheter Mitral Valve Repair and Replacement in Degenerative Mitral Regurgitation - Evolution of Treatment Strategies

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Abstract

The prevalence of Degenerative Mitral Regurgitation (DMR) has been increasing globally over the recent decades. It is a disorder that predominantly affects the older generation, this generation however is also affected by multiple other comorbidities. As a result, they are classified as being too high-risk for the conventional treatment of DMR, which is surgical intervention. Previously, their treatment options were limited. However, with the development of Transcatheter Mitral Valve Repair (TMVr) techniques this cohort of patients can receive interventions that are minimally invasive. These interventions have been proven to decrease the severity of mitral regurgitation whilst also improving the patient's quality of life. They are also associated with better long-term outcomes compared to patients receiving medical treatment alone.This review focuses on the role of Transcatheter Mitral Valve repair in the treatment of degenerative mitral valve regurgitation in surgically high-risk patients.

Introduction

Mitral regurgitation (MR) is one of the most common valvular heart diseases and results from impaired mitral valve leaflet closure, leading to retrograde blood flow from the left ventricle into the left atrium. Primary MR is commonly caused by structural abnormalities of the mitral valve which can result in leaflet prolapse.1 These structural abnormalities are commonly the result of myxomatous degeneration. A common subtype of primary MR is DMR. The prevalence of DMR has increased significantly over recent decades, with an approximate increase of 70% over 20 years. The incidence of secondary MR increases substantially with advancing age and is associated with progressive left atrial and ventricular dilatation, heart failure symptoms, atrial fibrillation, and increased mortality if left untreated.2 Management options for DMR traditionally include surgical mitral valve repair or replacement.

Surgical repair is generally preferred, as it is associated with improved long-term survival, improved preservation of left ventricular function and decreased rates of prosthesis related complications when compared to mitral valve replacement. However, concerns remain regarding durability in certain patient populations.3

Severe MR predominantly affects older patients, many of whom have significant comorbidities, resulting in a substantial proportion of patients untreated. These challenges have driven the development of minimally invasive transcatheter therapies, including transcatheter mitral valve repair and emerging transcatheter mitral valve replacement technologies, with the aim of expanding treatment options for high-risk patients and improving clinical outcomes.2 Currently, transcatheter mitral valve repair uses an edge-to-edge leaflet technique for patients with DMR who are considered high-risk for surgery.4

Pathophysiology of DMR

The mitral valve consists of two leaflets: an anterior and a posterior leaflet attached at their basal ends to a saddle-shaped mitral annulus. Chordae tendineae arise from the ventricular surfaces of the leaflets and insert into the anterolateral and posteromedial papillary muscles, preventing systolic prolapse and ensuring unidirectional blood flow from the left atrium to the left ventricle.5

DMR is most commonly caused by mitral valve prolapse, defined as systolic displacement of one or both mitral leaflets ⩾2 mm beyond the mitral annular plane into the left atrium. Mitral valve prolapse affects approximately 2–3% of the population and represents a leading indication for mitral valve surgery. Affected patients may develop complications such as heart failure, infective endocarditis, and arrhythmias.6

Two major phenotypes of DMR are: fibroelastic deficiency (FED) and diffuse myxomatous degeneration (DMD). FED is characterised by focal involvement of a single leaflet segment with relatively normal remaining valve tissue and is commonly associated with chordal elongation or rupture. In contrast, DMD typically affects both leaflets and multiple scallops, with marked leaflet redundancy and excess tissue. DMD is associated with a severely enlarged and flattened mitral annulus, loss of normal anteroposterior systolic contraction, and significantly increased leaflet length and area. Compared with FED, DMD demonstrates substantially greater prolapse height and prolapse volume during mid-to-late systole5.

DMR is a progressive disease, although the rate and pattern of progression remain unknown. In DMD, progressive annular dilation, loss of systolic annular contraction, and increasing dynamic prolapse volume contribute to worsening late-systolic regurgitation over time, whereas FED often presents with abrupt deterioration following chordal rupture5.

Conventional Treatment and Limitations

DMR is best treated with mitral valve repair (MVr) when intervention is indicated and a durable repair is likely, ideally in an experienced Heart Valve Centre. In symptomatic severe primary MR, surgery is recommended in operable patients. In asymptomatic severe primary MR, surgery is recommended when there is evidence of left ventricle (LV) decompensation: LVEF ⩽60% and/or LVESD ⩾40 mm. Selected low-risk asymptomatic patients with preserved LV function may also be considered for early repair in expert centres when durable repair is highly likely, particularly in the presence of additional risk markers (e.g., significant LA dilatation).7

