



Case Report / Olgu Sunumu

Trileaflet reconstruction of pulmonary valve for acute pulmonary valve insufficiency

Akut pulmoner kapak yetmezliğinde üç yaprakçıklı kapak rekonstrüksiyonu

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ABSTRACT

Iatrogenic pulmonary valve insufficiency is a life-threatening complication and its treatment options pose another challenge. Easily accessible mechanical valves have high complication rates. Xenografts and homografts are expensive materials and are not readily accessible in case of emergency. Although mono- and bileaflet reconstructions with autologous pericardium in the pediatric population has been reported frequently, trileaflet reconstruction of the pulmonary valve has not been reported in the literature, yet. Herein, we, for the first time, present a case of acute pulmonary valve insufficiency which was treated with the trileaflet reconstruction of the pulmonary valve.

Keywords: Pulmonary valve, insufficiency, parietal pericardium.

ÖZ

İyatrojenik pulmoner kapak yetmezliği hayatı tehdit eden bir komplikasyon olmakla birlikte, tedavi seçenekleri ayrı bir sorun teşkil etmektedir. Kolaylıkla ulaşılabilen mekanik kapakların komplikasyon oranları yüksektir. Ksenogreft ve homogreftler ise pahalı ve acil durumda erişimi kolay materyaller değildir. Otolog perikardın kullanıldığı çocuk hasta grubunda tek ve iki yaprakçıklı rekonstrüksiyonlar sıklıkla bildirilse de, pulmoner kapağın üç yaprakçıklı rekonstrüksiyonu literatürde henüz bildirilmemiştir. Bu yazıda, ilk kez pulmoner kapağın üç yaprakçıklı rekonstrüksiyonu ile tedavi edilen bir akut pulmoner kapak yetmezliği olgusu sunuldu.

Anahtar sözcükler: Pulmoner kapak, yetmezlik, parietal perikard.

Acute pulmonary valve insufficiency (PVI) after pulmonary valvuloplasty can lead to right ventricular (RV) and pulmonary failure with ultimate death.^[1] Recent reports describe the benefits of pulmonary valve (PV) replacement for severe PVI.^[2] Herein, we, for the first time, report a case of iatrogenic acute PVI which was diagnosed early after the resection of infundibular stenosis and was successfully treated with trileaflet valve reconstruction using the Ozaki procedure^[3] with a handmade template.

CASE REPORT

A 21-year-old male patient was operated for infundibular and PV stenosis with a maximum gradient of 80 mmHg on pulmonary valve. Massive infundibular muscle resection was made through the incision extending from the pulmonary conus to the RV infundibulum. Pulmonary valvuloplasty was

also carried out to reduce the transvalvular gradient. The infundibulo-conar incision was closed with a 3.5×7-cm bovine pericardial patch. Intraoperative transesophageal echocardiography (TEE) showed moderate pulmonary valve regurgitation and the operation was completed in a routine fashion. Although hemodynamic stability was achieved without inotropic support in the intensive care unit, oxygen saturation (<80%) and partial oxygen pressure in the blood gas analysis (<40 mmHg) were below normal limits after extubation. Transthoracic echocardiography (TTE) in the postoperative second day revealed that pulmonary insufficiency was so severe that all blood pushed to the pulmonary artery returned to the RV during diastole. He was, then, intubated for respiratory distress after moderate pericardial tamponade (2.5 cm effusion near to the RV). We operated the patient in the same day

Received: November 12, 2018 Accepted: December 07, 2018 Published online: April 24, 2019

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Cite this article as:

Kahraman D. Trileaflet reconstruction of pulmonary valve for acute pulmonary valve insufficiency. Turk Gogus Kalp Dama 2019;27(2):219-223

following hemodynamic collapse. Arterial tension was stabilized at about 60 to 75 mmHg immediately after opening the chest and draining tamponade. A written informed consent was obtained from the patient.

Technical aspects

We resected as much pericardium as it covers to the left anterior and left lateral of the heart, by preserving the left phrenic nerve integrity. The pericardium was stretched on a flat surgical panel using silk sutures and it was embedded into the glutaraldehyde solution. Aorta-bicaval cannulation, total cardiopulmonary bypass, and cross-clamping were done sequentially. The bovine patch over the pulmonary artery was unstitched until 2 cm to the PV remnants. The surgical field was widened by extending the incision transversely and putting stay sutures. The remaining valve remnants were excised.

