

## Original Research Article

# The use of intra-aortic balloon pump in cardiac surgery

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## ABSTRACT

**Background:** Objective of the study was to determine the incidence of use, indications, complications of intra-aortic balloon pump (IABP) and its impact on outcome.

**Methods:** Retrospective study of adult cardiac surgical patients presenting for cardiac surgery at Queen Alia Heart Institute in the period of time between September 2023 and February 2024. Patients' demographic, clinical, perioperative data were recorded and analysed. Time of initiation of intra-aortic balloon, indications and monitoring for complications were observed by the authors. Patients were divided into two groups according to the use of IABP; the IABP group and the non-IABP group. Both groups were compared regarding outcome. Ethical committee approval obtained.

**Results:** Data from 202 adult cardiac surgeries was analysed. Average age of patients was 57.2 years. Patients were 34 females (16.8%) and 168 males (83.2%). Most surgeries were elective (93.6%), while urgent surgeries comprised 3.5% and emergency surgeries were 3%. Coronary artery bypass grafting (CABG) was the most common procedure (78.2%). The IABP was most commonly used after combined procedures (50%) and to a lesser extent after isolated CABG (15.3%). IABP was inserted least frequently pre-operatively (10.7%), followed by postoperative insertion (35.7%), while intraoperative insertion to aid weaning from CPB was most common (53.6%). Patients from the IABP group were older, had longer CPB time (136.7 minutes) and AXC times (70.5 minutes), they also spent around 2 days more in the ICU and around 4 days more in hospital.

**Conclusions:** IABP was most commonly utilised for combined procedures, after prolonged CPB and aortic cross clamping. The use of IABP was associated with delayed tracheal extubation, longer ICU stay, longer hospitalisation, and higher rates of blood transfusion, higher incidence of re-opening and higher mortality.

**Keywords:** CABG, CPB, Extubation, IABP, ICU

## INTRODUCTION

Intra-aortic balloon pump (IABP) is the most widely used circulatory assist device in critically ill patients with cardiac disease with an annual estimate of 200 000 IABPs placed worldwide.<sup>1</sup> IABP can provide myocardial protection in high risk cardiac patients.<sup>2</sup> IABP is the simplest circulatory assist device that is cost-effective and is easy to implant and explant in the coronary care units, catheterization laboratories, and operative theatres, intensive care units by an interventional cardiologists,

cardiac surgeons, anaesthetists and intensivists. Therefore, good understanding of IABP is important to cardiac surgeons, anaesthetists and intensive care doctors dealing with cardiac surgical patients. Efficacy of use of IABP is known for more than half a century.<sup>3</sup> IABP was first described by Moulopoulos, Topaz, and Kolff in 1962 and introduced clinically by Kantrowitz et al in 1968.<sup>4</sup> In the early times of its use the IABP was inserted surgically, which delayed its use in emergency situations. Later on, in the 1980s Bregman et al presented the percutaneous method of insertion of IABP by the Seldinger's technique.<sup>5</sup>

The percutaneous method of insertion decreased vascular complications of insertion and time of insertion. The primary goal of IABP treatment is to increase myocardial oxygen supply and decrease myocardial oxygen demand. The intra-aortic balloon inflates during diastole synchronously with aortic valve closure and the appearance of a dicrotic notch resulting in the displacement of blood from the thoracic aorta that is followed by rapid deflation before the onset of systole phase of the cardiac cycle.<sup>6</sup>

