

Outcomes of Aortic Valve and Concomitant Ascending Aorta Replacement Performed via a Minimally Invasive Right Thoracotomy Approach

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Objective: Replacement of the aortic valve with concomitant replacement of the ascending aorta performed via a minimally invasive right anterior thoracotomy approach has not been reported. We evaluated the feasibility and safety of this procedure.

Methods: We retrospectively reviewed all minimally invasive aortic valve replacements (AVRs) with concomitant replacement of the ascending aorta performed at our institution between January 1, 2012, and December 30, 2012. The operative times, intensive care unit and hospital lengths of stay, postoperative outcomes, as well as mortality were analyzed.

Results: A total of 20 consecutive patients who underwent minimally invasive AVR with concomitant replacement of the ascending aorta were identified. There were 16 men (80%), with a mean (SD) age of 61 (13) years. The mean (SD) left ventricular ejection fraction was 58% (8%). The aortic valve was bicuspid in 18 patients (80%), with 14 (70%) being stenotic. The median aortic cross-clamp and cardiopulmonary bypass times were 163 [interquartile range (IQR), 141–170] minutes and 291 (IQR, 177–215) minutes, respectively. Hypothermic circulatory arrest was required in 19 patients (95%), with a median hypothermic circulatory arrest time of 35 (IQR, 33–39.5) minutes. The median intensive care unit and hospital lengths of stay were 24 (IQR, 23–41) hours and 5 (IQR, 4–6) days, respectively. There were no strokes, reoperations for bleeding, or conversions to sternotomy. The 30-day mortality was zero.

Conclusions: Minimally invasive AVR with concomitant replacement of the ascending aorta, via a right anterior thoracotomy approach, can be performed with low morbidity and mortality.

Key Words: Minimally invasive surgery, Aortic valve replacement, Ascending aortic aneurysm.

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Dilatation of the ascending aorta is common in the setting of aortic valve pathology.¹ The most common surgical approach to replace the aortic valve and the ascending aorta is a

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median sternotomy. Minimally or less invasive approaches have been developed to perform this type of surgery, mostly involving some type of partial sternotomy. At our institution, a right anterior thoracotomy approach is the preferred minimally invasive technique used for aortic valve pathology.^{2–4} Hereby, we present a subset of patients who required aortic valve replacement (AVR) with concomitant replacement of the ascending aorta via a minimally invasive right anterior thoracotomy.

PATIENTS AND METHODS

After obtaining approval from the institutional review board, we retrospectively reviewed all heart operations at our institution between January 1, 2012, and December 30, 2012, to identify the patients who underwent AVR with concomitant replacement of the ascending aorta via a minimally invasive right anterior thoracotomy approach.

All patients had their valvular lesions documented by diagnostic catheterization and echocardiography. A preoperative computed tomography scan was performed in all patients. All preoperative data, in-hospital outcomes, and postdischarge outcomes were reviewed. The definitions and variables selected were based on The Society of Thoracic Surgeons Database definitions. The surgical technique time was evaluated on the basis of aortic cross-clamp and total cardiopulmonary bypass times. The operative variables, blood transfusion requirement, operative morbidity, intensive care unit and hospital lengths of stay, as well as 30-day mortality were analyzed. All patients were evaluated clinically 30 days postoperatively with a follow-up visit with the surgeon.

Surgical Technique

All patients were approached via a right 6-cm anterior thoracotomy incision over the second or the third intercostal space, and the third or the fourth costochondral cartilage is dislocated (Fig. 1). Cannulation for cardiopulmonary bypass was performed from the femoral artery and vein. Cardioplegia was delivered in retrograde fashion via direct coronary sinus cannulation through a cannula placed via the right atrial appendage and in antegrade fashion via the coronary ostia. Left ventricular venting was established with a cannula placed directly into the right superior pulmonary vein. There were 12 patients (85.7%) who required hypothermic circulatory arrest and were cooled to 20°C, whereas 2 patients (14.3%) underwent direct aortic cross-clamping performed directly through

