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Surgical Experience of Ascending Aorta and Aortic Valve Replacement in Patient with Calcified Aorta

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Background: The conventional method of aortic cross-clamping is very difficult and increases the risk of cerebral infarct due to embolism of the calcified aorta in these patients. Accordingly, we analyzed our experience with 11 cases of ascending aorta and aortic valve replacement with hypothermic circulatory arrest. ***Materials and Methods:*** From January 2002 to December 2009, 11 patients had ascending aorta and aortic valve replacement with hypothermic arrest at our hospital. We performed a retrospective study. ***Results:*** There were 5 males and 6 females, with a mean age of 68 years (range, 44 to 82 years). Eight patients had aortic stenosis, and 3 patients had aortic regurgitation. An aortic cannula was inserted into the right axillary artery in 3 patients and ascending aorta in 6 patients. Two patients with aortic regurgitation had a remote access perfusion catheter inserted though the right femoral artery. The mean cardiopulmonary bypass time was 180 minutes (range, 110 to 306 minutes) and mean hypothermic circulatory arrest time was 30 minutes (range, 20 to 48 minutes). The mean rectal temperature during hypothermic circulatory arrest was 21°C (range, 19°C to 23°C). No patient had any new onset of cerebral infarct or cardiovascular accident after surgery. There was no hospital mortality. Early complications occurred in 1 patient who needed reoperation due to postoperative bleeding. Late complications occurred in 1 patient who underwent a Bentall operation due to prosthetic valve endocarditis. The mean follow-up duration was 32 months (range, 1 month to 8 years) and 1 patient died suddenly due to unknown causes after 5 years. ***Conclusion:*** Patients with a calcified aorta can be safely treated with a technique based on aorta and aortic valve replacement under hypothermic circulatory arrest.

Key words: 1. Aortic valve replacement
2. Calcified aorta
3. Total circulatory arrest, induced

INTRODUCTION

With the increasing elderly population, accompanied by increased incidence of aortic calcification, of aortic valve surgery patients are going. Associated with aortic calcification in patients has been an increase in stroke and systemic embolism after operation with a traditional aortic cross clamp [1-4]. As an alternative, a balloon cross clamp in the ascending aorta may be considered in ascending aorta replacement under circulatory arrest, aortic valve replacement under circulatory arrest, apico-aortic valve conduit, and transapical aortic valve implantation The aim of this study was to evaluate the

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outcomes for the initial 11 patients who underwent ascending aorta and aortic valve replacement under circulatory arrest.

MATERIALS AND METHODS

A total of 11 patients with calcified ascending aorta received ascending aorta and aortic valve replacement under circulatory arrest between January 2000 and December 2009 at our center. This study investigated the characteristics of the patients, skill of the surgeon and operation time, and postoperative mortality and morbidity through a review of medical records. Risk factors were preoperative cerebrovascular disease (stroke, hemorrhage, and seizure), diabetes mellitus, hypertension, heart failure, combined pulmonary disease, severity of aortic stenosis, or insufficiency under echocardiogram.

All patients underwent replacement under hypothermic circulator arrest. Aortic cannulation was inserted into the right auxiliary artery in 3 patients, the right femoral artery in 2 patients, and the ascending aorta in 6 patients during extracorporeal circulation. In 2 cases with severe aortic valve regurgitation, Remote access perfusion (RAP catheter; Estech Inc., Danville, CA, USA) was inserted through the ascending aorta and femoral artery. Also in these two cases, Pruitt's catheter (Le Maitre Vascular Inc., St. Petersburg, FL, USA) was inserted into the ascending aorta without calcification and ballooned at the left ventricle outflow to prevent distension of the left ventricle for aortic insufficiency and maintain a constant cardioplegic flow during operation. We searched for the ideal balloon site through transesophageal echocardiogram in the operation room. All patients used retrograde cardioplegic and retrograde cerebral protection.

Our center performed ascending aorta replacement under hypothermic arrest and aortic valve replacement under restarted extracorporeal circulation. We also performed endarectomy of the calcified ascending aorta and reinforcement of the proximal aorta with Teflon felt fixed inner and outer layers of the aorta during ascending aorta replacement. In case of aortic cannulation at the ascending aorta, we used a branched vascular graft during ascending aorta replacement.

