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Concomitant Aortic Valve and Ascending Aorta Replacement Approach for Mini-Thoracotomy in Bicuspid Aortic Valve Patients

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Abstract

Bicuspid aortic valve can progress to aortic valve dysfunction and associate aortic aneurysms commonly. Minimally invasive aortic valve replacement surgery has been popularized recently. Concomitant mini-thoracotomy aortic valve and ascending aorta replacements, however, has limited evidence. We show our experience of aortic valve and ascending aorta replacement through mini-thoracotomy. Two patients undergoing minimally invasive aortic valve and ascending aorta replacement at our institution from September, 2021 to February, 2022 were enrolled. They were discharged at 14th and 15th postoperative day. No one need to converse to full sternotomy. Minimally invasive aortic valve replacement with ascending aorta replacement is safe and feasible option in selected patients. It has smaller incision, less bone bleeding, earlier mobilization and shorter length of stay in comparison with full sternotomy. Further data collection might be warranted.

Keywords: Minimally invasive surgery; Right anterior thoracotomy; Aortic valve replacement; Ascending aortic aneurysm; Replacement of ascending aorta

Introduction

A Bicuspid Aortic Valve (BAV) is one of the most common congenital cardiac anomalies and can progress to aortic valve dysfunction. Associated aortic aneurysms have been reported in 20% to 40% of patients with BAV [1]. Thus, Aortic Valve Replacement (AVR) with Ascending Aorta Replacement (ASAR) in patients with a BAV is recommended earlier than in tricuspid aortic valve patients when valve dysfunction and an aortic aneurysm occur [2]. In BAV patients with aortic valve disease and an ascending aortic aneurysm, full sternotomy (FS) is the conventional standard approach in surgical treatment. However, several minimally invasive techniques have been developed as an alternative to reduce the invasiveness of the surgical procedure, while maintaining the quality and safety of the standard approach. Compared to conventional surgery, Minimally Invasive Aortic Valve Replacement (MI-AVR) has been shown to reduce postoperative mortality, morbidity, and pain while providing faster recovery, a shorter hospital stay, and better cosmetic results **[3].** Therefore, many clinical centers have been performing AVR via mini-sternotomy or mini-thoracotomy with better quality than FS. However, there is little evidence regarding the use of Right Anterior Thoracotomy (RAT) for AVR concomitant with ASAR. In this article, we describe our technique and experience in performing AVR with ASAR through RAT at the same time.

Methods

The study was approved by the Institutional Review Board. Data were retrospectively collected from 6 consecutive patients who underwent AVR with ASAR at our institution from January 2021 to March 2022. All surgical procedures were performed by a single surgeon. Among them, two patients underwent RAT for BAV by concomitant AVR and ASAR and were enrolled in the study.

Patient selection

The indications for AVR with ASAR via RAT in patients with a BAV were the following: (1) patients with severe aortic valve dysfunction with an ascending aortic aneurysm requiring AVR with ASAR **[4];** (2) suitability for RAT, indicated by an ascending aorta located greater than 50% rightward in respect to the right sternal border at the level of the pulmonary artery bifurcation, and an alpha angle of > 45° **[5];** and (3) no root dilatation (< 45 mm) and no arch dilatation.

