Original Article

This article is accompanied by an invited commentary by Dr. Murali Chakravarthy

A survey on the use of intra-aortic balloon pump in cardiac surgery

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ABSTRACT

Intra-aortic balloon pump (IABP) is an established tool in the management of cardiac dysfunction in cardiac surgery. The best timing for IABP weaning is unknown and varies greatly among cardiac centers. The authors investigated the differences in IABP management among 66 cardiac surgery centers performing 40,675 cardiac surgery procedures in the 12-month study period. The centers were contacted through email, telephone, or in person interview. IABP management was very heterogeneous in this survey: In 43% centers it was routinely removed on the first postoperative day, and in 34% on the second postoperative day. In 50% centers, it was routinely removed after extubation of the patients whereas in 15% centers it was removed while the patients were sedated and mechanically ventilated. In 66% centers, patients were routinely receiving pharmacological inotropic support at the time of removal of IABP. The practice of decreasing IABP support was also heterogeneous: 57% centers weaned by reducing the ratio of beat assistance whereas 34% centers weaned by reducing balloon volume. We conclude that the management of IABP is heterogeneous and there is a need for large prospective studies on the management of IABP in cardiac surgery.

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INTRODUCTION

High-risk patients undergoing cardiac surgery, especially those with severe coronary artery disease, are at high risk for myocardial ischemia, arrhythmia, and heart failure. Different therapeutic options are available to support the heart in the perioperative period: these include cardiovascular drugs such as inotropes, vasopressors, and vasodilators, devices such as intra-aortic balloon pump (IABP) and ventricular assist devices, or a combination of the above.

IABP increases myocardial oxygen supply by increasing diastolic coronary perfusion pressure, thereby increasing myocardial and subendocardial perfusion, and decreases myocardial oxygen demand by reducing left ventricular afterload. Additionally, IABP can also improve cardiac output (CO), ejection fraction (EF), and systemic perfusion. IABP can be placed before, during, or after surgery with preoperative IABP insertion being associated with lower in-hospital mortality rates in high-risk patients when compared to those who received it postoperatively.[1] IABP usually remains in place for a variable time after surgery which usually ranges from 24 to 72 hours; the duration of IABP support depends on patients' needs and/or local protocols. IABP can be used in combination with inotropes such as epinephrine, dobutamine, norepinephrine, levosimendan, etc.; however, there is no guideline whether to first perform the weaning from the IABP or from the inotropic or circulatory support drugs.[2] At the same time, there is no consensus on the weaning modalities from IABP. The IABP support can be programmed to assist every beat (1:1) or less often (1:2, 1:4, or 1:8)[3] and weaning from IABP can be achieved by

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reducing the ratio of assisted to non-assisted beats from 1:1 to 1:2 or less. Alternatively, IABP weaning can be achieved by gradually decreasing the balloon volume, thus reducing the circulatory support and myocardial perfusion support during each cardiac cycle. The aim of this national survey was to assess the management of IABP weaning, the combination of its use with drugs, and the rate of complications associated with its use.

MATERIALS AND METHODS

The authors conducted a survey regarding elective use of IABP during cardiac surgery in 66 Italian cardiac surgery centers. All centers answered a standardized questionnaire [Table 1] through email, or on telephonic interview, or in person. The physician in charge of the intensive care unit (ICU) or one of his colleagues was contacted. In Italy, anesthesiologists and intensive care specialists have the same curriculum and skills and they work in operating rooms and in ICUs. The survey was therefore answered by anesthesiologists and intensive care specialists. In less than half of the hospitals, the postoperative ICU management of patients undergoing cardiac surgery is performed by cardiac surgeons and in these cases the questionnaire was, in part, answered by cardiac surgeons. IABP positioning was usually performed by cardiac surgeons in the operating rooms and by anesthesiologists/intensive care specialists in the ICU. IABP removal was usually performed by anesthesiologists/intensive care specialists. Surgical positioning and removal of IABP was rare, and if required, performed by surgeons. The above-described practice is also the standard management at our center. Data are expressed as numbers and percentages.

