

Balloon Occlusion of the Ascending Aorta without Hypothermic Circulatory Arrest in Valve Surgery for Patients with a Porcelain Aorta

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ABSTRACT

Severe calcification of the ascending aorta and the aortic arch complicates cardiac surgery. The optimal approach in such patients is unknown. Four valve surgeries were performed with balloon occlusion without hypothermic circulatory arrest. All patients had femoral arterial cannulation, and all 3 patients who required an aortotomy had right axillary artery cannulation as well. A balloon catheter was inserted just proximal to the brachiocephalic artery via a purse-string stitch. Good cardiac arrest was obtained in all cases, and a good bloodless field was obtained in all 3 aortic valve cases. There were no balloon-related complications. The patients all showed good postoperative courses. Balloon occlusion of the ascending aorta without circulatory arrest is effective for performing a rapid and less invasive surgery that is not significantly different from the usual valve surgery.

INTRODUCTION

Severe aortic calcification of the ascending aorta and the aortic arch complicates cardiac surgery. Coronary artery bypass grafting can be done without cardiopulmonary bypass (CPB); however, in valve surgery it is usually necessary to establish CPB and to clamp the aorta. The optimal approach in such patients is unknown. Balloon occlusion of the ascending aorta without circulatory arrest is used when it is technically feasible. The purpose of this report is to describe the technical details and early clinical results with this strategy.

PATIENTS AND METHODS

Patient Selection

From June 2005 to January 2009, 4 patients undergoing valve surgery were treated with balloon occlusion without circulatory arrest by a single surgeon (T.I.). This surgeon performed 313 valve surgeries during this period. Table 1 summarizes the patients' characteristics. During this period, 1 patient underwent

valve replacement with circulatory arrest. The mean age was 73.4 years (range, 61-83 years). Three of the patients were female. One patient was treated for mitral valve regurgitation, and the other 3 patients were treated for aortic valve pathology. Two of these patients had aortic stenosis; the third had aortic regurgitation. All patients were symptomatic (Table 1).

All of the patients underwent a preoperative thoracic computed tomography scan, which showed severe calcification of the ascending aorta (Figure 1). An intraoperative epiaortic echocardiogram was performed in all cases, and the final decision to use balloon occlusion was made at that time.

Surgical Technique

The patients were placed in a supine position. Regional oxygen saturation in the bilateral frontal lobes was monitored with near-infrared spectroscopy [Yamashita 2001]. A median sternotomy was made. Digital palpation of the aorta and an intraoperative epiaortic echocardiography evaluation were done to assess the ascending aorta and the aortic arch. If a soft aortic wall was observed without mobile atherosclerosis >1.5 cm in diameter, insertion of a balloon catheter was planned. After confirming that cross-clamping was impossible and the lack of a site for arterial cannulation in the proximal aorta, the surgeon exposed the femoral artery and the right axillary artery in the usual fashion. All of the patients underwent femoral arterial cannulation, and all 3 patients who underwent an aortic valve procedure underwent right axillary artery cannulation as a second cannulation. A 16F to 18F DLP® arterial cannula (Medtronic, Minneapolis, MN, USA) was inserted directly into the femoral artery, and a 14F to 16F DLP arterial cannula was placed in the right axillary artery. Bicaval cannulation was routinely used, and in aortic valve surgery a

Table 1. Patient Backgrounds*

	Case 1	Case 2	Case 3	Case 4	Mean
Age, y	61	83	78	73	73.8
Sex	F	F	M	F	
Heart valve disease	AR	AS	MR, TR	AS	
NYHA class	3	3	3	3	3

*F indicates female; M, male; AR, aortic regurgitation; AS, aortic stenosis; MR, mitral regurgitation; TR, tricuspid regurgitation; NYHA, New York Heart Association.

