Reversal of paralysis and visceral ischemia after thoracic aortic ligation for infection via extra anatomic ascending aorta to infra-renal aorta bypass graft

Hamdy Awad, Haytham Elgharably, Lamia Buohliqah, Galina T Dimitrova and Michael R Go

Abstract
Surgical management of acute aortic infection is challenging, including excision of the infected segment and reconstruction either through extra-anatomical bypass or in situ graft replacement with higher risk of re-infection. Here in, we present a case of delayed paralysis developed after an extra-anatomic (axillary-bifemoral) bypass of infected thoracic aorta in a 51 year old Caucasian male. Reversal of paralysis was successfully achieved via larger extra-anatomical ascending aorta to infra-renal aorta bypass and cerebrospinal fluid (CSF) drainage.

Keywords: Paralysis, Aorta, Infection, Stent-graft, Perfusion

Background
Aortic infection, whether primary or secondary to surgical or stent-graft repair, is a rare and devastating complication often requiring aortic ligation. Incidence of aortic stent-graft infection specifically ranges from 1–4.7% with mortality rates reaching 25-75% [1–3]. Here, we present a case of ischemic spinal cord injury (ISCI) and visceral ischemia that complicated extra-anatomic (axillary-femoral) bypass done to restore distal perfusion after excision and ligation of an infected thoracic aorta. Reversal of paralysis and ischemia was achieved with a combination of a larger, extra-anatomical ascending aorta to infrarenal aorta bypass and CSF drainage. There was a concern about the inadequacy of the axillary/femoral bypass in restoring the flow versus the direct ascending aorta to infrarenal aorta bypass. This case raises an important question: what is the ideal extra anatomic bypass after complete ligation of the thoracic aorta?

Case presentation
A 51 year old Caucasian male with coronary artery disease status post stent placement, congestive heart failure with an ejection fraction of 22%, hypertension, diabetes, atrial fibrillation, peptic ulcer disease, and esophageal varices presented with a ruptured, infected mid-descending thoracic aorta. The etiology may have been a pseudoaneurysm (Figure 1a) from recent endoscopic cauterization of an esophageal bleed or primary aortic infection. A Gore TAG device (Figure 1b) 15 cm in length and 28 mm in diameter was emergently placed well below the subclavian artery and extended to 8 cm above the celiac artery to temporize the hemorrhage. As expected, postoperative CT angiography (Figure 1c) showed a peri-aortic and peri-endograft abscess. As an attempt at definitive repair, he then underwent right axillary to right femoral bypass with a 10 mm diameter Dacron graft and left thoracotomy with endograft removal, excision of the infected aorta, and aortic ligation. It was hoped that the 10 mm right axillary to right femoral bypass would provide sufficient retrograde perfusion to the viscera and spinal cord. However, two days after this procedure, the patient developed bilateral lower extremity paralysis, abdominal pain, and anuria with a patent axillary-femoral bypass. Although no objective measures of distal perfusion were done after axillary-femoral bypass such as ABIs or PVRs, we did suspect distal malperfusion with spinal cord, visceral, and renal ischemia. We did note that though the feet were warm and well perfused, he did not have palpable...
pulses, suggesting some decrease in perfusion given his otherwise normal arteries. An L4/5 lumbar spinal drain was placed 10 hours after the onset of weakness as an adjunct for his paralysis and the patient urgently went back to the operating room for sternotomy and bypass from the ascending aorta to the infrarenal aorta with a 20 mm Dacron graft, avoiding the left chest. Intraoperatively, the patient began making urine. He also did regain pedal pulses. The next day, the patient was able to wiggle his toes but still had proximal muscle weakness. ISP was maintained at 10 mm Hg. An intravenous naloxone infusion was administered at 0.001 mg/kg/hr for 3 days. Mean arterial pressure was maintained in the high normal range. Over the next several days, the patient regained motor function in his lower extremities, such that by postoperative day #9 the strength in his hip flexion and extension was 3/5, his knee flexion and extension was 4/5, and his ankle flexion and extension was 5/5. He was independent in all bed mobility and was able to transfer. He was able to ambulate with assistance and had good balance. The patient was transferred to a rehabilitation facility.

Discussion
Here, we present a case of delayed paralysis after surgical management of an infected thoracic aorta by axillary-femoral bypass. The axillary-femoral bypass was complicated by inadequate perfusion to the spinal cord and kidneys. This case raises an important point about the ideal extra anatomic bypass after complete ligation of the thoracic aorta? Which then leads to the question; does the axillary-femoral bypass adequately perfuse distal organs versus the ascending aorta infrarenal aortic bypass? and what is the flow volume and distal perfusion pressure required to maintain end-organ perfusion distal to an aortic ligation?

In this case, unfortunately flow volumes and pressures were not measured through the patent axillary-femoral bypass and there were no objective measures of distal perfusion done after axillary-femoral bypass such as ABIs or PVRs. Clinically, we did note that though the feet were warm and well perfused, he did not have palpable pulses, pointing to impaired distal perfusion given his otherwise normal arteries. Additionally, the patient developed anuria and lower limb paralysis suggesting direct renal and spinal cord malperfusion. The timing of delayed spinal cord ischemic injury could be attributed to the initiation of an apoptotic cascade within the neurons [4]. Before spinal drain catheter insertion, there was concern about putting spinal drain in an infected patient. After weighing risks and benefits, decision was made to insert the catheter. The ultimate reperfusion was achieved by surgical switch of the axillary-femoral bypass to an ascending aorta to infra-renal aorta bypass, which provided adequate perfusion to the kidneys and the spinal cord as evidenced by improved urine output and lower extremity neurologic function. We believe that the ascending aorta to infra-renal aorta bypass provided adequate distal perfusion while the axillary-femoral bypass did not. Other complications of axillary-femoral bypass are graft failure, aortic stump thrombosis, and rupture [5].