RESULTS

All 66 medical centers answered to the questionnaire. Overall, 40,675 cardiac surgeries were performed in the 12-month study period (mean: 616 per center) with an average of 31 IABP positioned per year per center. No IABP-related complication was reported in 52% of centers. The IABP-related complications reported by the remaining centers are listed in Table 2. The patient with the acute thrombosis of the abdominal aorta died and this was the only IABP-related fatal complication.

IABP was routinely removed on the first (43%) or second (34%) postoperative day while 23% of centers did not have fixed rules. All centers underlined that patients' clinical condition, hemodynamic status, and echocardiography data were carefully evaluated before removing IABP. Half of the centers performed weaning from IABP support when the patient was awake and extubated, 15% during patient sedation, and 15% when the patient was awake but intubated. Many centers (20%) did not have a single strategy and considered the clinical condition of each patient, and the comorbidities to choose the best strategy. IABP was removed before weaning from inotropic support in 51% centers and after weaning from inotropes in 46% centers, with few centers

Table 1: Questionnaire on the use of IABP administered to 66 Italian medical centers

Number of cardiac surgical procedures per year

Number of IABP placed per year

Major complications related to IABP in the last year:

A – none

B – at least one (specify)

IABP is usually removed:

A – on the first day after surgery

B – on the second day after surgery

C – other (specify)

Weaning from IABP and sedation/intubation:

A – the patient is sedated and intubated during weaning from IABP

B – the patient is awake, but intubated during weaning from IABP

C – the patient is awake and extubated during weaning from IABP

D – other (specify)

Weaning from IABP and inotropes:

A – IABP is removed first

B – inotropic support is removed first

C – other (specify)

Concomitant use of IABP and inotropes:

A – it routinely occurs

B – only if it is necessary

Weaning from IABP is performed:

A – by reducing the ratio of assisted to non-assisted beats from 1:1 to 1:2 to 1:4

B – by gradually decreasing the balloon volume, keeping the ratio of assisted to non-assisted beats 1:1

C – other (specify)

IABP: Intra-aortic balloon pump

Table 2: Major complications related to IABP in a 12-month period in 66 centers

Complication	Incidence of events
Leg ischemia	20
Bleeding	3
Retroperitoneal hematoma	2
Femoral hematoma	2
Acute thrombosis femoral artery	2
Acute thrombosis abdominal aorta	1
Intestinal ischemia	1
Balloon rupture	1
Aortic dissection	1
Embolism	1
IABP entrapment in the iliac artery	1
Blood in the balloon	1

IABP: Intra-aortic balloon pump

(3%) having multiple strategies. IABP was always used together with pharmacological inotropic support in the majority of centers (66%) while 39% of centers used one of the following agents only if clinically required: dobutamine, dopamine, epinephrine, norepinephrine, enoximone, and levosimendan. Weaning from IABP was performed in 57% centers by reducing the ratio of beat-to-beat assistance from 1:1 to 1:2 to 1:4, in other 34% centers by reducing IABP balloon volume, and two other centers using the two techniques simultaneously, one center turning the IABP off abruptly and two centers using modified techniques.

DISCUSSION

The results of this survey confirm that the management of IABP removal is heterogeneous among centers. Apparently, in the absence of evidence-based medicine, decisions are taken by the intensive care physicians on the basis of tradition, physiological hypothesis, or personal opinions. Different management strategies could be equivalent or one could be superior to the other one. It is unknown whether different modalities of IABP weaning (reducing the ratio of beat assistance or reducing the balloon volume) are equivalent in terms of clinically significant outcomes. Similarly, it is unknown whether removing the IABP on the first or on the second postoperative day in patients with an uneventful postoperative course could either decrease costs and infections (if the correct approach is to remove it early) or decrease the risks of low CO and organ failure (if the right approach is to remove it later).

