The Role of Antegrade Balloon Aortic Valvuloplasty in a Patient with Low-flow, Low-gradient Aortic Stenosis and ST-elevation Myocardial Infarction

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Selecting an appropriate therapeutic strategy for severe aortic stenosis (AS) is challenging in presence of ST-elevation myocardial infarction (STEMI). We report a case in which antegrade balloon aortic valvuloplasty (A-BAV) played an important role in temporizing a patient with severe AS and reduced left ventricular ejection fraction (LVEF) due to STEMI.

Our patient was an 85-year-old man who experienced anterior STEMI (peak creatine kinase = 5286 U/L) and fulfilled the criteria of classical LFLG-AS (aortic valve area = 0.68 cm², LVEF = 16%, and MPG = 20 mmHg). He had heart failure symptoms refractory to optimized therapy, including intra-aortic balloon pump (IABP) counterpulsation, even after successful recanalization of the coronary artery. Intervention for severe AS was required; however, the patient was identified to be at high risk for surgery (Society of Thoracic Surgeons score = 16.56%), and our hospital is not a transcatheter aortic valve replacement-capable facility. We performed A-BAV for hemodynamic restoration. A few days after successful A-BAV, tapering of norepinephrine and weaning of IABP were initiated. A cardiac rehabilitation program was initiated during the intensive care period, and which facilitated the patient to be discharged. A-BAV achieved convalescence with no recurrence of heart failure hospitalization at 510 days of follow-up.

KEY WORDS: balloon aortic valvuloplasty, low-flow low-gradient aortic stenosis, ST-elevation myocardial infarction

I. Introduction

Patients with acute coronary syndrome and concomitant aortic stenosis (AS) often require a combination of treatments, which are associated with procedural concerns, such as hemodynamic deterioration. Although selecting an appropriate therapeutic strategy for these patients is challenging, interventional cardiologists often encounter situations in which management of AS is required to offset heart failure symptoms. Balloon aortic valvuloplasty (BAV) is useful for cracking the calcified aortic valve and restoring hemodynamic stability in cases involving multiple

comorbidities and a questionable long-term prognosis. When using antegrade BAV, operators can accomplish BAV while preserving the femoral artery for mechanical support. Moreover, BAV is used for critically ill patients with AS in centers not performing transcatheter aortic valve replacement, without transferring these patients to another center. The therapeutic benefits of BAV, although short-term, can be obtained in various clinical settings.

II. Case report

An 85-year-old man with a 3-year history of memory impairment presented with ST-elevation myocardial infarction (STEMI). He had been treated with donepezil (5 mg/day). He arrived at our hospital 4 hours after the onset of symptoms. His initial vital signs in the ambulance included a blood pressure (BP) of 140/100 mmHg, heart rate of 120 bpm (irregular), respiratory rate of 20 bpm, and oxygen saturation of 95% at room air. An electrocardiogram (ECG) demonstrated ST elevation in leads I, aVL, V2, V3, V4, and V5. In the point-of-care transthoracic echocardiogram (TTE), the motion of the left anterior ventricular wall and aortic valve decreased with mild aortic regurgitation

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Fig. 1

A: Angiogram showing acute occlusion of the proximal left anterior descending (LAD) artery and linear calcifications along the vessel line.

B: Final angiogram. After modifying the calcific plaques with a cutting balloon, a drug-eluting stent (DES) was deployed. The DES was placed into the ostial LAD artery using intravascular ultrasound imaging; the left circumflex artery was not jailed by the stent struts, resulting in satisfactory coronary flow in both branches.

C: No significant stenosis in the right coronary artery and poor collateral supply for the LAD.

Fig. 2

A: Electrocardiogram on admission showing ST-segment elevation in leads I, aVL, V2, V3, V4, and V5, with atrial fibrillation, right bundle branch block, and reciprocal ST-segment depression in leads II, III, and aVF.

B: Prompt resolution of ST-segment elevation was achieved after primary percutaneous coronary intervention; however, the R-wave amplitude decreased in each precordial lead, with a QS complex in leads V1, V2, and V3.

(AR). Laboratory examination revealed normal levels of creatine kinase (CK = 203 U/L), with a slight elevation in troponin-I and serum brain natriuretic peptide levels (4.04 ng/mL and 259.6 pg/mL, respectively). Emergent coronary angiography revealed total occlusion in the proximal left anterior descending (LAD) artery with poor collaterals. Subsequent percutaneous coronary intervention, with a door-to-balloon time of 70 min, pre-dilatation of the calcified lesions with a cutting balloon (Wolverine 2.5 × 12 mm; Boston Scientific, Marlborough, MA), and stent implanta-

tion (Synergy 3.0 × 28 mm, Boston Scientific) into the ostial LAD artery restored good coronary flow (CK peaked at 5286 U/L) (Fig. 1). Recanalization of the lesion achieved ST-segment resolution (Fig. 2) and alleviated the patient's chest pain; however, 12 h later, a continuous decrease in arterial BP was observed (lowest reading: 85/50 mmHg). Meanwhile, the hemoglobin level showed no decrease. Echocardiography excluded mechanical complications (including ventricular septal rupture or free wall rupture). Persistent hypotension unresponsive to vol-

Fig. 3

A: The parasternal short-axis view of the transthoracic echocardiogram showing minimal opening of the valve. Decreased mobility of the right coronary cusp (RCC) and non-coronary cusp (NCC) was more prevalent than that of the left coronary cusp (LCC).

