Intra-aortic balloon pump entrapment and surgical removal: a case report

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Abstract   Intra-aortic balloon pump (IABP) use following myocardial infarction is now infrequent and reserved for cases of cardiogenic shock. As their use declines, so does our ability to promptly recognize and manage potential problems that may arise. A serious but rare complication of IABP insertion is balloon entrapment within the arterial tree. In this report, we share our experience of a case of balloon entrapment within the right common iliac artery and successful removal of the device via groin cut down under general anaesthesia.

Keywords   Intra-aortic balloon pump • Entrapment • Intra-aortic balloon pump management • Case report

Learning points

- Serious intra-aortic balloon pump (IABP) complications are rare; however, they may have major consequences.
- Prompt recognition of blood within the balloon pump's helium tubing is crucial as it indicates balloon rupture. This should then prompt immediate removal to reduce the risk for entrapment.
- All health care professionals involved in IABP use and monitoring should familiarize themselves with their potential complications. This is even more crucial now that they are encountered less commonly.
- There have been a number of extrication methods described when dealing with balloon pump entrapment. Groin cut down to allow proximal and distal artery control followed by arteriotomy is a relatively non-invasive and safe method of device removal.

Introduction

The intra-aortic balloon pump (IABP) was first introduced in the 1960s as a means to provide extra haemodynamic support to those in cardiogenic shock.[1] Over the next 40 years, the insertion of an IABP became a common occurrence in cases of cardiogenic shock not reversed with the use of pharmacological agents.[2] More recent studies, however, have called into question the mortality benefit of IABP use in myocardial infarction, and this has seen a sharp decline in their use in recent years.[3] Their use is still widespread, however, and the balloon pump remains a viable tool in the management of cardiogenic shock.

Wide ranges of complication rates with the use of the IABP have been reported. These vary from as low as 7% up to 50%.[4,5] The Japanese multi-institutional IABP Balloon Study group noted a 1.7% balloon rupture rate on the use of the IABP in 2803 patients.[5] Rupture was indicated by either the presence of blood within the pump tubing or activation of the pump's rupture alarm system. Of the 43 cases of rupture, 10 cases subsequently required surgical removal. As the use of the balloon pump continues to decline, familiarity in dealing with their rare, but serious, complications also decreases. Careful monitoring of these devices should be stressed at all times while *in situ*.

Timeline

Day	Events
1	Patient presents acutely with chest pain 3 weeks post-percutaneous coronary intervention (PCI) and stenting to left anterior descending artery (LAD).
	Angiogram performed: stent thrombosis causing left anterior descending/first diagonal (LAD/D1) occlusion—thrombus aspirated and stenting performed—TIMI 3 flow
	Hypotensive: dobutamine 5 μg/kg/min infusion commenced
2	Worsening hypotension—increasing dobutamine requirements. Increased to 10 μg/kg/min. Insertion of IABP
4 (p.m.)	Patient improving—reducing dobutamine requirements. Decision made to remove pump.
	Blood noted in tubing at the time of attempted removal—balloon entrapment
5 (a.m.)	Groin cut down and surgical removal of pump

Figure 1 Axial computed tomography image showing intra-aortic balloon pump lodged within right common iliac artery. Swan Ganz catheter located in right femoral vein.

Figure 2 Occlusion of right external iliac artery due to intra-aortic balloon pump entrapment.

Case presentation

A 56-year-old woman presented with sudden onset central chest pain and shortness of breath on a background of PCI and stenting for worsening angina 3 weeks before.

On examination, the patient was dyspnoeic with a heart rate of 100 beats/min and blood pressure of 110/70 mmHg. Normal S1 and S2 heart sounds were present on auscultation. An electrocardiogram was performed, which showed normal sinus rhythm with ST-elevation in leads I and aVL. The patient was haemodynamically stable on presentation; however, the condition of the patient deteriorated and a dobutamine infusion was commenced at a rate of 5 ug/kg/min. The patient was then transferred for primary PCI. The patient was on aspirin and clopidogrel 75mg along with atorvastatin 40 mg at night.

The patient had a 10 pack-year smoking history; however, they had not smoked for the past 10 years. Background medical history was significant for hyper-cholesterolaemia and a spontaneous intra-cranial bleed 4 years previously.

A coronary angiogram was performed that confirmed a LAD/D1 occlusion caused by a stent thrombosis. Thrombus aspiration and stenting was performed with good result and TIMI 3 flow. Clopidogrel was switched to ticagrelor following the procedure.

