Using Medtronic AP360 Mechanical Prosthesis in Mitral Valve Replacement for Patients with Mitral Insufficiency After Primum Atrial Septal Defect Repair to Reduce Left Ventricular Outflow Tract Obstruction Risk

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Case report

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Abstract

Background: Atrial septal defect is one of the most common congenital heart diseases in adults. Primum atrial septal defect (PASD) accounts for 4% to 5% of congenital heart defects. Patients with PASD frequently suffer mitral insufficiency, and thus, mitral valvuloplasty (MVP) or mitral valve replacement (MVR) is often required at the time of PASD repair. Unfortunately, recurrent unrepairable severe mitral regurgitation can develop in many patients undergoing PASD repair plus MVP in either short- or long-term after the repair surgery, requiring a re-do MVR. In those patients, risk of left ventricular outflow tract obstruction (LVOTO) has increased.

Case presentation: We present 5 such cases who were aged from 24 to 47 years and had a PASD repair plus MVP or MVR for 14 to 40 years, suffering moderate to severe mitral regurgitation. Using Medtronic AP360 mechanical mitral prostheses, only one patient occurred mild LVOTO.

Conclusions: Usage of Medtronic AP360 mechanical mitral prostheses to perform MVR in patients with MI who had a PASD repair history can potentially reduce the risk of LVOTO. Long-term follow-up is required to further confirm this clinical benefit associated with AP360 implantation in patients with PASD.

Introduction

Atrial septal defect is one of the most common congenital heart diseases in adults. Primum atrial septal defect (PASD), also known as endocardial cushion defect or partial atrioventricular septal defect, accounts for 4–5% of congenital heart defects[1, 2]. PASD is defined as a defect at the base of the interatrial septum caused by failure of the primum septum to fuse with the endocardial cushions. PASD is usually associated with defects in atrioventricular valves, especially in the anterior mitral valve leaflet, and thus patients with PASD are mostly complicated with mitral insufficiency (MI) requiring mitral valvuloplasty (MVP) or mitral valve replacement (MVR) at the time of PASD repair. Also, recurrent severe mitral regurgitation is observed in many patients undergoing PASD repair plus MVP in either short- or long-term after the repair surgery, requiring a reoperation[3]. An MVR is often required in these patients with unrepairable MI. Nevertheless, left ventricular outflow tract obstruction (LVOTO) often occurred after PASD repair in these patients, with or without MVR, leading to dyspnea, coronary insufficiency, congestive heart failure and even death[4]. Here, we present 5 cases of successful treatment of MI in patients with PASD repair history using Medtronic AP360 mechanical prostheses.

Case Report

Case 1

A 34-year-old female was admitted to our hospital because of chest pain complaint for two days. She had a PASD repair followed by an MVR 5 months after the PASD repair because of MI 25 years ago. Her echocardiography showed a peak left ventricular outflow tract (LVOT) pressure gradient of 109 mmHg, left ventricular outflow peak velocity of 5.23 m/s, minimum LVOT diameter in anteroposterior dimension of 7 mm, and the thickness of muscular part of interventricular septum of 14-16mm, causing severe LVOTO (Fig. 1A). The patient underwent MVR and LVOT repair via median sternotomy. Intraoperative examination revealed that part of the sewing cuff of the previously implanted mitral prosthesis was covered with hyperplastic annulus fibrosus tissue which protruded from the mitral annulus underneath the mechanical valve into the left ventricular outflow tract (Fig. 1B), and that one prosthetic valve lobe failed to open completely. Thus, the hyperplastic fibrous ring on the prosthetic valve and the thicken endocardium of the ventricular septum resulted in a stenosis ring. We implanted a 22# AP360 mechanical prosthesis (Medtronic, Inc., Minneapolis, MN, USA) to replace the previous prosthetic valve using non-everting pledget forced suture technique with pledget on the left ventricle (LV) side. The patient's postoperative echocardiography showed that the newly implanted mechanical valve worked well without residual LVOTO.

Case 2

Patient 2 was a 24-year-old female. She was hospitalized because of a one-month history of palpitation accompanied with occasional chest tightness and shortness of breath. She had PASD repair plus MVP 14 years ago. Her echocardiography at the hospital admission showed moderate to severe MI and anterior mitral valve leaflet cleft. The mitral valve was unrepairable and a 24# AP360 mechanical prosthesis implantation was performed. Mild postoperative LVOT stenosis was observed: Her postoperative echocardiography confirmed that the implanted prosthetic valve performed well and showed that her peak LVOT pressure gradient was 40 mmHg and minimum LVOT diameter in anteroposterior dimension was 8.9mm.