Surgical procedure

After anesthetic induction with a double-lumen endotracheal tube, external defibrillator pads were placed with the patient in the supine position. Intraoperative transesophageal echocardiography was used in all patients. An approximately 6- to 8-cm skin incision was placed horizontally along the right second intercostal space anteriorly. After the right lung was deflated, the right pleural cavity was entered and the third costal cartilage was disarticulated proximally and distally for better visualization. A soft tissue retractor (Alexis®, Modesto, CA, USA) and a rib spreader were used for optimal exposure. The right internal thoracic artery and vein were divided using metal clips. Because of aortopathy of the thoracoabdominal aorta in all patients, the right axillary artery was cannulated via a right infraclavicular approach using a 5cm transverse incision for arterial perfusion. Bicaval venous cannulations were done by the superior vena cava directly and the inferior vena cava percutaneously via the femoral vein by the Seldinger technique. After cardiopulmonary bypass was established, the left ventricle was vented via the right superior pulmonary vein and the surgical field was flooded with carbon dioxide. An aortic cross-clamp was applied and antegrade cardioplegia was delivered by root cannula because there was no aortic valve regurgitation. No deep hypothermic circulating arrest was used. Aortotomy was performed circumferentially 1 cm above the sinotubular junction, and the aneurysmal ascending aorta was resected under the aortic cross-clamp that was repositioned as distally as possible **(Figure 1A).** After three retracting sutures were placed at the commissures and tagged to the skin, the diseased aortic valves were removed. Sutured AVR with bioprosthetic valve was performed in a classic maneuver, then the ascending aorta was replaced (first proximal aorta anastomosis was performed, then distal aorta anastomosis) **(Figure 1B and**

C). After a temporary pacing wire was placed, then the aortic cross-clamp was removed, and patients were weaned uneventfully from cardiopulmonary bypass. The divided third costal cartilage was repaired during wound closing. In patient 1, a root enlargement procedure was added using a prosthetic vascular graft because of a small aortic root.