Despite successful intervention, the patient remained persistently hypotensive and an echo revealed a reduced ejection fraction of 10–15% with anterior apicoseptal hypokinesis, a dilated left atrium and moderate functional mitral regurgitation. Dobutamine requirements increased to 10 μg/kg/min, and the decision was made to insert an IABP and Swan Ganz catheter for management of the persistent hypotension in the setting of a reduced ejection fraction. This was done percutaneously via the right groin. Unfractionated heparin was commenced at 1000 IU/h.
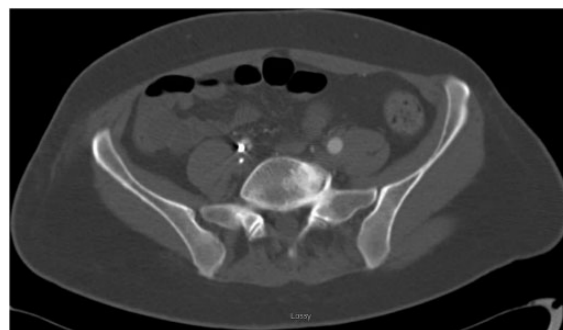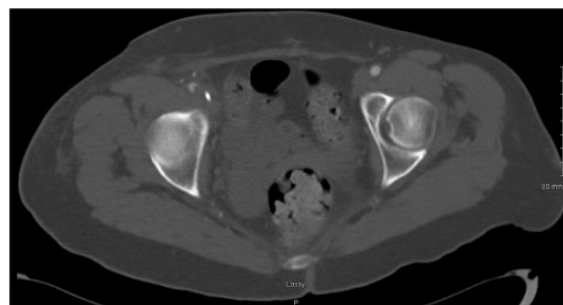
Over the next 48 h, the patient's condition improved with a reduction in ionotropic requirements and stable renal function. Due to this marked improvement in haemodynamic parameters, the decision to remove the device was made.

At the time of removal, however, it was noticed that there was blood within the helium tubing suggesting device perforation. The pump was removed without difficulty to 10 cm, at which point significant resistance was encountered suggesting balloon entrapment. Right lower limb pulses were not palpable, however, Doppler signals were present distally.

The vascular surgery team was contacted and a computed tomography angiogram was performed, which showed the tip of the balloon to lie within the distal right common iliac artery (*Figures 1–3*). Unfractionated heparin was re-commenced at 1000 IU/h.

The patient was brought to the operating theatre for cut down and removal under general anaesthesia.

A transverse incision was made in the right groin and extended inferiorly to form a T shape. A femoral arteriotomy was performed after achieving proximal and distal control of the common femoral artery. The existing arterial puncture site with catheter *in situ* was extended transversely, and the balloon was extracted without difficulty. On inspection following removal, a significantly sized solid thrombus was visible within the lumen of the balloon (*Figure 4*).

Figure 3 Tip of intra-aortic balloon pump within distal right common iliac artery.

Figure 4 Solid thrombus within balloon lumen.

Figure 5 Solid intraluminal thrombus.

A Fogarty catheter was used to perform an iliac embolectomy, which resulted in the removal of a small clot. The arteriotomy site was closed uneventfully as was the skin. The Swan Ganz catheter was left *in situ*. Good distal pulses were present following the procedure.
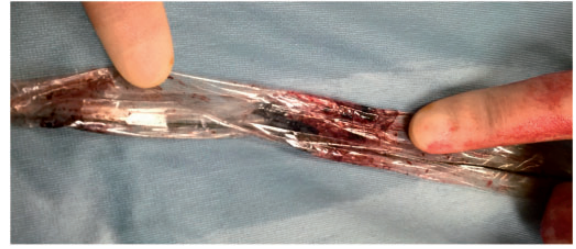
Testing of the balloon post-removal showed a number of small holes and a very solid thrombus that could not be fragmented with finger pressure (*Figures 5* and *6*)

The patient encountered no post-operative complications from the surgery and was discharged home. Management of heart failure in the setting of a reduced ejection fraction is ongoing.
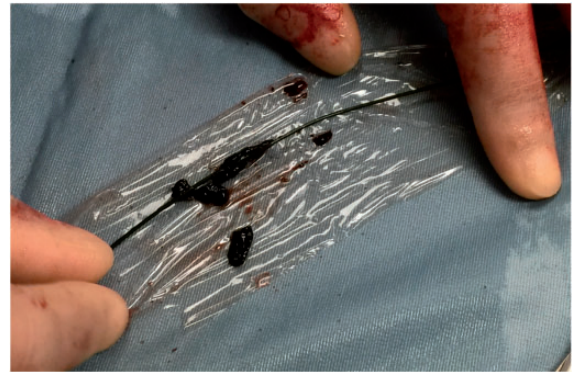
Discussion

Although their use is decreasing, IABPs are the most commonly used mechanical assist devices in the management of haemodynamic instability, which is not amenable to less invasive strategies.[6] It is an effective way to increase both diastolic blood pressure and coronary perfusion while reducing afterload.[6]

In general, the complication rate with the use of IABPs is low, given the cohort of patients involved. Analysis of just under 17 000 balloon pump insertions from 1996 to 2000 showed a 7% incidence of all complications with the use of an IABP.[4] Major complication rates were 2.6% and a mortality rate of 0.5% as a direct result of IABP use.[4] Other studies have suggested higher complication rates ranging from 20% to 50%.[5] When complications arise, however, they have the potential to be extremely serious including the loss of limbs and even death.