To maintain adequate perfusion of the kidneys, gut, spinal cord, and lower extremities distal to the excluded area of the aorta, a threshold volume flow and pressure is required. Effective proximal-to-distal aortic shunts have to carry 60% of baseline blood flow and maintain a mean pressure of 60–70 mmHg in the distal thoracic aorta. In cases of left heart bypass, flow rates of 25–40 ml Kg^{-1} min^{-1} produced by centrifugal pump are enough to maintain satisfactory renal and spinal cord perfusion [6]. Intraoperative measurement of blood flow through an extra-anatomic graft may be advised to assure adequate distal

![Figure 1 Progression of infection in native aorta and stent-graft. a. Angiogram on hospital day #2 demonstrating pseudoaneurysm of the descending thoracic aorta. b. 3D Angiography s/p placement of Gore TAG device (15 cm x 28 mm) over pseudoaneurysm of descending thoracic aorta. c. Chest CT scan demonstrating a large periaortic abscess around the region of the endograft measuring 8.2 cm x 8.8 cm x 8.2 cm.](http://www.cardiothoracicsurgery.org/)
aortic perfusion. Also, monitoring of spinal cord function through somatosensory and motor evoked potentials can be performed intraoperatively to predict future neurological dysfunction [7]. Regional cooling is another adjunct that may be considered for spinal cord protection during these cases. Regional cooling is an effective tool for neuroprotection during open repair of thoracoabdominal aneurysms that has not been described during endovascular procedures [8]. However, we believe that the ascending aorta–infra-renal bypass was the critical factor in reversing the ischemia.

We believe that when planning extra-anatomic bypass in cases where aortic ligation is necessary, measurement of pressures and flow volumes distal to the extra-anatomic bypass may help in the future to predict success or failure of distal perfusion which we have not done in our case.

Consent
Written informed consent for publication could not be obtained from our deceased patient’s next of kin despite all reasonable attempts. Every effort has been made to protect the identity of our patient and ensure anonymity.

Competing interests
The authors declare that they have no competing interests.

Authors’ contributions
MG performed the surgery, HA conducted the anesthesia for the case, and HE drafted the manuscript. HA, HE, LB, GD, and MG all are contributor in writing the manuscript. All authors read and approved the final manuscript.

Acknowledgment
We greatly acknowledge all surgeons and physicians in Department of Vascular surgery and Cardiac anesthesiology for their helpful discussions on this case.

None of the authors have any external funding source

Author details
1 Department of Anesthesiology, The Ohio State University Wexner Medical Center, 410 West 10th Avenue, Columbus, OH 43210, USA.
2 Department of Thoracic & Cardiovascular Surgery, Cleveland Clinic Foundation, 9500 Euclid Avenue (J4-133), Cleveland, OH 44195, USA.
3 Department Department of Otolaryngology - Head & Neck Surgery, 4000 Eye and Ear Institute, 915 Olentangy River Road, Columbus, OH 43212, USA.
4 Department of Surgery, Division of Vascular Diseases and Surgery, The Ohio State University Wexner Medical Center, 376 West 10th Avenue, Columbus, OH 43210, USA.

Received: 11 May 2014 Accepted: 4 August 2014
Published online: 05 September 2014

References
1. Heyer KS, Modi P, Morasch MD, Matsumura JS, Klibbe MR, Pearce WH, Resnick SA, Eskandari MK. Secondary infections of thoracic and abdominal aortic endografts. J Vasc Interv Radiol 2009, 20:173–179.
2. Cernohorsky P, Reijnen MM, Tellu JF, van Sterkenburg SM, van den Dungen JJ, Zeeligers C. The relevance of aortic endograft prosthetic infection. J Vasc Surg 2011, 54:327–333.
3. Coselli JS, Koksy C, LeMaire SA. Management of thoracic aortic graft infections. Ann Thorac Surg 1999, 67:1900–1903. discussion 1997–1998
4. Sakurai M, Hayashi T, Abe K, Sadahiro M, Tabayashi K. Delayed and selective motor neuron death after transient spinal cord ischemia: a role of apoptosis? J Thorac Cardiovasc Surg 1998, 115:1310–1315.
5. Diener H, Hellwinkel O, Carpenter S, Larena-Avellaneda A, Debus ES. Homografts and extra-anatomical reconstructions for infected vascular grafts. J Cardiovasc Surg 2014, 55:217–223.
6. Puchakayala MR, Lau WC. Descending thoracic aortic aneurysms. Contin Educ Anaesth Crit Care Pain 2006, 6:54–59.
7. Keyhani K, Miller CC 3rd, Estreja AL, Wegryn T, Sheinbaum R, Safi HJ. Analysis of motor and somatosensory evoked potentials during thoracic and thoracoabdominal aortic aneurysm repair. J Vasc Surg 2009, 49:36–41.
8. Awad H, Elgharably H, Popovich PG. Role of induced hypothermia in thoracoabdominal aortic aneurysm surgery. Ther Hypothermia Temperature Manage 2012, 2:119–137.

doi:10.1186/s13019-014-0142-4
Cite this article as: Awad et al.: Reversal of paralysis and visceral ischemia after thoracic aortic ligation for infection via extra anatomic ascending aorta to infrarenal aorta bypass graft. Journal of Cardiothoracic Surgery 2014 9:142.