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Original Article

Preoperative Intra-Aortic Counterpulsation in Cardiac Surgery: Insights From a Retrospective Series of 588 Consecutive High-Risk Patients

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Objective: To support a rational use of preoperative intra-aortic balloon pump (IABP) in cardiac surgery.
Design: Retrospective, observational study.
Setting: Single university hospital.
Participants: The study included 588 (mean age 68.5 ± 9.6 yr) consecutive patients who received IABP before cardiac surgery from 1999 to 2016.
Interventions: Coronary surgery was performed in 573 (97.4%) cases. IABP indications were prophylaxis (n = 147), unstable angina (n = 239), and rapid worsening of hemodynamics (n = 202). Baseline characteristics of patients were analyzed with multivariable methods. Comparison of outcomes postsurgery between 74 patients undergoing IABP because of left main coronary artery disease (LMCAD) (stenosis ≥ 50%) and a new series of 1,360 patients experiencing LMCAD but who did not receive an IABP using propensity-score matching.
Measurements and Main Results: Throughout the study period, the rate of IABP use for prophylaxis and unstable angina increased ($p = 0.0029$) despite reduction in patient surgical risk ($p = 0.0051$). Early period of surgery ($p = 0.032$), rapid worsening of hemodynamics in the operating room ($p = 0.0029$), renal impairment ($p < 0.0001$), and ventilation before surgery ($p = 0.0032$) were predictors of in-hospital mortality. The cumulative rate of IABP-related complications was 6.8%. Current smoking ($p = 0.025$) and the use of a 9 Fr catheter ($p = 0.0017$) were predictors of IABP-related vascular complications. No difference was found regarding outcomes postsurgery for 43 pairs of IABP/non-IABP matched patients with LMCAD, even though preoperative IABP was associated with an increased use of bilateral internal thoracic artery grafting.
Conclusions: Preoperative use of IABP in cardiac surgery was shown in this study to be safe, even for high-risk patients. LMCAD is not by itself a sufficient indication for prophylactic IABP.

Key Words: intra-aortic counterpulsation; left main coronary artery disease; outcomes; prevention; risk-factor analysis

INTRA-AORTIC COUNTERPULSATION, or the intra-aortic balloon pump (IABP), has been used for decades in cardiac surgery to prevent perioperative depression of cardiac function in patients at high risk for death and perioperative complications. After diastolic inflation and systolic deflation, coronary blood flow is increased and afterload is decreased, which results in an augmentation of oxygen supply and lowering of oxygen demand.[1]

Throughout the last 20 years, many randomized controlled trials[2–12] and meta-analyses[13–18] have been performed to

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establish the role of preoperative IABP in cardiac surgery. According to most of these studies,[2–9,11,13–18] the use of IABP before surgery could lower early mortality after surgery, reduce incidence of low output syndrome, and shorten the length of intensive care unit and hospital stays. However, even though recently published randomized trials have confirmed acceptable safety for IABP, they have provided limited or no support for the use of prophylactic IABP in high-risk cardiac surgeries.[10,12] Thus, no definite consensus has been obtained regarding the impact of preoperative IABP on outcomes postsurgery despite many optimal (but conflicting) randomized controlled trials and meta-analyses about the topic. Even though several authors highlight hypothetical benefits of preoperative IABP for high-risk patients experiencing left ventricular dysfunction[3,5] or left main coronary artery stenosis[19,20] and those undergoing redo[2] or off-pump surgery, [6,9,11] other investigators are more skeptic or emphasize the risk of IABP-related complications.[10,12] Consequently, there seems to remain only observational data to evaluate the efficacy of IABP, especially in niche indications, and additional studies to inform optimal patient selection, timing, and use of associated therapies are required to characterize the role of preoperative IABP in contemporary practice and optimize outcomes in high-risk patient subsets.[21,22]

In this context, the authors of the present study reviewed the outcomes of a large series of patients who underwent IABP implantation at their institution. The aims of the study were to characterize these patients according to IABP indication, to show the changes in IABP management that occurred over time, and to assess the effect of these changes on the incidence of IABP-related complications.

Hypothetical benefits of preoperative IABP for patients experiencing significant left main coronary artery disease (LMCAD) (stenosis $\geq 50\%$) were explored in a supplementary analysis.

Materials and Methods

Study Patients

Between January 1999 and December 2016, a total of 9,128 patients underwent surgery at the authors' institution; IABP was implanted preoperatively in 588 (6.4%; mean age 68.5 $\pm$ 9.6 yr) consecutive patients who were enrolled in this retrospective study. Baseline characteristics, surgical data, and postoperative complications were recorded prospectively for every patient in a computerized data registry. The risk profile of each patient was established preoperatively according to the European System for Cardiac Operative Risk Evaluation II (EuroSCORE II).[23] Unless otherwise stated, definitions and cutoff values of the preoperative variables were those used for EuroSCORE II.[23] Definitions of postoperative complications were in accordance with the internationally agreed on definitions of complications after cardiac surgery.[24]

Study patients were divided in the following 3 groups according to indication for preoperative IABP: prophylaxis (n = 147, 25%); unstable angina (n = 239, 40.6%); and rapid worsening of hemodynamics (RWH) (n = 202, 34.4%), which was defined as severe hypotension, life-threatening arrhythmias, myocardial ischemia, and/or low cardiac output before surgery or in the operating room (OR) during induction of anesthesia or coronary graft harvesting (ie, before cardiopulmonary bypass commenced) (Table 1).

Perioperative IABP Management

The catheterization laboratory with diagnostic imaging equipment, emergency room, intensive care unit, and OR all were locations of IABP implantation. The balloon was introduced into the descending aorta through the common femoral artery and advanced in retrograde mode up to the ostium of the left subclavian artery. During cardiopulmonary bypass, IABP was set up in internal mode to ensure a pulsed flow.[25] The percutaneous technique was almost invariably adopted, and surgical exposure of a diseased femoral artery was needed only occasionally. A 9 Fr 40 mL IABP catheter was always used until 2006 when smaller (7 or 7.5 Fr) catheters were introduced progressively in clinical practice. Sometimes, in the presence of a very little and pathological femoral artery, the IABP catheter was used without a sheath to reduce arterial obstruction and the risk of leg ischemia. In such instances, and when a 9 Fr catheter was used, a continuous intravenous infusion of dextran 70, heparin, or both was started on postoperative day 1. From 1999 to 2009, correct balloon site within the aorta was verified after surgery in the intensive care unit with chest x-ray; however, since 2010, correct placement has been confirmed during surgery using a transesophageal ultrasound probe. The balloon usually was removed with the compression technique. However, when it had been introduced by means of surgical exposure of the femoral artery or when it had been in place for more than 5 to 7 days, the balloon was removed with surgical technique in the intensive care unit.

Surgery

Surgery was performed through a median sternotomy with cardiopulmonary bypass, with or without cross-clamping the aorta, or off-pump technique. When performed, myocardial protection usually was achieved with multidose cold blood cardioplegia, more rarely with St. Thomas' Hospital solution No. 2 (Plegisol; Pfizer Inc., New York, NY)[26] and very occasionally with multidose warm blood cardioplegia. Since July 2009, a single-dose crystalloid solution, the Custodiol histidine-tryptophan-ketoglutarate solution (Essential Pharmaceuticals, Durham, NC),[27] generally was chosen when mitral valve or aortic surgery were scheduled. Cardioplegic solutions were delivered in antegrade and retrograde modes. Coronary bypass surgery, heart valve surgery, and combined coronary

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