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Review Article

Beating Heart Mitral Valve Replacement in Secondary Mitral Regurgitation with Poor Left Ventricular Function Literature Review

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Abstract

The poor early and mid-term prognosis of secondary mitral regurgitation (MR) with impaired left ventricular function after restrictive annuloplasty with cardioplegic arrest has opened the way for transcatheter repair. The indication for surgery is only incontestable when concomitant coronary revascularization is required. Beating heart mitral valve surgery without aortic clamping has been promoted as an alternative to the technique of cardioplegic arrest. Its potential advantage is the elimination of ischemic reperfusion injury and its impact on myocardial function. On the other hand a randomized study confirmed that for ischemic MR, mitral valve replacement (MVR) reduces the rate of MR recurrence and re-hospitalization compared to restrictive annuloplasty.

We performed a review of the literature to assess the strength of the evidence supporting the efficacy of beating heart MVR without aortic clamping compared to the conventional technique for secondary MR with poor left ventricular function. In a randomized study of patients with chronic severe mitral regurgitation and left ventricular dysfunction, beating heart MVR was associated with better LV function, reduction of cardiac enzymes early postoperatively, reduced duration of mechanical ventilation, and ICU than MVR using warm blood cardioplegic arrest. This together with the absence of related perioperative mortality and the major complications suggests that this technique is safe and beneficial to LV function. This finding has been verified by a multitude of other observational studies which have shown that the benefit of this technique is more palpable in cases of redo mitral surgery or in cases of MR with poor left ventricular function.

Keywords: heart failure; dilated cardiomyopathy; mitral regurgitation; beating heart

Introduction

In the era of transcatheter edge-to-edge repair, surgical indications for secondary mitral regurgitation (MR) with severe left ventricular (LV) dysfunction remain limited, especially when not associated with significant coronary lesions (class IIb) [1]. This is due to the lack of a proven survival advantage of restrictive annuloplasty in these patients [2]. A randomized trial found that in secondary MR, mitral valve replacement (MVR) does not have a significant impact on survival after two years of follow-up compared to restrictive mitral annuloplasty, although it significantly reduces the incidence of recurrent MR, heart failure and re-hospitalizations [3].

Furthermore, despite the efficacy and safety of the various cardioplegic arrest protocols, each strategy has its limitations and pitfalls, and none has achieved general consensus. The ischemia-reperfusion injury they cause is often associated with non-negligible morbidity and mortality, particularly in cases of preoperative left ventricular dysfunction [4, 5]. This has led to a renewed interest in beating heart MVR [6]. This technique provides continuous coronary perfusion with oxygenated and normothermic blood, thus avoiding ischemia-reperfusion injury and constitutes physiological myocardial protection, particularly for patients with poor left ventricular function. Moreover, Calafiore [7] has highlighted the implication of aortic manipulation in the increased incidence of strokes in patients with extra coronary vasculopathy.

In order to improve the short and long term outcomes of secondary MR surgery with severe LV dysfunction, beating heart MVR without aortic cross-clamping has been proposed

Surgical technique [8]:

In order to avoid cerebral gas embolisms that can occur during this clampless beating heart surgery, several precautions should be rigorously observed: (a) Patients must be in Trendelenburg position, (b) mean

arterial pressure must be maintained around 70-75 mmHg, keeping the aortic valve constantly closed, (c) aspiration of the aortic root must be effective, (d) left atriotomy should be performed with a transitory cross-clamping of the aorta, until the mitral valve is opened with a suction cannula (e) A soft LV vent cannula should be placed in the centre of the mitral valve prosthesis to prevent LV anterograde ejection as well as to avoid any injury to the LV wall, (f) De-airing of the left heart chambers should be performed under aortic cross-clamping and finally (g) aortic root suction should be maintained until completion of heart filling.

Advantages of this technique:

(1) Continuous coronary perfusion with normothermic and oxygenated blood provides good myocardial protection, resulting postoperatively in low myocardial enzyme levels. Despite the progress made with the different cardioplegia protocols, myocardial ischemia-reperfusion injury remains unavoidable [9]. Furthermore, it has been shown that cardioplegic arrest impairs cardiac lymphatic drainage, thus generating myocardial oedema that may affect postoperative myocardial function [10].

In contrast, beating heart mitral valve surgery offers more physiological and less aggressive conditions particularly in impaired LV. Matsumoto demonstrated in a randomized trial that this technique significantly reduces troponin levels and the levels of catecholaminergic drugs required, compared to patients operated on with continuous infusion of warm blood cardioplegia [11]. In other experimental studies, a reduction in extracellular fluid accumulation and lactate production and a better preservation of energy reserves were observed when the myocardial protection strategy was based on continuous coronary perfusion with normothermic and normokalemic blood [11, 12]. These results provide the experimental basis for the use of beating heart valve surgery when prolonged periods of myocardial ischemia are expected.

