Neo-Leaflet Failure after Comprehensive Aortic Root and Valve Reconstruction

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The comprehensive aortic root and valve reconstruction (CARVAR) technique comprises two main procedures, which are aortic root reduction using prosthetic rings and neo-leaflet reconstruction using a pericardial patch. Although concerns about durability of the pericardial neo-leaflet have been raised in the CARVAR technique, complications related to leaflet reconstruction have not been reported to date. The present report describes two cases of complications associated with leaflet reconstruction. After resecting the reconstructed leaflets, aortic valve replacement was performed in the patients. Careful and close follow-up is required for patients who had undergone CARVAR surgery, and aortic valve surgery should be performed in a timely manner if needed.

Key words: 1. Aortic valve  
2. Surgery  
3. Aortic root  
4. Pericardium  
5. Calcification  
6. Reoperation

CASE REPORTS

Since the comprehensive aortic root and valve reconstruction (CARVAR) technique was first introduced in 2006 [1], the underlying safety issues of the procedure itself and the associated complications have been reported by several series of cases and reports [2,3]. This technique consists of two main procedures: (1) aortic root reduction achieved by implanting prosthetic rings on the inner and outer surfaces of the sinotubular junction (STJ) and/or annulus, and (2) neo-leaflet reconstruction using a pericardial patch. The reported complications following the use of this technique include late aortic root aneurysm formation and coronary ostial stenosis due to a foreign body reaction around the prosthetic rings. These results are associated with the prosthetic rings implanted in the STJ. Although concerns about the durability of the pericardial neo-leaflet have been raised with respect to the CARVAR technique, complications related to leaflet reconstruction have not been reported thus far. The present report describes two cases of complications associated with leaflet reconstruction.

1) Case 1

A 64-year-old female patient was admitted due to progressive dyspnea. Six years before, the patient underwent aortic valvuloplasty (AVP) with the CARVAR technique for the management of severe aortic insufficiency. The AVP in the prior operation consisted of two main procedures: (1) STJ re-
Fig. 1. Enhanced computed tomography images showing the motion limitation of the right coronary cusp (*) according to the cardiac cycle of (A) systole and (B) diastole.

Fig. 2. All the reconstructed aortic valve leaflets consisting of a native leaflet and a bovine pericardial patch were thickly stiffened.

duction was attempted by using two prosthetic rings, namely the inner ring (26 mm) and the outer ring (32 mm) (ScienCity Co., Seoul, Korea), which were implanted on the inner and outer surfaces of the STJ, and (2) all native leaflets were partially resected and extended with bovine pericardium (Supple Peri-Guard; Synovis, Deerfield, IL, USA). The immediate postoperative transthoracic echocardiography reported no residual aortic valve (AV) regurgitation, and no aortic stenotic components were found.

In the current evaluation, the follow-up echocardiography revealed severe AV stenosis with an AV area of 0.70 cm² and motion limitation of the right coronary cusp. Details of the AV leaflet morphology and dynamics were confirmed by computed tomography images (Fig. 1). Intraoperatively, peri-aortic adhesion was very extensive, particularly around the outer ring, and then, transverse aortotomy was performed just above the ring. After removing the inner ring of the STJ and resecting the AV leaflets, aortic valve replacement (AVR) was performed using mechanical prosthesis (Overline, 18 mm; Sorin Biomedica, Saluggia, Italy). All the reconstructed AV leaflets consisting of a native leaflet and a bovine pericardial patch were thickly stiffened (Fig. 2), which led to motion impairment in the right coronary cusp as well as motion limitations in the left and non-coronary cusp. The redo-AVR was completed uneventfully with smooth weaning of cardiopulmonary bypass (CPB). The postoperative course was also uneventful.

2) Case 2

A 40-year-old man was referred to Asan Medical Center for two weeks of progressive dyspnea and fever. Before being referred to our hospital, blood cultures were obtained, and broad-spectrum antibiotics were started. The transthoracic echocardiogram performed at another hospital reported severe aortic regurgitation with prolapse and perforation of the non-coronary cusp. The patient had previously undergone CARVAR-type AVP eight years before this presentation for
the management of severe aortic insufficiency. The CARVAR technique consisted of two main components as in case 1: (1) STJ reduction using two prosthetic rings (26 mm and 34 mm, ScienCity Co.) and (2) leaflet extension with bovine pericardium (Supple Peri-Guard, Synovis).

After the patient’s admission, we saw that his microbial results revealed that *Streptococcus mitis* grew in multiple sets of blood cultures performed at another hospital, and the profile was confirmed by the same results obtained at our hospital. His antibiotics were then changed to reflect the microbial profile. A transesophageal echocardiogram was performed after admission. It showed prolapse and severe destruction of the left coronary cusp (LCC) with two discrete 3-mm tissue defects, but protruding mobile structures were not observed. The tissue defects and the flail motion of the LCC were compatible with infective endocarditis, and hence, AVR was planned. Intraoperative findings confirmed the echocardiographic findings of infective endocarditis showing both commissural detachment of the LCC and multiple tiny pieces of debris lying on the leaflets (Fig. 3). The leaflets of the AV and two prosthetic rings were excised, considering the probability of infection. AVR was performed using mechanical prosthesis (ATS, 22 mm; ATS Medical Inc., Minneapolis, MN, USA), and ascending aorta replacement was performed using a 24-mm Hemashield (Boston Scientific, Boston, MA, USA) vascular graft because a significant portion of the aortic wall tissue defect remained after the excision of the prosthetic rings. CPB weaning failed because of the decreased contractility of the right coronary artery (RCA) territory and an unstable heart rhythm. This may be attributable to inadequate myocardial protection. A cardioplegic solution was delivered only in a retrograde fashion because severe periaortic adhesion precluded the exposure of the aortic root. CPB was substituted with venous-arterial-type extracorporeal membrane oxygenation (ECMO), and then, the patient was transferred to the cardiac intensive care unit. After 5 days of ECMO support, the patient was weaned off the ECMO successfully. The postoperative echocardiogram performed on postoperative day 8 showed complete restoration of the RCA territorial contractile function. The patient was discharged on postoperative day 35 after completion of the antibiotic therapy.

