

Intra - Aortic Balloon Pump in High Risk Patients Undergoing Coronary Artery Bypass Grafting: A Systematic Review

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Abstract: *Intra aortic balloon pump has revolutionized coronary artery bypass surgery in terms of both intra and post operative management of cardiac patients. Its role in low cardiac output is well defined. There have been multiple studies regarding effect of IABP on post operative outcomes in both off pump as well as on pump coronary artery bypass grafting. Here we present a comprehensive review of thirteen such studies.*

Keywords: Intra - aortic balloon pump, Coronary artery bypass grafting

1. Introduction

Intra - aortic balloon pump has been in use since 1967. It has been used in the treatment of patients with cardiogenic shock, postoperative left ventricular failure, unstable angina and post infarction angina ⁽¹⁾. It increases coronary blood flow and therefore decreases cardiac work. This leads to a favourable ratio of myocardial demand and supply ⁽²⁾. This article aims to review the efficacy of IABP insertion in high risk patients undergoing CABG.

2. History

Kantrowitz first described augmentation of blood flow to the coronaries by decreasing arterial pulse pressure in animals in 1952 ⁽³⁾. In 1962 Mouloupoulos and colleagues developed a prototype of IABP. It's inflation and deflation were synchronised with the cardiac cycle ⁽⁴⁾. Kantrowitz in 1968 showed improvement in systemic arterial pressure and urine output on IABP in two patients with cardiogenic shock ⁽¹⁾. The Bergman and colleagues in 1977 described the first percutaneous insertion of IABP ⁽⁵⁾.

3. Review of Studies on IABP

Poirier et al conducted a systematic review and meta - analysis to evaluate the safety and benefits of IABP prior to

CABG. They included 11 RCTs AND 22 observational studies from 1977 to 2015 with a total of 46, 067 patients. Their analysis suggested that pre op IABP was associated with reduction in hospital mortality (odds ratio 0.20, 95% confidence interval p<0.0001), 30 - day mortality (OR 0.43, 95%, P<0.00001), shorter ICU stay (95% CI, p<0.00001) and reduced hospital length of stay (95% CI p+0.0009). They, however stated that there were significant bias and limitations among the included studies. They concluded that clinical benefit of IABP in high risk patients is limited and requires further randomized studies ⁽⁶⁾.

Deppe et al did a meta - analysis of 23 studies (7 RCT, 16 observational studies) which included a total of 9212 patients. They included studies which had comparison of patients with prophylactic IABP before CABG with control group and reported at least one desired clinical end point including all - cause mortality, MI, CVA and renal failure. They stated that Absolute risk reduction in mortality in RCTs was 4.4%. Pre op IABP decreased the risk of MI (OR|+0.58, p=0.004), CVA (OR 0.67, p=0.042) and renal failure (OR 0.62, p=0.0014). They also reported that length of hospital stay (p<0.0001) and ICU stay (p<0.0001) were also significantly reduced in patients with pre op IABP placement. They concluded that current RCTs and observational studies showed benefits with pre op IABP in high risk CABG patients ⁽⁷⁾.

A retrospective study by Joskowiak et al included 472 patients with acute MI who underwent emergency CABG. 158 patients (57 pre op and 101 intra op) received IABP. Overall in hospital mortality was 17% (17.6% pre op group and 16.8% intra op group). Midterm and long term survivals were comparable in both groups. In their conclusion they stated that CABG with IABP in high risk patients with AMI had acceptable in hospital mortality and long term survival rates⁽⁸⁾.

Ahmed et al did a retrospective observational non interventional study at North West General Hospital and Research Centre, Peshawar from December 2018 to March 2020. Their sample size was 360 patients who underwent CABG. IABP was required for patients with moderate to severely reduced ejection fraction. 100% previous MI patients, 86% hypertensive patient, 64% diabetics 21% coronary end arterectomy patients and 7% smoker required IABP post CABG. In conclusion 3.9% of CABG patients required IABP insertion in the hospital. IABP is essential in post CABG patient with left ventricular dysfunction after cardiopulmonary bypass with moderate to severely reduced ejection fraction, Myocardial infarction, hypertension, diabetes mellitus. Smoking and endarterectomy were not significantly related to IABP induction in their study⁽⁹⁾.

Hunaid A Vohra and Wadhi R Dimtri studied the effect of elective IABP in high - risk off - pump CABG in their retrospective study on 625 patients who underwent OPCAB between 1996 and 2004. Patients were divided into 2 groups. Group 1 had patients who had pre op insertion & group 2 who did not have IABP insertion. There was no significant difference between the two groups in terms of the need for inotropes, duration of ventilation, arrhythmias, GI, cerebrovascular & infective complications. Acute renal failure - was more in group 2. 16% patients in group 2 required post op IABP. Group 1 patients had earlier discharge. There was no difference in mortality among the two groups⁽¹⁰⁾.