Indications for IABP include acute myocardial infarction, refractory left ventricular failure, cardiogenic shock, persistent arrhythmias, acute mitral valve regurgitation, ventricular septal defect post myocardial infarction, cardiomyopathies, high risk catheterization and coronary angioplasty, severe septic shock, refractory unstable angina, and infants and children with complex heart congenital anomalies.<sup>7,8</sup> It is also frequently used peri-operatively and intra-operatively in cardiac surgery mainly to aid weaning from cardiopulmonary bypass; however, its use can be associated with complications. Complications can be classified as either vascular or non-vascular. Complications can vary in severity from minor to major and the potential benefits of IABP must be weighed against its possible complications. Vascular complications are found to be the commonest, and include limb ischaemia, vascular trauma during insertion (dissection or laceration) leading to bleeding, haematoma formation, abdominal compartment syndrome and false aneurysm formation. An incorrectly positioned or incorrectly sized IABP catheter may lead to compromised abdominal visceral perfusion, mesenteric ischaemia, or renal injury because of juxtarenal balloon positioning manifested by decreased urine output after the insertion of IABP. Non-vascular complications include thrombocytopaenia from platelet deposition on the balloon and catheter, from mechanical disruption of platelets, or due to heparin induced thrombocytopaenia. An IABP is thrombogenic; therefore, anticoagulation is always required. Haemolysis also occurs from disruption of erythrocytes and can reduce the haematocrit by up to 5%. Local or systemic infection and sepsis may occur, particularly in patients with prolonged IABP therapy. Rarely, gas embolism from balloon rupture may occur, although the console will detect the drop of gas (helium) pressure inside the balloon and catheter immediately, which will stop gas inflation to cease functioning.<sup>9,10</sup> Contraindications for use of IABP are classified as absolute and relative. Absolute contraindications include aortic regurgitation, aortic dissection, and chronic end-stage heart disease with no anticipation of recovery, aortic stents, and patient refusal. The relative contraindications are uncontrolled sepsis, abdominal aortic aneurysm, tachyarrhythmia, severe peripheral vascular disease and major arterial reconstruction surgery.<sup>11</sup>

## METHODS

This is an observational retrospective analysis of adult cardiac surgical patients presenting for cardiac surgery for

different cardiac pathologies at Queen Alia Heart Institute (QAH) in the period of time between September 2023 and February 2024. Patients' demographic, clinical, perioperative data were recorded and analysed. Time of initiation of intra-aortic balloon, indications and monitoring for complications were observed by the authors. Patients were divided into two groups according to the use of IABP; the IABP group and the non-IABP group. Both groups were compared regarding intra-operative, post-operative variables and surgical outcome. Data was analysed using Microsoft excel. Type of IABP used was Maquet Cardiosave Hybrid™. Ethical committee approval obtained.

## RESULTS

Data from 202 adult cardiac surgeries was analysed. Average age of patients was 57.15 years (SD=9.9) and ranged from 19 to 78 years. Patients were 34 females (16.8%) and 168 males (83.2%). Most surgeries were elective (93.6%), while urgent surgeries comprised 3.5% and emergency surgeries were 3%. Coronary artery bypass grafting (CABG) was the most common procedure (78.2%). Average cardiopulmonary bypass (CPB) duration was 109.9 minutes and average aortic cross clamp duration was 65.7 minutes. Out of total of 202 patients the IABP was utilised in 28 patients. Rate of usage of IABP was 13.9% (Table 1).

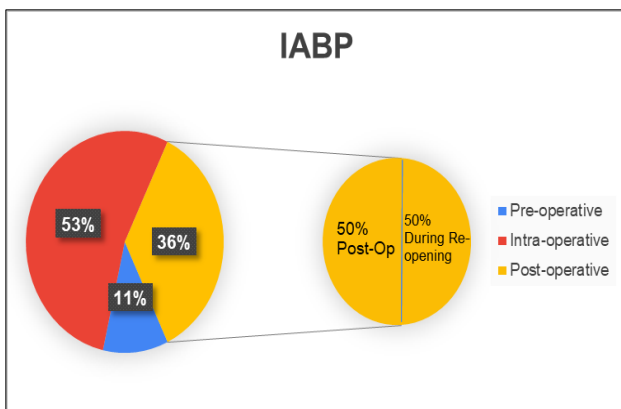
**Table 1: Patients' demographic and clinical characteristics.**