**DISCUSSION**

During the past two decades, there have been several attempts to preserve the native aortic valve tissue in the management of aortic insufficiency. In cases of aortic insufficiency secondary to the dilatation of the aortic root or ascending aorta without primary leaflet disease, a David- or Yacoub-type aortic root replacement procedure has become the standard surgical technique. However, aortic insufficiency involving leaflet pathology such as leaflet restriction or prolapse requires a distinctive leaflet repair technique according to the mechanism of valve dysfunction [4]. In contrast to the mitral valve, however, the lack of aortic valve tissue hampers the valve repair. Therefore, additional tissue material such as a pericardial patch is required in severe cases of leaflet restriction found in bicuspid, degenerative, or rheumatic valvular disease, resulting in the calcification and thickening of the AV leaflets [4].

However, an ideal material for leaflet reconstruction is yet to be found. Bovine pericardium is generally known to be highly prone to calcification and structural deterioration when used in bio-prosthetic valves. Only limited data are available for cases in which the bovine pericardium has been used as the material for leaflet reconstruction, and the outcomes were unacceptable [5]. Furthermore, although some previous studies reported acceptable long-term durability and outcomes of leaf-

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**Fig. 3.** Excised aortic valve leaflets. The left coronary cusp was detached from both the commissures, and multiple tiny pieces of dirty debris lied on the leaflets.
let repair by using an autologous pericardial patch [6], the overall experience with aortic valve repair is relatively little and the fate of the repaired valve and the reconstructed leaflet is still unclear. Therefore, thus far, aortic valve replacement has been regarded as the standard surgical procedure for aortic insufficiency involving primary leaflet pathology.

Comprehensive aortic root and valve reconstruction, or the CARVAR technique, involves both aortic root reduction and leaflet correction. The reduction of the aortic root size is achieved by using specially designed prosthetic rings, which are implanted in the inner and outer surfaces of the STJ. Therefore, correction of the associated aortic insufficiency is expected as a result of the similar mechanism in the David- or Yacoub-type aortic root replacement procedures. Selected patients have undergone concomitant leaflet procedures, such as neo-leaflet creation or leaflet extension using a bovine pericardial patch, according to the condition of the aortic valve leaflets. With simultaneous correction of the aortic root and leaflets, we introduced the CARVAR technique that is applicable to a wide range of indications and can facilitate the maximal functional and structural preservation of the aortic root [1].

Concerns about the CARVAR technique are based on many factors, such as selection of the subject patients, safety issues regarding the predicted complications, and long-term durability or results [7]. Some cases of complications associated with the STJ prosthetic rings have already been reported. Cases of coronary ostial stenosis after the CARVAR procedure were reported where a foreign body reaction around the prosthetic rings was suspected to be the contributing factor to the fibrous ingrowth obstructing the coronary ostium [2]. We previously reported a case of late aneurysmal dilation in the aortic root following CARVAR surgery [3]. In a Marfan syndrome patient, isolated progressive aortic sinus aneurysmal dilatation had developed between the prosthetic aortic valve and the prosthetic rings within six years since the CARVAR-type surgery, which consisted of mechanical AVR, graft interposition of the ascending aorta and hemiarch, and STJ reduction using prosthetic rings. Although the inherent safety problems regarding the use of prosthetic rings or indiscriminate performance of the CARVAR technique have not been reported thus far.

Song et al. [8] recently published the early and midterm outcomes of aortic valve reconstruction surgery with the CARVAR technique. In contrast to previous reports that showed unsatisfactory long-term durability and outcomes with bovine pericardium as the material for aortic valve reconstruction [5], Song et al. [8] noted that they had never seen degenerative leaflet changes on echocardiographs. Furthermore, they insisted that the pericardial leaflet durability may not be a concern in the CARVAR technique because of reduced mechanical stress on the leaflets attributable to their excellent hemodynamic profiles. In contrast to the cited report [8], a significant motion limitation of the reconstructed aortic leaflet occurred in the present case. This is the first case reporting a pericardial neo-leaflet failure following the CARVAR procedure.

As a consequence of the neo-leaflet failure, secondary aortic valve replacement was required in these cases, but implantation of the prosthetic valve was considerably problematic in patient 1. STJ of the aorta at the level of the previous prosthetic rings showed significant narrowing despite the removal of the inner ring. As a result, we had to implant a relatively small mechanical valve considering the patient’s body surface area. Careful echocardiographic follow-up will be required in the patient.

Although we cannot reach a definitive conclusion from these cases about the durability of reconstructed leaflets in the CARVAR technique, the present case reporting the first complication of reconstructed pericardial leaflets may attract the attention of many readers and be of significant value. Careful and close follow-up is required for patients who have undergone CARVAR surgery, and aortic valve surgery should be performed in a timely manner if needed.

**CONFLICT OF INTEREST**

No potential conflict of interest relevant to this article was reported.

**REFERENCES**

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