Redo Valve Surgery Nowadays: What Have we Learned?

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Abstract. Re-operative valvular surgery is common nowadays. Increased mortality and morbidity are generally associated. Re-operations in cardiac surgery are technically more difficult because of adhesions and a more advanced cardiac status of the patient. Results reported 20 years ago carried a high mortality risk. Experience and technological evolution have produced a substantial reduction in postoperative mortality nowadays. The present review focuses on historical results of redo valve surgery, risks factors for postoperative mortality, technical progress and surgical strategies contributing to better results.

Introduction

Re-operations are an integral part of the cardiac surgeon’s current daily practice. Among heart valves case load, re-operations on prostheses represent between 2.5% (1) and 17% (2). Morbidity of cardiac re-intervention is higher than in a first operation because of cardio-pericardial adhesions (Fig. 1) and more advanced cardiac pathology. Resternotomy carries a high risk of cardiac injury and subsequent catastrophic hemorrhage. More advanced cardiac pathology is associated with increased operative and postoperative morbidity and mortality. Longer ICU stay (mean stay up to 4 days) is associated with heart valve re-operations (3). Redo operations are identified as risks factors for blood transfusion requirements (4). Risk factors for major sternal wound infections and mediastinitis include re-operations (5, 6). Several postoperative complications are associated with redo heart surgery.

Indications for redo valve surgery

Indications for redo valve surgery have been changing through the years. Autologous fascia lata had been used for reconstruction of the ventriculo-arterial valves. However, this technique rapidly lead to valve degeneration, both right- and left-side (7, 8). However, there are no extended reports concerning these re-operations. The first important series of heart valve re-operations reported in the literature concerned degenerated heterografts (9-11). Young age at implantation was found to favour accelerated degeneration, negating the benefit of the lack of need for long-term anticoagulation. Limited durability of these bioprostheses (9, 10), specially of earlier design and generation (12) swung the pendulum in favour of mechanical valves (13). Recent reports of increased durability of modern bioprostheses, especially pericardial (12, 14), explain a current tendency to implant more bioprostheses in the elderly (a group of increasing number in our society). Actuarial results show that freedom from heart valve re-operation at 5 and 10 years for all bioprosthesis was 96.0% +/- 0.4% and 74.9% +/- 1.1% compared to 93.6% +/- 1.2% and 87.9% +/- 2.5% for mechanical prostheses (15). Throughout the years, degeneration of bioprostheses as a surgical indication for valve re-replacement falls from 44% in the 80s (16) to 24% in the 90s (17). However the most common cause of heart valve re-operation after implantation of a bioprosthesis remains structural valve failure (15). Non-structural dysfunction, particularly paravalvular leak, which is the leading cause of mechanical heart valve re-operations, is far less common (17). Native valve disease also leads to the indication for redo valve surgery. Increased survival after heart valve operation is associated with native valves evolving lesions. The actuarial survival rate is 52% at 5 years and 33% at 10 years. Actuarial survival rate with normal prosthetic function is 41% at 5 years and 19% at 10 years. The functional results of these patients remain good with over 90% of surviving patients in class I or II (17).

Results and evolution

In early studies, redo valve surgery carried a higher mortality risk than primary valve procedures (16). The first results concerning large series of redo valve surgery were reported in the early 1980s. The operative mortality rate was of 14% (18). This rate was significantly higher than for primary valve procedures performed during the same period. At that time, a mitral valve
re-replacement held twice the risk of a first mitral ope-
ration while aortic valve re-replacement held three times
the risk of a first aortic operation (18). During that
period, the operative mortality for a first re-operation
(530 patients) was 5.9% for the aortic position and
19.6% for the mitral position (19). Terada confirmed this
trend (108 patients) in the late 80s with an overall mor-
tality of 15.7% (20).

Tendency through the years to improved results

Throughout the years, the mortality associated with redo
valve surgery has dropped significantly. Recent changes
in the management of the cardiac surgical patient may
explain the improvement in results in more recent series.
During the 70s, the operative mortality rate in redo valve
surgery was as high as 41% (21). During the 90s, a sig-
ificant reduction in overall hospital mortality, down to
10%, was observed (3). In another series, a decrease in
mortality from 16% in the early 80’s to 8% in the early
90s was observed (2), possibly related to technical
improvement and increased surgeons’ experience.