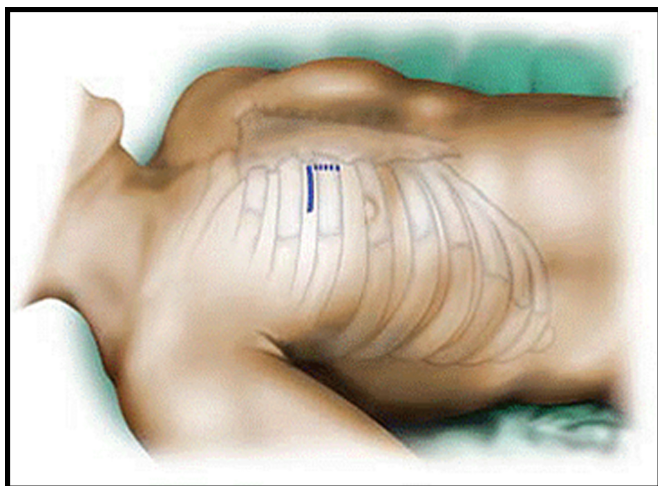


FIGURE 1. Minimally invasive right thoracotomy approach for aortic valve and ascending aorta replacement. A right 6-cm transverse parasternal incision is made over the second or the third intercostal space, and the third or the fourth costochondral cartilage is dislocated.

the thoracotomy incision. The patients requiring circulatory arrest had retrograde cerebral perfusion, which was performed with a 24F venous cannula inserted through the chest tube incision then into the superior vena cava cannula. Replacement of the ascending aorta and the aortic valve proceeded in the usual manner as it would via a sternotomy incision. A two-layer closure of both suture lines was performed. After arresting the heart and cooling began, when indicated, the dilated portion of the aorta and the aortic valve were resected, leaving the aortic root at the level of the sinotubular junction in place. The amount of the distal ascending aorta removed was tailored on the basis of the pathology. If circulatory arrest was used, anastomosis of the graft to the distal aorta was performed first. If circulatory arrest was not used, the proximal anastomosis was easier to perform first. Afterward, cardiopulmonary bypass was commenced, and a clamp was placed on the graft just proximal to the suture line. The remainder of the procedure continued as usual, first replacing the aortic valve then completing the graft anastomosis to the sinotubular junction of the native aorta. After removal of air from the graft, the patient was weaned off cardiopulmonary bypass. The cannulas were removed. A pleural chest tube and a flexible pericardial tube were placed. The incision was closed in the usual fashion.

Statistical Methods

Continuous variables are shown as mean (1 SD) or median and interquartile range (IQR) (25%–75%), as appropriate. The statistical analyses were performed using the Statistical Package for the Social Sciences, version 17 (SPSS Inc, Chicago, IL USA).

RESULTS

There were 20 consecutive patients identified who underwent AVR with concomitant replacement of the ascending aorta through a minimally invasive right anterior thoracotomy approach. There were 16 men (80%) and 4 women

(20%), with a mean (SD) age of 61 (13) years. Their mean (SD) left ventricular ejection fraction was 58% (8%), and none of them had a previous heart surgery. Most of the patients had bicuspid aortic valves (90%). Fourteen patients (70%) had aortic stenosis, three (15%) had aortic insufficiency, and three (15%) had combined stenosis and insufficiency. The mean (SD) diameter of the ascending aorta was 45 (4) mm. All patients had dilatation of the ascending aorta that began at the sinotubular junction, and in 18 of them, this dilatation extended to the proximal arch (Table 1).

The median aortic cross-clamp time was 163 (IQR, 141–170) minutes, whereas the median cardiopulmonary bypass time was 201 (IQR, 177–215) minutes. Most of the patients (95%) had circulatory arrest with a hemiarch technique, and their median hypothermic circulatory arrest time was 35 (IQR, 33–39) minutes. One patient did not require circulatory arrest and therefore had a tube graft sewn from the distal ascending aorta just proximal to the aortic cross-clamp (Table 2). Adequate surgical exposure was obtained in all patients, and there were no conversions to sternotomy performed.

