CASE REPORT

Limb salvage following iatrogenic arterial injury: complications of cardiac support using intra-aortic balloon pumps

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SUMMARY

This is a unique case report describing complex limb salvage in a patient who experienced acute limb ischaemia due to a complication of intra-aortic balloon pump (IABP) counterpulsation. This case focuses on a patient who had an IABP counterpulsation device inserted following myocardial infarction, requiring urgent coronary artery bypass grafting for acute coronary syndrome. Postoperatively, the IABP could not be removed, with consequent iliac thrombosis and acute limb ischaemia. Emergency femoral-to-femoral crossover bypass was performed using a polytetrafluoroethylene graft. A portion of the IABP balloon tip was entrapped and retained, however, and became the focus of delayed septicaemia, resulting in graft infection and wound breakdown 6 weeks later. Explantation of the residual balloon tip, ligation of the right external iliac artery and redo femoral–femoral crossover using the great saphenous vein were successfully performed.

Deployment of large calibre sheaths within stenosed femoral and iliac vessels can cause limb hypoperfusion, as can problems of thrombosis and distal embolisation. Dissection or thrombosis of an entire iliac system with entrapment of the balloon device and failure of withdrawal is rarely seen, but does highlight the importance of considering vascular anatomy and pathology with utilisation of these devices. Given that this anatomy is often subject to significant vascular pathology in the subset of patients requiring IABP, complications cannot be completely obviated, yet there is a clear imperative to minimise any iatrogenic effects of this intervention.

CASE PRESENTATION

A 75-year-old man presented to the emergency department 9 hours after the sudden onset of crushing chest pain at rest, radiating to his left arm. This occurred on a background of a week's intermittent chest pain on exertion. His medical history was limited to hypercholesterolaemia, with no previously reported cardiac history. His only regular medication was atorvastatin. At presentation, he was independent in all activities of daily living, and continued to work as the manager of a business. He had never smoked, and did not consume significant amounts of alcohol.

He was haemodynamically stable at the point of admission, with an unremarkable physical examination, temperature of 36.6°C, heart rate of 68, blood pressure of 155/79, respiratory rate of 17 and peripheral oxygen saturations of 100%.

Initial investigations included an elevated serum troponin at 169 ng/L (normal <16), and an ECG demonstrated signs of an acute myocardial infarction, with new intermittent left bundle branch block and ST-segment elevation in leads I and aVL.

Medical treatment was initiated with aspirin and ticagrelor, and the patient was transferred urgently to the cardiac catheter suite for coronary angiography. Transfemoral coronary angiography via the right groin identified triple vessel disease, with 60%, 90% and 95% stenoses, respectively, in the left anterior descending, left circumflex and right coronary arteries. A decision was therefore made to proceed to CABG. As the patient was deemed to be at high risk of perioperative cardiogenic shock, an IABP counterpulsation device was inserted in the catheter lab, while the patient was prepared for urgent surgery the following day. He received a total of 23 hours of IABP counterpulsation support.

BACKGROUND

Cardiogenic shock following acute myocardial infarction has a mortality of 40%, even with early revascularisation and best medical management. Despite conflicting evidence of the efficacy of intra-aortic balloon pump (IABP) counterpulsation in such patients,^{1–4} it is recommended as a treatment modality in US and European guidelines on the treatment of cardiogenic shock, and remains in widespread use, where invasive monitoring, optimal venous filling and inotropic support cannot successfully stabilise haemodynamics, and when short-term recovery remains a possibility.^{5–6} The results of a recent meta-analysis additionally support its use perioperatively in patients undergoing high-risk coronary artery bypass grafting (CABG).⁷

Vascular complications arising from insertion, deployment and withdrawal of lines and devices are frequent, in part due to high levels of comorbid aortoiliac occlusive disease in those with cardiac conditions. The simplest problems are of arterial and venous injury at the point of attempted cannulation, potentially mandating device withdrawal or re-siting. Ultrasound-guided compression or thrombin injection may be considered for treatment of simple pseudoaneurysms, but repair via an open,^{8–9} endovascular¹⁰ or hybrid stent-graft approach¹¹ may be required.

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Attempts to remove the IABP in the cardiac care unit, 1 day after coronary surgery, and 2 days after its initial insertion in the cardiac catheter lab, proved unsuccessful. The device had been in situ for 55 hours at this point. The patient subsequently developed acute right leg ischaemia and the vascular team was called to assess the patient.

A CT angiogram performed at this time found the distal metallic tip of the partially withdrawn IABP to be located within the right external iliac artery, at the level of an atheromatous calcified plaque, and the right iliac vasculature to be completely thrombosed, with no evidence of a patent luminal channel (figure 1).

The patient was scheduled for emergency surgery by the vascular surgical team, which performed a left-to-right femoral-femoral cross-over bypass graft, using an 8 mm reinforced polytetrafluoroethylene (PTFE) graft. This successfully restored adequate perfusion to the patient's right leg, ~8 hours after the onset of ischaemia. Prophylactic right lower limb four-compartment fasciotomies were therefore performed.