B: The aortic valve area was traced as 0.68 cm^2 .

C: The annulus plane of the computed tomography image demonstrated the distribution of calcified nodules on the leaflets better. Dense calcifications on the NCC and spotty calcifications on the RCC and LCC were evident.

ume replacement was accompanied by cold extremities, appetite loss, oliguria, and dyspnea. Although the treatments were refined for congestion, including positive inotrope (dobutamine $3 \mu\text{g/kg/min}$), oral diuretics (azosemide 60 mg/d , tolvaptan 7.5 mg/d), and noninvasive positive pressure ventilation, a bedside echocardiogram confirmed worsening motion in aortic valve leaflets (Fig. 3). The restricted motion of the aortic valve (aortic valve area [AVA] = 0.68 cm^2) in a state of left ventricular dysfunction (left ventricular ejection fraction [LVEF] = 16% and indexed stroke volume [SV] = 14 mL/m^2) with a discordant gradient (mean pressure gradient [MPG] = 20 mmHg) met the diagnostic criteria for classical low-flow, low-gradient (LFLG) severe AS. The right heart catheterization data suggested both low cardiac output (cardiac index [CI] = 1.62 L/min/m^2) and pulmonary congestion (pulmonary artery wedge pressure [PAWP] = 25 mmHg) despite optimal therapy, including intra-aortic balloon pump (IABP) counterpulsation. The patient had a high surgical risk (Society of Thoracic Surgeons [STS] score = 16.56%); however, our institution did not have the facility for transcatheter AVR (TAVR). After careful consideration of the risks and benefits of the procedure and after obtaining informed consent, we decided to perform BAV.

BAV was performed using an antegrade approach with local anesthesia at the puncture site. A 14-Fr sheath was placed in the right femoral vein, and the left atrium was accessed with an 8-Fr Mullins sheath (Medtronic, Dublin, Ireland) through trans-septal puncture. The Inoue balloon (Toray, Tokyo, Japan) was advanced over the extra-stiff wire to position across the aortic valve; however, it did not pass through. Therefore, we used a VACSII balloon (OSYPKA Medtec, Longmont, CO). Although the VACSII balloon required rapid ventricular pacing, IABP and vasopressor support facilitated procedure completion. We inserted the AcuNav catheter (Siemens-Acuson, Inc. Mountain View, Cali-

fornia, USA), or intracardiac echocardiography (ICE) from the right jugular vein for AR monitoring. Multiple inflations of the calcified aortic valve, while increasing the inflation diameter stepwise (from 2 mL underfilling to nominal size), successfully increased AVA (from 0.68 cm^2 to 1.08 cm^2), SV (from 21 mL to 42 mL), and LVEF (from 16% to 31%), with no increase of AR to > moderate. On the day after the successful BAV, arterial BP showed a continuous increase between 120/40 mmHg and 160/40 mmHg. On the next day, norepinephrine was discontinued followed by weaning of IABP support. A cardiac rehabilitation program was initiated during the intensive care period, which facilitated the patient to get discharged on the 58th hospital day. He scored 18/30 on the Mini-Mental State Examination at discharge. In the next 1 month after discharge, he developed progressive cognitive dysfunction, which manifested as a reduced ability for self-care, and came to our outpatient clinic using a wheelchair. We continued giving cardioprotective medications, and did not proceed to TAVR. He was followed-up for 510 days without cardiovascular hospitalization.

III. Discussion

In this case, the patient experienced acute myocardial injury (peak CK = 5286 U/L) and fulfilled the criteria of classical LFLG-AS (AVA = 0.68 cm^2 , LVEF = 16%, and MPG = 20 mmHg). Despite optimization of treatments, including successful PCI and IABP counterpulsation, the patient experienced severe symptoms with pulmonary congestion (PAWP = 25 mmHg) and low cardiac output (CI = 1.62 L/min/m^2). Although the True or Pseudo-severe Aortic Stenosis-Transcatheter Aortic Valve Implantation registry has reported that TAVR is associated with improvements in LVEF and clinical outcomes in patients with LFLG-AS and severely decreased LVEF (<30%)¹⁾, little evidence exists on the selection of treatment strategies for patients

with symptomatic LFLG-AS, STEMI, and progressive acute heart failure. Emergent TAVR is the most feasible life-saving treatment; however, further studies are needed to define the role of this procedure^{2–4}.

