WEANING INTRAAORTIC BALLOON COUNTERPULSATION: THE EVIDENCE

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ABSTRACT

The aim of this paper was to determine the most effective manner to wean intraaortic balloon counterpulsation (IABP) based on research evidence. An exhaustive search of the PubMed, Medline, CINAHL, Cochrane, Science Direct and Ovid databases was carried out to source relevant literature. The search revealed a paucity of literature related to the cessation of IABP. Evidence is unanimous in suggesting the minimization of pharmacological assistance before withdrawing any form of mechanical IABP. However, opinion related to the direct weaning of IABP by either volume reduction or frequency reduction is mixed. The assimilation of IABP studies would imply volume reduction weaning to be the most effective method of IABP support withdrawal. Volume reduction offers a more physiological approach in comparison to frequency reduction weaning, which fails to significantly differ from the complete cessation of IABP treatment. When initiating the withdrawal of any IABP support, volume reduction should be the method of choice.

INTRODUCTION

It is necessary to take a number of factors into consideration when weaning from intraaortic balloon counterpulsation (IABP). The two main approaches are volume reduction weaning or frequency reduction weaning. Because frequency reduction weaning can expose the heart to large afterload variance, it would appear volume reduction is a more physiologic approach to weaning from IABP.

INTRAAORTIC BALLOON COUNTERPULSATION

An intraaortic balloon pump is a device widely used in patients whose cardiac function is compromised or potential compromised. IABP requires the positioning of an intraaortic balloon catheter in the descending thoracic aorta, immediately inferior to the origin of the left subclavian artery and superior to the renal arteries (Overwalder, 1999). The catheter is then attached to an external pump which will inflate and deflate it in synchrony with the cardiac contractions. Balloon inflation occurs at the onset of diastole when blood ceases to eject from the heart. Inflation of the catheter results in displacement of blood volume within the descending thoracic aorta. Proximal blood is returned to the heart to oxygenate the coronary arteries while blood in the distal descending aorta is circulated around the body. Catheter deflation is timed to occur immediately before the onset of systole and the heart commences ejection. This action ensures that afterload is reduced and blood is ejected into a partially empty aorta. Cardiac workload and the consequent demand for oxygen can thus be reduced. This reduction in afterload also improves cardiac output and increases systemic perfusion (Overwalder, 1999).

IABP primarily increases myocardial oxygen supply and decreases myocardial oxygen demand. In addition, it improves cardiac output, increases coronary perfusion pressures, increases systemic perfusion, reduces mitral regurgitation and reduces afterload which will subsequently decrease left ventricular workload (Bolooki, 1999; Overwalder, 1999).

The field of IABP has been studied widely and a large number of papers concerning best practice, complications, indications and outcome have been published (Hanlon-Pena and Pitner, 2000; Cohen et al, 2003; Azeem et al, 2004; Jafary et al, 2004; Urban et al, 2004; Elahi et al, 2005). However, despite extensive research into IABP and the critical condition of patients undergoing IABP, few papers specifically address IABP withdrawal. This article reviews the current literature relating to the weaning of IABP and addresses pharmacological weaning, volume reduction weaning and frequency reduction weaning. The aim of this study, through an extensive literature review, is to identify the best method to wean IABP.

SEARCH PROCESS

The PubMed, Medline, CINAHL, Cochrane, Science Direct and Ovid databases were used to source literature relating to IABP. The key words which were used in the search were IABP, IABC, intraaortic, intra-aortic, balloon, pump/ing, counterpulsation, weaning, removal, cardiac; assist, device/s, catheter, and compromise. Combinations of these words were also used (e.g. IABP and weaning.)

