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Minimally invasive mitral valve repair: A new surgical option for mitral insufficiency

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Eamon has clinical and research interests in cardiothoracic and trauma surgery, infectious diseases, and rural and remote medical practice. Eamon is currently involved in research into the online delivery of medical education, in-hospital patterns of antibiotic prescribing and damage control resuscitation. In 2010 he is studying in Broken Hill, NSW, in association with the Spencer Gulf Rural Health School and the University of Sydney.

Minimally invasive mitral valve repair (MIMVR) is a relatively new alternative to median sternotomy for valvular heart surgery, and has become increasingly appealing due to its improved cosmetic results and more rapid recovery time. Patients suffering mitral valve disease are increasingly turning to their medical practitioners for advice regarding this procedure. It is the aim of this article to provide a review of MIMVR to allow students and doctors to better understand this recent development in cardiac surgical therapy.

Introduction

Mitral valve incompetence is characterised by 'ballooning' or prolapse of the mitral valve, followed by the eventual retrograde flow of blood into the left atrium during ventricular systole. Most commonly caused by degenerative, rheumatic, ischaemic or infectious pathological processes, 2,182 Australians were diagnosed with mitral valve insufficiency and 370 with mitral valve prolapse in 2004/05. [1,2] Congenital deformities, endocardial lesions, cardiomyopathies and connective tissue disorders are less frequent triggers of disordered mitral valve function. [1]

Degenerative changes are the most common cause of mitral insufficiency, resulting in a range of conditions including mitral valve prolapse, insufficiency ('floppy valve syndrome') and, in a minority of patients, severe mitral regurgitation (due to rupture of the chordae tendineae, dilatation of the mitral valve annulus or a combination of both complications) (Figure 1).

Chronic rheumatic heart disease is a common cause of mitral valve disorders in Aboriginal and Torres Strait Islander populations, with a prevalence of 16.6 per 1,000 population in the Top End of the Northern Territory and 12.5 per 1,000 in Central Australia, compared with respective figures of 1.7 per 1,000 and 0.6 per 1,000 amongst other Australians. [3] Although more commonly associated with mitral stenosis, rheumatic heart disease may result in a combined stenosis and insufficiency, or occasionally, an isolated rheumatic insufficiency. [1]

Whatever the cause, mitral valve insufficiency ultimately results in retrograde flow of blood from the left ventricle (LV) to the left atrium during left ventricular systole, leading to a volume overload of the left atrial chamber. The response of the myocardium varies depending on the pathophysiological syndrome present when regurgitation occurs. In acute severe mitral regurgitation, the sudden volume overload of the left atrium and left ventricle precludes the development of compensatory eccentric hypertrophy (due to the rapid nature of the condition), with a consequent simultaneous reduction of forward cardiac output and pulmonary congestion.

The patient presents with severe symptoms including dyspnoea, a systolic murmur (although it may not be pansystolic and occasionally may be absent) and an S3 heart sound or early diastolic rumble. [4] In comparison, the myocardium of patients experiencing a chronic, mild mitral regurgitation will undergo eccentric hypertrophy, resulting in a compensatory increase in end-diastolic volume that results in an increased stroke volume and restoration of cardiac output. [4]

Eventually, these patients will experience left ventricular decompensation, with a considerably reduced systolic ejection capability. This results in a reduced forward output, often with an ejection fraction in the lower normal range (EF 0.50-0.60), [4] and consequent volume overload of the left atrium with left atrial dilatation and potentially the development of atrial fibrillation. LV dysfunction and left atrial volume overload also generate a retrograde pressure gradient through the pulmonary circulation, resulting in pulmonary congestion, and respiratory signs of heart failure. Physical examination of patients with chronic asymptomatic mitral regurgitation frequently demonstrates displacement of the apex beat due to eccentric hypertrophy and possibly a palpable heave. An S3 heart sound is usually present and there may be a pansystolic murmur. Findings indicative of the development of pulmonary hypertension in these patients are suggestive of an advanced disease state and worsening prognosis. [4]

Diagnosis of mitral valve insufficiency is based on symptoms, physical findings and two-dimensional and Doppler echocardiography indicating a leaflet thickness of >5mm and/or leaflet prolapsed >2mm. [4]