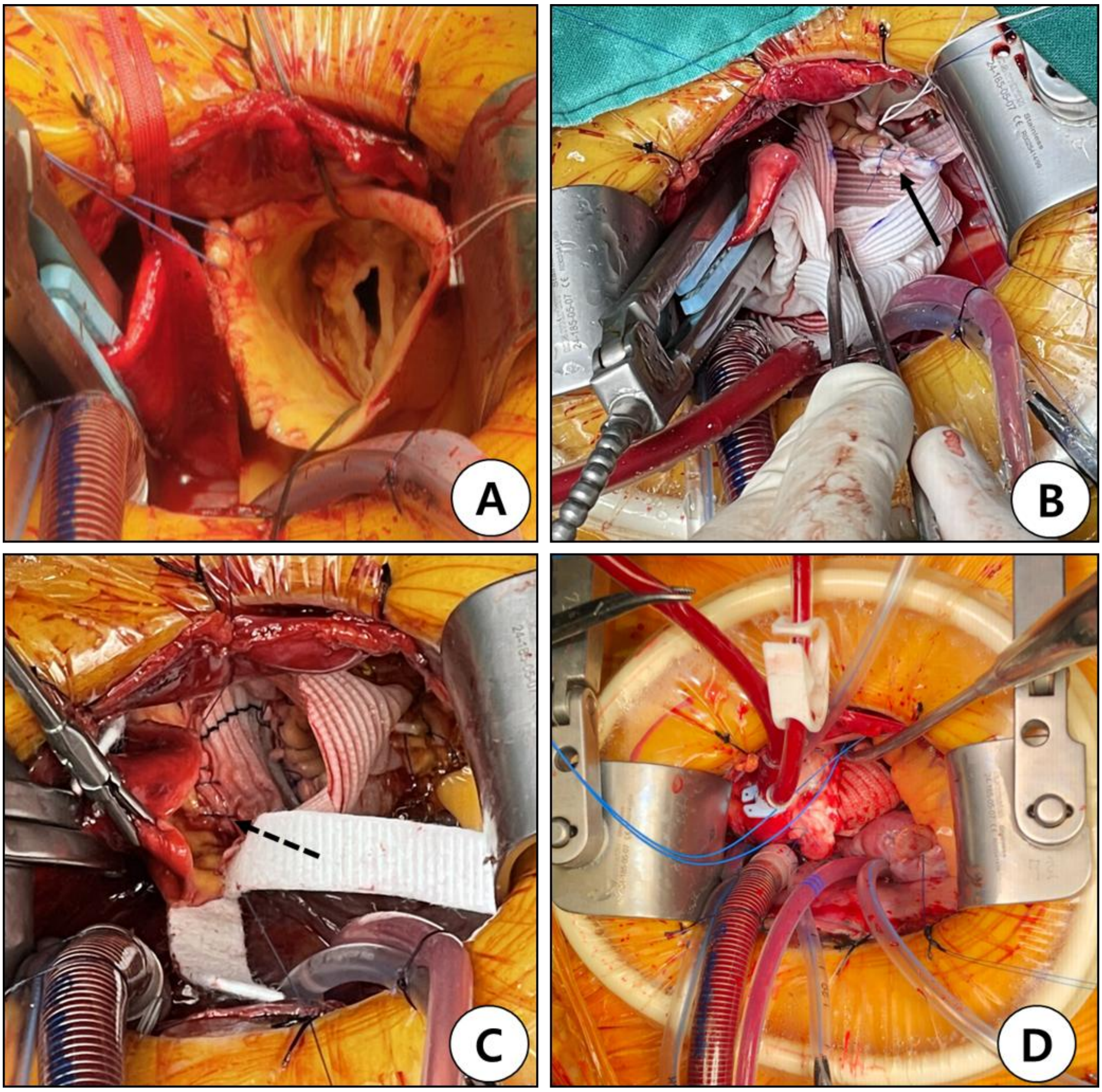

Figure 1: Images of the surgical procedures. (A) After aorta transection about 1 cm above the sinotubular junction, the bicuspid aortic valve was identified. After aortic valve replacement was performed, (B) proximal anastomosis (arrow) and (C) distal anastomosis (dashed arrow) were done. Before distal anastomosis, we repositioned the aortic cross-clamp as distally as possible. (D) Ascending aorta replacement was completed, and the root cannula was reinserted for de-airing.

Results

The baseline characteristics of the two patients are depicted in **Table 1**. Detailed results of the perioperative outcomes are shown in **Table 2.** The operation time was 405 and 455 minutes, respectively. The cardiopulmonary bypass time was 256 and 295 minutes, and the aortic cross-clamp time was 214 and 262 minutes, respectively. In both cases, the native aortic valve was replaced to bio-prosthetic valve (Carpentier-Edwards Perimount Magna®; Edwards Lifesciences Inc.). Vascular grafts (Vascutek®; Ltd., Renfrewshire, Scotland, UK) with sizes of 30 mm and 32 mm, respectively, were used.

Table 1: Baseline characteristics of the patients

	Patients 1	Patient 2
Age/Sex	67/female	83/male
BSA (m^2)	1.39	1.91
DM	-	-
HTN	-	-
COPD	-	-
CKD	-	-
CCr	57.62	46.22
LVEF (%)	61	66
AVPG	121	75
NYHA class	II	II
EuroScore II	1.61	3.49
STS PROM	1.377	2.509
Aneurysm[1)] (mm)	50	59
SoV (mm)	34	37

BSA: body surface area; DM: diabetes mellitus; HTN: hypertension; COPD: chronic obstructive pulmonary disease; CKD: chronic kidney disease; CCr: creatinine clearance rate; LVEF: left ventricular ejection fraction; AVPG: aortic valve pressure gradient; NYHA: New York Heart Association; STS PROM: Society of Thoracic Surgeons score predicted risk of mortality; SoV: maximum diameter of the sinus of Valsalva; Aneurysm[1)], maximum diameter of the ascending aorta aneurysm

Table 2: Perioperative data on the patients.