RESULTS

1) Patient characteristics and indication

The mean age was 68 years (range, 44 to 82 years) and 5 patients were male. Two patients exhibited porcelain ascending aorta in the preoperative chest contrast computer tomography (CT). Diagnostic methods were manual palpation during the operation for 1 patient who underwent surgery in 2002 and preoperative aorta non-contrast CT for all others. Three patients had preoperative combined cerebrovascular disease. One patient had cerebral infarct without symptoms 3 years earlier. One patient was epileptic, so he had been taking medication. Another patient had a carotid stent inserted in 2004 due to the diagnosis of left carotid totally occlusion. Two patients had combined pulmonary disease (pulmonary tuberculosis and chronic obstructive pulmonary disease) (Figs. 1, 2). The 2 patients with aortic regurgitation were diagnosed with Takayasu's vasculitis. Indications for surgery included aortic valve stenosis (8 patients) and aortic valve regurgitation valves (3 patients) that included a case of reoperation for infective endocarditis after tissue valve replacement at another hospital. Three patients with aortic valve stenosis showed a bicuspid valve (Table 1).

2) Results

Eleven patients underwent ascending aorta and aortic valve replacement under hypothermic circulatory arrest. The mean cardiopulmonary bypass time was 189 minutes (range, 110 to 136 minutes) and mean circulatory arrest time was 30 minutes (range, 20 to 48 minutes). The mean hypothermic rectal temperature was 21°C (range, 19°C to 23°C) (Table 2). The intensive care unit stay duration was 3.8 days (range, 1 to 8 days) and hospitalization period was 15 days (range, 5 to 20 days).

The average period of intubation was 1.3 days (range, 1 to 4 days) and there were no pulmonary complications after operation. There were no neurologic complications (cerebral infarct or embolism) after operation. However, a seizure occurred in 1 patient who was taking antiepileptic medication preoperatively. Two patients were reoperation cases. One patient was bleeding at the right atrium and 1 patient experienced a pericardial hematoma 4 days postoperatively. Other

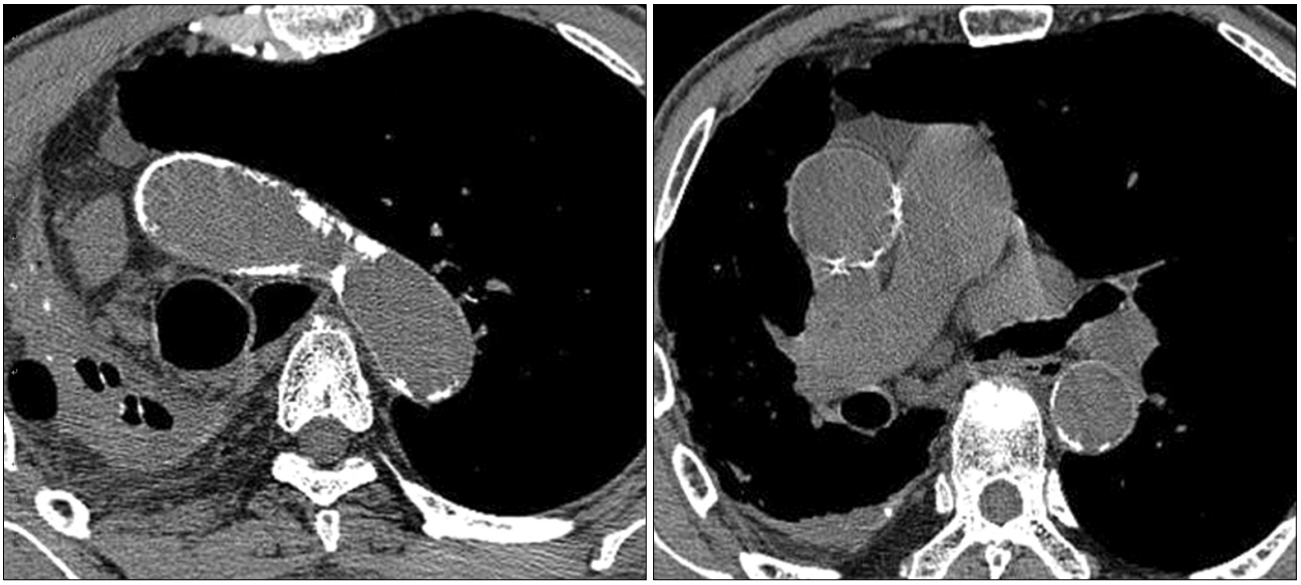

Fig. 1. Preoperative aorta non-contrast computer tomography: an 85-year-old male with severe aortic stenosis and a tuberculosis destroyed lung.