This case exemplified the following characteristics: 1) acute cardiovascular symptoms due to classical LFLG-AS, 2) requirement for management of AS in the presence of anterior STEMI, 3) high-risk for AVR (STS score = 16.56%), 4) hospitalized in a facility which is 40–60 minutes away from a TAVR-capable facility, and 5) advanced old age (>85 years) and pre-existing frailty. Moreover, the patient demonstrated severe preoperative symptoms, as well as LVEF < 30% and use of preoperative intravenous inotropic agents, which have been reported to be independent predictors of severe sequelae of TAVR⁵. These multiple comorbidities made the evaluation of the likelihood of physiological recovery after TAVR more challenging. With this uncertainty, it may be difficult to justify the procedural risks and costs involved with transferring for TAVR. Therefore, we preferred BAV as the first-line therapy.

We selected antegrade BAV (A-BAV) rather than retrograde because we had already initiated cardiac support using IABP from the right femoral artery and preserved the left femoral artery for extracorporeal membrane oxygenation insertion in case of hemodynamic deterioration. There are four reasons for performing BAV with preprocedural IABP insertion: 1) severe AR is relatively uncommon after BAV, with a reported occurrence rate of 1%–2%^{6, 7}), 2) even a modest increase in AVA could lead to a significant short-term increase in functional status⁸), 3) preprocedural AR grading in this case was mild, and 4) imaging-guided BAV is important for avoiding complications. Mizutani et al. reported that the complication rate could be offset by stepwise dilatation using intraoperative transesophageal echo-

cardiogram⁹). Taken together, these assessments, support our practice of using the intracardiac imaging catheter and relatively undersized balloon for BAV to achieve valvuloplasty effect, while reducing the complication rate.

We evolved A-BAV by utilizing an ICE catheter for real-time monitoring of AR and balloon positioning during multiple inflations (Fig. 4). Successful A-BAV increased AVA (from 0.68 cm² to 1.08 cm²), SV (from 21 mL to 42 mL), and LVEF (from 16% to 31%) (Fig. 5) and yielded therapeutic benefit without causing AR > moderate.

Fig. 4 Selected cineradiograph demonstrating the VACS II balloon placed across the aortic valve. The balloon (arrow) was positioned antegradely through the right femoral vein. A total of seven inflations were performed under rapid right ventricular pacing, using a 5-Fr pacemaker catheter placed through the left femoral vein. An intracardiac echocardiography catheter (arrowhead) was inserted from the right jugular vein for monitoring aortic regurgitation and balloon positioning during balloon inflations.

GW: guide wire, LV: left ventricle

Fig. 5

A: The transthoracic echocardiogram (TTE) before balloon aortic valvuloplasty (BAV) showing minimal opening of the valve. The aortic valve area (AVA) was traced as 0.68 cm².

B: TTE after BAV demonstrating enlarged valve opening. AVA improved to 1.08 cm².

RCC: right coronary cusp, LCC: left coronary cusp, NCC: non-coronary cusp

The BAV goal was a temporary reduction of cardiac load by increasing AVA and concomitant improvement of the clinical condition in order to bridge the patient to a more durable treatment, while not aggravating AR. Our patient experienced effective symptom relief after BAV; however, in the next 1 month, he demonstrated exacerbation of cognitive impairment and a clinical frailty scale (CFS) of 7. The CFS score of 7 is characterized by a progressive dependence in personal care and facing high risk of 1-year mortality (45%)¹⁰. We made a decision in conjunction with the patient and relatives about the ceiling of treatment to involve the patient and did not proceed to TAVR. With BAV alone, it is inevitable that the patient will be readmitted in the hospital. The next time the patient was admitted with severe symptomatic AS, we would provide him with expectant medications and best supportive care.

BAV is one of the most effective treatments for temporizing patients with AS and the burden of significant comorbidities¹¹. We consider the following strengths of BAV: 1) By utilizing real-time ICE, the diameter of the valve dilatation balloon is safely approached to the size of the surgical valve ring. This is advantageous in cases where contrast-enhanced CT should be avoided, with severe renal dysfunction. 2) When using A-BAV, operators can accomplish BAV while preserving the femoral artery. This is advantageous in cases requiring mechanical circulatory support and cases with severe peripheral artery disease. 3) BAV improves hemodynamics and allows re-evaluation by the cardiac team under better conditions. This facilitates selection of candidacy for a definitive treatment strategy even in cases where the initial indication of AVR was poor. Therefore, BAV plays an important role in the TAVR era.

IV. Conclusion

A-BAV was useful in treating a patient with acute decompensated heart failure due to classical LFLG-AS in an acute setting of anterior STEMI.

Acknowledgments

None.

Conflicts of interest

The authors declare no conflicts of interest.

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