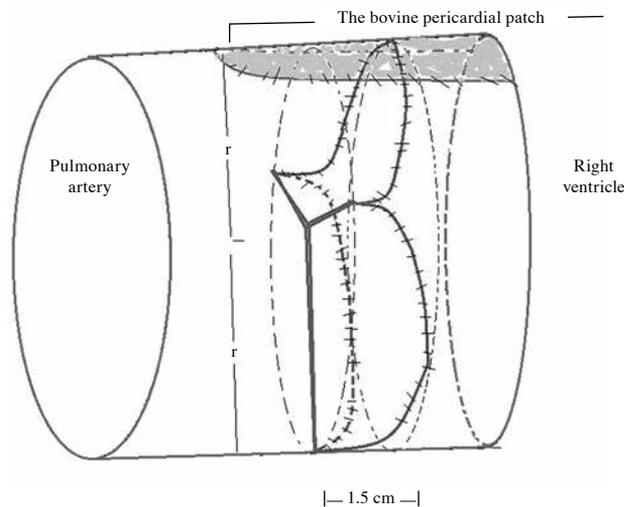


Figure 1. Imitation of aortic root into pulmonary artery.

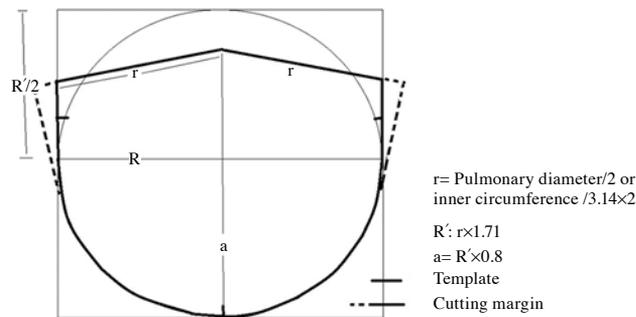


Figure 2. The handmade template. Dark line represents borders of the template and dark dots represent cutting border of pericardial leaflets.

First, we drew two circles inside the pulmonary trunk which were 1.5-cm away from each other to imitate the aortic annulus anatomy (Figure 1). The proximal circle close to the RV would be for the base of leaflets, and the distal one was for the tip of the commissures. A silk string was lied over the distal circle to measure the circumference (C) and the radius (r) of the coaptation plane of the leaflets with the following formula: $r=C/2\pi$. Each circle was divided to three equal pieces in a manner that each dividing-mark on the proximal circle corresponded to center of distal one third of piece. Again, we drew semicircles on the luminal surface of the pulmonary trunk to connect one mark on distal circle to the adjacent one, while the base of semicircles touched to the dividing marks on the proximal circle.

Secondly, we made a handmade template on a sterile paper-based surgical towel. We drew a square with an edge-length equal to 'R' ($R=1.71 \times r$). A complete circle with diameter of R was drawn into that square. Then, we drew the line 'a' to the center of this square on the vertical axis to measure the height of the template ($a=0.8 \times r$). We delineated the free-margins of the cusp by drawing two lines starting from the tip of the line-a to the lateral margins of the square. Since those would be coapting free-margins, each should be exactly as long as 'r' of the pulmonary trunk. The template was ready to cut (bold line on Figure 2). We copied all three leaflets from the same template. However, to preserve the coapting margins in correct length, we cut the template in such a manner that the lateral connections had additional stitching pieces at each site (Figure 2) as described by Ozaki et al.^[3] We used 5/0 prolene sutures to sew the leaflets to the new pulmonary root starting from the central mark on the proximal circle

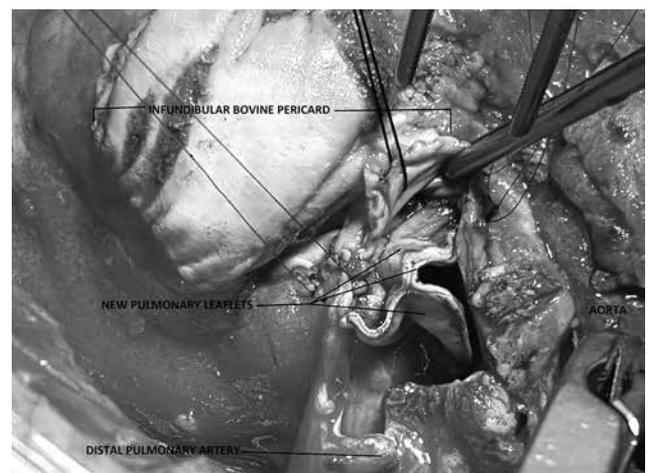


Figure 3. New pulmonary valve leaflets after finishing reconstruction showing a fairly well coaptation plane.

