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Case Report: Pre-emptive intra-aortic balloon counterpulsation in patients with aortic regurgitation initiated after cross-clamping during cardiopulmonary bypass

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Preoperative implantation of an intra-aortic balloon pump has been shown to reduce mortality in high-risk cardiac surgery cases. However, one main contraindication for its use is severe aortic regurgitation. We describe a case of safe and beneficial use in a patient presenting with moderate to severe aortic regurgitation and highly reduced ejection fraction undergoing aortic valve replacement.

KEYWORDS

IABP, intra-aortic balloon pump, cardiac surgery, aortic valve surgery, aortic regurgitation, reduced ejection fraction

1. Introduction

Multiple meta-analyses have shown that pre-emptive treatment with an intra-aortic balloon pump (IABP), i.e., an implantation before the start of surgery or at least before cardiopulmonary bypass (CPB), improves outcomes and reduces mortality in hemodynamically stable high-risk patients undergoing cardiac surgery. Most of these studies have been performed on patients with reduced left ventricular function undergoing coronary arterial bypass graft surgery (CABG). Throughout these studies, redo surgery and a reduced ejection fraction (EF) were commonly agreed upon to identify patients potentially benefiting from this strategy (1–5).

The S3 Guideline of the German Society for Thoracic and Cardiovascular Surgery highlights the beneficial effect of IABP-induced pulsatility during cross-clamping on overall organ function and especially on renal function. No studies have shown an adverse effect; thus, when pre-emptively implanting an IABP, using the benefit of counterpulsation during the CPB seems beneficial (6).

Sparse data analyzing the outcome effects of pre-emptive IABP treatment in patients undergoing valve surgery are available (7), even though the well-established effects of counterpulsation on venous congestion, increasing mean arterial pressure and thus improving overall organ perfusion suggest a possible benefit.

One of the main contraindications for IABP is severe aortic regurgitation due to the aggravating effect of balloon inflation on retrograde blood flow during diastole (6, 8).

To the best of our knowledge, preoperative implantation and initiation of IABP therapy after cross-clamping the aorta during an aortic valve replacement procedure in a patient with aortic regurgitation has not yet been reported.

2. Case description

A 60-year-old man was admitted due to shortness of breath on light exertion (NYHA III) on 28 May 2021. No syncope or typical angina pectoris symptoms were reported. The patient had a history of aortic valve replacement and CABG (LIMA-LAD) in March 2015 and NSTEMI in October 2015 and November 2020, necessitating urgent percutaneous coronary intervention (PCI) procedures (DES LAD/RD1 and DES RCX). Echocardiographic imaging after the last NSTEMI and PCI showed severely impaired LV function not fully explained by previous ischemic damage to the myocardium. Left ventricular biopsy showed a resolving/chronic lymphocytic myocarditis. Molecular-pathologic analysis indicated the presence of Epstein-Barr virus and human herpes virus 7. An internal cardioverter/defibrillator was implanted as primary prophylaxis in December 2020.

After admission, transthoracic echocardiography showed a highly degenerated aortic valve prosthesis with severe aortic stenosis (V_{max} 3.8 m/s, aortic valve area 0.9 cm²), moderate regurgitation [pressure half-time (PHT) 220–260 ms], and signs of pulmonary hypertension [systolic pulmonary arterial pressure (sysPAP) 43 mmHg plus central venous pressure, right ventricle dilated] and severely impaired left ventricular ejection fraction of approx. 20%–25%. Right and left heart catheterization showed a stable coronary status and a pulmonary capillary wedge pressure (PCWP) of 30 mmHg, a transpulmonary gradient of 14 mmHg, a pulmonary arterial pressure (PAP) of 74/26/44 mmHg (systolic/diastolic/mean), a cardiac index (CI) of 1.71 L/min/m², a mixed venous saturation (SvO₂) of 62%, a stroke volume index (SVI) of 26 ml/m², and right ventricular pressures of 71/8/12 mmHg (systolic/diastolic/end-diastolic).

After a multidisciplinary discussion with our heart team, a transfemoral aortic valve implantation (TAVI) procedure was ruled out due to the close proximity of the left coronary ostium to the aortic valve.

After induction of anesthesia following a standardized in-house protocol (sufentanil, propofol, dexmedetomidine, and rocuronium) and the insertion of a central venous catheter and a pulmonary arterial catheter for continuous monitoring of the mixed venous saturation (SvO₂) and semicontinuous cardiac output (HemoSphere monitoring, Edwards Lifesciences, Irvine, USA), perioperative anesthesia was continued with remifentanyl, propofol, and dexmedetomidine. Transesophageal echocardiography revealed severe aortic regurgitation (PHT 200 ms). The cardiac index before surgery was 1.9 L/min/m² [SvO₂ 70%, right ventricular EF 36%, end-diastolic volume index (EDVI) 98 ml/m², SVI 36 ml/m², PAP 50/30/14 mmHg, PCWP 19 mmHg]. A continuous application of levosimendan (0.1 µg/kg/h) for 24 h was started, and a sheathless IABP (Sensation Plus 8 French, 50 cc, Datascope, Fairfield, USA) was inserted before surgical incision. The IABP was started

immediately after cross-clamping of the aorta with a rate of 60 bpm. After implanting the new valve (21 mm Perimount Magna Ease, Edwards Lifesciences, Irvine, USA) and declamping the aorta, dual chamber pacing/sensing with 80 bpm was initiated, and weaning from extracorporeal circulation was achieved with ECG-triggered IABP and low doses of continuous noradrenaline. No blood products were required during surgery.

The patient was transferred to our ICU and extubated timely. Hemodynamics improved significantly after the return of spontaneous ventilation and additional fluid substitution (400 ml of 20% albumin and 1,500 ml of balanced crystalloids). In addition, three units of red blood cell units were transfused. No further vasopressor therapy was needed after 24 h. IABP weaning was initiated 18 h after surgery, and the IABP was removed 9 h later. The cardiac index was between 2.2 and 3.1 L/min/m² after IABP removal. The patient was transferred to the surgical ward in stable condition on the second postoperative day.

3. Discussion

This case demonstrates the feasibility of preoperative IABP implantation and initiation of counterpulsation after cross-clamping the aorta in a patient suffering from impaired LV function undergoing aortic valve replacement surgery due to moderate-to-severe aortic regurgitation. Our treatment strategy resulted in a successful and smooth transition from cardiopulmonary bypass and facilitated a fast-track approach including early extubation, mobilization, and discharge from ICU less than 48 h post surgery.

Implantation of an IABP prior to initiation of cardiopulmonary bypass and commencing aortic counterpulsation immediately after aortic cross-clamping may provide an alternative to an approach of watchful waiting until more invasive measures such as arteriovenous extracorporeal life support or other modalities of mechanical circulatory support may become necessary in patients with aortic regurgitation and severely reduced LV function.

Data availability statement

The original contributions presented in the study are included in the article. Further inquiries can be directed to the corresponding author.

Ethics statement

Written informed consent was obtained from the patient for the analysis and publication of the anonymized data included in this article.

Author contributions

LM: Writing – original draft. DH: Writing – original draft. SS: Writing – review & editing. MV: Writing – review & editing. MH: Supervision, Writing – review & editing.

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Conflict of interest

MH reports consulting and lecture fees from Edwards Lifesciences.

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