Risk factors in redo valve surgery

The experience acquired during the last 20 years in heart
valve re-operations is considerable. Various prognostic
factors influencing outcome after redo valve surgery
have been identified. The most frequently quoted risk
factor associated with death in redo valve surgery is the
New York Heart Association (NYHA) functional class
(1-3, 17-20, 22, 23). Mortality up to 30% has been asso-
ciated with stage IV compared to less than 10% in stage
II and III (20, 21). One of the first reports of redo valve
surgery clearly suggests that when significant valve dys-
function is first noted, re-operation should be undertaken
to minimize operative risk (19). Later observations
generally emphasized this recommendation. This is par-
ticularly true in patients who benefit from a bioprosthesis
in the mitral position. The most common cause of re-
replacement of a prosthetic valve is bioprosthesis dege-
neration (2). Structural valve degeneration of a bioprosthesis
generally appears after 8 years of follow-up, espe-
cially in young patients and in the mitral position (24).
Closer follow-up, reducing from a 12 to a 6-month
interval should be recommended in patients with mitral valve insufficiency, in order to avoid rapid valve failure precipitating patients in to class IV NYHA. This observation should be extended to all other situations with rapid deterioration of valvular function. Prosthetic endocarditis with Staphylococci and mechanical valve thromboses with leaflets fixed in the open position are good examples. Furthermore, early re-operation before irreversible deterioration occurs was advised, since myocardial function was found to be a major determinant of surgical results (1, 20). The second most frequently reported risk factor is the degree of urgency in the re-operation of patients (1, 3, 16-20, 22, 23). The reported mortality risk of elective re-operation is as low as 5.4% to 11%, while, for emergency procedures, it could be as high as 38 to 61.5% (1, 20, 21).

Other risk factors, perhaps of secondary influence, have been reported. The influence of the valve position as a risk factor is controversial. Some data suggest that redo mitral surgery increases risks (19.6%) compared to aortic (5.9%) (19). Another series reports the contrary, that mitral valve re-operation carries a 12% risk versus 26% in the aortic position (1). The valve position was recently found not to be a determinant risk factor (23). Double valve replacement compared to single, represents a significant risk factor (17): mortality increases from 3.2% in single to 25.0% in double valve recipients (13). The number of previous operations has been reported as a risk factor (17). Mortality had been reported as high as 21.7% for the second, 20% for the third and 55.6% for the fourth re-operations (17). Tricuspid valve surgery requirement (replacement or annuloplasty) is associated with a higher mortality than the same operation without tricuspidal disease (16), probably reflecting more advanced disease and higher pulmonary artery pressures. Pre-operative morbidity bears a significant correlation with mortality. Prosthetic valve endocarditis has been associated with a postoperative mortality of up to 50% (1, 16, 20). Mechanical valve thrombosis also carries an important risk (43%) of death compared to structural deterioration of bioprostheses (9%) (21). A short duration since the previous implantation may be a risk factor: a duration of implantation of less than 3 months has been identified as such (17). This observation could be related to early valve surgery complications such as mechanical valve thrombosis and prosthetic endocarditis. Associated coronary artery lesions and associated CABG requirements present a higher operative mortality (22). Gender has been identified as a risk factor, female having been
recently reported to present a higher operative mortality compared to male (23). Risk associated to gender, contradicted in the past in this particular surgery (16), is currently accepted as a general risk factor in cardiac surgery today (25). Previous thrombo-embolism had been reported as a risk factor in this surgery (3). Higher capillary wedge pressure has also been evoked as a risk factor (1), even though this notion is controversial (20). Creatinine level was higher in non-survivors compared to survivors (1). Operation time (20), aortic cross clamp time (17, 20) and pump run (1, 17, 20) are reported to have been significantly longer in patients who died. The type of prosthesis implanted originally seems not to influence patient outcome after heart valve re-operation (15, 16). However, failing mechanical prostheses are associated with a higher mortality (21%) than bioprosthesis degeneration (a more progressive event: 10%) (21). Bioprostheses and mechanical prostheses lead to different complications. This difference may be related to the different pre-operative diagnosis: mechanical prostheses are exposed to thrombo-embolism and bioprostheses much less so. The era of operation had been reported as a risk factor of mortality (1, 2, 17). As previously mentioned, studies concerning patients operated on between 1980 and 1992 clearly exhibited a decreased mortality through the years. Cohn reported that mortality for re-replacement fell, between 1980 and 1992, in aortic valve from 15% to 10%, in double valve from 20% to 9%, and in mitral valve from 16% to 6% (2). Such improvements in mortality have been confirmed in other studies (1).