	Patient 1	Patient 2
Operative time (min)	405	455
CPB time (min)	256	295
ACC time (min)	214	262
Valve type	Type 0	Type 1
Prosthesis size (mm)	23	23
Graft size (mm)	32	30

CPB: Cardiopulmonary Bypass; ACC: Aortic Cross-Clamp

The ventilator time was 14 and 15 hours and the intensive care unit length of stay was 43 and 47 hours, respectively. The patients were discharged on the 14th and 15th postoperative days. In patient 2, one pint of packed red blood cells was transfused immediately postoperatively. Patient 1 did not need a transfusion. A Comparison of preoperative and pre-discharge echocardiography results showed that the aortic valve pressure gradient was decreased from 121 to 14 mmHg in patient 1, and from 75 to 12 mmHg in patient 2, and there was no paravalvular leakage. **Table 3** summarizes the detailed postoperative outcomes. Before discharge, follow-up computed tomography was performed on each patient, which revealed no problems **(Figure 2).**

Table 3: Postoperative data on the patients

	Patient 1	Patient 2
Ventilator time (hours)	14	15
ICU stay (hours)	43	47
Hospital stay (days)	14	15
Post OP initial Hb	10.2	9.0
Blood transfusion (RBC)	-	1 pint
6hr tube drainage	225	335
Conversion to full sternotomy	-	-
Reoperation	-	-
Follow-up AVPG	14	12
Paravalvular leakage	-	-
Wound infection	-	-
Respiratory complication[1)]	-	-
Postoperative A-fib	+	-
Mortality	-	-

ICU: intensive care unit; OP: operation; Hb: hemoglobin; RBC: red blood cells; AVPG: aortic valve pressure gradient; A-fib: atrial fibrillation; Respiratory complication[1)], pneumothorax, pneumonia, lung atelectasis, or chest tube insertion due to pneumothorax or pleural effusion

