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Review Article

Contemporary Clinical Niche for Intra-Aortic Balloon Counterpulsation in Perioperative Cardiovascular Practice: An Evidence-Based Review for the Cardiovascular Anesthesiologist

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THE USE OF intra-aortic balloon pump (IABP) counterpulsation in various clinical scenarios recently has become controversial.[1–3] In light of the debate initiated by high-quality randomized controlled trials and subsequent comprehensive meta-analyses, both North American and European guidelines have downgraded the use of the IABP from a class I to a class II recommendation.[4–9] This article summarizes the greatest impact of these randomized controlled trials and most pertinent meta-analyses on the practicing cardiovascular anesthesiologist. The clinical aspects of the IABP are reviewed as a platform for further discussion of the related evidence.

Background

The IABP is a percutaneously inserted cardiac assist device that unloads the left ventricle by deflation in systole and increases coronary perfusion pressure by inflation in diastole.[10–14] The mechanical concept involves the synchronous inflation and deflation at specific points in the cardiac cycle, timed with either the electrocardiogram (ECG) or arterial waveform. Systolic enhancement involves deflation before aortic valve opening at the onset of left ventricular ejection (Fig 1). The mechanics by which the IABP decreases afterload is a matter of some complexity and debate.[15] The most compelling theory is the Windkessel effect.[15,16] The Windkessel concept relates a decrease in arterial impedance to left ventricular outflow as the mechanism for "decreased afterload."[16] A detailed analysis of this concept is beyond the scope of this review, but it should be noted that the concept of a systolic enhancement by the IABP encompasses intricate principles of physics. Diastolic enhancement involves inflation with aortic valve closure (indicated by the dicrotic notch on the arterial waveform) at the onset of diastole, increasing perfusion to the coronary arteries (Fig 2). The beneficial hemodynamic effects of the IABP include increases in the following variables: cardiac output, ejection fraction, mean arterial pressure, and coronary perfusion pressure.[10,17] Furthermore, these benefits also include decreases in the following variables:

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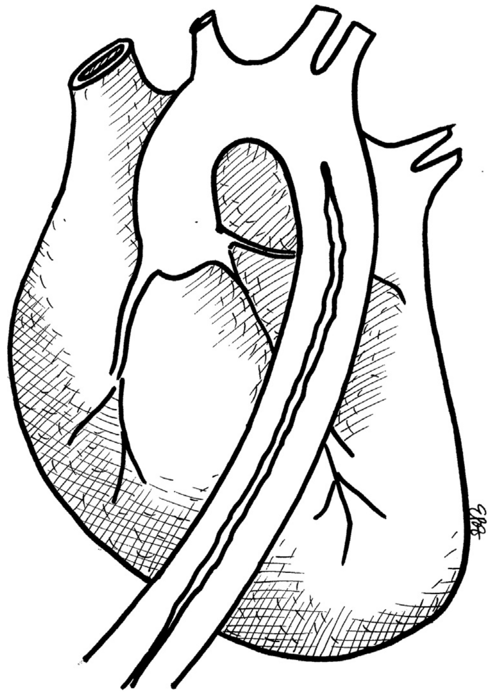

Fig 1. Cardiac systole. The intra-aortic balloon pump is positioned in the descending thoracic aorta and is deflated in systole.

aortic systolic pressure, left ventricular end-diastolic pressure, pulmonary capillary wedge pressure, and left atrial pressure.[10,17]

The primary indication for IABP counterpulsation is cardiogenic shock. Cardiogenic shock caused by acute coronary syndrome, myocardial infarction, myocarditis, hypertrophic or dilated cardiomyopathy, ventricular septal rupture, and acute ischemic mitral regurgitation all are indications for an IABP.[17,18] Additional clinical indications for the IABP include procedural support during percutaneous coronary intervention (PCI), preoperative stabilization of the general surgical patient experiencing cardiogenic shock, preoperative stabilization of the cardiac surgery patient, and failure to separate the patient from cardiopulmonary bypass.[10,17–19]

