Immediate and long-term results of mitral prosthetic replacement using a right thoracotomy beating heart technique

M.J. Thompson, A. Behranwala*, C. Campanella, W.S. Walker, E.W.J. Cameron

Department of Cardiothoracic Surgery, Royal Infirmary NHS Trust, 1 Lauriston Place, Edinburgh EH3 9YW, UK

Received 4 October 2002; received in revised form 21 March 2003; accepted 25 March 2003

Abstract

Objective: Repeat median sternotomy is a potentially dangerous technique providing variable but mainly poor access to the mitral valve. Right thoracotomy is an alternative route previously used to access the mitral valve in the early years of cardiac surgery that offers the advantage of a fresh surgical field in the context of redo surgery. We have reviewed our experience with mitral prosthetic replacement undertaken via a right thoracotomy in order to determine the immediate and long-term results obtained with this approach. Methods: The operation was carried out on a beating heart using normothermic bypass without cross-clamping the aorta. Arterial inflow was achieved via the femoral artery or ascending aorta and venous drainage with bi-caval cannulae. Pre-, intra- and postoperative data were documented from case note review. Long-term follow-up was established from the UK Heart Valve Registry, referring Cardiologist, direct patient contact and the Scottish Registry for births and deaths. Statistical analysis was undertaken using a desktop computer package. Results: One hundred and twenty-five patients (mean age 63 years) underwent mitral prosthetic replacement by this technique. One hundred and eleven patients (86%) were in NYHA grades III or IV preoperatively. Twenty-two patients (16.6%) had also undergone previous CABG. Thirty-five patients (28%) had undergone two or more sternotomies. Mean bypass time was 83.6 min (SD 43.1). Postoperatively, mean duration of ventilation was 44 h; mean ITU stay was 4 days (SD 5.3) and mean inpatient total stay was 12 days. Thirty-six patients (28.8%) required inotropic support postoperatively. Complication rates were low: pleuro-pulmonary, 30 patients (24%), re-operation for bleeding, four patients (3.2%) and CVA, two patients (1.6%). Eight patients (6.4%) died within 30 days. Ten-year survival figures (Kaplan–Meier) were: 47% for all causes of mortality and 82.9% when only valve related causes of death were considered. Most of the patients (97.5%) had not required re-operation at 10 years. Conclusion: Mitral prosthetic replacement via a right thoracotomy on beating heart under normothermic bypass offers a safe alternative to redo median sternotomy in this high-risk group. Operative access is facilitated and procedural time reduced. Complication rates are low and perioperative mortality is lower than that generally reported with conventional surgery.

Keywords: Mitral valve; Re-operation; Thoracotomy; Beating heart; Survival; Outcome

1. Introduction

Revisional valve surgery has become increasingly frequent in the last four decades [1] reflecting the growing number of patients in whom valve prosthesis has been implanted. It has also been suggested that as time progresses, more patients requiring mitral valve repair or replacement [2,3] will present with patent internal mammary artery or vein grafts. Revisional valve surgery is more complex than primary surgery and consequently is associated with higher mortality and morbidity [1]. There is some controversy regarding the degree of additional risk associated with repeat valve surgery. Although some authors deny any appreciable increase in risk [4–6], others have noted a significantly increased risk [7] for patients undergoing multiple procedures. Also, the evidence from US (Society of Thoracic Surgeons) and UK (Society of Cardiothoracic Surgeons) national databases would support the view that revisional mitral valve surgery carries a twofold to threefold increase in mortality.

A right lateral thoracotomy approach has been used previously in mitral valve surgery re-operations and has well-established benefits [2]. It has been suggested that this approach is time saving, safer for emergency procedures on
thrombosed or acutely malfunctioning mitral valves [2] and helpful in situations where difficult dissection of the heart would be anticipated or patent internal mammary artery or saphenous vein grafts are present. In addition, surgery on this group of patients demands optimal myocardial protection and in theory, this is best achieved by maintenance of the coronary circulation during surgery.