Surprisingly, cardiac index does not appear as a risk factor. While coronary artery re-operations also involve higher mortality, especially related to the reduced left ventricular function (26), objective indices of left ventricular dysfunction as risk factors were not clearly identified in redo valve surgery.

**Technical progress**

Several improvements have been implemented over the last quarter of century. Some are related to technological evolutions, others to increased surgical experience:

- Femorofemoral ECC (Fig. 2) before sternotomy is done if the cardiosternal contact is important on lateral chest x-ray. Thin walled venous tubing development has considerably improved venous drainage in femorofemoral bypass. If required, active venous suction using a centrifugal pump, may be helpful.
- Redo sternotomy uses an oscillating saw (Fig. 3) to limit the risk of tearing underlying structures (innominate vein, ascending aorta, right atrium and right ventricle).
- Defibrillation patches directly applied on to the patient’s skin allow rapid external electric shock administration if the patient starts fibrillating during the early stages of the operation. Electro-cautery utilisation sometimes induces ventricular fibrillation. Defibrillation should be insured in this situation as quickly as possible. Cardio-pericardial adhesions could impair the possibilities to internally defibrillate the heart. External defibrillation should be used in such a situation. Another lifesaving procedure is the rapid opening of both pleural spaces and transpleural internal defibrillation.
- Primary extensive cardio-pericardial adhesions liberation had been reported to facilitate mobilization and evacuation of intra-cardiac air and to make the intra-cardiac procedure easier and safer (20). Adhesiotomy using electro-cautery (Fig. 4) limits bleeding. This strategy is weighed against limited dissection as for isolated aortic valve replacement in redo patients. In non atheromatous patients, arterial cannulation of the groin avoids clustering of the operative field.
- Thoracotomy surgery: atrio-ventricular valve surgery can be done through an antero-lateral thoracotomy as first reported in the late 80s (27). A series of ten patients with multiple previous cardiac operations underwent antero-lateral right thoracotomy to avoid re-entry risks and adhesions dissection for redo atrio-ventricular valve surgery (24). Patients included in this series underwent their third to sixth valve replacement operation. Femorofemoral bypass, profound hypothermia and low flow perfusion without aortic cross clamping or cardioplegia was performed. Authors suggest the following indication for this strategy: previous mediastinitis, severe right ventricular and pulmonary hypertension with previous multiple sternotomies, intact coronary arteries bypass grafts (especially mammary pedicles) and previous aortic valve replacement (especially with high profile prostheses) without any new aortic valve indication for surgery.
- Mitral exposure during re-intervention can be hazardous. Cardio-pericardial adhesiotomy can be difficult and time consuming in some circumstances. Precocious left mediastinal pleurotomy through median sternotomy achieved ventricular mobilisation and improved exposure of the mitral valve (28). Moreover, this simple, safe and time-saving technique, if realized before sternal retraction, allows the avoidance of shear-stress on medial structures, such as the innominate vein, the right atrium and ventricle and the aorta. Right pleurotomy may serve the same purpose.
- Improved ECC technology, particularly biocompatibility, has reduced the systemic inflammatory response syndrome. Systemic hypothermia, low flow and circulatory arrest can all help in the management of delicate redo-related technical difficulties.
– Improved myocardial protection technique: hypertrophied hearts, frequently found in heart valve disease, make myocardial protection critical. Antegrade cardioplegia associated with topical cooling of the heart can be impaired in redo valve surgery: aortic regurgitation limits the efficacy of antegrade cardioplegia (unless given directly into the coronary ostia) and extensive adhesions oppose adequate topical cooling. Although retrograde cardioplegia efficiency had been challenged, especially in hypertrophied myocardium, it has been widely used in both valve and coronary surgery with success (29). Despite less complete right ventricle protection, retrograde cardioplegia is a safe alternative in conditions where myocardial protection is inadequate in valve surgery with aortic insufficiency (30).