Mitral valve surgery improves symptoms and can preserve LV function; repair is preferred over replacement when feasible due to better LV preservation and lower valve-related complications compared with replacement4
Mitral interventions include surgical repair, surgical replacement, and transcatheter options. Transcatheter edge-to-edge repair (TEER) e.g., MitraClip, mimics the surgical edge-to-edge technique by accessing the left atrium via femoral venous approach with transseptal puncture, then grasping the anterior and posterior leaflets to improve coaptation and reduce MR. TEER is mainly used for patients with severe symptomatic MR who are at high surgical risk with suitable anatomy.8

For pre-procedural assessment, echocardiography is the key investigation to define severity, mechanism, leaflet/chordal pathology, annular dimensions, and LV/LA response. For transcatheter mitral valve replacement (TMVR), ECG-gated cardiac CT is especially valuable for detailed 3D anatomy, sizing, and assessing risks such as left ventricular outflow tract obstruction (LVOTO) and anchoring/sealing challenges.8

TMVR may provide more complete and reproducible MR elimination in selected anatomies, but it is limited by anatomical constraints and procedural challenges (anchoring, sealing, LVOTO risk etc.).8

Many patients may be ineligible due to frailty, severe MR, prior aortic valve therapy, or unfavourable mitral anatomy. Outcomes for ineligible/medically managed patients can be poor (e.g. 11.8% cardiac death and 22.4% death/HF hospitalization at 1 year in one cohort).9 In addition, a large proportion of patients with severe MR have significant comorbidities and are deemed ineligible for surgery, as operative risks outweigh the anticipated benefits.4

Transcatheter Mitral Valve Repair

Over the years, there have been many surgical advancements in the field of MVr. These developments are important as they increased treatment options for DMR for patients that were not able to receive open-heart surgery. Through these advancements came the development of robot-assisted surgical techniques, 3D visualisation-based techniques and transcatheter mitral valve repair devices. The usage of the transcatheter mitral valve repair to treat DMR has been used in patients who are unfit to receive conventional surgeries due to comorbidities or frailty. The use of transcatheter procedures on the mitral valve has proven to be difficult in the past due to the variable pathology, however through the development of TEER it has changed the field of TMVr. TEER has become one of the most prominent methods of TMVr, and it is done through the use of devices such as the MitraClip or the PASCAL system. These devices are clipped onto the anterior and posterior leaflets of the mitral valve and as a result create a better seal in the valve to stop any backflow of blood.10

Numerous trials have been conducted regarding these devices. The COAPT trial was done to test the safety and efficacy of the MitraClip in heart failure patients with functional mitral regurgitation, the trial concluded that the use of the MitraClip increased the survival rates of patients who underwent the procedure.

To further support the use of the MitraClip evidence from the MATTERHORN trials concluded that there was no significant difference in the results of the procedure between the patients who underwent TEER with the use of MitraClip and the conventional surgical option and that the patients that had the MitraClip had significantly fewer major adverse events 30 days post-op.11

The PASCAL system is another device that was later developed and included some improvements that were then implemented in the MitraClip as well. It had a central spacer, to account for a gap after clipping the two leaflets together to stop any residual mitral regurgitation. Additionally, to account for the fact that leaflets may have different lengths it implements independent leaflet grasping, so the surgeon can grasp one leaf at a time with this device.

Through the evolution of MR treatments has come the development of procedures and devices that can help target the mechanisms by which the MR is caused. Specific to DMR caused by isolated chordal pathology, one of the devices that can be used is the HARPOON TSD-5 system. Offering the possibility of implantation of artificial chords under leaflets that are being affected by prolapse. This is just one of many advancements that shows the growth in the field of TMVr.
With any new procedure there are always concerns, whether they are the long-term outcomes or quality of life. However, recent studies show the post-procedural success rate can go as high as 98%, patients also experience an increase in their quality of life and around 91.5% of patients do not have to be hospitalised due to heart failure.12

Future Innovations

Whilst the field of MVr has significantly evolved over the years there are still limitations to the procedures. One of the main issues when using MVr to treat MR is the lack of annular stabilisation.10 This is an important issue as annular stabilisation is needed to limit the risk of recurrent mitral valve regurgitation. In the near future it is likely there will be an integration of annuloplasties with TEER to increase the durability of the valve repair.11

Currently, there are advanced imaging techniques in development to help develop more precise interventions. Another front-runner in medical advancements is the integration of Artificial Intelligence (AI) in several medical fields. AI and machine learning are being used in the planning of the interventions, however soon they may have a more integral role in the therapies. Together these innovations will significantly change the way MVr will be undertaken in a few years, there will be a shift turning it into a more individualised and evidence-based discipline.10

Conclusion

The emergence of TMVr has significantly changed the way DMR can be treated in surgically high-risk patients. Whereas previously, treatment options of this cohort relied solely on medical management, the development of the transcatheter treatment approach has demonstrated significant impacts on their quality of life, symptom management and most importantly, the long-term outcomes. The continued advancement of these procedures and long-term data gained will further strengthen the role of TMVr in the treatment of DMR.

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