The median ventilation time was 11 (IQR, 6–25) hours. The median chest tube drainage in the first 24 hours was 520 (IQR, 450–710) mL, whereas the median intensive care unit length of stay was 24 (IQR, 22–48) hours. There were no significant postoperative complications noted, including reoperation for bleeding, renal failure, cerebrovascular accidents, or in-hospital deaths. The median length of hospital stay was 5 (IQR, 4–6) days, and the 30-day mortality rate was zero (Table 2).

DISCUSSION

Indications for concomitant AVR with replacement of the ascending aorta exist.^{5,6} Most notably, the association of dilatation of the ascending aorta in the setting of a bicuspid aortic valve is even more concerning because of the higher

TABLE 1. Patient Demographics

Variables	No. Patients (N = 20)
Age, mean (SD), y	61 (13)
Men	16 (80%)
Body mass index, mean (SD), kg/m ²	27.7 (5)
Ejection fraction, mean (SD), %	58 (8)
Aortic valve pathology	
Calcific degeneration	2 (10%)
Bicuspid aortic valve with fusion of the right and left coronary cusps	14 (70%)
Bicuspid aortic valve with fusion of the right and noncoronary cusps	4 (20%)
Aortic valve lesion	
Stenosis	14 (70%)
Insufficiency	3 (15%)
Combined stenosis and insufficiency	3 (15%)
Ascending aortic diameter, mean (SD), mm	45 (4)
Congestive heart failure	1 (5%)
Diabetes mellitus	4 (20%)
Hypertension	15 (75%)
Preoperative creatinine level, mean (SD), mg/dL	0.9 (0.2)

TABLE 2. Procedural Characteristics and Postoperative Results

Aortic cross-clamp time, median (IQR), min	163 (141–170)
Cardiopulmonary bypass time, median (IQR), min	201 (177–215)
Patients requiring hypothermic circulatory arrest, n (%)	19 (95)
Hypothermic circulatory arrest time, median (IQR), min	35 (33–39)
No. units of packed red blood cells transfused, median (IQR)	1 (0–3)
Ventilation time, median (IQR), h	11 (6–25)
Chest tube drainage for 24 h, median (IQR), mL	520 (450–710)
Prolonged intubation	1 (5%)
Intensive care unit length of stay, median (IQR), h	24 (23–41)
Intensive care unit readmission	0
Postoperative atrial fibrillation	2 (10%)
Sepsis	0
Reoperation for bleeding	0
Acute kidney injury	0
Cerebrovascular accidents	0
Hospital length of stay, median (IQR), d	5 (4–6)
Thirty-day mortality	0

IQR indicates interquartile range.

incidence of postoperative aortic complications.^{6–8} With minimally invasive aortic valve surgery becoming more common, more complex pathology is being addressed via smaller incisions.

Various different minimally invasive approaches have been used for surgery of the aortic root and the ascending aorta. These include an upper T incision⁹; right-side partial sternotomy¹⁰; upper J incision^{11,12}; S-shaped partial sternotomy¹³; right parasternal incision^{14,15}; T incision¹⁶; L incision¹⁷; as well as Z, I, and reversed C-shaped ministernotomy incisions.^{18–20} In a review of all these techniques, it was concluded that not only is a minimally invasive approach for complex aortic pathology feasible, but there were significant advantages when compared with conventional sternotomy, which included reduced postoperative bleeding and pain, lower risk for mediastinitis, better esthetic results, as well as faster respiratory function recovery.⁹

Deschka et al²¹ recently published a series of 50 patients who underwent surgery of the ascending aorta and arch via upper partial sternotomy. They reported excellent clinical outcomes with short intensive care unit and hospital lengths of stay. Similarly, Byrne et al²² reported their series of 290 consecutive patients who underwent aortic valve, aortic root, and/or ascending aorta replacement via either a partial upper sternotomy or a parasternal approach. They found that this approach was feasible with acceptable incidence of complications without compromising the surgical procedure. Tabata et al²³ performed a retrospective review of 128 patients who had ascending aortic, arch, and root surgery via an upper ministernotomy. They were able to follow their patients for 5 years. They concluded that not only was this approach feasible for complex aortic pathology, but they had an excellent 5-year survival of 97.2%.

