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REVIEW

Intra-Aortic Balloon Counterpulsation in Contemporary Practice – Where Are We?

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The intra-aortic balloon pump (IABP) remains the most widely used form of mechanical circulatory support in current clinical practice. This article will review the current evidence to guide IABP use, focussing on large registry and prospective, randomised data, and seek to establish appropriate roles for the IABP in contemporary practice. Despite a paucity of clinical evidence, the IABP remains a useful clinical tool in selected settings, although its routine, up-front use in relatively unselected MI populations is not supported by data. Although current evidence no longer supports routine use in certain high-risk groups, further studies of appropriately selected high-risk patients may yet demonstrate benefit in patients with moderate-severe degrees of shock.

Keywords Shock • Myocardial infarction • Haemodynamic support • Assisted circulation • Counterpulsation

Introduction

The intra-aortic balloon pump (IABP) remains the most widely used form of mechanical circulatory support in current clinical practice. It is also the form of haemodynamic support with which clinicians have the longest experience, having been in use for more than 40 years. Despite long clinical experience, its exact clinical role remains poorly defined, due largely to the paucity of randomised, prospective evidence to guide its use. This article will review the current evidence to guide IABP use, focussing on large registry and prospective, randomised data, and seek to establish appropriate roles for the IABP in contemporary practice.

Background

The basic physiologic premise underlying the IABP is the diastolic augmentation of aortic root and coronary pressure. This was first described by Kantrowitz in animal models in 1952 and was achieved by the removal of aortic blood in systole, with rapid volume replacement in diastole [1]. It was 10 years until the first prototype of the IABP, which was followed by the first-in-man experience of Kantrowitz in 1967 with a report of two patients with cardiogenic shock, one of whom survived to discharge, the other died with the device in situ [2]. The percutaneous IABP, as we know it, was first implemented clinically in 1980 [3] and remains the most widely used form of mechanical support in most centres. It consists of a flexible balloon catheter with two lumens – one to allow flushing, aspiration and for aortic pressure to be transduced; the other to allow the rapid shuttling of gas (usually helium) to and from the balloon. This balloon is typically inserted through the femoral artery using a sheath and positioned in the proximal descending aorta, immediately distal to the origin of the left subclavian artery (Figure 1), under either fluoroscopic or echocardiographic guidance [4,5].

More than just diastolic augmentation, the term 'counterpulsation' describes the volume displacement of blood both proximally and distally in the ascending and proximal descending aorta. The IABP achieves this by balloon inflation in diastole and then rapid deflation in systole, resulting in a decrease in systolic blood pressure and an increase in diastolic pressure. The result is afterload reduction in systole and augmentation of aortic root and coronary artery pressure

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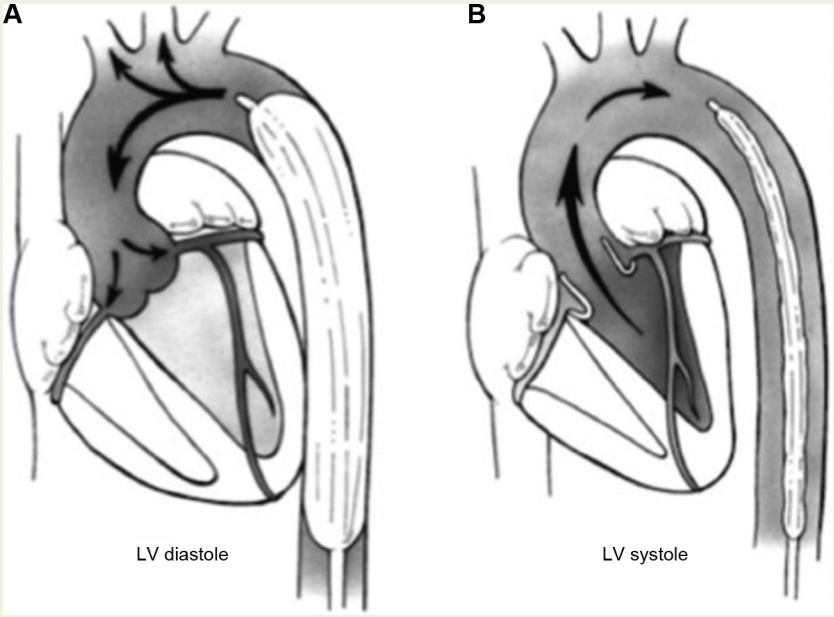

Figure 1 The IABP is positioned distal to the left subclavian origin and inflates in diastole (A), increasing aortic root and coronary perfusion, then deflates in systole (B), reducing LV afterload. (Reproduced with permission from Jones HA et al. J Invasive Cardiol 2012;24(10):544-550).

in diastole (Figure 2), when coronary perfusion pressure is maximal.

In addition to the reduced left ventricular (LV) wall stress and myocardial demand that result from reduced afterload, studies have shown modest increases in both stroke volume and cardiac output with IABP support [6–10]. Although not supported by evidence, it is intuitive that this would, in turn, lead to improvements in end organ perfusion. Although an improvement in coronary perfusion is widely cited as an important mechanism in the haemodynamic effects of the IABP, the impact of counterpulsation on coronary artery perfusion is inconsistent and probably varies across a spectrum of coronary vascular resistance, which itself can be variable in states of shock [11–15].

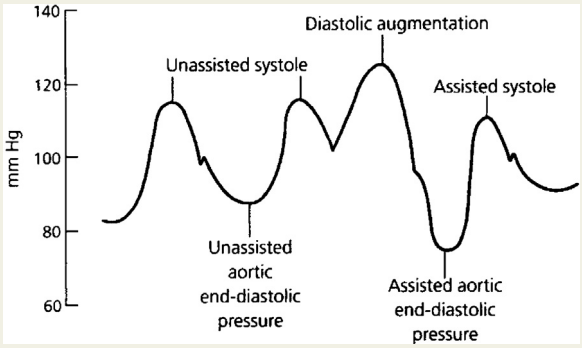

Figure 2 The pressure waveform transduced from the tip of the IABP demonstrates a reduction in systolic pressure and augmentation of diastolic pressure with counterpulsation. (Reproduced with permission from Parillo J et al. Chest. 1999;116(3):801-802).

Indications

The accepted clinical indications for IABP use are wide-ranging but the available clinical evidence is largely limited to the following indications:

- Cardiogenic shock (CS)
- Myocardial infarction without shock
- High-risk percutaneous coronary intervention
- Cardiac surgery

Other indications such as mechanical complications of myocardial infarction (i.e. acute ischaemic mitral regurgitation and ventricular septal defect), intractable arrhythmia and refractory heart failure are less common, yet generally accepted indications for IABP support. However, only small case series or small, retrospective analyses support these indications so this review will not focus on these indications. Refractory unstable angina has previously been held as an indication for IABP support but this indication is less relevant in an era of early invasive management of acute coronary syndromes.

Although from an era prior to widespread early invasive management, the largest real-world series documenting the relative frequency of IABP indications in clinical practice comes from the international Benchmark registry, across 203 centres worldwide [16]. Of the almost 17,000 patients included in this registry, the support and stabilisation of patients around the time of catheterisation (21%) and CS