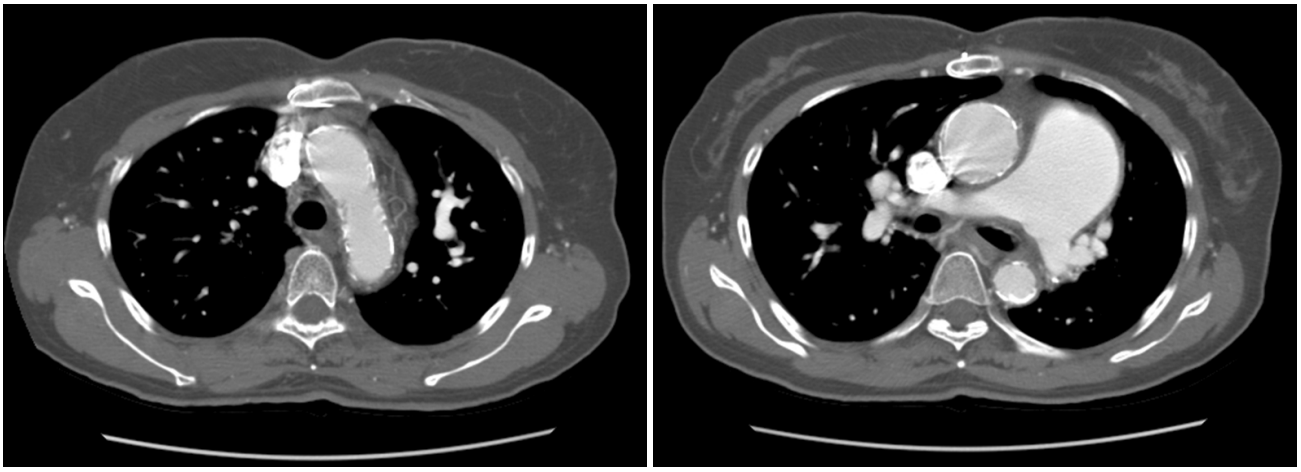

Fig. 2. Preoperative aorta non-contrast computer tomography: a 46-year-old female with aortic regurgitation and Takayasu's disease.

postoperative complications, including arrhythmia, acute renal injury, acute myocardiac infarction, and paravalvular leakage, did not occur in any patients. The mean duration of follow-up was 3.8 years (range, 1 month to 8 years). There was 1 case of late morbidity. An 85-year-old male patient had a fever after 5 months. CT showed a paravalvular infection in the aortic tissue valve though, so he underwent a Bentall operation with a homograft. The other patients had no paravalvular infection or leakage, or cerebrovascular complications during follow-up. There was no late mortality. One patient died suddenly due to unknown causes after 5 years.

DISCUSSION

Cerebrovasular disease is a severe complication after cardiac surgery. Previous series have suggested cerebral infarction after cardiac surgery related to embolism of a calcified ascending aorta and a higher prevalence in old age patients [1,2]. Blauth et al. [3] investigated the prevalence of embolism after cardiac surgery. They performed autopsies on

Table 1. Preoperative patient profile

No.	Age	Sex	Diagnosis	Associated disease
1	56	F	AR	Prior CVA, A.fib
2	44	M	AS	
3	46	F	AR (redo)	Takayasu's disease, previous tissue AVR
4	72	M	AS with AR	COPD
5	65	F	AR	Takayasu's disease
6	85	M	AS with AR	HTN, pulmonary TB
7	70	F	AS (bicuspid)	HTN, DM, A.fib
8	69	M	AS	HTN, A.fib
9	82	M	AS (bicuspid)	HTN, SSS
10	79	F	AS with AR	HTN, DM
11	78	F	AS (bicuspid)	HTN

AR=aortic regurgitation; CVA=cerebrovascular accident; A.fib=atrial fibrillation; AS=aortic stenosis; AVR=aortic valve replacement; COPD=chronic obstructive pulmonary disease; HTN=hypertension; TB=tuberculosis; DM=diabetics mellitus; SSS=sick sinus syndrome.

Table 2. Operative profile

No.	Cannular method	CPB (min)	ACC (min)	HCA (min)	Rectal temperature (°C)	Combined operation
1	Axillary	216	90	33	23	
2	Axillary	306	122	20	12	CABG
3	Femoral (RAP)	244	167	48	19	
4	Aorta	203	147	29	20	
5	Femoral (RAP)	110	84	31	22	
6	Axillary	152	80	31	22	CABG
7	Aorta	177	115	23	21	
8	Aorta	217	118	30	20	
9	Aorta	161	102	30	23	Pacemeker insertion
10	Aorta	159	97	28	23	
11	Aorta	138	85	27	21	

CPB=cardiopulmonary bypass; ACC=aorta cross clamp; HCA=hypothermic circulatory arrest; CABG=coronary artery bypass graft; RAP=retrograde access perfusion.