Characteristics	n (%)
<b>Average age (±SD) (years)</b>	57.15 (±9.9)
<b>Females</b>	34 (16.8)
<b>Males</b>	168 (83.2)
<b>Elective surgery</b>	189 (93.6)
<b>Urgent surgery</b>	7 (3.5)
<b>Emergency surgery</b>	6 (3)
<b>CABG</b>	158 (78.2)
<b>AVR</b>	8 (4)
<b>MVR</b>	11 (5.4)
<b>TVR</b>	2 (1)
<b>Combined surgery (CABG+ valve or &gt;1 valve)</b>	11 (5.4)
<b>Ascending aortic replacement, bental procedure</b>	7 (3.5)
<b>ASD</b>	1 (0.5)
<b>VSD</b>	1 (0.5)
<b>Myxoma</b>	1 (0.5)
<b>Right coronary re-implantation</b>	2 (1)
<b>Average CPB (minutes)</b>	109.9
<b>Average AXC (minutes)</b>	65.7
<b>Average time of post-operative ventilation (hours)</b>	33.5
<b>Average ICU stay (days)</b>	5.4
<b>Average hospital stay (days)</b>	13.6

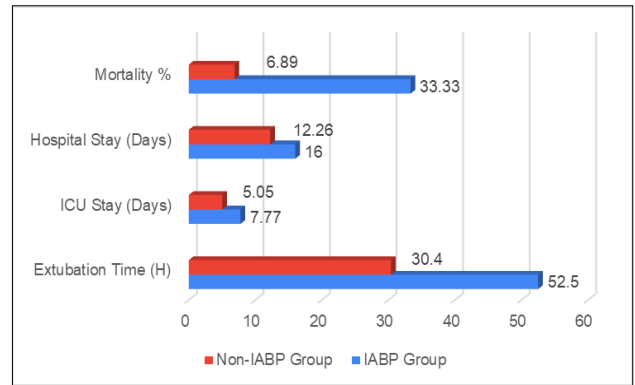
Regarding time of insertion of IABP; the IABP was inserted preoperatively in 3 patients (10.7%), while intraoperative insertion was documented in 15 patients (53.6%) and post-operative insertion was recorded in 10 patients (35.7%) (Figure 1).

Patients were divided into two groups according to the use of IABP; the IABP group and the non-IABP group. The average age of patients who had IABP was 59.14 years, while the average age of the non-IABP group was 56.83 years; indicating the IABP was more commonly used in patients who were older in age. When considering the urgency of surgery, the majority of cases were elective; however, the IABP group had more urgent (7.1%) and emergency (7.1%) cases than the non-IABP group (2.9% and 2.3%, respectively). Patients from the IABP group had longer average cardiopulmonary bypass (CPB) time (136.68 minutes) in comparison to the non-IABP group (105.6 minutes). Similarly, patients from the IABP group had longer average aortic cross clamp (AXC) time (70.54 minutes) in comparison to the non-IABP group (64.93 minutes). Regarding blood transfusion requirements, patients from the IABP group needed on average more blood (red blood cells) transfusion (2.64 units), in comparison with the non-IABP group (1.93 units). Cell saver was less commonly used in the IABP group (17.86%) than the non-IABP group (21.26%). The rate of re-opening (re-sternotomy) was significantly higher in those who had an IABP (35.7%) than those who did not (9.2%). In addition, patients with IABP were extubated on average after 52.5 hours from their arrival to the ICU, in comparison with those who did not had an IABP who were extubated after 30.5 hours. The IABP group had longer average ICU stay (7.78 days) than the non-IABP group (5.05 days). The overall hospital stay was also longer in the IABP group (16 days) than the non-IABP group (12.3 days). Mortality rate was also higher in the IABP group (28.57%) than the non-IABP group (6.9%) (Figure 2).

There was no significant difference in the body mass index (BMI) or pre-operative and post-operative haematocrit between the two groups (Table 2).