Much of the literature reviewed shows the feasibility and outcomes of minimally invasive techniques for complex aortic pathology involving some type of partial sternotomy. We discuss our novel technique of performing minimally invasive complex aortic surgery with AVR via a right anterior thoracotomy, without any sternal invasion. We have performed 20

procedures through this approach. Our results revealed acceptable intraoperative and postoperative intensive care unit and total hospital lengths of stay, with no neurological and bleeding complications as well as no deaths at 30 days. We favor a right anterior thoracotomy approach to perform this procedure because we hypothesize that, by not performing any type of sternotomy, it will lead to less surgical trauma and thereby may lead to better outcomes.

The present study included patients with aortic valve disease and dilatation of the aorta that extended up to but not into the arch and had a well-defined or normal sinotubular junction. Therefore, the surgery involved replacing the aortic valve and the ascending aorta, sparing the aortic root. We have since performed, via the same approach, replacement of the aortic valve, the root with coronary reimplantation, and the ascending aorta in four patients, who have achieved similar results.

A preoperative computed tomography scan was performed in all patients to better delineate the anatomy as well as determine the presence and extent of calcification of the aorta. The patients excluded from this procedure were those in whom the ascending aorta was not greater than 4.5 cm in diameter. A calcified ascending aorta is not a contraindication to this procedure. However, if the aortic arch is heavily calcified, then these patients would require a sternotomy.

Study Limitations

The current study is subject to the limitations inherent in a single-center, retrospective study design. The sample size is small, and the patients are fairly homogeneous in that all had bicuspid aortic valve pathology. The patients were young, with no significant comorbidities. The follow-up period is limited to 30 days. All operations were performed by a single surgeon (JL). It is important to mention that our results are applicable to minimally invasive surgery by a right minithoracotomy, as described in Methods, and cannot be extrapolated to other techniques. A limitation of the minimally invasive minithoracotomy procedure is that antegrade cerebral perfusion cannot be performed because the head vessels cannot be clamped or occluded. We have not performed this procedure on patients with a prior sternotomy or prior right thoracotomy, so presently, we consider this to be a relative contraindication to this procedure.

CONCLUSIONS

Minimally invasive aortic valve and ascending aorta replacement via a right anterior thoracotomy approach can be performed with low morbidity and mortality. It should be considered an option in patients with concomitant aortic valve disease and dilatation of the ascending aorta.

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CLINICAL PERSPECTIVE

This is a retrospective case series from Dr LaPietra and his group at Mount Sinai Heart Institute in Miami, FL USA. They reported on 20 consecutive patients who underwent minimally invasive aortic valve replacement with concomitant replacement of the ascending aorta. It was a relatively low-risk group of patients, with a mean ejection fraction of 58%. The great majority of patients had bicuspid aortic valve disease. Hypothermic circulatory arrest was required in 19 patients, with a median circulatory arrest time of 35 minutes. There was no 30-day mortality, and there were no strokes, reoperations for bleeding, or conversions. The authors concluded that minimally invasive aortic valve replacement with concomitant replacement of the ascending aorta via a right anterior thoracotomy approach can be performed with low morbidity and mortality.

The authors are to be congratulated for their excellent results. However, readers are to be reminded that this is one of the most experienced groups in the country in minimally invasive surgery, and these excellent results may not be able to be replicated in less experienced centers. Whether this approach can be widely recommended requires further study.