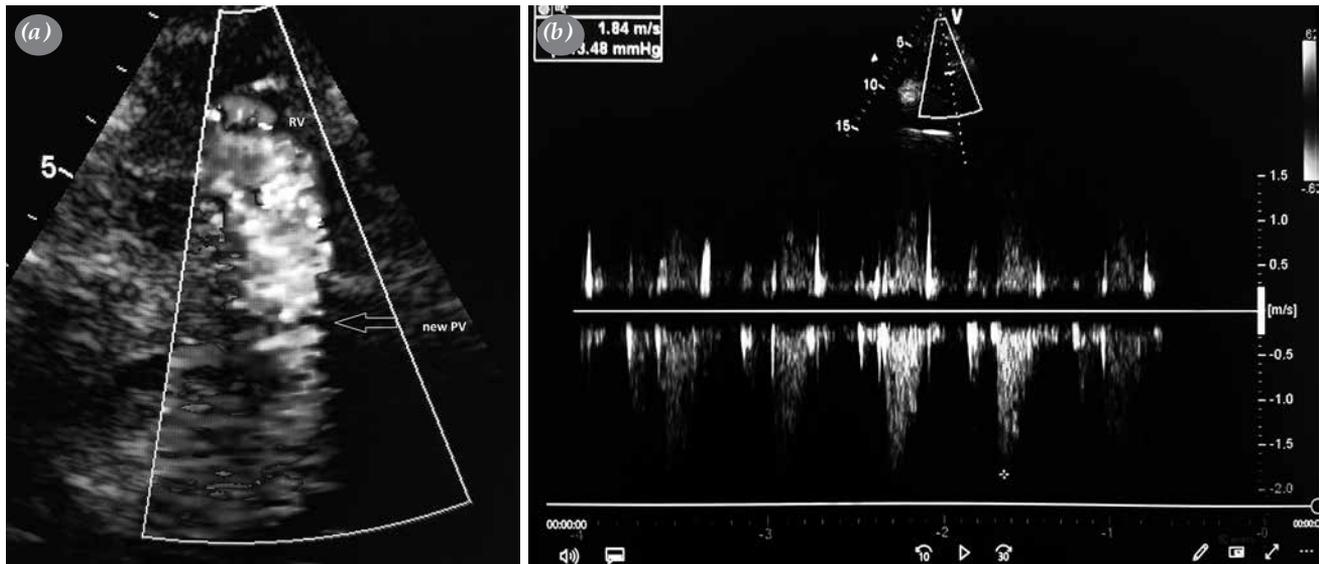


Figure 4. Control transthoracic echocardiography (a) with trace amount of reflux and (b) minimum transvalvular pressure gradient.

throughout corresponding semicircle and ending at the mark on distal circle (Figure 1).

After finishing PV reconstruction (Figure 3), pulmonary arteriotomy was closed and weaning from cardiopulmonary bypass was performed ordinarily. Intraoperative TEE and control TTE after extubation revealed that new PV had a trace amount of reflux and minimal pressure gradient (maximum gradient 13.8 mmHg) (Figure 4a, b).

DISCUSSION

In the literature, there are large series of experiences on left-sided prosthesis in urgent conditions; however, the issue about the PV is still controversial. Although there are enormous experiences in children and most authors often recommend xenografts and homografts for the PV replacement, they are usually not available in most centers in the emergency setting.^[4] The most optimal options seem to be bileaflet mechanical valves, while one may hesitate to replace PV with it, due to possible thrombotic complications ranging from 25 to 56% during follow-up.^[5]