Against this background, our technique for mitral prosthetic replacement through a right thoracotomy has been developed. The aims of the study are, therefore, to describe the technique, present the perioperative complications in this series of 125 patients and to discuss the possible benefits of the technique and their implications in an increasing population of mitral valve re-operations.

2. Materials and methods

2.1. Data acquisition

A retrospective case note review was performed on all patients undergoing right thoracotomy beating heart mitral prosthetic valve replacement between 1985 and 2001. The case notes were obtained for all patients. The factors analysed (Table 1) were selected as being relevant following a literature search of papers presenting revisional mitral valve surgery data. The survival status of all patients discharged from hospital was determined from the referring general practitioner and cardiologist, the UK heart valve registry [8] and the Scottish Registry for births and deaths.

2.2. Surgery

The indications for surgery were valve dysfunction due to degeneration, infection, thrombosis or mechanical failure. All procedures were undertaken through a right anterolateral thoracotomy using normothermic (37°C) bypass at full-calculated flow. The heart was perfused as normal through the aortic root and allowed to beat. The heart was not fibrillated at any point in the procedure and neither aortic cross-clamping nor cardioplegia were used.

The right anterolateral thoracotomy was created through the fifth inter-space. Arterial inflow was provided by cannulation of the ascending aorta (99 patients), right femoral artery (24 patients) or a combination of both vessels (two patients). Venous drainage was effected by caval cannulae inserted through purse string sutures placed in the fused pericardial and right atrial walls. The cannulae were advanced through the right atrium into the SVC and IVC.

On full flow, a left atriotomy was made and a pump sucker used to rapidly empty the left atrium and cross the mitral valve if this was not already incompetent. Air embolism was avoided by keeping the left heart empty and vented to the atmosphere. Blood in the left ventricle was, therefore, preferentially expelled across the mitral valve because atmospheric pressure is much less than the aortic root pressure. Florid aortic incompetence is an obvious contraindication to this procedure. Minimal incompetence can be accepted although there is then the need for continued intra-cavity pump suction of the left ventricle during the surgery so that the valve can be adequately visualised. In general, we ran these cases with an on pump mean aortic pressure of 50–60 mmHg.

2.3. Data analysis

Data was entered into an Excel 5 spreadsheet database (Microsoft). Statistical analysis was carried out using a desktop computer package (Statview 5).

3. Results

3.1. Preoperative characteristics

One hundred and twenty-five patients (92 females, 73.6% and 33 males, 26.4%) were identified and studied. This represented 29.6% of all patients undergoing revisional mitral valve surgery in this period with the remaining
298 patients operated on through a conventional median sternotomy. The mean age was 63 years (range: 30–80 years). Thirty-nine had previously received a biological valve and 86 a mechanical valve. All patients had undergone at least one previous sternotomy. Thirty-two patients (25.6%) had two previous sternotomies and three patients had three previous sternotomies. In addition, 21 patients had undergone a previous left thoracotomy for closed mitral valvotomy and five patients had already had mitral valve surgery through the right chest. The majority of patients (111, 86%) were in NYHA classes III or IV preoperatively. Most (106, 84.8%) presented either urgently i.e. during an acute admission to hospital with evidence of cardiac decompensation ($n = 83$) or as an acute emergency ($n = 23$). The mean length of time since previous cardiac surgery was 7.7 years.

### 3.2. Perioperative findings

The duration of operation and cardiopulmonary bypass times is summarised in Table 2. Nineteen patients had some coronary artery disease although only three required bypass grafts to the right coronary artery. Some degree of technical difficulty was encountered in ten patients (8%) who were found to have significant aortic incompetence, which had not been diagnosed on pre-operative investigation. This lead to significant reflux of blood into the operative field during surgery but could be managed with the use of vent suction.

### 3.3. Postoperative course

The mean postoperative blood loss was 581 ml (SD 426, range 120–2500). Patients stayed an average of 4 days (SD 5.3, range 0–36) in the cardiac ICU, with a further mean HDU stay of 10.6 days (SD 16.4). The overall hospital mean stay was 11.6 days (SD 18.9).

