Minimally invasive aortic valve replacement via hemi-sternotomy: a preliminary report

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Abstract

Objective: Aortic valve replacement has been approached by standard sternotomy. We described a technique of aortic valve replacement where the aortic valve is exposed through a hemi-sternotomy. Good exposure is obtained for aortic valve surgery with standard aortic and right atrial cannulation to establish cardiopulmonary bypass (CPB).

Methods: From October 1996 to April 1997, 19 consecutive aortic valve replacements (AVR) via hemi-sternotomy were performed by one surgeon. The results were collected and analysed prospectively. Results are expressed as mean ± standard deviation. Nineteen patients (13 male, 6 female) had AVR with this approach. Two cases were redo AVR. The mean age was 58 ± 15 years. The New York Heart Association (NYHA) class was 2.8 ± 0.7. Results: Aortic cross clamp time was 54 ± 13 min. One of six patients requiring defibrillation after reperfusion needed conversion to full sternotomy. Four patients were extubated at the conclusion of surgery. One patient died 4 h postoperatively from low cardiac output. All patients had normal valvular function demonstrated on postoperative transoesophageal echocardiography. There were no neurological events.

Conclusions: Minimally invasive aortic valve replacement can be safely performed via hemi-sternotomy with standard equipment. Less surgical trauma to the sternum has the potential benefit of less pain and shorter intensive care and hospital stay.

Keywords: Minimally invasive aortic valve replacement; Hemi-sternotomy

1. Introduction

Minimally invasive surgical procedures have been well established in general surgery, with the advantages of less wound morbidity and shorter hospital stay. Cannulations to conduct cardiopulmonary bypass (CPB) and exposure of cardiac structures require a full sternotomy. Recently, Cosgrove described a technique of minimally invasive aortic valve operation through a right parasternal incision [1]. Some surgeons have performed aortic valve surgery via an upper sternotomy with an inferior ‘T’ to horizontally transect the sternum. Konertz has described a superior para-median sternotomy for access to the ascending aorta and pulmonary artery [2]. The above approaches to aortic valve replacement have the disadvantages of disrupting the sternum and in some cases dividing the internal thoracic arteries. Our approach to the aortic valve uses an upper partial median sternotomy (hemi-sternotomy) without trans-ecting the sternum. With this approach, the aortic valve is well exposed and CPB can be established using standard aortic and right atrial appendage cannulation. This offers a stable sternum, with no risk of injury to the internal thoracic artery and has the potential benefit of shorter post-operative recovery with reduced surgical trauma.

2. Methods

From October 1996 to April 1997, 20 consecutive patients referred to one surgeon for isolated AVR were asked to consider surgery via hemi-sternotomy. Nineteen patients consented. Patients requiring coronary artery bypass or other valve procedures were excluded. Data were collected prospectively. All patients were followed up with echocardiography to assess valve function and at the out-patient clinic. Paired parameters were tested with Student’s t-test. There were 13 male and six female patients, with a mean age of 58 ± 15 years. Fourteen patients had aortic stenosis, four had aortic regurgitation, and one had...
mixed disease. Two male patients had previous AVR. One had xenograft degeneration 18 years after his initial surgery. The other had a ‘ball cage’ valve associated with symptomatic paravalvular leak. The pre-operative New York Heart Association (NYHA) class of patients was 2.8 ± 0.7. The pre-operative ejection fraction (EF) was 54 ± 18% ranging from 25 to 86%.

2.1. Operative technique

The patient is prepared and monitored in standard fashion. External defibrillator pads are placed anteriorly and posteriorly on the left lateral chest wall. A skin incision is made from below the sternal notch to the fourth intercostal space. The upper half of the sternum is divided in the midline with a sternal saw. A Tuffier retractor is placed to expose the superior mediastinum. The pericardium is opened longitudinally and sutured to the wound with strong traction to help expose the aorta and right atrial appendage, which are then cannulated (Fig. 1). One patient who had previous aortic valve replacement required right femoral vein cannulation because of scarring of the right atrial appendage, which precluded safe cannulation. A retrograde coronary sinus cannula is inserted at this stage or after CPB is established which improves exposure of the remainder of the right atrium. The position of the retrograde cannula is checked with wave-form tracing and appropriate pressure rise on injection of normal saline solution. Further assessment may be made with transoesophageal echocardiography.

After the venous cannula is secured and tied with a heavy ligature, the undivided end of the ligature is then passed through a stab wound in the right fifth or sixth intercostal space. Traction is applied to the tie which will draw the right atrial appendage and the venous cannula to the right and inferiorly. The venous and coronary sinus cannulas are tucked under the cross bar of the retractor. This provides excellent exposure of the aortic root. Cardiopulmonary bypass is established and the patient is cooled to 32°C. The aorta is encircled with a tape and cross-clamped. Cold crystalloid cardioplegia is infused via the aortic root and coronary sinus.

An oblique aortotomy extending to the non-coronary sinus is made. The left ventricle is vented through the aortic valve. Alternatively a vent may be placed in the left atrial appendage. Due to the small incision this is only accessible once the patient is on bypass and the pulmonary artery has collapsed. Using stay stitches to each commissure, the aortic valve is hitched towards the wound to improve exposure. The aortic valve is replaced in the usual manner (Fig. 2), During aortotomy closure, the vent is withdrawn to allow the left ventricle to fill. The heart is de-aired through the aortic vent and the left atrial vent, if this has been inserted. Transoesophageal echocardiographic monitoring is used to determine that the heart is adequately de-aired [3]. Atrial and ventricle pacing wires may be inserted in the standard fashion. The hemi-sternotomy is closed with three parasternal wires. A single chest drain is inserted.