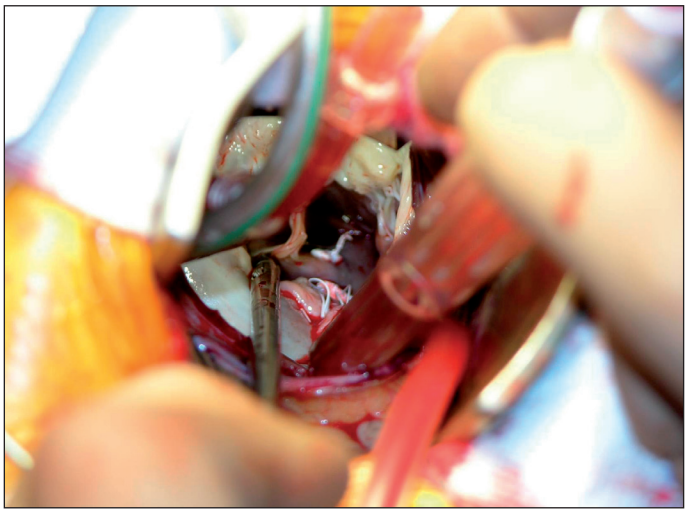

Figure 1. *Long-shafted instruments in use during mitral valve repair.*

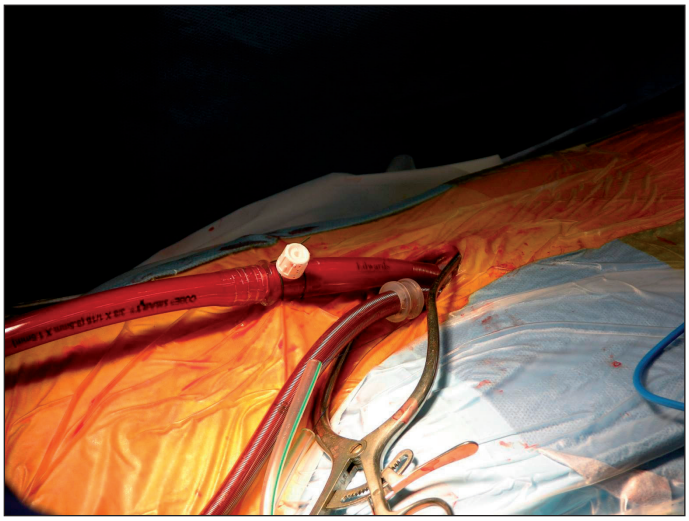

Figure 2. *Femoro-femoral bypass cannulae in situ.*

Minimally invasive mitral valve surgery

Currently, there are three different operations performed for mitral regurgitation: repair, replacement with preservation of the mitral structures, or replacement with removal of the mitral structures.

The indications of mitral valve surgery are:

- Symptomatic acute severe mitral regurgitation.
- Chronic severe mitral regurgitation with at least one of the following:
  - NYHA functional class II, III, IV symptoms in the absence of severe LV dysfunction (severe LV dysfunction defined as EF <0.30) and/or end-systolic dimension >55mm; or
  - Asymptomatic with mild to moderate LV dysfunction, EF 0.30 – 0.60 and/or end-systolic dimension >/= 40mm; or
  - Asymptomatic chronic severe mitral regurgitation with preserved LV function and new; or
  - Asymptomatic chronic severe mitral regurgitation with preserved LV function and pulmonary hypertension (Pulmonary artery systolic pressure >50mmHg at rest or >60mmHg with exercise).
  - Chronic severe mitral regurgitation due to a primary abnormality of mitral apparatus and NYHA classification III-IV symptoms with severe LV dysfunction (EF <0.30 and/or end-systolic dimension >55mm) in whom mitral valve repair is highly likely.

Mitral valve repair may be considered in:

- Severe chronic mitral regurgitation, requiring surgery.
- Asymptomatic chronic severe mitral regurgitation with preservned LV function (EF >o.60 & end-systolic dimension <40mm).
- Chronic severe secondary mitral regurgitation due to severe LV dysfunction, with persistent NYHA class III-IV symptoms despite optimal heart failure therapy, including bi-ventricular pacing.