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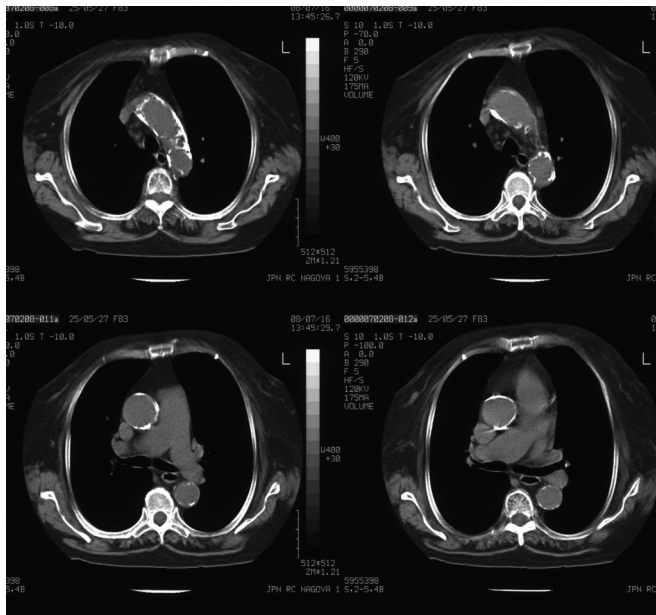


Figure 1. Computed tomography images (case 2).

retrograde cardioplegic cannula was inserted into the coronary sinus under direct vision. The patients were placed on CPB. Only the one patient who underwent mitral valve repair had a root cannula placed through a narrow soft spot. The other patients did not have a root cannula. A small purse string was made with a 4-0 polypropylene suture, and a Lock Balloon Catheter® (Tokai Medical Products, Aichi, Japan) was inserted just proximal to the brachiocephalic artery. The balloon was carefully inflated with saline. The balloon was palpated from the outside the aorta to avoid overdistention. The initial dose of cardioplegia was given.

An aortotomy was made in cases of aortic valve surgery. When leakage was observed inside the aorta around the balloon, saline was added to the balloon.

Valve surgery was performed. The aortotomy was closed. Special care was usually necessary for closing the aortotomy.

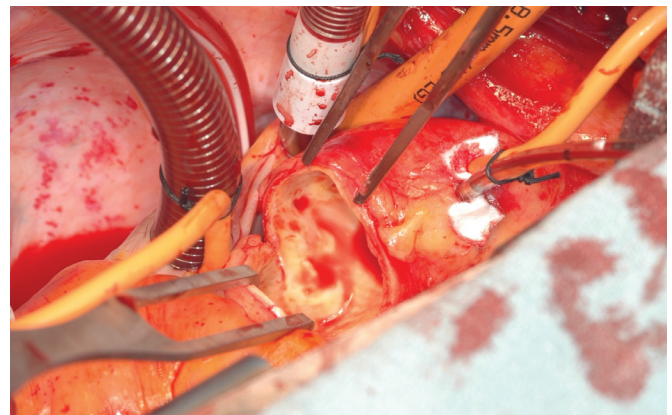


Figure 2. Intraoperative photograph. A view of the aortotomy is shown.

A partial endarterectomy was done when it was indicated. The heart was de-aired via a root cannula or a needle hole on the aortic root. The balloon was deflated. After weaning off CPB, patients were decannulated, and hemostasis was obtained. The chest was closed in the usual manner.

RESULTS

The operation was completed in all 4 patients without major problems. Good cardiac arrest was obtained in all cases, and a good bloodless field was obtained in all 3 aortic valve cases (Figure 2). Femoral and axillary cannulation was feasible in all cases. Cerebral oxygen saturation did not deteriorate in any of the cases. There were no balloon-related complications, such as dissection or rupture of the aorta.

In the first case, which was performed in 2005, the patient was cooled down to 22°C because of the limited experience of the surgical team. Mild hypothermia was used in subsequent procedures, with a lowest rectal temperature of 28.4°C to 31.1°C.

The mean cardiac arrest time was 82.8 minutes (range, 67-98 minutes). The mean pump time was 139.3 minutes (range, 131-156 minutes). The first case also had the longest period of moderate hypothermia. The mean operation time

Table 2. Operative and Postoperative Data*

	Case 1	Case 2	Case 3	Case 4	Mean
Valve procedure	AVR	AVR	MVP, TAP	AVR, annular enlargement	
Arterial cannulation	FA, AA	FA, AA	FA	FA, AA	
Lowest rectal temperature, °C	22.1	29.3	31.1	28.4	29.3
Clamping time, min	67	77	89	98	82.8
CPB time, min	156	137	133	131	139.6
Operation time, min	340	278	235	282	283.4
Complications	Respiratory failure, AF	AF	None	None	

*AVR indicates aortic valve replacement; MVP, mitral valvuloplasty; TAP, tricuspid annuloplasty; FA, femoral artery; AA, axillary artery; CPB, cardiopulmonary bypass; AF, atrial fibrillation.

was 283.8 minutes (range, 235-340 minutes). Again, the operation time was longest in the first case (Table 2).

