Technical Challenges and Complications of Double Valve Replacement in the Presence of Small Aortic and Mitral Annuli

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A 57 year old female with rheumatic heart disease affecting both aortic and mitral valves underwent double valve replacement. The presence of small aortic and mitral annuli contributed to a series of intraoperative complications: left coronary ostium occlusion and type III atrioventricular groove disruption. The latter was repaired with a generous fresh autologous pericardial double layer patch and implant of a bileaflet mechanical prosthesis over the patch. Postoperatively, the patient developed prolonged respiratory insufficiency and pneumonia, transient myocardial dysfunction and acute renal failure. She was eventually discharged home without residual defects.

The combination of small aortic and mitral aortic annuli poses a technical challenge when double valve replacement is necessary[1]. Considerations about valve selection include the effective orifice of the implanted valve, sizes of the annulus and left ventricular outflow tract, body surface area, patient age and level of physical activity; these factors are important elements in avoiding patient-prosthesis mismatch and its clinical consequences[2,3].

The limited space available to implant two left-sided prostheses demands a good surgical strategy and careful attention to myocardial protection. We herein report such a case in which small aortic and mitral annuli contributed to a series of complications at double valve replacement.

Case Report

A 57 year-old female with past medical history of rheumatic fever presented with shortness of breath on exertion. and peripheral edema. Preoperative echocardiography revealed a trileaflet aortic valve, with 3+ aortic regurgitation and mild aortic stenosis, 3+ mitral regurgitation due to doming of the anterior leaflet with mild mitral stenosis (valve area 1.8 cm^2), and 3+ tricuspid regurgitation with right ventricular systolic pressure of 41 mmHg. The left ventricular function was preserved, with ejection fraction of 60%, left ventricular end-diastolic diameter of 4.5 cm, left ventricular end-systolic diameter of 2.4 cm; the left atrial diameter was 3.7 cm.

The operation was performed to address symptomatic rheumatic heart disease affecting the aortic and mitral valves, functional tricuspid regurgitation and single vessel coronary artery disease affecting the right coronary artery, which was detected incidentally on coronary angiogram.

Cardiopulmonary bypass was instituted through aortic and double venous cannulation after heparin administration. Myocardial protection was achieved through mild systemic hypothermia and intermittent antegrade and retrograde cold blood cardioplegia. The mitral valve was approached through an extended transeptal incision.

The operation initially consisted of mitral valve replacement with a 25 mm Carpentier-Edwards pericardial prosthesis (Edwards Lifesciences, Irvine, CA), aortic valve replacement with a 19 mm Carpentier-Edwards Magna prosthesis (Edwards Lifesciences, Irvine, CA), tricuspid valve repair with a 26 mm MC3 ring (Edwards Lifesciences, Irvine, CA) and coronary artery bypass grafting with reversed saphenous vein graft to right coronary artery. Both mitral and aortic valves were typically rheumatic in appearance with thickened leaflets and fusion of the commissures. The mechanism of mitral regurgitation was restriction of the posterior leaflet related to calcification and fusion between primary and secondary cords and the posteromedial papillary muscle. The noncoronary cusp of the aortic valve had a perforation close to the commissure with the left coronary cusp. Due to the severity of the valve pathology, double valve replacement was the only possible strategy.

Both the mitral and aortic annuli were small and somewhat non pliable because of annular calcification. Removal of the anterior and posterior leaflets with corresponding chordae tendinae in addition to calcium debridement were necessary to allow implantion of a 25 mm size mitral bioprosthesis. The small aortic root made implantation of a 19 mm bioprosthesis challenging. After aortic valve replacement, inspection of the left coronary ostium suggested the possibility of obstruction by the prosthesis. This suspicion was confirmed after the aorta was unclamped. Although the heart began to eject, intraoperative echocardiography clearly demonstrated wall motion abnormalities in the distribution of the left anterior descending and circumflex arteries, despite the presence

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of some flow into the left main trunk. The decision was made to revascularize both arteries with two segments of reversed saphenous vein. The procedure was performed with cardioplegic arrest, gently retracting the heart because of the presence of the mitral bioprosthesis. Weaning from cardiopulmonary bypass required low-dose inotropes, with normalization of ventricular contraction.