AN OVERVIEW OF WEANING

There are a number of factors involved in weaning a patient from IABP. Some patients who are undergoing IABP may require respiratory support through mechanical ventilation. As a result weaning from IABP principally integrates the withdrawal of mechanical support, with a reduction in the patient's pharmacodynamic support through weaning the inotropic, vasopressor and vasoactive drugs. Evidence supports the view that pharmacological support should be withdrawn before IABP support (Bavin and Self, 1991; Sorrentino and Feldman, 1992; Quaal, 1993; Bolooki, 1998; Krau, 1999; Vitale, 1999). However, there is a lack of consensus among researchers about the best way for withdrawing mechanical support from the drive console.

The IABP drive console offers the clinician two weaning methods: intraaortic balloon catheter volume reduction and intraaortic balloon catheter frequency reduction. The available research discusses the current use of both methods, either singularly or in conjunction with each other, and the evidence has shown success for each variation on weaning (Bavin and Self, 1991; Sorrentino and Feldman, 1992; Kantrowitz et al, 1993; Bolooki, 1998; Krau, 1999).

The withdrawal of mechanical ventilation is equally problematic. Mechanical ventilation increases intrathoracic pressure and this in turn places greater force on the heart, thus assisting ejection and lowering the heart's workload. Increased intrathoracic pressures, however, also diminish the filling capacity of the heart and consequently reduce cardiac output. Isolated literature discusses reducing IABP either before or after extubation (Bolooki, 1984; Bolooki, 1998) as well the potential benefit of positive end expiratory pressure assisting cardiac ejection fraction (Kontoyannis et al, 1999).

IABP WEANING TECHNIQUES

Pharmacological reduction weaning

Whether frequency reduction or volume reduction are used in isolation or in various combinations with one another, the weaning process commences with the reduction of pharmacological support (Bavin and Self, 1991; Sorrentino and Feldman, 1992; Kantrowitz et al, 1993; Bolooki, 1998; Krau, 1999; Vitale, 1999). A major aim in the management of cardiac failure is the reduction of myocardial oxygen consumption. It is also important to reduce afterload which decreases the workload of the heart in overcoming the pressure within the aorta, thus reducing the myocardial oxygen demand.

Reducing the level of pharmacological support also decreases cardiac workload as drugs such as adrenaline increase the work of the heart. By reducing the level of pharmacological support therefore, myocardial oxygen demand is also reduced (Vitale, 1999). However, a small amount of pharmacological support will provide a cushion should the patient's condition deteriorate after the IABP has been discontinued. If necessary a low level of pharmacological assistance can be recommenced and the maximum scope of pharmacological support explored before any other assistance is sought. The reinstitution of drugs is an easier, safer and more economical option than the reintroduction of IABP (Krau, 1999). However, in cases of leg ischaemia it is not advisable to reduce the level of pharmacological support before the commencement of volume or frequency weaning. The levels of morbidity which are associated with leg ischaemia necessitate either the immediate removal of the catheter or a change in insertion site (Bolooki, 1998; Vitale, 1999).

The inotropic, vasopressor and vasoactive drugs which are used commonly in conjunction with IABP therapy include dopamine, dobutamine and noradrenaline (Krau, 1999). These particular drugs enhance cardiac rate and output, reduce systemic vascular resistance, increase blood pressure and increase systemic perfusion (Anon, 2005). When titrating pharmacological therapy before commencing volume or frequency weaning, it is initially important to move away from more aggressive drugs such as noradrenaline to either dopamine or dobutamine (Bolooki, 1998; Krau, 1999). Titration of the remaining drugs to a low or minimal dose will naturally follow. Bolooki (1998) offers advice on minimal levels of pharmacological support and states that a single pressor such as dopamine or dobutamine should not be run at a greater rate than than 5 μg/kg/minute.

Before commencing volume or frequency weaning Bavin and Self (1991) taper drugs to relatively low doses until they no longer require frequent titration. Kantrowitz (1993) and Krau (1999) meanwhile suggests the complete discontinuation of pharmacological support before any mechanical weaning takes place.