3. Results

Fourteen mechanical and five bioprosthetic valves were implanted, with a mean size of 23 ± 3 mm. The mean bypass time was 76 ± 24 min and the aortic cross clamp (ischaemic) time was 54 ± 13 min. De-airing of the heart during weaning of CPB was satisfactory in all cases on transoesophageal echocardiography monitoring. One patient required conversion to full sternotomy due to persistent ventricular fibrillation when the heart was reperfused. Multiple attempts at defibrillation were unsuccessful and large defibrillating pads were required to revert the heart to sinus rhythm. The patient subsequently made an uncomplicated recovery.

The post-operative blood loss was 634 ± 592 ml. The time to extubation from completion of surgery was 13 ± 9 h. Four patients were extubated at the completion of surgery, and a further three prior to 6 h. Eight patients were discharged to the ward within 24 h, with a mean ICU stay of
2.1 ± 1.7 days. Hospital stay ranged from 5 to 39 days with a median of 6 days.

One patient died 4 h postoperatively from low cardiac output. He had end-stage aortic stenosis compounded by severe chronic obstructive pulmonary disease (COPD) with acute exacerbation. His ejection fraction preoperatively was 18%. His COPD was stabilised 3 weeks preoperatively and it was felt that the minimally invasive approach would offer the patient less respiratory morbidity. There were no re-operations for bleeding. One patient required sub-xiphoid drainage of a moderate size pericardial effusion 6 days post-operatively. This was attributable to the retrosternal chest drain being dislodged 5 h postoperatively.

Two patients had superficial wound infections. One was a patient with complete heart block who also had a superficial MRSA wound infection. His pacemaker site was also infected and this required removal of the pacemaker. Sinus rhythm returned not long after and his wound healed satisfactorily with intravenous antibiotics.

No patients had gross neurological deficit postoperatively. There were no significant change in cardiac function pre- and post-operatively on echocardiographic assessment (EF 55.8 ± 16.5% vs. 56.6 ± 14.4%, respectively).

4. Discussion

We have found that hemisternotomy without transecting the distal end is an alternative to full median sternotomy in aortic valve surgery. Other minimally invasive approaches require greater exposure and result in a potentially unstable segment of the chest wall. A horizontal transection results in a small area of coaption which is difficult to stabilise, and if conversion to full sternotomy is required then the sternum is in four fragments which is difficult to wire. There is risk of injury to the internal thoracic vessels when the sternum is divided horizontally. Thoracotomy or transverse approaches are painful and conversion to sternotomy is not possible. In our series the sternum fractured inferiorly in four cases, however the periosteum was always intact and the sternum stable.

Our technique does not require exposure of the right superior pulmonary vein for venting of the left ventricle. If the left atrial appendage is not easily accessible, venting may be safely performed through the aortic vent. Owing to this, less exposure is required and the sternum does not become disrupted through excessive distraction. Other advantages are that cardiopulmonary bypass can be established without a groin incision for femoral cannulation, no special equipment is required, and standard anterograde and retrograde cardioplegia can be delivered. The actual technique of valve replacement is no different from a standard approach, and this approach may be employed even if root enlargement techniques are required.

There is no risk of complete sternal wound dehiscence with wound infection. As the linea alba is not incised there is no risk of epigastric hernia formation. The chest is not widely opened, therefore there is less risk of traction injuries of the brachial plexus. The small incision, with less wound morbidity, is more acceptable to patients and may have potential advantages of early extubation, shorter intensive care and hospital stay.

As with any less invasive approach, it is important that the smaller incision does not reduce the safety of the procedure, and that the principal operation is not limited for the sake of access. We have demonstrated that this approach can be done safely both in primary and re-operative surgery with normal postoperative aortic valve function, and no significant reduction in left ventricular function. With the routine use of intraoperative transoesophageal echocardiography to monitor de-airing, we have found that the removal of air through the aortic vent is complete. Clinically there were no neurological events.

Defibrillation may be performed using either external pads or paediatric defibrillation paddles. The hemi-sternotomy may be quickly converted to a full sternotomy if the need arises. This was required in one case where cardioversion from ventricular fibrillation was not successful with paediatric defibrillation paddles. The patients undergoing this procedure were unselected and included patients with poor left ventricular function who are at high risk. Despite this the morbidity and mortality were acceptable.
One of the major risks in redo cardiac surgery is right ventricular injury during re-sternotomy. This is due to right ventricular adhesion to the inner table of the sternum. Using this approach this risk is completely eliminated. Conversely, patients who have undergone hemi-sternotomy requiring re-operation in the future will have this risk minimised.

One of the major post-operative morbidities in cardiac surgery is sternotomy wound pain. This may severely limit the patient’s inspiratory effort, cough and ability to perform chest physiotherapy. The divided sternum takes 3 months to unite and initial instability is a major source of pain and discomfort. There are potential benefits in any procedure where post-operative pain and sternal instability can be reduced. We believe that AVR via hemi-sternotomy has less surgical trauma and will assist in a shorter recovery after surgery.

References