During this emergency vascular procedure, however, ~8 mm of the distal tip of the IABP was found to be entrapped in the iliac plaque. Attempts at complete removal resulted in eversion of the artery, with concern over the risk of aortoiliac rupture. As a result, as well as the patient's preoperative instability, and the already prolonged ischaemic time, it was elected to cut the balloon and leave the tip in situ within the right iliac artery. The patient stabilised following this procedure, and hence this outcome was accepted and the patient transferred 2 weeks post-operatively to his local hospital for further recovery and rehabilitation. At that point, both groin wounds were intact and healing well, and a standard perioperative antibiotic prophylaxis regimen had been completed.

Six weeks after the initial surgery, the patient was referred back to our tertiary vascular unit, with sepsis secondary to a deep-seated infection of the crossover graft, which was found, on examination, to be discharging frank pus via the right groin wound. There were signs of shock, with a temperature of 36.5°C, heart rate of 90, blood pressure of 98/65, respiratory rate of 18, peripheral oxygen saturations of 95%, and raised C reactive protein (279 mg/L, normal <5) and white cell count ($16.7 \times 10^9/L$, normal 4.0–11.0). Pus and blood cultures yielded methicillin-resistant *Staphylococcus aureus*, sensitive to vancomycin. CT angiography demonstrated an occluded right common and external iliac artery

Figure 1 Horizontal CT section demonstrating thrombosed right iliac system with indwelling IABP device (arrow) IABP, intra-aortic balloon pump.

Figure 2 Horizontal CT section of same patient following graft infection suppurating to right groin (arrow 1) with femoral-femoral PTFE graft in situ (arrow 2). PTFE, polytetrafluoroethylene graft.

with radiological signs suggestive of infection tracking from the retained IABP catheter tip, and involving the PTFE cross-over graft (figure 2).

The patient underwent further urgent surgery to explant the infected femoral-femoral crossover PTFE graft, remove the IABP tip, ligate the thrombosed right external iliac artery and perform a thorough washout of the operative field, followed by a redo femoral-femoral crossover using the residual reversed autologous great saphenous vein (GSV), harvested from the left thigh (the sole remaining portion of suitable conduit following recent autologous GSV harvest for coronary surgery). Duplex sonography—our standard means for graft follow-up where there are no clinical concerns for further ischaemia—demonstrated good results following this procedure. Given the satisfactory clinical outcome, further post-procedural CT/MRI angiography was not performed.

DIFFERENTIAL DIAGNOSIS

Post-operative fever is a commonly encountered problem and clearly, after major surgery—particularly in a high-dependency environment—a full examination and septic screen should be undertaken to differentiate between post-operative fever due to a systemic inflammatory response following surgical trauma, which is common, characteristically involves low-grade fever and generally settles spontaneously, and sepsis.

An infective focus should therefore be actively sought or excluded. After major abdominal and thoracic surgery, wound infections, abdominal sepsis or end organ ischaemia due to compartment syndrome, as well as perforation, should be considered.

In the ventilated patient, pneumonia is common, with regular suctioning of airways, humidified oxygen and monitoring on plain chest radiography used to minimise this risk. Atelectasis requires post-operative chest physiotherapy and adequate pain management to treat, and prevent, incipient chest infections.

Line sepsis should be considered, particularly when venous and arterial catheters have been in situ for several days, for patients requiring prolonged support. Similarly, urinary tract infections are common, especially with the use of urinary catheters. If epidural analgesia is used, the puncture site should be also inspected for signs of infection.

Graft infection may be difficult to establish as the definitive focus of sepsis, and positron emission tomography CT as well as

radiolabelled white cell count scans can be useful adjuncts, where the clinical picture is not as definitive as in this case.

OUTCOME AND FOLLOW-UP

In consultation with our microbiologists, a peripherally inserted central catheter was sited for prolonged intravenous antibiotic therapy with vancomycin. Post-operative duplex sonography demonstrated the vein graft to be functioning well. With limb salvage successfully achieved, the patient was discharged to his referring hospital for rehabilitation without further complication.

DISCUSSION

Vascular complications of IABP

Initial experience of IABP counterpulsation was described by Kantrowitz *et al*¹² in 1968. The technique has undergone development and been widely adopted, with use increasing through the 1980s and 1990s, and IABP currently have a number of indications within acute cardiology and cardiothoracic surgery.^{6 13 14}

Their principle use is as a short-term mechanical adjunct in the treatment of cardiogenic shock, particularly following out of hospital cardiac arrest, myocardial infarction and revascularisation, in conjunction with invasive monitoring, fluid optimisation and pharmacological agents, as a bridge to recovery.⁴ These patients are an extremely high-risk group, often refractory to maximal inotropic support, and although the possibility of recovery is entertained, even with best medical therapy, including early revascularisation, their expected mortality is high.¹⁵

Several retrospective single-centre case series have been published in Europe, Australia and the USA, documenting the high rate of complications associated with IABP usage. Heterogeneity of population groups and reported data lead to widely differing estimates of their incidence, however.