Postoperative complications occurred in 67 patients (53.6%). Pulmonary complications are summarised in Tables 3 and 4 and other complications in Table 4. Re-opening for bleeding and/or a low cardiac output state was required in four patients and only two patients developed a cerebrovascular accident (1.6%). One of these was secondary to a major ventricular arrhythmia postoperatively.

Eight patients (6.4%) died within 30 days of surgery. Three died within hours of surgery from myocardial infarction, severe fixed pulmonary hypertension in combination with a low cardiac output and cardiogenic shock secondary to a severe protamine reaction, respectively. The remaining five patients died from a variety of causes: low cardiac output ($n = 2$), sepsicaemia ($n = 1$), respiratory failure ($n = 1$) and acute renal failure in combination with bowel infarction ($n = 1$).

### 3.4. Survival

Kaplan–Meier levels for 10-year survival are shown in Fig. 1. Overall 10-year survival with all causes of mortality considered was 47%. Survival when only valve-associated causes of death were considered was 82%. Freedom from reoperation at 10 years was 97.5%.

### 4. Discussion

Excellent survival has been reported by other authors using the right thoracotomy approach [2,4,8,9]. We believe that our beating heart technique offers further clinical advantages and is substantiated by the relatively large number of cases here reported. There is no survival data reported in the literature for re-operated mitral valve

<table>
<thead>
<tr>
<th>Complication</th>
<th>Number of patients</th>
<th>Percentage of total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reopening of thoracotomy</td>
<td>4</td>
<td>3.2</td>
</tr>
<tr>
<td>Ventricular arrhythmia</td>
<td>3</td>
<td>2.4</td>
</tr>
<tr>
<td>Acute renal failure</td>
<td>3</td>
<td>2.4</td>
</tr>
<tr>
<td>Wound infection</td>
<td>6</td>
<td>4.8</td>
</tr>
<tr>
<td>Other infection</td>
<td>2</td>
<td>1.6</td>
</tr>
<tr>
<td>Wound dehiscence</td>
<td>3</td>
<td>2.4</td>
</tr>
<tr>
<td>Complete heart block</td>
<td>1</td>
<td>0.8</td>
</tr>
<tr>
<td>Gastrointestinal bleed</td>
<td>1</td>
<td>0.8</td>
</tr>
<tr>
<td>Acute myocardial infarction</td>
<td>1</td>
<td>0.8</td>
</tr>
<tr>
<td>Cerebrovascular accident</td>
<td>2</td>
<td>1.6</td>
</tr>
</tbody>
</table>
patients but our survival rate of 47% compares favourably
with survival following first time mitral valve replacement
(55% at 10 years: UK valve Registry). All non-randomised
studies have the potential for selection bias but the right
thoracotomy cases represented a significant proportion
(29.6%) of our overall re-operative workload for mitral
valve surgery. Thus, we believe that apart from satisfying
the criteria for this approach, the procedure was made
readily available to all suitable patients by those surgeons
with an interest in this technique. We are currently con-
ducting a further study comparing the outcomes of redo
sternotomy and right thoracotomy for revisional mitral
valve surgery.

Normothermic perfusion reduces the risks of induced
hypothermia including coagulopathy in a patient group
susceptible to this complication. Our mean blood loss was
581 ml, which is less than our experience with for mitral
valve re-operations through a median sternotomy when our
mean blood loss is currently 843 ml. This is consistent with
other published experience with the right thoracotomy
approach for prosthetic mitral valve replacement. These
have demonstrated decreased blood loss [10] and a 50% 
reduction in transfusion requirement compared with con-
ventional redo-sternotomy [11]. Furthermore, it is known
that limitation of pericardial dissection in combination
with pharmacological manipulation of coagulation further
minimises blood loss [1]. In our technique, there is no
pericardial dissection. The low post-operative re-opening
rate our series of 3.2% reflects the lack of haemorrhagic
complications.