Similarly, removing the IABP with the patient sedated and intubated could reduce pain and stress or, conversely, not allow the patient to have the IABP support during extubation, probably the most stressful postoperative period. Should all patients with IABP receive inotropic agents (with all the positive and detrimental effects of these drugs)? Should we consider all inotropic agents harmful when meta-analyses of randomized trials suggested that in the specific setting of cardiac surgery these drugs potentially reduce or increase perioperative mortality?[4,5] An intriguing aspect that has only recently come to the attention of the medical community is that, at least in selected patients, IABP could be substituted by new inotropes.[6]

Although the incidence of complications associated with the use of IABP has decreased significantly, IABP still holds a risk for complications. The most common vascular complication is limb ischemia. It may occur in 14-45% of patients receiving IABP therapy. If signs of ischemia appear, the balloon should be removed. Other complications associated with IABP are arterial injury (dissection or perforation), peripheral embolization, femoral artery thrombosis, infection, and bleeding. Additionally, the balloon can break into the bloodstream resulting in gas embolization.[7] Complication rate was low in this survey with only one fatal complication occurring. The new devices and techniques of insertion have rendered this technique safe. Further, due to improvement in technology and use of new materials, IABP nowadays plays a very important role in the management of ischemic and dysfunctional myocardium.[7]

A recent consensus conference identified IABP support among the few techniques/strategies capable of reducing perioperative mortality in the setting of cardiac surgery.[8] In fact, a recent meta-analysis of randomized controlled trials suggested that preoperative IABP can reduce mortality in high-risk CABG patients.[1]

CONCLUSIONS

The IABP support was used in more than 1800 patients in 66 centers including 40,675 cardiac surgery procedures performed in 1 year. The IABP management was very heterogeneous in this survey. The weaning from IABP support consisted of reducing the ratio of beat-to-beat assistance or reduction in balloon volume. The IABP support was removed either on the first or second postoperative day, in awake and extubated patients or in sedated and mechanically ventilated patients; the patients were either weaned from or receiving inotropic support. Since IABP management can either improve patients' outcome or unnecessarily prolong ICU stay and iatrogenic complication, this topic should be further evaluated in prospective studies.

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Invited Commentary

The survey by Bignami *et al*.[1] focusing on the Italian perspective of use, discontinuation, and complications related to intra-aortic balloon pump (IABP) is timely. The authors confirm the expected results. IABP is one of the most versatile mechanical supports in the armamentarium of the cardiac anesthesiologists. There are differences in the way the IABP is inserted—with a sheath or sheath less; the way the IABP is removed—earlier to cessation of mechanical ventilation or after weaning from mechanical ventilation, or earlier to discontinuation of inotropes or afterward. Clinicians across the globe use various permutation and combination of these variables. In our experience, the final outcome of the patients is unrelated to the technique of weaning of IABP support and we believe it does not differ among various other centers. The outcome of the survey is expected to be similar, had it been performed anywhere else. In nutshell, the IABP use is not "standardized"[2] and the techniques of IABP circulatory support gives the users a degree of leeway.

IABP is inserted to thwart rapidly deteriorating left ventricular failure or on-going myocardial ischemia. What matters during these times when the heart is struggling is quick insertion of the IABP catheter whether percutaneous or via a sheath. The "holy grail" in these moments of imbalanced and unfavorable myocardial oxygen supply and demand is quick improvement in oxygen supply and reversal of excessive myocardial oxygen demand. The most important parameter at this moment is time and every second saved is extra second of better perfusion of the myocardium and therefore salvage of the ischemic myocardium. This manoeuvre also enhances tissue perfusion and oxygen delivery. Similarly, the method of weaning—whether reduction of balloon volume or frequency or inotropic agents or one or more of them may not affect weaning as long as the clinicians monitoring the patient quickly recognizes the onset of low-output syndrome and reverses the process of weaning by re-establishing "full augmentation."[3] In our experience, reducing one support at a time has been the golden rule in these situations. The discussion whether the patient should be rendered susceptible to the harmful effects of extubation is a moot one. At the same time, it is neither plausible to keep the counter-pulsation indefinitely nor to keep the inotropic medications or mechanical ventilation for long periods of time. The incidence of removal of IABP support on the first day in this publication[1] suggests that it was inserted in well-indicated patients at an appropriate time. The disrepute that IABP gained in the early days may have been due to wrongly indicated patient and inappropriate time.

The decreasing rates of complications associated with the use of IABP counter-pulsation in the Italian survey is a reflection of the global scenario. Bignami and colleagues could have evaluated the incidence of IABP insertions via the sheath, because it has been pointed out that the vascular complications would be higher in insertions via the sheath.[4,5] Apparently, the vagaries of the physicians should less influence the use of IABP insertions and a global survey would be welcome to decide the optimal course. An outcome-related survey would offer more information and help the clinician decide whether a technique is better than the other.