Case 3

5 Patients no. 3 to 5 were aged from 29 to 47 years and hospitalized because of MI. They had PASD repair plus MVP 15 to 40 years ago. The existing mitral valve was beyond repair, and thus MVR was performed on the patients. Medtronic AP360 mechanical prostheses of proper sizes were implanted using everting suture. All the 3 patients recovered uneventfully.

Table.1 Clinical data of 5 patients.

Case no.	gender	age	Previous surgery	Preop MI	interventricular septal thickness	Preop gradient of LVOT	Preop peak velocity of LVOT	Prosthesis implantation and suturing technique	Postop LVOTO
1	Female	34	PASD repair, MVR	Mild	14-16mm	109 mmHg	5.23 m/s	22# AP360, non-everting suture	None
2	Female	23	PASD repair	Severe	8mm	<40mmHg	<3.0 m/s	24# AP360, everting suture	Mild (peak velocity 3.2 m/s, gradient 40 mmHg)
3	Male	57	PASD repair	Severe	9mm	<40mmHg	<3.0 m/s	24# AP360, everting suture	None
4	Female	29	PASD repair	Moderate to severe	10mm	<40mmHg	<3.0 m/s	24# AP360, everting suture	None
5	Female	45	PASD repair	Severe	9mm	<40mmHg	<3.0 m/s	26# AP360, everting suture	None

MI mitral incompetence, LVOT left ventricular outflow tract, LVOTO left ventricular outflow tract obstruction, PASD partial atrial septal defect

Discussion

LVOTO with an incidence rate of up to 6% is one of the most common complications in patients undergoing PASD repair[5, 6]. In this case series, we performed MVR on the 5 patients who had MI at hospital admission and had previous PASD repair. All of them were implanted with a Medtronic AP360 mechanical mitral valve including one re-MVR, and only one patient developed mild postoperative LVOTO.

We used AP360 valves in these 5 patients because we believe the design of AP360 could reduce the risk of LVOTO. In the normal anatomy, LVOT is only a few millimeters long and the aorta is “wedged” between the mitral and tricuspid valves. However, in patients with PASD, the aortic valve is anterior and rightward but is not positioned between the two normal atrioventricular (AV) valves, which consequently changes the anteroposterior dimension of the LVOT. The should-be position of the aortic root creates extra length of LVOT, which is absent in the heart with the normal anatomy. Moreover, the deficiency of the septum makes a convexity towards the ventricular side, narrowing the LVOT. These anatomic abnormalities lead to a narrow and elongated LVOT with an abnormal outlet angle, which is described classically as the “goose neck” deformity in angiography[6].

Because of the anatomic characteristics of PASD, a prosthetic valve protruding into the LVOT may worsen LVOTO[7, 8]. A prosthetic valve with pannus and hyperplastic annulus fibrous tissue can partially block the LVOT and thus increase the risk of LVOTO. In Case 1 of this report, we found that part of the sewing cuff of the previously implanted prosthetic valve was covered with hyperplastic annulus fibrous tissue protruding into the LVOT. The development of the hyperplastic anulus fibrous tissue may be associated with the blood flow. Medtronic AP360 mechanical prosthesis, whose sewing cuff is different from that of other prosthetic valves in terms of positioning, can possibly avoid hyperplastic anulus fibrous tissue formation. According to the unique design of AP360, an implanted AP360 prosthesis locates mostly in the atrial side, while an implanted other mechanical valve, such as ATS mechanical mitral valve, locates partly in the ventricular side (Figure. 2A&B). Thus, the potential risk of LVOTO associated with AP360 prosthesis implantation can be reduced.

Notable, for Carbomedics Orbis Universal mechanical mitral valve, because of its flexible and longitudinal symmetrical sewing cuff, the Carbomedics Orbis Universal mechanical mitral prosthesis can be squeezed by the scarred annulus and thus sink into the ventricular side (normally pushed to the atrial side due to pressure difference) and worsen LVOTO. Although other types of mechanical valves with a similar design as the ATS prosthetic valves may be not as bad as the Carbomedics Orbis valves in terms of the risk of LVOTO, could still sink to the LV to some degree. Implantation of Medtronic AP360 prosthesis using non-everting suture can lift the prosthesis up to the left atrium (LA) and avoid this situation.

We had encountered a case showing a Carbomedics Orbis valve implantation associated LVOTO. A 40-year-old female was diagnosed with primum ASD, anterior mitral valve leaflet cleft and moderate tricuspid regurgitation. She underwent tricuspid valvuloplasty and PASD repair. However, her mitral valve was beyond repair and thus a 27# Carbomedics mechanical mitral valve was then implanted. Her postoperative TEE showed the well-performed implanted prosthetic mitral valve, a peak LVOT pressure gradient of 34 mmHg, and left ventricular outflow peak velocity of 2.9 m/s. Her postoperative 3-month follow up echocardiography showed a moderate LVOT stenosis with a peak LVOT pressure gradient of 73 mmHg, left ventricular outflow peak velocity of 4.2 m/s, minimum LVOT diameter in anteroposterior dimension of 13 mm, and interventricular septum thickness of 10mm. Postopoerative 18-month follow-up echocardiography showed a severe LVOT stenosis with a peak LVOT pressure gradient of 92 mmHg, left ventricular outflow peak velocity of 4.8 m/s, minimum LVOT diameter in anteroposterior dimension of 6.6 mm and interventricular septum thickness of 12 mm. The patient refused a re-MVR.

