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Case report

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Optimizing outcomes of open thoracoabdominal aortic aneurysm repair

Abstract

Open thoracoabdominal aortic aneurysm (TAAA) repair is a high-risk surgery associated with significant morbidity and mortality. It can be difficult to accumulate experience managing open TAAA repairs due to the low volume of cases and the increasing popularity of endovascular approaches. It is important to review management strategies for these challenging cases as clinical situations remain for which an open repair is preferred. Recent advances now allow for distal aortic perfusion during an off-pump open thoraco abdominal aortic aneurysm repair. This approach is not without risks and a clear, team based, plan is essential for successful management. Key considerations include managing co-morbidities, spinal cord protection, prevention of ischemia (coronary, cerebral, visceral, and peripheral), renal protection, massive transfusion, rapid hemodynamic changes, acidosis, coagulopathy, one lung ventilation, and postoperative pain control. In this case report, we detail an off-pump perioperative approach involving retrograde aortic perfusion, transesophageal echocardiography, and multiple spinal cord protective strategies which resulted in a favorable patient outcome.

Keywords: thoracic aorta, thoracoabdominal aortic aneurysm, retrograde aortic perfusion, temporary axillofemoral bypass, vascular anesthesiology, spinal cord protection

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Abbreviations: TAAA, thoraco abdominal aortic aneurysm; POD, post operative day; TEE, tran-sesophageal echocardiography; CPB, cardiopulmonary bypass; Lvads, left ventricular assist devices

Introduction

Aneurysmal degeneration of the aorta is a significant cause of death in first world nations. Repair of descending aortic aneurysms presents unique challenges, which could be encountered by any anesthesiologist involved in the management of vascular cases. Core management approaches are controversial and variations exist between leading institutions. Options include cancelling the case (medical management), fenestrated endovascular aortic aneurysm repair, hybrid repair (combined open and endovascular approach), or open surgery. When open surgery is preferred options include clamp and sew, full cardiopulmonary bypass, partial bypass, or retrograde perfusion via a temporary shunt. Key considerations include managing co-morbidities, spinal cord protection, prevention of ischemia (coronary, cerebral, visceral, and peripheral), renal protection, massive transfusion, rapid hemodynamic changes, acidosis, coagulopathy, one lung ventilation, and postoperative pain control. This publication describes our management approach and expands upon the above considerations.

Case description

A 57 year old male patient with a Crawford type II thoracoabdominal aortic aneurysm presented for open surgical repair. The aneurysm extended from the left subclavian artery to the abdominal aorta and involved the renal arteries. A multi-disciplinary preoperative assessment found no evidence of end organ failure and the patient was deemed to be optimized for the procedure.

The patient was brought into the operating room and standard monitors were applied. A thoracic epidural was placed for postoperative pain management. A lumbar drain was then placed with the patient in the right lateral decubitus position. A right radial arterial line was inserted. The patient was induced using sufentanil, midazolam, propofol, and rocuronium. An 8.5mm endotracheal tube was used with an Arndt bronchial blocker placed in the left main bronchus. The balloon was kept down until one-lung ventilation was required. An internal jugular Cordis and an 8.5 French rapid infusion catheter were established. Fast flow fluid warmers and emergency medications were primed. A transesophageal echocardiogram probe was introduced for hemodynamic monitoring and a femoral arterial line was placed to monitor retrograde perfusion pressure.

Under general anesthesia a tunnelled right axillofemoral artery bypass was performed using a 10mm Gore-Tex graft. The patient was then placed in a partial right lateral decubitus position and the table was hyperextended. An incision extending from above the symphysis pubis through to the fourth rib provided surgical access for the extensive dissection. A 20cm portion of the aorta, just distal to the left subclavian artery, was then isolated using two clamps. Visceral perfusion distal to the caudad clamp was provided by retrograde flow from the axillofemoral bypass and monitored using the femoral arterial line. A 28mm Dacron tube graft was attached to the aorta in an end to end fashion. By sequentially clamping and unclamping progressively distal portions of the aorta, the graft was extended beyond the renal arteries. The celiac, superior mesenteric, renal, and three intercostal arteries (added using a separate Crawford patch technique) were incorporated into the graft. Following surgical closure the temporary axillofemoral bypass graft was removed. The patient was in the operating room for 11.5 hours.

Discussion

Coagulopathy

The optimal management of coagulation during thoracoabdominal aortic aneurysm repair is challenging. Massive transfusion, hypothermia, acidosis, and the fibrinolytic state induced by visceral

ischemia all increase the risk of bleeding. At the same time, arterial cross-clamping results in stagnant blood and presents a significant risk of intra-arterial thrombus formation. The fibrinolytic state induced by supraceliac cross-clamping appears to occur secondary to increased release of tissue-type plasminogen activator from ischemic vascular tissues.[1] In cardiac cases antifibrinolytics have been found to reduce the need for blood transfusions with occasional inconsistent concerns regarding worsened renal, neurological, and cardiac outcomes.[2-10] Tranexamic acid, has been shown to be effective in reducing the need for allogeneic blood transfusion during thoracoabdominal aortic aneurysm repair. For this case, one gram of tranexamic acid was given prior to thoracotomy followed by an infusion of 1mg/kg/h for the duration of the case. Postoperatively there was no neurologic deficit and minimal deterioration in renal function (of note mannitol 0.5g/kg was given prior to aortic cross-clamping for renal protection). Renal function returned to baseline within two days. Supraceliac cross-clamping also reduces liver perfusion which may alter the coagulation cascade and has been shown to prolong the effect of heparin.[11] For this case, heparin was used for the axillo femoral artery bypass then reversed with protamine. For the duration of supraceliac aortic cross-clamping no heparin was used and point of care arterial blood gas and INR measurements were completed every 10minutes. Fresh frozen plasma (total volume 3745ml) was transfused as needed to target an INR of less than 1.6. Cryoprecipitate (9ml), platelets (678ml), Cell saver RBCs (2022ml), and allogeneic RBCs (3633ml) were replaced as needed. No arterial thrombotic complications were noted.