Christenson et al evaluated the effect of pre op IABP in high risk patients undergoing CABG. Patients were randomized into 3 groups: group 1 IABP one day prior to surgery, group 2 IABP 1 - 2 hour prior to CPB, group 3 no pre op IABP. CPB time was shorter in group 1&2. Ischemia time showed no difference among the groups. In hospital mortality was higher in group 3. Post op low cardiac output was more in group 3 vs group 1&2. Cardiac index was increased significantly prior to CPB in group 1&2. Post op IABP requirement was more in group 3 compared to group 1 & 2. ICU stay was shorter in group 1&2. All groups required dopamine in post op, required in lower doses in group 1 & 2. Dobutamine requirement was 23% in group 1, 32% in group 2 & 95% in group 3. Adrenaline requirement was 40% in group 3, 5% in group 2 & none in group 1. Group 1 had better improvement in cardiac performance than group 2⁽¹¹⁾.

In an RCT conducted by Christenson et al between June 1994 and March 1996, 33 patients undergoing CABG were randomized into 2 groups: pre op IABP was inserted in group 1 while group 2 did not receive pre op IABP. The ischemia time was similar in both the groups and there was no in hospital mortality. In Group 2, 3 patients had low

cardiac output and 9 patients required post op IABP. 20% patients in group 1 had decreased ICU stay. Increased cardiac index was reported in group 1. They concluded that pre op IABP: beneficial in patients with hypertension, low LVEF & LVH⁽¹²⁾.

Between June 1994 and October 1996, Christenson et al conducted an RCT in which 42 high risk patients who underwent redo CABG were randomized into two groups of 24 patients each, group 1 received pre op IABP 2 hours prior to CPB and group 2 did not receive IABP. Forty - one patients had preoperative left ventricular ejection fraction less than or equal to 0.40 (85%), 38% (18 patients) had left main stem stenosis greater than or equal to 70%, and 54% (26 patients) had unstable angina preoperatively. The study reported that time of CABG was shorter in group 1 (86 vs 110 mins). No in hospital deaths were seen in group 1 and 4 deaths were reported in group 2. Cardiac index was higher in group 1. IABP decreased low cardiac output syndrome. Group 1 had shorter ICU stay⁽¹³⁾.

Marra et al conducted a single centre prospective randomised study between January 1999 and September 2001. The study included 60 CABG patients with pre op LVEF < 0.30. Patients were randomized into 2 groups. Group A had 30 patients who received pre op IABP and Group B 30 patients were included who received intra op IABP. Survival in group A was significantly higher than group B. Cardiac performance was improved in both groups, more in group A. Dose & duration of inotropes were lesser in group A. there were no major IABP related complication⁽¹⁴⁾.

Gong et al conducted a retrospective study in which they reviewed their database from 2002 - 2003. 311 patients received pre - operative IABP. Out of them 41 were high risk who had first time on pump or off pump CABG. High risk patients had three or more of the following criteria: left ventricular ejection fraction < 0.45, unstable angina, CABG combined with aneurysmectomy, or left main stenosis greater than 70%). 20 patients underwent pre op IABP placement & 21 patients had IABP placed intra op or post op. They concluded that there were no significant differences in the need for inotropes, or in cerebrovascular, gastrointestinal, renal, and infective complications postoperatively. There were no IABP - related complications in either group. Major adverse cardiac event (severe hypotension and/or shock, myocardial infarction, and severe hemodynamic instability) was higher in Group 2 (p < 0.0001) during surgery. The duration of ventilation and ICU stay was shorter in group 1. There were no differences in mortality between the two groups⁽¹⁵⁾.

Wan et al in their meta - analysis on the effects of Intra - Aortic Balloon Pumps on Mortality in Patients Undergoing High - Risk Coronary Revascularization included 12 RCTs which enrolled 2155 patients. They concluded that there was no decrease seen in short term or long term mortality with IABP use. The findings remained stable in patients with acute myocardial infarction with or without cardiogenic shock. In high - risk CABG patients, IABP was associated with reduced mortality⁽¹⁶⁾.