(2) Suppression of myocardial ischemia-reperfusion injuries preserves immediate postoperative systolic function, leading to easy CPB weaning and perioperative hemodynamic stability. This will result in a shorter duration of CPB with fewer side effects on the different organs, thus reducing the duration of mechanical ventilation and intensive care. This finding was made in patients with a very high operative risk [13, 14, 15, 16].

In patients with MR and poor LV function; Ghoch noted that this technique significantly reduces the observed mortality compared to the mortality predicted by the EuroSCORE [17]. Pasic recently published a series of 120 very high-risk surgical patients (mean logistic EuroSCORE: 26.1 ± 20.6%) who underwent beating heart mitral surgery. He noted that despite their significant preoperative co-morbidities, hospital mortality was only 10% on average., 7.5% in patients without cardiogenic shock and only 2.4% in the group of ischemic MR patients with severe LV dysfunction (mean LVEF=23 ± 5.5%) [15]. It is important to note that the same author's team reported in a previous article, an operative mortality exceeding 30% in the group of ischemic MR operated with cardioplegic arrest [18].

In a randomized study of patients with chronic severe mitral regurgitation and left ventricular dysfunction, beating heart MVR was associated with better LV function early postoperatively, reduced duration of mechanical ventilation and ICU than MVR using warm bloody cardioplegic arrest. This together with the absence of related perioperative mortality and the major complications suggests that the beating heart approach is safe and beneficial to LV function [19].

It has also been shown that the beating heart approach via a right thoracotomy in redo mitral surgery reduces the duration of mechanical ventilation, as well as the number of blood transfusions and operative mortality, compared to fibrillating heart surgery in moderate hypothermia (28°) [14]. Indeed, electrically induced ventricular fibrillation significantly decreases oxygen delivery to the myocardium and redistributes coronary flow away from the subendocardial regions [14]. Furthermore, avoidance of extensive surgical dissection, no need for aortic cross-clamping and cardioplegia delivery, simplify otherwise difficult and risky procedures.

Zhang noted that the minimally invasive beating heart technique outperformed the conventional technique of median resternotomy with a arrested heart for mitral valve surgery in patients with previous sternotomy and a giant left ventricle, as it reduces the operation time and CPB time, decreases the transfusion ratio and the amount of transfusion, shortens the postoperative ICU stay and length of hospital stay, promote early which resulted in faster patient recovery [20].

Disadvantages of this technique:

Aortic valve integrity is a prerequisite for a bloodless surgical field in beating heart mitral valve surgery without aortic cross-clamping. The presence of a minor aortic leak can significantly interfere with the exposure and the course of the procedure. Salerno used a trans-septal approach for clampless beating heart mitral valve surgery in 214 patients to reduce aortic insufficiency and improved visualization of the mitral apparatus [21]. To counteract this discomfort, Ricci published a technique for continuous coronary perfusion, combining the retrograde and anterograde routes with aortic cross-clamping, which allowed him to perform beating heart polyvalvular surgery [22].

The main concern of this beating heart approach, without aortic clamping, is the risk of gas embolisms. Two randomized studies, based on intraoperative neurological monitoring (electroencephalogram, bi-spectral index, transcranial Doppler) [23] and postoperative neurocognitive testing [24] found no significant difference in neurologic disorder between beating heart and arrested heart mitral valve surgery. This has also been found in other observational studies [16, 22] of beating heart mitral or polyvalvular surgery.

In the setting of these dilated left ventricles and associated subvalvular tethering, restrictive mitral annuloplasty is associated with a high risk of recurrent MR and re-hospitalization [3]. A meta-analysis [25] confirmed that preservation of the subvalvular apparatus during MVR, compared to its complete excision, significantly reduces operative mortality, postoperative low cardiac output and mortality at 5 years after surgery. Furthermore, Yun demonstrated in a randomized study comparing complete versus partial preservation of the subvalvular apparatus (posterior mitral leaflet only), that the first approach is associated with a significant reduction in LV size, LV systolic stress and LV mass, as well as a significantly higher LVEF [26].

Possible indications:

Patients considered at high surgical risk or unsuitable for mitral surgery in cardioplegic arrest, such as patients in cardiogenic shock, patients on mechanical ventilation, patients on inotropic support or circulatory support [15], (2) mitral redo surgery [14, 20], (3) MR with severe LV dysfunction [17], (4) porcelain aorta [15].

Conclusion

Clampless beating heart mitral valve replacement with total preservation of the subvalvular apparatus may improve the short- and mid-term outcomes of surgery of secondary mitral regurgitation with poor left ventricular function, considered at very high risk for conventional surgery.

Abbreviations

CPB: Cardiopulmonary-bypass.

Euroscore: European system for cardiac operative risk evaluation.

LV: Left ventricle**.**

LVEF: Left ventricle ejection fraction**.**

MR: Mitral regurgitation.

MVR: Mitral valve replacement.

Declaration: The authors have no conflicts of interest to declare.

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