– Improved intensive care management may also have contributed to the general amelioration of the results. During the last 20 years, mechanical and pharmacological support of the failing heart have progressed greatly. Monitoring with the Swan Ganz catheter allows precise haemodynamic evaluation nowadays at the cost of an occasional catastrophic pulmonary haemorrhage (31).

– The Cell Saver has proved useful in redo cardiac surgery patients, even if its efficacy in reducing transfusion requirements for redo valvular patients remains questionable (32).

– Aprotinine: peri-operative blood loss and blood transfusion requirements were reduced by aprotinine use in primary cardiac surgery under bypass (33, 34). This benefit should also improve blood loss during redo surgery. Hypersensitivity to Aprotinin should be tested in cases of recurrent administration of this drug.

Experience in redo valve surgery should influence first operation strategies. Large pericardial windows have previously been used by some to prevent cardiac tamponade, a benefit still awaiting demonstration. Experience in redo surgery absolutely negates the usefulness of such practice. Eighty-eight percent of the haemorrhages during re-entry in redo cardiac surgery occur in situations in which the pericardium had not been closed in a first operation (35). Meticulous haemostasis during the first operation considerably limits the formation of adhesions: some surgeons produce safer redo candidates than others.

Surgical strategies

Judicious combination of the above improvements and strategies tailored to the individual patient are probably the key points in achieving the better results observed today in redo valve surgery. Stiffness of the structures and cardio-pericardial adhesions reduce heart mobilisation possibilities and secondary exposition of the structures and different cavities. Multiple operations on the same heart valve are generally associated with increased technical difficulties. Identification of the mitral annulus in a first operation is easy, but much more difficult ten years after bioprosthesis mitral implantation. Preservation of this important structure is the key point for a safe re-replacement of the mitral valve to avoid coronary artery injury (circumflex artery) and paravalvular leak. The final aim is to provide secure and comfortable access to the concerned valve.

For example, femorofemoral bypass can be helpful in different situations:

1) Before sternotomy in multiple redo procedures with close cardio-sternal contact, increased central venous, right ventricle or pulmonary artery pressure.

2) Right lateral thoracotomy to achieve AV valve access.

3) Re-entry accidents involving the ascending aorta are often fatal. If aorto-sternal adhesion is anticipated (aneurysm, false aneurysm), in order to allow a safe sternal re-entry, deep hypothermia can be achieved before resternotomy using a femorofemoral bypass. Once a rectal temperature of 20°C is reached, under circulatory arrest with ascending aorta submitted to a low blood pressure and flow, re-entry can be achieved. In the same situation, a clamshell incision limits the risk of aortic injury (but also access to the aortic valve if it would be deemed necessary).

Present results of redo valve surgery

A recent report in redo valve surgery quotes an overall mortality of 8.4% (23). This retrospective study includes 154 patients collected between January 1985 and December 2000. We retrospectively analyzed in-hospital data from January 1 1996 to December 31 2001, in 187 patients. All patients had had previous valve surgery and needed a new valve operation. Indications included native valve defect and bioprothetic or mechanical valve complications. Seventy five percent were first redo valvular surgery and 23% second redo. Third, fourth and fifth redo represented 2% of the population. The observed mortality in this population was 8%. These results illustrate considerable improvement related to surgical experience and technical progress. However, redo cardiac surgery will always carry a higher mortality related to potential re-entry accident, particularly concerning the aorta. A recent report of direct vision technique before resternotomy has been reported with zero significant cardiac injury (36). It may well be that techniques based on this principle will permit a further significant reduction in operative mortality in redo cardiac surgery.
References


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