The midline sternotomy remains the most common incision in cardiothoracic surgery, offering excellent access to all intrathoracic structures. It currently remains the standard approach for aortic and mitral valve surgery. [5]

Minimally invasive mitral valve surgery, specifically port-access mitral valve surgery, is a video-assisted endoscopic technique allowing mitral valve replacement or repair (valvuloplasty and/or annuloplasty) via a series of intercostal ports, thus removing the need for median sternotomy. [5-9]

The minimally invasive technique described is based on the use of the EndoCPB© endovascular cardiopulmonary bypass system, created by Heartport Inc (Redwood City, CA, USA). It is based on initial experience

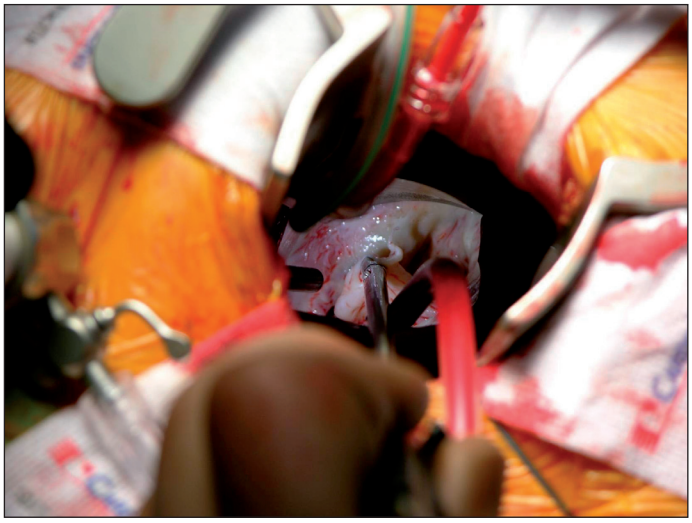

Figure 3. *Surgeon's view through left-sided atriotomy showing the mitral valve in the centre of the picture.*

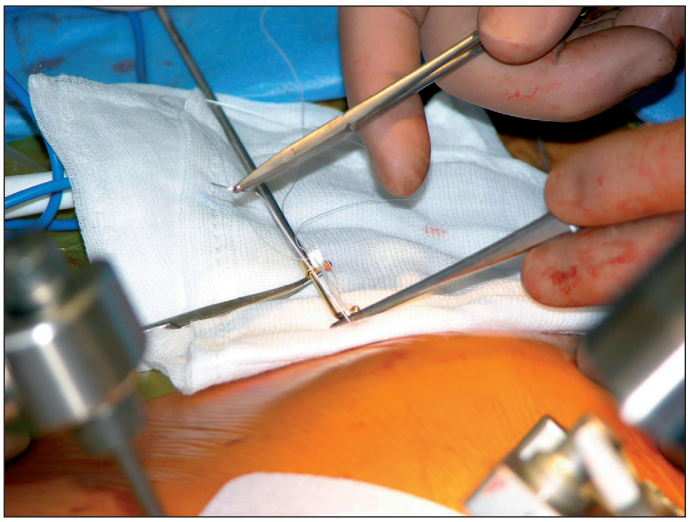

Figure 3. *Preparation of Gore-Tex sutures measured against long-arm callipers.*

with the Da Vinci Robotic Surgical System, which may be used to perform minimally invasive mitral valve repair. The technique outlined below does not use the Da Vinci system, instead being performed directly by the surgeon utilising specific long-shafted instruments (Figure 2).

Pre-operative assessment of vascular status is important as use of the EndoCPB© system may be contraindicated in some patients with peripheral vascular disease. [6] Physical examination and Doppler sonography remain the mainstay of pre-operative vascular assessment.

Intubation is performed by a qualified cardiothoracic anaesthetist with a double-lumen endotracheal tube. The patient is placed in the dorsal decubitus position and transoesophageal echocardiography is commenced. Femoral cutdown is performed and access is gained to the jugular vein, allowing placement of cannulae for femoro-femoral cardiopulmonary bypass (Figure 3) and endocoronary sinus catheter placement respectively. [5,7,8]

Once cardiopulmonary bypass cannulae are in place, a 4-5cm incision is made in the skin of the right inframammary groove, and a port is created in the fourth intercostal space. Soft tissue retractors are then used to retract the soft tissues, providing access to the thoracic cavity (Figure 4). [5-9] A second port is created in the third intercostal space to allow access for the thoracoscope.

The ascending aorta is clamped and retrograde cardioplegia delivered to the heart. Aortic clamping is obtained through the use of either a standard aortic cross-clamp at the root of the aorta or an endoaortic balloon clamp that also allows monitoring of aortic root pressure.