Mortality (ranging in these series from 37% to 58%) is related to the extent of myocardial injury—patients with large anterior infarcts being particularly likely to suffer refractory cardiogenic shock, corresponding to echocardiography and serum biomarkers.⁶ As these series do not quote such indices, they are not entirely comparable. The cardiothoracic mortality rates (Meharwal quotes 5.6% in a series of 911 patients requiring short-term IABP support following cardiac surgery between 1994 and 2000) are significantly lower, and probably relate to a more stable patient group.¹⁶

The majority of vascular complications arise from mechanical, thrombotic or embolic occlusion of the branches of the aorta,^{17 18} of which acute limb ischaemia is the most common presentation, with an incidence of 3–36%.^{16–23} Rarer complications such as device failure,²⁴ aortic dissection¹⁶ and balloon rupture²⁵ are occasionally encountered.

Cardiothoracic series report notably lower rates of leg ischaemia (Meharwal quotes 3%, while Sirbu quotes 13.5%), perhaps due to overall short duration of deployment. Meharwal also found a lower rate of ischaemic complications in the latter half of his series, when IABP devices were used without sheaths.^{16 21} Cardiothoracic surgeons, who employ a mix of Seldinger and open surgical insertion techniques, additionally report fewer local arterial injuries and lower bleeding complication rates.

Almost all patients with acute limb ischaemia will require intervention in some form. Early series from the 1970s identified 23% of all patients as requiring simple thrombectomy, and a further 6% requiring crossover grafts.²⁰ A major

amputation rate of 3% was reported in 1979 by Sutorios in a series of 109 patients, while more recent series report a rate of 0–1%.^{17 19 21 26}

IABP balloon entrapment

Entrapment of intra-aortic balloons is a rare complication of IABP use, estimated to occur at a rate of 1%.^{16 23} It is most frequently reported in association with balloon rupture.^{27–38} In this case, there was no evidence of extravasation of blood into the balloon lumen, with entrapment only of the distal tip, both features atypical for mechanical failure.

Successfully reported interventions for removing entrapped intra-aortic balloons include pharmacological lysis of thrombus within the lumen of the balloon to allow deflation and removal,³⁴ and open surgical intervention. Retrograde removal of entrapped IABP balloons via an axillary approach has also been described.^{22 34}

Iliac limb salvage and IABP

Infra-inguinal crossover grafts have been used to revascularise thrombosed iliac vessels, both after IABP withdrawal, and during use, to enable ongoing IABP therapy, by revascularising the limb distal to the iliac system where IABP removal is not yet possible.^{20 21} In the latter instance, the graft is necessary only while the balloon catheter remains in use, as device withdrawal on myocardial recovery restores limb perfusion. Subsequent graft follow-up with such a strategy, where competitive flow might be anticipated, is not available. Endovascular stenting of thrombosed iliac limbs after IABP withdrawal has also been described.³⁹

IABP infection

Being inserted under sterile conditions, infective complications from IABP, while recognised, are uncommon. Sanfelippo and Meharwal report rates of 0.2% and 0.9%, respectively, while Meco found a higher infection rate of 6% in a smaller series.^{16 17 26}

While the association between retained foreign bodies and infection is well recognised,^{40–43} we have been unable to identify any documented cases of graft infection associated specifically with IABP insertion; our operative findings suggest the retained tip was the most likely source of graft infection. This is, therefore, a novel case of balloon entrapment in the absence of rupture and of graft infection following a retained fragment of IABP.

Conclusion

While placement of infra-inguinal grafts as a limb salvage procedure has been previously described in similar cases—with the use of a prosthetic conduit being a comparatively quick and less invasive approach—our report emphasises the risks of incomplete removal of such intravascular devices, even when perfusion has been successfully restored using bypass surgery.

Clearly, given the contexts in which IABP therapy is used, there may also be significant risks in prolonging operative time, quite apart from the general potential for further iatrogenic damage to major vessels.

Hence, our experience in this case underlines the importance of careful assessment, in each patient, of the risks and benefits of IABP insertion and of the approach taken where complications do occur.

In the rare instances where complete removal is not possible, early consideration of an infected graft as a nidus for infection and institution of appropriate antibiotic cover are paramount.

Learning points

- Cardiogenic shock has a high mortality and the selective use of intra-aortic balloon pump (IABP) counterpulsation as a bridge to recovery is widespread. There are, however, risks associated with every stage of IABP use—deployment, duration of use and at or following device removal—particularly if complete removal is not achieved.
- Entrapment of intra-aortic balloons may occur even in the absence of device failure.
- Where retention of any part of the intra-aortic balloon is suspected, the aim of complete device removal needs to be carefully balanced against the risks of further iatrogenic damage.
- Complete explantation of infected vascular prostheses is mandatory, and if revascularisation is then necessary, a biological conduit and appropriate antibiotic regimen should be employed.

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