Based on our experience, we believe choosing a AP360 prosthesis with a proper size matching the patient’s anatomic structure is critical for good clinical outcome. An oversized AP360 may cause valve dysfunction. One of the lobes of an oversized prosthesis could be blocked by the thickened interventricular septum, leading to valve dysfunction. Aggressive implantation of an oversized prosthetic valve to avoid mitral prosthesis-patient mismatch, which remains to be controversial regarding patient outcome, is not recommended[9].

Some pediatric cardiac surgeons suggest that the chimney technique can be used to avoid LVOTO in young patients undergoing MVR[10]. THE Chimney technique is to suture a several-millimeter-long tubular dacron graft to the sewing cuff of a prosthetic valve and then suture the graft to the native mitral annulus, forming a composite graft floating in the LA like a “chimney”. Although the chimney technique shows promising LVOTO prevention in children, the long-term effect is still unknown in patients with PASD.

Conclusion

Usage of Medtronic AP360 mechanical mitral prostheses to perform MVR in patients with MI who had a PASD repair history can potentially reduce the risk of LVOTO. Long-term follow-up is required to further confirm this clinical benefit associated with AP360 implantation in patients with PASD.

Abbreviations

PASD: Primum atrial septal defect; MI: mitral insufficiency; MVP: mitral valvuloplasty; MVR: mitral valve replacement; LVOT: left ventricular outflow tract; LVOTO: left ventricular outflow tract obstruction; LA: left atrium; LV: left ventricle; AV: atrioventricular.

Declarations

Acknowledgement: Not applicable.

Authors’ contributions: LG and QY drafted the original manuscript. YN and LG participated in the treatment. YN and JZ revised the manuscript. All authors read and approved the final manuscript.

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Figures

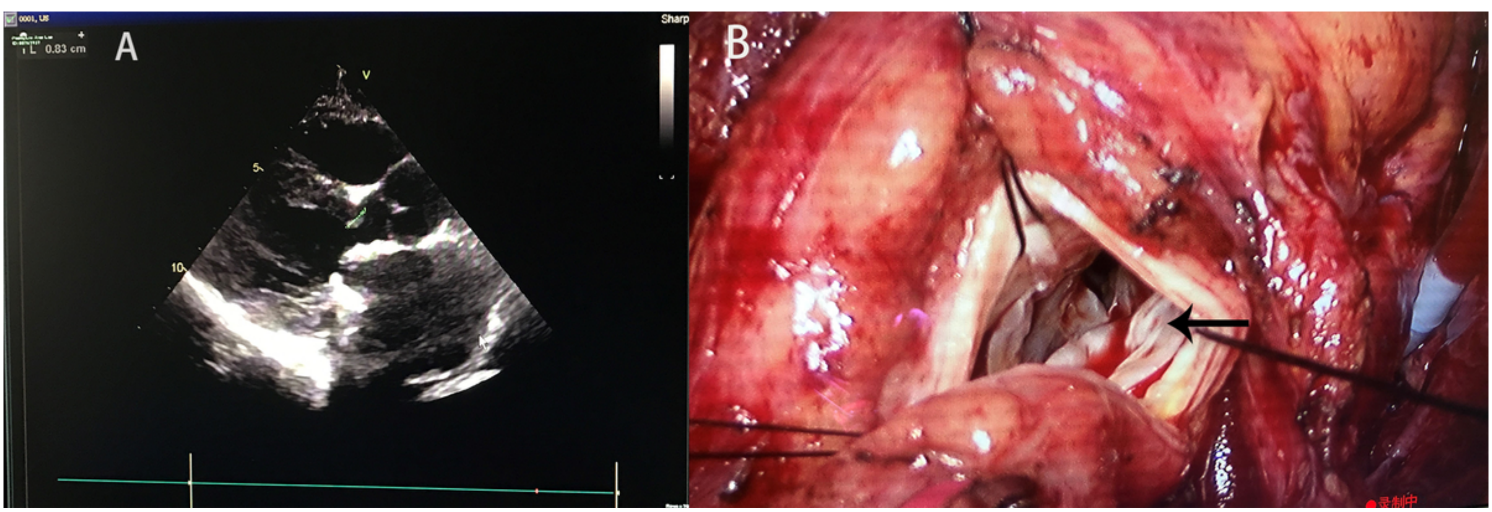

Figure 1

(A) Preoperative echocardiography showed and (B) intraoperative findings of case 1. The black arrow indicates the protruding mitral annulus tissue.