Studies on IABP

S NO.	Author	Study	Method	Result
1.	Poirier et al	Meta - analysis	11 RCTs & 22 observational studies. 46, 067 patients Pre op IABP vs no IABP	Pre op IABP significantly decreased hospital mortality & 30 day mortality
2.	Deppe et al	Meta - analysis	23 studies including RCTs & observational studies. 9212 patients. Pre op IABP vs controls	Decreased risk of MI & renal failure Decreased length of ICU & hospital stay
3	Joskowiak et al	Retrospective study	472 patients with AMI Emergency CABG 57 pre op IABP 101 intra op IABP	midterm survival 17.6% pre op IABP vs 16.8 % intra op IABP 1 yr survival 78.6% pre op IABP 73.7% intra op IABP 3 yr 71.4% vs 68.7% 5 yr 64.3% vs 54.6%
4	Ahmed et al	Retrospective observational	Retrospective analysis of patients who required IABP support post CABG	Previous MI 100% Hypertension 86% Diabetes 64% Coronary end arterectomy 21% Smoker 7% Required IABP post CABG IABP is an essential support for post CABG patients with LV dysfunction post CPB, moderate to severe ejection fraction, MI, hypertension, DM, smoking & endarterectomy
5	Vohra et al	Retrospective study	628 OPCAB High risk (more than or equal to 2 criteria: Left main stem stenosis >70% Unstable angina Poor LV function) patients were divided into Group 1 pre op IABP Group 2 no IABP	No significant difference among the two groups as regards the need for inotropes, duration of ventilation, arrhythmias, GI, cerebrovascular & infective complications Acute renal failure - more in group 2 16% in group 2 required post op IABP Group 1: earlier discharge No difference in mortality
6	Christenson et al	RCT	48 high risk patients Group 1 24 patients - pre op IABP Group 2 24 patients – no IABP 54% had pre op unstable angina	Time of CABG was shorter in group 1 (86 vs 110 mins) No in hospital deaths in group 1 4 deaths in group 2 Cardiac index higher in group 1 IABP decreased low cardiac output syndrome Group1: shorter ICU stay
7	Christenson et al	RCT	High risk patients (more than or equal to 2 criteria: Left main stem stenosis > 70% LVEF <40% Redo CABG Unstable angina) Group 1: IABP 1 day prior to surgery Group 2: 1 - 2 hour prior to surgery Group 3: no pre op IABP	CPB time - shorter in group 1&2 Ischemia time: no difference In hospital mortality: higher in group 3 Post op low cardiac output: more in group 3 vs group 1&2 Cardiac index: increased significantly prior to CPB in group 1&2 Post op IABP requirement: more in group 3 compared to group 1&2 Shorter ICU stay in group 1&2 All groups required dopamine in post op, required in lower doses in group 1&2 Dobutamine requirement: 23% in group 1, 32% in group 2 & 95% in group 3 Adrenaline requirement 40% in group 3, 5% in group 2 & none in group 1 Group 1: better improvement in cardiac performance than group 2
8	Christenson et al	RCT	33 patients Mean age 65 years 90% females Pre op LVEF < 40%	Similar ischemia time No hospital death Group 2: 3 patients had low cardiac output 9 required post op IABP

			TVD Established hypertension LVH Group 1: pre op IABP Group 2: no IABP	20% in group 1 had decreased ICU stay Increased cardiac index in group 1 Pre op IABP: beneficial in patients with hypertension, low LVEF & LVH
9	Marra et al	Prospective study	60 CABG patients with pre op LVEF < 0.30 Group A: 30 patients - pre op IABP Group B: 30 patients - intra op IABP	Survival in group A: significantly higher Cardiac performance improved in both group, more in group A Dose & duration of inotrope: lesser in group A No major IABP related complications
10	Gong et al	Retrospective study	41 patients with first time on pump or off pump CABG Group 1: 20 patients with pre op IABP Group 2: 21 patients with intra op or post op IABP	No significant differences in the need for inotropes, or in cerebrovascular, gastrointestinal, renal, and infective complications postoperatively. No IABP - related complications in either group. Major adverse cardiac event higher in group 2. Duration of ICU stay & ventilation shorter in group 1. No difference in mortality between the two groups.
11	Wan et al	Meta - analysis	12 RCTs including 2155 patients.	IABPs did not significantly decrease short - term mortality or long - term mortality. In high - risk CABG patients, IABP was associated with reduced mortality
12	Baskett et al	Multicentre study	29, 950 patients undergoing CABG. Pre op IABP in 1896 patients	Pre op IABP was associated with higher mortality
13	Udell et al	Meta - analysis	10 RCTs with 1261 subjects	Mortality was significantly lower in patients receiving IABP compared with control. Risk of major adverse cardiac event was also lower with IABP. No significant differences in major bleeding events or vascular complications.

4. Comments

After reviewing the studies done on IABP in high risk patients undergoing CABG, the authors are of the view that IABP is beneficial in high risk patients who undergo CABG. IABP resulted in decreased mortality and shorter ICU and in hospital stay. It also decreased the adverse cardiac outcomes after CABG. IABP has improved outcomes in CABG as regards the mortality and morbidity. It has proved to be an asset in high risk patients undergoing CABG. However, more RCTs are required to be done as regards IABP use in CABG especially in cases of off pump CABG.

Abbreviations

IABP: Intra - aortic balloon pump

CABG: Coronary artery bypass grafting

RCT: Randomized controlled trial

OPCAB: On pump coronary artery bypass

CPB: Cardiopulmonary bypass

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