The gold standard for reconstruction of the right ventricular outflow tract is a pulmonary homograft.^[6] To the best of our knowledge, this case is the only tri-leaflet autograft reconstruction in the literature. The leaflet mobility and adaptation to the hemodynamics of the right ventricular outflow tract seems to be excellent in a short time period. Since the autografts do not induce immune response, graft rejection would not be the probable cause of dysfunction. Rather

than immunogenicity, hemodynamic stress should be considered in pulmonary valve which has less pressure gradient than the aortic root where it provides good short- and mid-term results with good hemodynamics and good quality of life without anticoagulation.^[3] Regarding the superior event-free survival of patients with pulmonary homograft,^[6] it may be reasonable to expect at least same similar favorable outcomes of PV constructed from autologous pericardium. The follow-up of the patient with more cases would definitely help to overcome suspicions.

Except the wasted peripheral region, we used about 21 cm² of pericardium in our case. If a satisfactory asymptomatic period would be achieved, and if needed in the future, it seems to be reproducible option for subsequent reconstruction of PV with remaining pericardium. Moreover, unlike the fabricated homografts, intended sizes could be constructed on-table with this template formula.

In conclusion, if expected favorable outcomes can be achieved with follow-up of such rare cases, this type of reconstruction technique would open a wide scope for on-table production of pulmonary valve in patients with pulmonary valve dysfunction late after tetralogy of Fallot operations and totally autologous aortic root reconstruction or hybrid root operations with pericardial valve leaflets in the aortic valve endocarditis.

Declaration of conflicting interests

The author declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The author received no financial support for the research and/or authorship of this article.

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EDITORIAL COMMENT

Cem Alhan

In the 1950s, Dr. Dwight Emary Harken defined Ten Commandments for the prosthetic valve as follows:^[1]

1. It must not propagate emboli.
2. It must be chemically inert and not damage blood elements.
3. It must offer no resistance to physiological flows.
4. It must close promptly (less than 0.05 second).
5. It must remain closed during the appropriate phase of the cardiac cycle.
6. It must have lasting physical and geometric features.
7. It must be inserted in a physiological site (generally the normal anatomic site).
8. It must be capable of permanent fixation.
9. It must not annoy the patient.
10. It must be practical to insert.

Indeed, we can add one more commandment that is it must not obstruct or damage neighboring structures (i.e., coronary ostia, atrioventricular node [AV] node).

After more than six decades, we can easily state that these properties have not been fully met yet, and there is no ideal prosthetic valve. There is an apparent limitation of durability with bioprosthetic valves and an apparent disadvantage of anticoagulation with mechanical prostheses. On the other hand, hemodynamic properties (i.e., effective orifice area and transvalvular gradient) of prosthetic valves are

worse, compared to native valves. Therefore, severe improvements have been achieved in aortic valve repair in the last five decades. Aortic valve repair using autologous pericardial cusp extension has been described by Duran and associates.^[2] Halees et al.^[3] in their 16-year follow-up of aortic valve reconstruction showed that the mode of valve degeneration differs between the bovine pericardium and the autologous pericardium. The failed bovine pericardial valves tended to show heavy calcification and extensive fibrosis which made the reoperation technically more difficult than with the autologous pericardium, showing still pliability with less fibrosis and calcification.

Neo-cuspidization either in aortic or pulmonary position^[4] is probably the most optimal alternative to mechanical or bioprosthetic replacement due to its superior hemodynamic properties such as largest effective orifice area, least transvalvular gradient. In addition, no foreign material is used and AV block incidence is almost zero. Another advantage of neo-cuspidization is the avoidance of anticoagulation. Only low-dose aspirin is usually given for three months postoperatively.

The only, but probably the most important drawback of neo-cuspidization is its durability. In a recent study, Ozaki et al.^[5] reported their experience in 850 consecutive patients operated for aortic stenosis, some of them with additional procedures (43.6%). The median age was 71 years and the mean follow-up was 53.7±28.2 months. Actuarial freedom from death,

cumulative incidence of reoperation, and that of recurrent moderate-to-severe aortic regurgitation was 85.9%, 4.2%, and 7.3%, respectively, with the longest follow-up of 118 months. The authors reported no conversion to a prosthetic valve replacement and only one case out of 850 underwent reoperation for structural valve degeneration.

These results seem to be consistent with the clinical outcomes of all current prosthetic valves. In pediatric patients and in specific cases such as patients with small aortic annulus, this technique may provide additional benefits.

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