After 20 minutes, massive bleeding arising posteriorly occurred, requiring emergent institution of cardiopulmonary bypass. The heart was arrested and the interatrial septum was reopened; a type III atrioventricular dissociation was found, extending from just lateral to the base of the anterolateral papillary muscle obliquely towards the right and approaching the mitral annulus at the 5 o'clock position. The bioprosthesis was explanted and attention turned to the left ventricular disruption. The repair consisted of a generous fresh autologous pericardial double layer patch. This was affixed to the ventricular endocaridium deep to the tear using interrupted pledgeted 3-0 polypropylene sutures and to the left atrium using running sutures. A 25 mm bileaflet mechanical prosthesis was implanted over the reconstructed annulus taking sutures throught the pericardial patch and the annulus. Myocardial recovery required extended reperfusion time, high-dose inotropes and eventually an intra-aortic balloon pump. Bleeding improved, but coagulopathy developed, requiring delayed chest closure.

Postoperatively, the chest was closed on the 3rd day, the intra-aortic balloon removed on the 4th day, and inotropes discontinued on the 6th day. The patient had prolonged respiratory insufficiency and pneumonia and required tracheostomy. Transient acute renal failure required dialysis for a few days. The patient was eventually discharged home approximately 1 month after surgery with her tracheostomy removed, in good condition without residual defects.

Comments

This report illustrates several surgical aspects that may complicate the operative course of patients requiring both aortic and mitral valve replacement in the setting of small annuli. Moreover, early recognition of potential complications, followed by prompt intervention is essential when facing these complications.

Modern high-performance prosthetic valves have in common reduced sewing rings that impact surgical implantation by reducing the flexibility of the valve. Insertion of a properly sized prosthesis in the mitral position deforms the aortic annulus and reduces its abilty to conform to the shape of the aortic prosthesis. When the annuli are small, use of bioprostheses, which are more flexible than mechanical valves, and preservation of more intervalvar fibrosa between the two prostheses may facilitate double valve replacement. However, our patient had such a small mitral annulus that even a 25 mm diameter prosthesis was implanted with difficulty. Then, a series of complications occurred. Acute occlusion of the left coronary ostium was a consequence of a very limited space to implant a 19 mm aortic prosthesis; the small annulus, combined with the presence of a mitral prosthesis, caused the aortic prosthesis to tilt upward posteriorly, compromising the left coronary ostium.

Finally, type III atrioventricular groove rupture was multifactorial, likely due to complete removal of the mitral sub-valvular apparatus, manipulation of the heart during myocardial revascularization, prosthesis oversize and use of a bioprosthesis which by design has a strut at 6 o'clock. This complication is extremely dangerous and it carries an elevated mortality, complicated by the prolonged cardiopulmonary bypass time. Correction was successfully performed using a large autologous pericardial patch and reconstruction of the atrioventricular groove from the endocardium[4]. The patch must be generous and under no tension, softly covering the endocardium and the rupture. At mitral valve re-replacement, we used a mechanical prosthesis to avoid contact between a strut and the endocardial patch. We packed the posterior mediastinum for 24 hours before closing the chest, in order to support and secure the repair. Some groups have advocated bench repair of the heart and auto-transplantation as an option[5], a good indicator of the level of desperation felt when encountering this complication.

Enlargement of the aortic and mitral annuli, followed by patch reconstruction of the intervalvular fibrosa would be a useful procedure to prevent this problem[6]. However, this operation is difficult and requires perfect exposure and understanding of the surgical anatomy and the geometrical considerations relating to the juxtaposition of the mitral prosthesis and the left ventricular outflow tract. Exposure is by extended transseptal approach or division of the superior vena cava to extend the atriotomy to the dome. Care must still be taken not to oversize the mitral prosthesis with this involved approach. Moreover, the approximation of transitional areas (mitral prosthesis ring, patch and fibrous trigone) must be perfect to avoid leakage and hemolysis. Either mechanical or biological prosthesis can be used, with similar results[7]. The reported surgical risk and midterm outcomes with this technique in experienced hands have been acceptable[8]. Anatomical implantation of a homograft or stentless aortic prosthesis on top of an acceptable sized mitral prosthesis is another approach to the patient with small annuli.

In summary, double valve replacement with combined small aortic and mitral annuli is a surgical entity that requires a very thoughtful approach, sometimes including enlargement and reconstruction of the intervalvular fibrosa to avoid patient-prosthesis mismatch and hazardous complications.

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