The device used in this case involved a 40 cm^3 polyurethane balloon, which can be easily inflated and deflated with helium. Helium is used as it is a low-viscosity gas that facilitates its quick introduction and removal to the balloon in diastole and systole, respectively.[6]

Complications associated with balloon perforation such as in this case can be catastrophic. Arterial helium embolism is a documented complication of larger perforations in the balloon membrane allowing a sudden introduction of a large volume of helium into the systemic circulation and resulting in significant neurological deficit and even death.[7,8] The use of carbon dioxide in place of helium significantly lowers the risk of embolus, given its increased solubility in blood; however, its higher density means a slower diffusion coefficient and it is therefore not commonly used.[9]

Smaller micro-perforations such as in this case tend to result in the entry of blood into the lumen of the catheter. This is because pressure inside the balloon is not sufficient enough to overcome the surface tension at the balloon—blood interface and as a result blood moves into the cavity.[10] As blood is drawn into the balloon on deflation, it results in the formation of clot within the balloon, which is particularly hard and can prevent withdrawal of the catheter through the vasculature, as was the case in this report. Entrapment is seen more commonly within the female vasculature, and this is felt to be due to the narrower calibre of the female femoral artery.[11] The presence of atherosclerosis is also a known risk factor for entrapment.[11]

As the use of balloon pump becomes less common in the era of PCI via a radial approach, this case report should serve to highlight

Figure 6 Small holes visible when water is introduced under pressure.

the importance of close observation and rapid action to remove the IABP in the event of perforation.

Immediate action can result in the successful removal of the device before the development of dense clot. The use of intraluminal thrombolytic administration can be used to aid removal; however, its use in cases where the balloon thrombus has been present for a period of >1 h, such as in this case, is debatable, given the solid consistency of the clot.[12–15]

The optimal removal strategy of an entrapped IABP is still unclear, given its rarity. A number of different approaches have been referenced in the literature with varying degrees of success. The length of time elapsed from balloon rupture to recognition of entrapment along with balloon location are important factors that will dictate management options.

Millham *et al.*[15] reported two cases of entrapment in 1991 at the end of which they concluded that the abdominal aorta should be controlled proximally in cases where the catheter tip resides above the inguinal ligament.

Fukushima *et al.*[13] describe a case of entrapment within the aorta of a 68-year-old gentleman, where removal was carried out using a guidewire with fluoroscopy via the axillary artery.

As is evident from this, there have been numerous techniques used since the late 1980s for the removal of entrapped aortic balloon pumps. In the case reported herein, it was possible to gain both proximal and distal control of the involved vessels to ensure any bleeding could be controlled quickly and adequately should the need arise. The technique used here did not require the need for retro peritoneal aortic exposure, and the associated morbidity that comes with this, as suggested by Millham *et al.*[15] Pre-operative imaging to delineate anatomy and identify the location of obstruction is vital in planning the most appropriate approach on a case-by-case basis, as it helps determine the most appropriate method for its removal.

If blood is noted within the external tubing supplying the balloon pump, it should prompt swift extraction of the balloon. Helium should be the only thing within the helium tubing and blood can only enter if the balloon surface has been damaged. Often an alarm will sound on the IABP console if blood gets in this tubing, but this is unreliable and often will not sound, as was the situation in this case. Vigilance in monitoring this tubing is therefore paramount in the overall care of patients under IABP support. If blood is noted—it should prompt the removal of the balloon within 30 min, as the longer it is left after its rupture the drier the clot becomes and the less likely it is to extract at the bedside.

Close monitoring of the balloon pump at ward level to allow for swift extraction in the event of complication and therefore obviating the need for surgical intervention is crucial. This case report should serve to highlight the importance of strict vigilance of IABPs by ward staff that may be less familiar with their use and complications as balloon pump use becomes more infrequent.

Author Contributions

N.H. and N.S. were involved in compilation of data and writing of this piece. J.C. and P.M. were lead consultants/senior authors involved in the management of the case.

Consent

Informed consent was obtained from this patient for publication of this case history and associated images in line with COPE recommendations.

Conflicts of interest: none declared.

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