Our technique of operating on the beating heart via a
right thoracotomy with normothermic perfusion differs from
those described by Praeger [2], Cohn [5], Turina [11] and
Tribble [9]. All used some degree of hypothermia and
Pregar and Tribble also fibrillated the heart. Induced ven-
tricular fibrillation [2,9] avoids the need to cross-clamp the
aorta and deliver cardioplegia, but may not provide optimal
cardiac protection. Oxygen delivery to the left ventricle is
markedly reduced and coronary flow re-distributed away
from the sub-endocardium during electrically induced
fibrillation [12]. We believe that allowing the myocardium
to beat at normothermia with maintenance of normal
coronary perfusion offers optimal myocardial protection
with better preservation of myocardial blood flow distri-
bution. This is of particular importance in patients with
long-standing mitral valve disease who frequently have
impaired ventricular function, a particular problem when
such patients present in an emergency. We have experi-
cenced a relatively low inotropes support after revisional
mitral valve surgery (28.8%). Considering the nature of
patient population, low figure may reflect inherent advan-
tage of maintaining continuous myocardial protection. It is
also the case that the right thoracotomy approach avoids
retraction compression of the right ventricle.

We have no data regarding transient neurological
dysfunction and in a retrospective study of this nature
such data would be difficult to obtain in a reliable manner.
We, therefore, chose a ‘hard’ criterion i.e. CVA that we
would also suggest is the issue of importance as transient
dysfunction does not represent a long-term problem. The
overall CVA rate in our series (1.6%) was remarkably low.
This may relate in part to the avoidance of aortic cross-
clamping in elderly patients. It also clearly demonstrates
that the operative technique offers a secure guarantee
against air embolism. The most frequent post-operative
complication was pulmonary infection, which occurred
in 24% of cases. Tribble [9] suggested that pulmonary
function might be more compromised than with a
median sternotomy approach. This would be a logical
consequence of the thoracotomy approach but, in our
experience, the mean ventilation time of 44 h is no longer
than that required following mitral valve re-operation
through a sternotomy.

5. Conclusion

In our experience, revisional mitral prosthetic valve
replacement undertaken through a right thoracotomy
approach on a beating heart with normothermic perfusion
has proved to be a safe, effective and reliable technique.
Operative access is excellent. The perioperative mortality
is relatively low at 6.4% and the CVA rate particularly
encouraging at 1.6%. Blood loss would appear to be reduced
also. We commend this technique as having general benefit
in all revisional mitral valve surgery but there may be areas
of particular benefit. Aortic cross-clamping is not necessary
which is likely to be advantageous in elderly patients;
difficult dissection is avoided which may be relevant where
previous sternal infection has occurred and patent coronary
grafts can be preserved. It is also likely that this technique
may have further application in the field of minimal access
mitral valve surgery.
References


Appendix A. Conference discussion

Mr Ottavio Alfieri (Milan, Italy): Why do you think that this technique is not widely used and generally not well accepted? Did you experience ventricular fibrillation during manipulation of the heart?

Mr Campanella: No, for two reasons. One, you don’t manipulate the heart. The heart is well away from you.

Dr Alfieri: Yes, but if you have to replace a valve, you have to make some traction.

Mr Campanella: Yes, that’s right. I attempt to keep the temperature towards 37, 37.5, 38, the patient absolutely warm. To answer your first question, why. I think there are published data of surgical groups that have tried with hypothermia in fibrillation or with moderate hypothermia, but, again, the problem of cross-clamping the aorta, giving cardioplegia, or avoiding fibrillation. Now, fibrillation is bad, as we all know very well.

Dr R. Frater (Bronxville, New York, USA): I think the reason why people are frightened of this is there is sort of a taboo. I have encountered it numerous times. People think it is a horrible thing to do to have the heart open and beating, but if you keep your mind alert about how to prevent air from getting from the open ventricle into the aorta, it is not a problem, and you are doing it right, obviously.

Mr Campanella: What have you shown you is not theory. This is real life. Of 125 patients, we had two patients with a CVA, one was solid, and it just does not happen. That is the point.