**Figure 1: The time of insertion of IABP in relevance to surgery.**



**Figure 2: Outcome of surgery regarding the use of IABP.**

**Table 2: Comparison between the IABP and the non-IABP groups.**

Variable	IABP group (%)	Non-IABP group (%)
<b>Number of patients</b>	28 (13.9)	174 (86.1)
<b>Average age (years)</b>	59.14	56.83
<b>Gender</b>		
Male	92.9	81.6
Female	7.1	18.4
<b>Elective surgery</b>	24 (85.7)	165 (94.8)
<b>Urgent surgery</b>	2 (7.1)	5 (2.9)
<b>Emergency surgery</b>	2 (7.1)	4 (2.3)
<b>CPB time (minutes)</b>	136.68	105.6
<b>AXC time (minutes)</b>	70.54	64.93
<b>Amount of blood (RBCs) transfused (units)</b>	2.64	1.93
<b>Cell saver usage</b>	17.86	21.26
<b>ICU stay (days)</b>	7.78	5.05
<b>Hospital stay (days)</b>	16	12.3
<b>Extubation time (hours)</b>	52.5	30.5
<b>Reopened</b>	35.7	9.2
<b>BMI</b>	28.7	28.7
<b>Pre-op. haematocrit</b>	38.17	38.66
<b>Post-op. haematocrit</b>	29.32	30.29
<b>Mortality</b>	28.57	6.9

## DISCUSSION

The frequency of use of intra-aortic balloon pump in the context of cardiac surgery varies in literature between cardiac surgical units between 2.1% in one study, and 22% in another study.<sup>12,13</sup> In our cardiac centre, the use of IABP has increased over the last decade. In our previous research from 2011, the rate of use of IABP was 6.46% of all adult cardiac surgical patients.<sup>14</sup> In this current study, the incidence of utilization of IABP was 13.9% which might reflect the more complex procedures performed and the higher risk patients presenting for cardiac surgery compared to the past. In our study, IABP usage was

significantly more common in combined procedures such as 'CABG and valve(s) replacement', while in isolated CABG the usage of IABP was considerably lower, with no usage reported in AVR, MVR, and other specific procedures like ASD, VSD, and myxoma surgeries.

Regarding the time and place of insertion of the IABP in relevance to cardiac surgery; 11% of patients from the IABP group had their IABP inserted before surgery (in the cardiac catheterisation laboratory or in the operative theatre before the start of surgery), 53% had the IABP inserted during cardiac surgery to aid weaning from CPB, and 36% of the insertions were after cardiac surgery if patients showed signs of deterioration in the ICU or during re-exploration in the operative theatre (Figure 1). The pre-operative insertion of IABP in high risk cardiac surgical patients has been shown to improve outcome and reduce mortality in several studies. Böning et al reported significant benefit for patients with preoperative compared to intraoperative IABP insertion in the higher risk cardiac surgery.<sup>15</sup> Suhail et al reported improved mortality in high risk patients with pre-operatively inserted IABP.<sup>16</sup>

We compared the intra-operative and post-operative parameters of patients who had IABP utilized and in those without IABP. Patients from the IABP group were on average around 3 years older. The CPB and AXC times were significantly longer in the IABP group, the rate of blood transfusion was higher in the IABP group. There was also higher frequency of IABP usage after combined surgeries. All of these intraoperative parameters indicate higher risk of patients and more technically difficult surgeries among the IABP group. Regarding the postoperative outcome, patients from the IABP group had longer average duration of postoperative mechanical ventilation, longer ICU length of stay, higher rates of early postoperative re-opening (re-sternotomy) and higher mortality rates, which also indicates the higher risk of patients in the IABP group (Figure 2). These results provide insights into the patient profiles and outcomes of cardiac surgery with and without IABP. The use of IABP is associated with longer CPB times and ICU stays, possibly reflecting more severe or complex cardiac conditions. The higher re-opening and mortality rates in the balloon group could also indicate higher-risk surgeries or more critical patient conditions. This analysis highlights the importance of considering patient-specific factors and surgical complexities when evaluating the use of IABP in cardiac surgeries.

Complicated use of IABP was evident in 3.6%. Most of the complications were vascular and were either related to more difficult insertion or post-operative lower limb ischaemia. Complications of insertion are more common in patients with peripheral arterial vascular disease.<sup>17</sup> Recent multicentre studies by Heuts et al demonstrated that using smaller-sized catheters, sheathless implantation, and imaging guiding during insertion are necessary to reduce complications of IABP.<sup>18</sup>

## CONCLUSION

The use IABP increased over the last decade. Most common indication for IABP was to aid weaning from CPB. IABP was more commonly needed for combined procedures, after prolonged CPB and aortic cross clamping. The use of IABP was associated with delayed tracheal extubation, longer ICU stay, longer hospitalisation, and higher rates of blood transfusion, higher incidence of re-opening and higher mortality.

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