Frequency reduction weaning

Full IABP assistance consists of the inflation of the intraaortic balloon catheter at the onset of diastole after every cardiac contraction. Frequency reduction weaning requires a decrease in the total amount of assisted cardiac contractions. Assistance is withdrawn on a ratio basis from full assistance of 1:1 (IABP assistance of every cardiac contraction) to partial assistance (IABP assistance less than every cardiac contraction). The initial frequency reduction is from 1:1 to 1:2 (IABP assistance of every second cardiac contraction). This is followed by the further reduction from 1:2 to 1:4 and in some cases a final reduction from 1:4 to 1:8 but not all drive consoles have a capacity to pump at a 1:8 ratio.

A reduction in frequency exposes the heart to large variations in afterload on a beat-to-beat basis. As a result this variation has an impact on the amount of work the myocardium is expected to perform (Kantrowitz et al, 1993). The effectiveness of frequency reduction weaning in the gradual withdrawal of cardiac support is questionable and there are no relevant experimental studies addressing this issue specifically.

However, Fuchs et al (1983) have studied a related issue. Their study compared the effects of IABP on regional myocardial blood flow in patients with unstable angina. Great cardiac vein flow measurements were used as an indicator of the ability of IABP to augment the diastolic perfusion of arteries fed by post-stenotic portions of the left anterior descending coronary artery. Fuchs found at a frequency of 1:1, IABP increased great cardiac vein flow. He also demonstrated that a frequency of 1:1 provided an increase in great cardiac vein flow regardless of the intermediate catheter volume (Fuchs et al, 1983). Assist ratios of less than 1:1, however, led to no increase in great cardiac vein flow despite full catheter volume. Furthermore, great cardiac vein flow does not significantly differ whether the assist frequency is set to 1:4 or if the pump is turned off (Fuchs et al, 1983).

After studying the haemodynamic data from twelve post-cardiotomy patients, Bolooki (1998) suggests that a frequency ratio of 1:3 should be considered as balloon 'off', and Bavin and Self (1991) assert that a frequency ratio of 1:8 does nothing more than maintain catheter movement which simply prevents thrombus formation. Frequency assistance at a ratio of 1:8 will provide little, if any support. It may therefore be suggested that reduced frequency ratios may not represent intermediate IABP assistance, but rather the haemodynamic equivalent of complete IABP withdrawal.

Volume reduction weaning

Volume reduction weaning involves the gradual reduction in the volume of gas which inflates the balloon. The drive console allows the clinician to decrease the catheter volume in 10% increments from a maximum of 100% to a minimum of 0%. While the drive console may allow 10% volume reductions, literature discusses a reduction of catheter volume in 20% (Kantrowitz et al, 1993; Krau, 1999) or 25% (Bolooki, 1998) increments. However, neither Kantrowitz or Bolooki, provide any justification for their chosen volume reduction increments.

In a study by Kantrowitz et al (1993) the catheter volume was reduced in 20% increments. With each incremental reducation that level of assistance was continued for between and 15 and 30 minutes. If the haemodynamic parameters for the patient remained essentially the same, the catheter volume could be decreased by a further 20% and the process repeated until the total catheter volume is reduced to 20%.

Larger catheter columes provide a greater degree of cardiovascular support and this requires assistance to be continued over a longer timeframe (Kantrowitz et al, 1993). Consequently weaning IABP by volume reduction will commence slowly and finish more briskly. If a variable haemodynamic response is encountered while reducing the catheter volumes, it is necessary to proceed weaning with caution. If the patient begins to decompensate and his/her haemodyndamic status is such that a cardiac output cannot be physiologically maintained, full IABP assistance should be reinstated. Volume reduction can be attempted again in a few hours (Kantrowitz et al, 1993). from the literature search there was very little information on IABP weaning and more specific advice on the length of time that should lapse before trying again could not be found. In addition, total catheter volume should not be reduced any lower than 20% owing to a high risk of clot formation on the surface of the catheter (Kantrowitz et al, 1993; Krau, 1999).