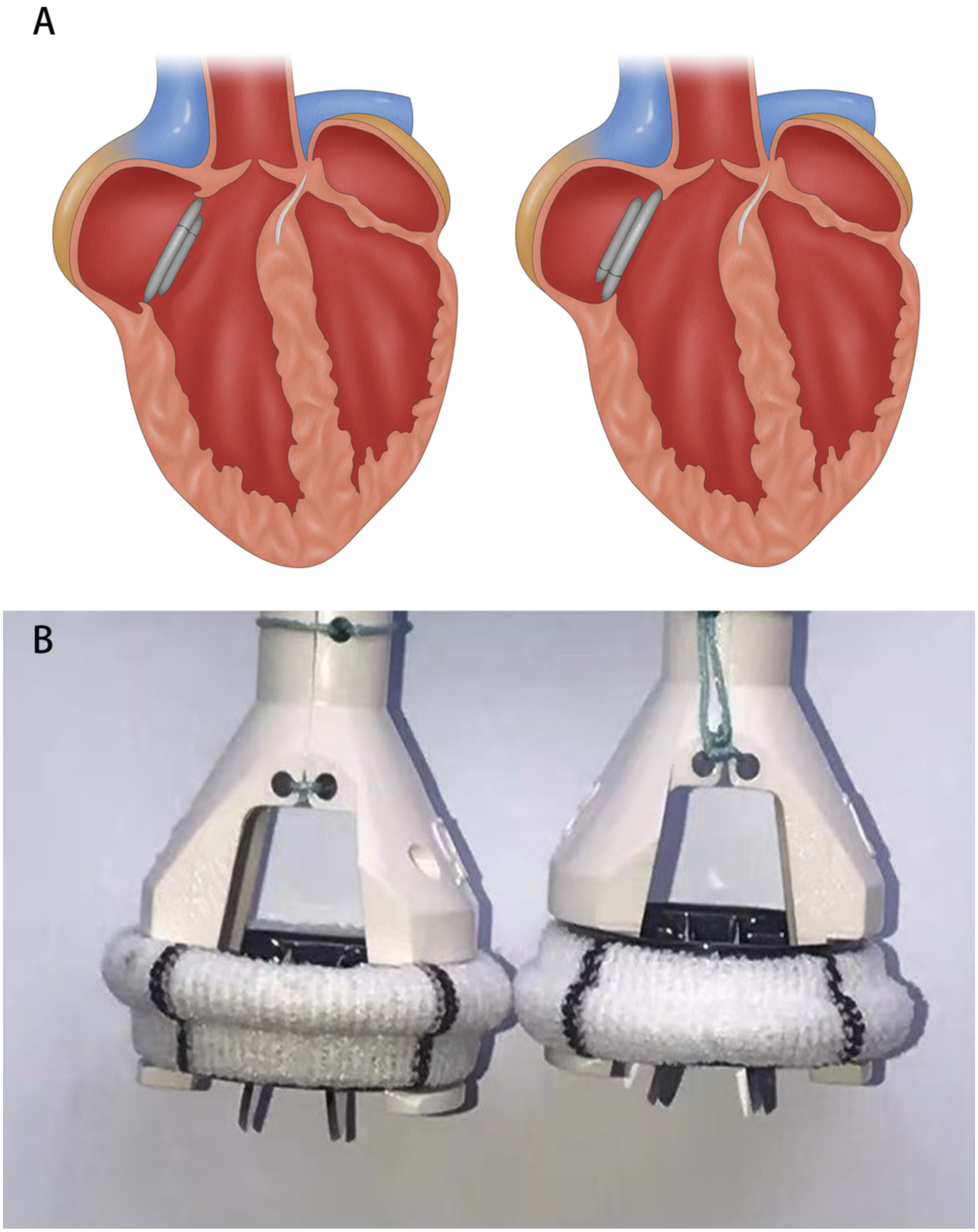

Figure 2

(A) Cartoon showing an implanted ATS mechanical mitral valve (left) and AP360 (right) after MVR, and (B) Photos of an ATS mechanical mitral valve (left) and AP360 (right). The panel A shows that after the implantation, ATS valve will subside more substantially into the LVOT than an AP360, resulting a higher risk of LVOTO. The panel B shows that with the sewing cuff in the same plane, the ATS is approximately 3 mm lower than the AP360. MVR: mitral valve replacement; LVOT: left ventricular outflow tract; LVOTO: left ventricular outflow tract obstruction.

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