Complications associated with the IABP most frequently are vascular in origin, including aortic perforation, aortic dissection, femoral artery thrombosis, femoral artery pseudoaneurysm, lower extremity ischemia, visceral ischemia, and peripheral embolization.[18,20–22] Hematologic complications such as hemolysis, thrombocytopenia, and hemorrhage also may occur. Mechanical complications include balloon perforation, incorrect positioning, gas embolization, and inadvertent removal.[20,22] Contraindications for the application of the IABP include severe aortic regurgitation, aortic dissection, aortic aneurysm, peripheral arterial disease, and dynamic left ventricular outflow tract obstruction because these entities typically are aggravated by this intervention.[10,17]

The typical technique for insertion of an IABP begins with determining the balloon size and length based on patient height, assuming percutaneous placement via the femoral artery.[10,14] Using sterile technique, the femoral artery is accessed by way of the Seldinger technique. After arterial access has been obtained, a J-tipped guidewire is inserted to the level of the aortic arch. The arterial puncture site is enlarged with successive dilators to facilitate introduction of the balloon into the arterial system, finishing in the descending thoracic aorta just distal to the left subclavian artery (Figs 1 and 2). Real-time guidance of appropriate placement can be achieved with either transesophageal echocardiography or fluoroscopy.[23,24]

Timing of IABP inflation and deflation involves synchronizing to either the ECG tracing or the arterial pressure tracing.[10,14] The anchor for ECG timing in this setting is the QRS complex as the indicator for ventricular systole. Once an R-wave is sensed, the IABP is timed to inflate in the late phase of the T-wave that signals the onset of diastole.[10,14,15] In the setting of an arrhythmia, the IABP can be timed from the arterial tracing.[10,14,15] In the arterial timing approach, balloon inflation is synchronized with the onset of the dicrotic notch that is due to aortic valve closure at the onset of diastole. It remains essential to optimize this timing cycle to maximize the clinical benefit derived from the IABP. Balloon deflation that occurs with every cardiac cycle is described as 1:1 cycling. Weaning of an IABP is performed by decreasing the ratio of counterpulsation (eg, 1:1 decreased to 1:2), followed by frequent assessments of clinical stability.[10,14] Anticoagulation guidelines from the American Heart Association (AHA) have recommended an activated partial thromboplastin time of 60-to-80 seconds or an activated clotting time > 200 seconds to minimize the thromboembolic risk of the balloon.[25] This requirement for anticoagulation for the IABP must take into account the overall bleeding risk. In the setting of recent major cardiac surgery, this requirement may be waived to prevent the

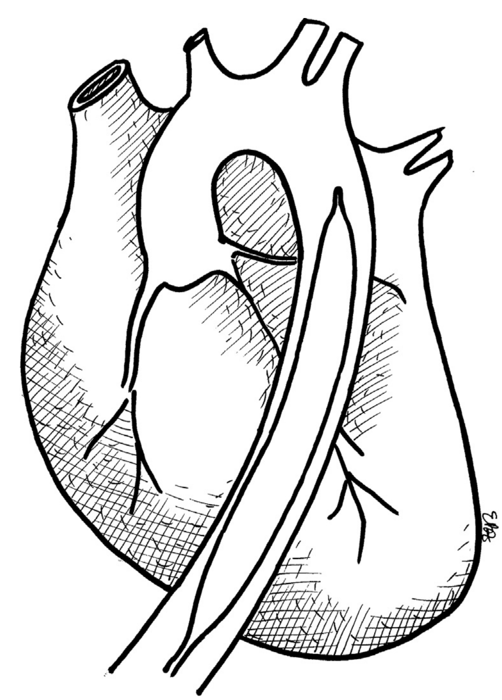

Fig 2. Cardiac diastole. The intra-aortic balloon pump is positioned in the descending thoracic aorta and is inflated in diastole.