221 patients after cardiac surgery in 1992. They found 46 deaths from embolization and 95.8% were related to severe arthrosclerosis in an ascending aorta embolism. Barbut et al. [4] reported a 24% cerebral embolization rate when removing aortic cross clamp in coronary artery bypass surgery in 1994. Aortic valve replacement or coronary artery bypass surgery has a higher prevalence of cerebrovascular complications for thromboembolism because these surgeries require incision at near the origin of the ascending aorta. Okita et al. [5] reported that the operative mortality was 20% and postoperative cerebral infarct was 11% with arthrosclerosis of the aorta. In particular, mortality was 50% in cerebral infarct patients. Gillinov et al. [6] also reported similar mortality and morbidity in aortic valve replacement surgery.

Therefore, patients in old age must have calcification of ascending aorta checked before surgery. If accompanied by aortic calcification, avoiding using an aortic cross clamp if at all possible can reduce the frequency of cerebrovascular complications.

Aorta balloon clamp can be regarded as an alternative to traditional aorta cross clamp in ascending aorta and aortic valve replacement under hypothermic circulatory arrest, apico-aorta conduit and transapical valve replacement for instead [7]. To evaluate aortic calcification before surgery, chest X-ray or aortic non-contrast CT can be used, while aortic non-contrast CT is more effective for checking calcification or distribution of calcification in the aorta [8].

This study also used aortic non-contrast CT for preoperative evaluation in 10 patients. The method of examination in the operating room was aortic palpation, transesophageal ultrasound, and epiaortic scanning (EPS). According to many reports, EPS is more accurate than transesophageal ultrasound and direct palpitation and more helpful in decreasing the frequency of postoperative cerebral infarct [9-11]. In this study, 1 patient was diagnosed by palpitation during operation because aortic CT had not yet been introduced in the hospital. EPS is currently used.

Aortic valve replacement under hypothermic circulatory arrest was introduced by Coselli and Crawford [12] in 1986. Byrne et al. [13] reported that reduced mortality and cerebraovascular complications after introducing this surgical technique [12]. Gillinov et al. [6] investigated the treatment of calcification of the ascending aorta at the same time as aortic valve replacement under hypothermic circulatory arrest in aortic calcification patients. They compared the mortality and morbidity of aortic endarterectomy, ascending aorta replacement, and balloon clamping in the ascending aorta. They reported that ascending aorta replacement has a lower fre-

quency of cerebral infarct than the other methods [6]. Therefore, our hospital chose to perform ascending aorta and aortic valve replacement under hypothermic circulatory arrest in elderly patients with aortic calcification. Our experience confirmed that cerebrovascular complications and systemic thromboembolism events did not occur after surgery. Intra-aortic balloon clamping was introduced by Cosgrove [14] in 1983. Ooi et al. [15] reported aortic valve replacement with an intra-aortic balloon clamp by Foley catheter without complications in 2006 [14].

However, some cases of complications of this method have been reported. Zingone et al. [16] reported that balloons can cause aortic endothelial injury and did not find any difference in the frequency of postoperative cerebrovascular accident and systemic thromboembolism and mortality. In our hospital, similar cases have also been reported. We undertook aortic valve replacement though balloon clamping with a RAP catheter in 7 patients who experienced difficulties with aortic cross clamping including pseudoaortic aneurysm. However, we failed adaptation of aortic occlusion because of balloon migration, balloon rupture, limitation in size, and dissection of the aorta. In such a case, Pruitt's catheter can be inserted via the ascending aorta and the left ventricular outflow can be blocked while maintaining cardioplegic perfusion and aortic clamping [17]. Aortic endarectomy alone can result in dissection or rupture of the aorta because aortic wall becomes thin. Therefore, when we undertook aortic endarectomy with aortic replacement under hypothermic circulatory arrest in 8 patients, we reinforced the aortic wall with Dacron felt to prevent dissection of the aorta [18]. Cribier et al. [19] reported the first successful aortic valve replacement via a transapical or transfemoral approach with a catheter in high-risk aortic stenosis patients without extracorporeal circulation in 2002. Walther et al. [20] reported early mortality and morbidity of transapical aortic valve replacement in high risk patients. In their series, transapical aortic valve replacement had a good survival rate similar to the classic procedure and nor were there any cerebrovascular complications [20]. However, transapical valve replacement has the risks of ventricular perforation, coronary artery occlusion, contrast induced kidney injury, and vascular injury during the procedure. Also, there has been no long term follow-up reports on the procedure, so we believe that more study is needed regarding the safety and long term outcomes of this method compared to classic surgery such as the Placement of Aortic Transcatheter Valve trial.