Bicarbonate

The use of sodium bicarbonate in the context of reversible lactic acidosis is controversial. Most experts agree that sodium bicarbonate therapy is reasonable in the context of lactic acidosis if the PH is below 7.1 and adequate ventilation can be maintained.[12] The aim of bicarbonate therapy is to avoid severe acidosis which can be associated with reduced left ventricular contractility, arrhythmias, arterial vasodilation, enzymatic dysfunction, and impaired responsiveness to catecholamines.[12] Unfortunately, the potential benefits do not come without risks which include increased pCO2, accelerated lactate generation, reduced ionized calcium, hypernatremia, and extracellular fluid expansion.[13,14] Given the easy diffusion of CO2 across membranes, a paradoxical increase in intracellular acidosis has been reported with bicarbonate therapy. Additionally, some studies have reported a protective effect of acidosis and suggest that rapid correction of acidosis following ischemic insult may lead to increased cellular death.[14] Finally, given the appropriate clinical context, there is some evidence to suggest an increased mortality with bicarbonate use.[14] Thoracoabdominal aortic aneurysm repair inevitably results in significant visceral ischemia. Severe acidosis can occur rapidly particularly during aortic unclamping. For this case an aggressive prophylactic sodium bicarbonate infusion (841ml of 8.4% sodium bicarbonate) was used. The lowest recorded pH was 7.27. No adverse clinical impact was noted.

Transesophageal echocardiography

Transesophageal echocardiography (TEE) is a minimally invasive monitor that provides unparalleled real time monitoring of cardiovascular function. Throughout this case, TEE was used to assess cardiac function (ejection fraction, regional wall motion abnormalities, and diastolic parameters), delineate the extent of disease (in particular to rule out proximal aortic dissection), monitor fluid status, monitor for ischemic changes, guide surgical interventions, and assess the status of surgical repair. Intraoperative acute diastolic dysfunction secondary to aortic cross clamping has been described and may carry significant morbidity.[15] Intraoperative TEE is particularly useful for guiding fluid management. Left ventricular end diastolic volume estimated in the short-axis view at the mid papillary level provides a real time surrogate for volume status.[16] A cardiac index>2 L/min/m2 was targeted and TEE played a key role in determining fluid and inotropic management.

Spinal Cord Protection

Spinal cord ischemia can occur during aortic cross-clamping or postoperatively due to the aortic graph partially occluding the blood supply to the spinal cord. Rates of paralysis of up to 40% have been reported in the literature.[1] Numerous techniques have been used in an attempt to avoid this devastating complication including: temporary shunting, CSF drainage, epidural cooling, systemic cooling, local or systemic pharmacological interventions, spinal cord monitoring, and re-implantation of intercostal arteries. A 2012 Cochrane review stated that observational studies from experienced centres suggest a potential benefit for distal aortic perfusion, however, there are no randomized control trials investigating the use of distal aortic perfusion.[17] For this case femoral arterial pressure was maintained with a target MAP between 70-100mmHg. This target took into consideration maintaining spinal cord perfusion pressure and avoiding excessive hypertension which would increase bleeding. Options for distal aortic perfusion include cardiopulmonary bypass (CPB), left ventricular assist devices (LVADs), and temporary bypass grafts. CPB and LVADs may allow for more control over distal aortic perfusion but these techniques are not without risks.[18] In particular, prevention of circuit thrombosis, the need for systemic heparinization, induced hemolytic/fibrinolytic states, and complications related to access sites must be considered.

While there are randomized control trials investigating the role of CSF drainage, the results are mixed. A 2012 Cochrane review concluded that there is limited data supporting the role of CSF drainage in thoracoabdominal aneurysm surgery based on three trials with a total of 287 patients.[19] For this case a total of 177ml of CSF was drained during the 11.5 hour procedure. A CSF pressure of less than 10mmHg was targeted and the maximum rate of CSF drainage was kept below 20ml/h. At the end of the surgery the anesthetic was lightened briefly in order to confirm intact motor function in the legs.

Postoperative course

Postoperatively the patient was taken to the intensive care unit. He was extubated and weaned off vasopressors (target MAP 80 - 90mmHg) by postoperative day (POD) #1. His lumbar drain was clamped and then discontinued on POD #2. The epidural was removed on POD #5. On POD #12 an incidental segmental PE was discovered on follow-up imaging and required anticoagulation. The patient was discharged home on POD #15 and continued to do well as of his most recent follow up two years postoperatively.

Conclusion

Open thoracoabdominal aortic aneurysm (TAAA) repair is a high-risk surgery associated with significant morbidity and mortality. Successful perioperative management requires a large team working together with a clear operative plan. Team leaders need to be aware of the numerous risks and implement strategies to mitigate these risks. We detail an off-pump perioperative approach involving retrograde aortic perfusion, transesophageal echocardiography, and multiple spinal cord protective strategies which resulted in a favorable patient outcome.

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Conflicts of Interest

The authors do not have any Conflict of interests.

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