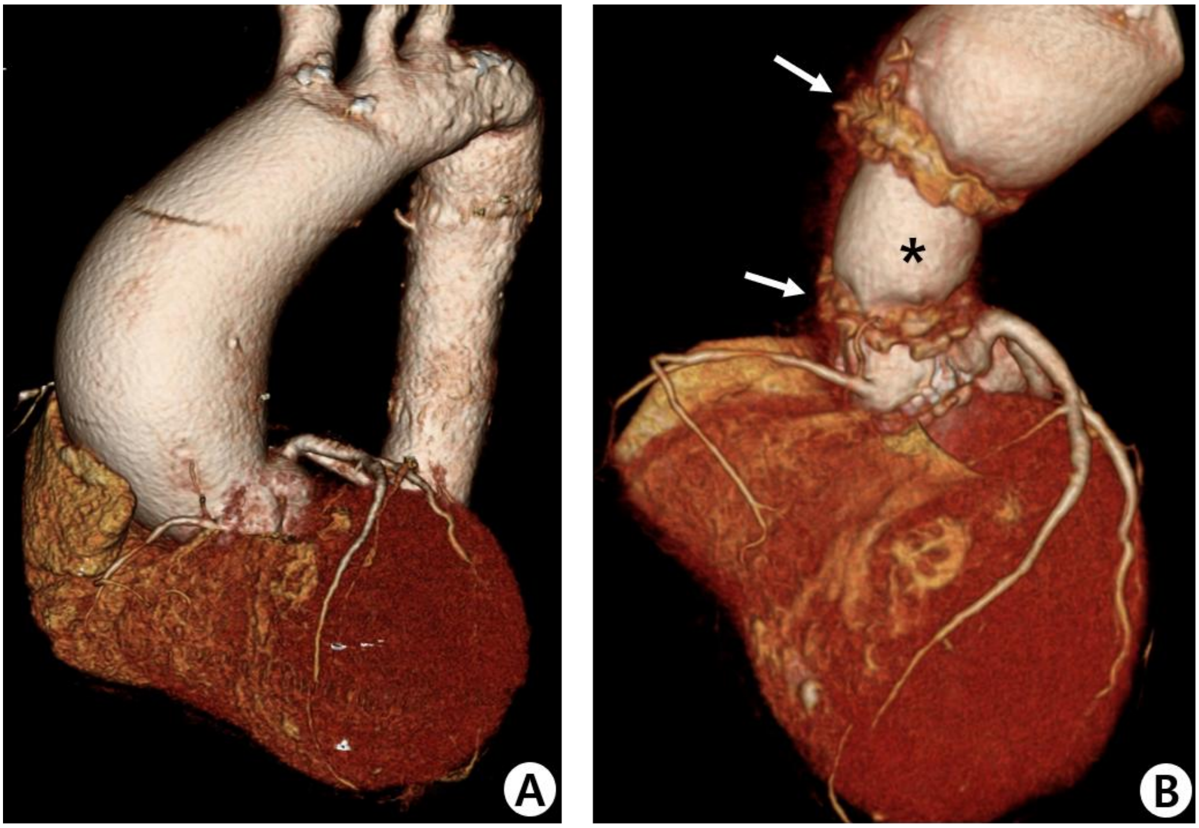

Figure 2: These images show the comparison of (A) pre- and (B) postoperative three-dimensional computed tomography in patient 2. The maximal size of the ascending aorta was decreased significantly from 59 mm to 32 mm (artificial graft (Astro-mark) was patent). The anastomotic sites are shown by an arrow.

Discussion

According to several reports, MI-AVR is safe and feasible with good results [3,6]. While it has obstacles such as a limited visual field, prolonged operation time, and other issues, the incidence of RAT surgery has increased in recent years because it has many advantages like a smaller incision and smaller scar, less bone bleeding, reductions in reoperation due to postoperative bleeding, earlier mobilization, and shorter length of hospital stay [6]. This has been further expanded for the Bentall procedure, ascending aorta replacement, and hemiarch repair, showing good results [5,7,8]. In our opinion, AVR with ASAR via RAT would share the same advantages as MI-AVR. After surgery at our center, patients had fewer respiratory complications and less pain. They were also satisfied with the cosmetic results of a small wound. Previously, we tried to AVR with ASAR via RAT in BAV by the inlay technique. In that case, the inlay technique and native aorta wrapping was used for ASAR, because we expected this method would prevent bleeding in the aorta. Additionally, we underwent rapid deployment AVR to reduce operation time. After surgery, the patient had no postoperative bleeding problems. On the follow-up chest CT, however, narrowing and torsion in the replaced portion of the aorta were found (Figure 3). We believe that this was due to hematoma and length mismatch between the native aorta and artificial graft owing to the inlay technique. On follow-up echocardiography, paravalvular leakage (less than mild grade) was noted. After that, we changed our policy from an inlay and wrapping technique to transection and graft interposition, and from rapid deployment AVR to sutured AVR in BAV patients.

Figure 3: This image show postoperative three-dimensional reconstruction heart computed tomography in the first case of aortic valve replacement with ascending aorta replacement via mini-thoracotomy in a bicuspid valve patient at our institution. The aortic replacement portion was narrowed and distorted after wrapping with the native aorta.

The Columbia University group has used the deep hypothermic circulatory arrest method for AVR with ASAR via RAT. It required an arresting time for patients with hypothermic status, so we did not use that method **[8].** After aortic transection and aneurysm resection followed by aortic cross-clamp, the working field size was increased. Thus, circumferential dissection of the distal ascending aorta was possible to the level of the innominate artery by caudal traction of the distal ascending aorta, by which we repositioned the aortic cross-clamp as distally as possible. Root enlargement was added to the procedure in patient 1 with no complications. Other procedures like septal myectomy, the Bentall procedure, the David procedure, and hemiarch repair may also be attempted via RAT. Thus, further case collections and experiences are warranted. Since there were only two cases and the surgical method has not been fully established, it is necessary to make use of the advantages and compensate for the disadvantages in the operative procedure in the future.

Conclusion

Many clinical centers have been performing MI-AVR with better quality and results than those of FS. However, there is little evidence on RAT AVR concomitant with ASAR in BAV patients. In our study, RAT AVR with ASAR had the advantages of RAT surgery and showed results similar to that of FS surgery. While further studies are warranted, we expect that RAT AVR with ASAR will be equal to or a better alternative to FS surgery in selected patients.

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