CONCLUSION

In conclusion, ascending aorta and aortic valve replacement under hypothermic circulatory arrest without the aortic cross clamping technique showed no cerebrovascular complications after operation in calcified ascending aorta patients, specifically in an elderly group. Therefore, this method may be safely used in patients who have difficulties undergoing aortic cross clamping.

REFERENCES

1. Ngaage DL, Cowen ME, Griffin S, Guvendik L, Cale AR. *Early neurological complications after coronary artery bypass grafting and valve surgery in octogenarians.* Eur J Cardiothorac Surg 2008;33:653-9.
2. Davila-Roman VG, Murphy SF, Nickerson NJ, Kouchoukos NT, Schechtman KB, Barzilai B. *Atherosclerosis of the ascending aorta is an independent predictor of long-term neurologic events and mortality.* J Am Coll Cardiol 1999;33: 1308-16.
3. Blauth CI, Cosgrove DM, Webb BW, et al. *Atheroembolism from the ascending aorta: an emerging problem in cardiac surgery.* J Thorac Cardiovasc Surg 1992;103:1104-11.
4. Barbut D, Hinton RB, Szatrowski TP, et al. *Cerebral emboli detected during bypass surgery are associated with clamp removal.* Stroke 1994;25:2398-402.
5. Okita Y, Ando M, Minatoya K, Kitamura S, Takamoto S, Nakajima N. *Predictive factors for mortality and cerebral complications in arteriosclerotic aneurysm of the aortic arch.* Ann Thorac Surg 1999;67:72-8.
6. Gillinov AM, Lytle BW, Hoang V, et al. *The atherosclerotic aorta at aortic valve replacement: surgical strategies and results.* J Thorac Cardiovasc Surg 2000;120:957-63.
7. Girardi LN, Krieger KH, Mack CA, Isom OW. *No-clamp technique for valve repair or replacement in patients with a porcelain aorta.* Ann Thorac Surg 2005;80:1688-92.
8. Quint LE, Francis IR, Williams DM, et al. *Evaluation of thoracic aortic disease with the use of helical CT and multiplanar reconstructions: comparison with surgical findings.* Radiology 1996;201:37-41.
9. Aranki SF, Nathan M, Shekar P, Couper G, Rizzo R, Cohn LH. *Hypothermic circulatory arrest enables aortic valve re-*

placement in patients with unclampable aorta. Ann Thorac Surg 2005;80:1679-86.

10. Zingone B, Rauber E, Gatti G, et al. *The impact of epiaortic ultrasonographic scanning on the risk of perioperative stroke.* Eur J Cardiothorac Surg 2006;29:720-8.
11. Ibrahim KS, Vitale N, Tromsdal A, Kirkeby-Garstad I, Fraser AG, Haaverstad R. *Enhanced intra-operative grading of ascending aorta atheroma by epiaortic ultrasound vs echocardiography.* Int J Cardiol 2008;128:218-23.
12. Coselli JS, Crawford ES. *Aortic valve replacement in the patient with extensive calcification of the ascending aorta (the porcelain aorta).* J Thorac Cardiovasc Surg 1986;91:184-7.
13. Byrne JG, Aranki SF, Cohn LH. *Aortic valve operations under deep hypothermic circulatory arrest for the porcelain aorta: "no-touch" technique.* Ann Thorac Surg 1998;65:1313-5.
14. Cosgrove DM. *Management of the calcified aorta: an alternative method of occlusion.* Ann Thorac Surg 1983;36:718-9.
15. Ooi A, Iyenger S, Langley SM, Haw MP. *Endovascular clamping of porcelain aorta in aortic valve surgery using Foley catheter.* Heart Lung Circ 2006;15:194-6.
16. Zingone B, Gatti G, Rauber E, Pappalardo A, Benussi B, Dreas L. *Surgical management of the atherosclerotic ascending aorta: is endoaortic balloon occlusion safe?* Ann Thorac Surg 2006;82:1709-14.
17. Choi JH, Park PW. *Endovascular aortic balloon clamping for various heart disease.* Korean J Thorac Cardiovasc Surg 2008;41:61-7.
18. Svensson LG, Sun J, Cruz HA, Shahian DM. *Endarterectomy for calcified porcelain aorta associated with aortic valve stenosis.* Ann Thorac Surg 1996;61:149-52.
19. Cribier A, Eltchaninoff H, Bash A, et al. *Percutaneous transcatheter implantation of an aortic valve prosthesis for calcific aortic stenosis: first human case description.* Circulation 2002;106:3006-8.
20. Walther T, Schuler G, Borger MA, et al. *Transapical aortic valve implantation in 100 consecutive patients: comparison to propensity-matched conventional aortic valve replacement.* Eur Heart J 2010;31:1398-403.