Bolooki (1998) suggests a slower and more cautious approach and weaning timeframes are based around the duration of IABP therapy. Catheter volume is reduced initially to no lower than 50%. A final 25% volume is tested for 10–15 minutes before the IABP support is discontinued. Bolooki (1998) agrees with Kantrowitz et al (1993) in advising the immediate recommencement of IABP support if the patient decompensates ans cannot physiologicaaly maintain a cardiac output.

IABP in high risk surgical patients

Past studies demonstrate that if the diastolic pressure is augmented with IABP there can be a redistribution of coronary blood flow towards the ischaemic areas of the myocardium (Watson et al, 1974; Gill et al, 1975). To prevent myocardial ischaemia and possible pre-operative cardiac impairment, high risk cardiac surgical patients may require IABP preoperatively. The commencement of IABP before anaesthetic will prevent a decrease in coronary perfusion pressures which have resulted from a diminished blood pressure (Dietl et al, 1996). Considering this and the critical nature of the patient's condition, a reduction in IABP augmentation would appear to be the weaning method of choice. Reducing the volume of gas shuttled to the catheter inflates it to a lesser extent, thus displacing less aortic blood and consequently increasing cardiac afterload. Cardiac workload gradually increases in correspondence to the catheter volume making IABP support withdrawal a gradual process. This would allow the clinician to make smaller support adjustments, better suiting the patient's requirements.

WHAT THE EVIDENCE SUGGESTS

With no direct evidence to suggest that either frequency weaning or volume weaning exhibits greater success, both are offered as legitimate options for the withdrawal of IABP support (Bavin and Self, 1991; Sorrentino and Feldman, 1992; Kantrowitz et al, 1993; Bolooki, 1998; Krau, 1999). It can be suggested, however, that frequency reduction may not be as effective as volume reduction when weaning IABP. Assist ratios of less than 1:1 fail to increase cardiac vein flow (Fuchs and et al, 1983). Additionally, examination of haemodynamic outcomes of weaning IABP in heart failure found frequency reduction to result in greater haemodynamic suppression when compared with volume weaning (O'Malley, 2000). When considering the patient's haemodynamic status, any reduction in intraaortic balloon frequency could be the equivalent of complete IABP withdrawal. However, volume weaning may be seen as a more physiological approach. The reduction of intraaortic balloon catheter volume will gradually increase cardiac workload and it has also been demonstrated that larger catheter inflation volumes may further augment cardiac output (Cohen et al, 2002). Moreover, diastolic pressures augmented with IABP result in the redistribution of coronary blood flow toward ischaemic areas of the myocardium (Watson et al, 1974; Gill et al, 1975). When these arguments are considered together it may be concluded that volume weaning would be the clear method of choice when initiating the withdrawal of any IABP support.

CONCLUSIONS

Overwhelmingly the literature claims no authority regarding the practice of IABP weaning. However, the critical analysis of numerous papers may lead to the conclusion that volume reduction weaning is the most effective weaning method as frequency reduction weaning appears to be more problematic. However, even though frequency reduction weaning involves withdrawing IABP support dramatically rather than gradually, it is still used with success (Kantrowitz et al, 1993; Krau, 1999). Considering this, a need for the gradual withdrawal of IABP support once sufficient cardiac function has been demonstrated would appear unwarranted. The reduction of pharmacological support provided concomitantly with IABP therapy may be all that is required. The popularity of IABP as a treatment for cardiac failure serves only to increase the need for a formalized, researched and justified weaning model.

KEY POINTS

- Despite extensive research few papers specifically address intraaortic balloon counterpulsation withdrawal
- Pharmacological assistance should be withdrawn prior to a reduction in any form of intraaortic balloon counterpulsation support
- Frequency reduction exposes the heart to large variations in afterload on a beat-to-beat basis
- Studies suggest volume reduction weaning to be the most effective weaning method
- Volume reduction weaning in comparison to frequency reduction weaning is felt to be a more physiologic approach

KEY WORDS

IABP; assisted circulation; cardiac output, low; weaning.

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