Table 1. *The benefits of minimally invasive mitral valve repair, as compared to conventional surgical approaches.*

Benefits of MIMVR
Smaller incision (4-5cm)
Avoids sternotomy
More rapid return to normal activity
Reduced pain
Reduced incidence of sepsis and wound infection
Reduced occurrence of new-onset atrial fibrillation
Shorter hospital stay
Lower requirement for transfusion
Lower mortality
Improved patient satisfaction
Reduced costs

Surgical access to the mitral valve is gained via a left atriotomy, allowing the surgeon to look down through the lumen of the valve into the left ventricle (Figure 5). The damage to the valve can then be assessed visually, and repaired through valvuloplasty, chordal repair or annuloplasty. Ruptured chordae tendineae can be excised and replaced by Dacron suturing measured against the distance from valve leaflet to papillary muscle by long-arm suture calipers. If annuloplasty is required, the valve size is measured using a valve sizer, and an annuloplasty ring lowered to the atrial surface of the valve. The atriotomy is then closed, the patient placed in the Trendelenburg and lateral decubitus positions, and de-airing commenced. Heartbeat is resumed, and the patient is weaned from cardiopulmonary bypass prior to transfer to the intensive care unit. [5-9]

Discussion

Minimally invasive mitral valve repair (MIMVR) is an evolving procedure that, although developed in 1996, [5] is now coming to play a large part in the surgical management of valvular heart disease.

While no thorough analyses have been completed by government or clinical authorities (such as the UK National Institute of Clinical Excellence or the Australian Safety and Efficacy Register of New Interventional Procedures - Surgical), original research suggests that MIMVR is a viable and safe alternative to standard median sternotomy for mitral valve surgery, conferring a multitude of benefits to the patient (Table 1). [5-16]

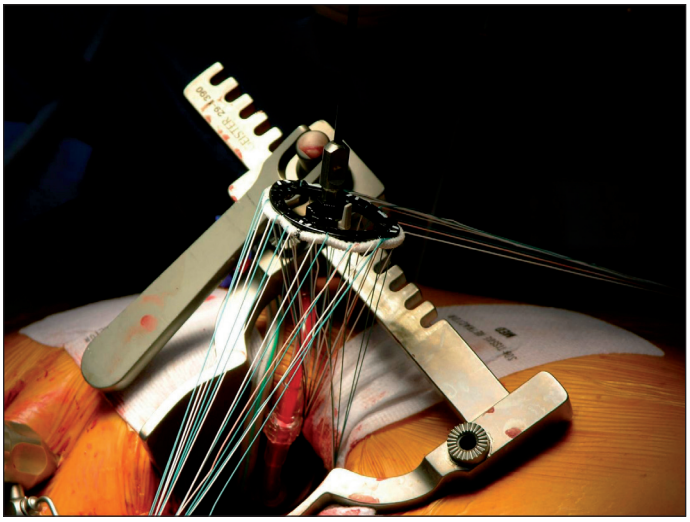

Figure 5. *Insertion of annuloplasty ring.*

Yet despite its multiple benefits, reduced costs and improved cosmetics, MIMVR has its own unique set of potential complications. By 1999 there had been 25 reported cases of retrograde aortic dissection worldwide associated with surgery. Potential exists for cerebrovascular accident (occurring in 0.6% of cases in the port-access international registry). The endoaortic balloon may migrate to the aortic valve, perforate, or be captured during suturing. Femoral arterial cannulation may prove to be impossible in some patients necessitating a change of procedure to median sternotomy. Other potential complications include kinking or obstruction of the venous cannulae inadvertent placement of the venous cannula in the superior vena cava and perforation of the coronary sinus, right atrium by a guidewire or of the left atrium via an atrial septal defect. [5,14]

Overall however, MIMVR is held to be a viable alternative to median sternotomy, with a comparable level of clinical safety. [5-16] Data from one study suggests that MIMVR is associated with a lower morbidity and shorter hospital stay in elderly patients when compared to standard mitral valve replacement via median sternotomy. [13] Whilst one prospective, randomised study suggested that there were no significant advantages of minimally invasive port access technique over median sternotomy, and that MIMVR was associated with a longer operating time and more intraoperative procedure-related problems, the authors conceded that their study was limited by their own experience with minimally invasive techniques. Further, the small sample sizes of their groups restricted their ability to detect statistically significant differences in clinical, biochemical and neuropsychological variables. [15]

Conclusion

MIMVR is a safe, viable alternative to median sternotomy in patients with adequate peripheral vasculature, and offers significant advantages in terms of morbidity, cost, patient satisfaction and cosmetics when performed by experienced practitioners.

Conflict of Interest

None declared.

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