There was no surgical mortality. The first patient developed respiratory failure. This patient was on a ventilator for 7 days. The other patients were extubated at 5, 8, and 28 hours after surgery. Two patients developed atrial fibrillation (Table 2).

DISCUSSION

Patients with severe atherosclerotic disease of the aorta are at a high risk for stroke and death after cardiac surgery [Blauth 1992]. Blauth et al reported that 37% of patients with severe disease of the ascending aorta had atheroemboli, with the brain being the most commonly affected site in autopsy series of patients who had undergone cardiac operations [Blauth 1992].

Unlike coronary artery surgery, valve procedures require CPB. Aortic manipulation is absolutely necessary for aortic valve procedures. Although mitral valve surgery without clamping of the aorta has been reported [Katircioglu 2008], it is not common in most centers. Several techniques have been reported for managing aortic valve disease in these patients. These techniques include hypothermic circulatory arrest [Coselli 1986], aortic endarterectomy [Svensson 1996], replacement of the ascending aorta [Kouchoukos 1994], and balloon occlusion with the aid of hypothermic circulatory arrest [Cosgrove 1983]. Each procedure has its advantages and disadvantages. Balloon occlusion without circulatory arrest has been reported only in a case report of an unexpected situation [Girardi 2005].

The difference between the procedure described for the cases in this report and previously reported series of balloon occlusion is the use of hypothermic circulatory arrest. Cosgrove et al [1983] placed the balloon catheter from the aortotomy, which had been made under circulatory arrest. The patients in the present study had the balloon inserted inside the aorta via a purse-string stitch placed on a soft spot in the ascending aorta. The first patient was cooled down to 22°C, and the pump flow was decreased while the aortotomy was open. After experience was gained, the procedure was performed without cooling the patients as much. CPB and operation times became considerably shorter. The operative mortality and morbidity are relatively high in such patients. Gillinov et al [2000] reported 14% mortality among 62 patients. Although such patients do have more comorbid conditions than usual [Gillinov 2000], it cannot be denied that long CPB and circulatory arrest times may be partially responsible. Girardi et al reported that a long CPB time was a risk factor for death in these patients [Girardi 2005].

Because the balloon catheter was placed via purse-string stitches and was inflated without direct visualization of the inside of the aorta, one could argue that this method might have a greater chance of inducing emboli during insertion and inflation of the balloon. With the aid of intraoperative epiaortic echocardiography, it was possible to determine that no plaque was protruding at the site of the purse string and the balloon. This is a report of only 4 cases, however, and the accumulation of more patients is required.

Both the left femoral artery and the right axillary artery were cannulated in most patients. The main reason for this procedure was to avoid malperfusion during balloon occlusion. The balloon could potentially block the orifice of the brachiocephalic artery. By cannulating both the right axillary artery and one of the femoral arteries, one should be able to safely maintain circulation to the right brain and other parts of the body, even in this situation. We also measured cerebral oxygen saturation so that we could detect malperfusion immediately if it occurred.

Inserting a balloon catheter via a purse-string stitch may not always be possible, particularly when there is no place to place a purse string in the ascending aorta and when placing a balloon in the ascending aorta without direct vision would be too dangerous because of the presence of multiple protruding plaques. The described technique is contraindicated in these situations. Therefore, preoperative computed tomography scanning and epiaortic echocardiography are very important. When feasible, balloon occlusion of the ascending aorta without circulatory arrest can provide a rapid and less invasive surgery that is not significantly different from conventional valve surgery.

CONCLUSIONS

Four valve surgeries were performed with balloon occlusion without hypothermic circulatory arrest. The patients all showed good postoperative courses.

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