Dr Frater: Did I miss the mention of carbon dioxide? That is very useful.

Mr Campanella: Sure. My anesthetists tell me that all the time.

Dr Frater: And there are many other little things you can do. You can put the ventricle apex up with a vent in it and get all the air out from there before you finally close.

Mr Campanella: I do the same, but in fact I put the patient’s head down with their feet right over there, and their apex is right over there, and my vent goes through the valve right over there. Absolutely.

Dr Frater: Another taboo is whether you put a vent through a mechanical valve. If you know how to do it, it is perfectly safe and easy and keep it up in the apex until all the air is out.

Mr Campanella: That’s right. It is a soft PVC, it goes very well, and we have never damaged anybody in 15 years.

Dr A. Jatene (Sao Paolo, Brazil): When I saw your presentation I remembered the early 60s where we started this surgery on the mitral valve, always you do it with this access, and I remained until that time using this access when the patient is a woman. So you can do the operation with a beating heart all of the time or you can clamp the aorta and do circulatory arrest. I think it is a good access, especially for a woman.

Mr Campanella: The bottom line is if you do a procedure that does have 15% mortality you are bound to sit down and say, what am I doing? And if you found a methodology revamped, it doesn’t matter if it is 50 years old or two months old and it works with those results, why not? That is the comment I wanted to make.

Dr M. Sousa Uva (Lisbon, Portugal): My questions have already been partially addressed. When you expose the mitral valve you may create aortic regurgitation, and the solution may be to temporarily clamp the aorta. I was wondering if you had to do that or not?

Mr Campanella: No, no, just forget it.

Dr Sousa Uva: You just put the vent?

Mr Campanella: Not even that. You put an extra sucker. Aortic incompetence is not a contraindication to the procedure. I have done about maybe 10 or 11% with aortic incompetence. You see the blood coming down all the time. You take another sucker from the perfusionist, you put it there, you sit down, nice and quiet, you work very well.

That was what we were used to and given training in years ago. I don’t know if that answers your question.

Dr D. Harris (Cape Town, South Africa): I think this is an excellent series. I like to do this procedure myself. One thing that does concern me is the risk of air embolism. Can you give me details about the two patients that had CVA’s in your series and do you think this could have been due to air embolism and do you think you should be performing TEE during the procedure to look for air?

Mr Campanella: Those two patients were, I suspect, fragment material while we were removing the valve, and also one of them was later during the post-op. So I don’t think the relation was cause and effect. Certainly that is why I was quite adamant to emphasize in 125 patients we had a 1.2% incidence of CVA. Because the first thing that you think when you start this procedure is, good Lord, what happened to the air, and if you think very carefully, once you open the atrium and your valve is incompetent, the atmospheric pressure is there, your ventricle can never win the pressure on your aortic valve. It is shot by cannula; you are pushing blood in at about 70, 80 mmHg. It just does not happen.

I brought an echo with me where you see the atrium all full of bubbles with a transmural vent, and after the operation, all the air is gone.

Dr R. Frater: Another taboo is whether you put a vent through a mechanical valve. If you know how to do it, it is perfectly safe and easy and keep it up in the apex until all the air is out.

Dr Frater: Another taboo is whether you put a vent through a mechanical valve. If you know how to do it, it is perfectly safe and easy and keep it up in the apex until all the air is out.

Mr Campanella: That’s right. It is a soft PVC, it goes very well, and we have never damaged anybody in 15 years.

Dr A. Jatene (Sao Paolo, Brazil): When I saw your presentation I remembered the early 60s where we started this surgery on the mitral valve, always you do it with this access, and I remained until that time using this access when the patient is a woman. So you can do the operation with a beating heart all of the time or you can clamp the aorta and do circulatory arrest. I think it is a good access, especially for a woman.

Mr Campanella: The bottom line is if you do a procedure that does have 15% mortality you are bound to sit down and say, what am I doing? And if you found a methodology revamped, it doesn’t matter if it is 50 years old or two months old and it works with those results, why not? That is the comment I wanted to make.