Case Reports

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Successful Use of a Thoracic Branched Endograft in the Setting of Blunt Thoracic Aortic Injury

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INTRODUCTION

Blunt thoracic aortic injury (BTAI) presents a significant challenge in trauma management in patients presenting with multi-system injury. It remains the second most common cause of death in the setting of blunt chest trauma [1]. The pathogenesis is secondary to rapid deceleration, which exerts shear and tensile forces on the aortic wall, concentrated at the aortic isthmus, distal to the left subclavian artery (LSA) [2]. These forces can cause intimal tears, intramural hematomas, and even aortic transection as summarized in the GRADE classification (Table 1) [3].

Most patients with BTAI die before arriving at the hospital and in-hospital mortality has been reported to be as high as 46% [4]. Early diagnosis is critical as many in-hospital deaths occur within the first 24 hours [5]. In the absence of competing management priorities for hemodynamic instability and concomitant injuries, such as traumatic brain injury (TBI), medical management of BTAI includes anti-impulse therapy. In the context of descending thoracic aortic injuries, anti-impulse therapy consists of maintaining a target blood pressure of 100–120 mmHg and a heart rate of less than 60 bpm [6].

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Surgical management depends on both the degree of injury and the required triaging of concomitant injuries. Aortic rupture is a surgical emergency requiring immediate intervention. Intimal tears are managed with anti-impulse therapy alone. Intramural hematomas are usually treated using anti-impulse therapy, with surgical intervention individualized to the patient considered in a delayed fashion [5]. Management of an aortic pseudoaneurysm is surgical, with timing of surgical intervention dependent on the presence of high-risk features (Table 2). An emergency intervention is indicated when

Table 1 GRADE classification of blunt thoracic aortic injury (BTAI).

GRADE classification of BTAI
1. Intimal tear
2. Intramural hematoma
3. Aortic pseudoaneurysm
4. Aortic rupture

Table 2 High risk features of aortic pseudoaneurysm in blunt thoracic aortic injury (BTAI).

High risk features of aortic pseudoaneurysm in BTAI
Aortic arch hematoma
Ascending aortic, aortic arch, or great vessel involvement
Mediastinal hematoma causing mass effect
Posterior mediastinal hematoma > 10 mm
Lesion to normal aortic diameter ratio > 1.4
Disruption of > 50% of aortic wall circumference
Pseudocoarctation of the aorta
Large left hemothorax

high risk features are present. Otherwise, an intervention is recommended within the first 24 hours [5].

Thoracic endovascular aortic repair (TEVAR) is the mainstay of surgical intervention due to its superior survival rate compared to open repair, especially in unstable patients [7]. The challenge remains in the management of BTAI with extension into the aortic arch, without a suitable landing zone distal to the LSA. Coverage of the LSA with a Zone 2 TEVAR deployment may be required in some cases to ensure adequate seal of the site of injury, and concomitant injuries may preclude safe extra-anatomic revascularization of the arch vessels.

Novel innovations such as the Gore Thoracic Branched Endoprosthesis (TBE) add to the toolbox of the vascular surgeon in the setting of BTAI. In Canada, the TBE device has recently received Health Canada approval with limited authorized special access across the country. The use of a TBE device allows for Zone 2 stent graft deployment with simultaneous endovascular revascularization of the LSA. The following is the presentation of the first two Canadian cases of BTAI treated with the Gore TBE.

CASE SERIES

Case Report 1

A 27-year-old male was involved in a motor vehicle collision at highway speeds. On arrival at a peripheral hospital, he was hemodynamically stable with a Glasgow Coma Scale score of 8. Endotracheal intubation was attempted for airway protection but failed, following which a cricothyrotomy was performed. The computed tomography (CT) scan showed a large traumatic hematoma centered in the left submandibular space, bilateral pulmonary hemorrhage, pneumomediastinum, subarachnoid hemorrhage, and a traumatic aortic injury with intimal tearing in Zones 2 and 3 of the aorta. This scan was initially interpreted as a Grade 1 injury.

The patient was transported to our tertiary level 1 trauma center. The BTAI was managed with anti-impulse therapy with agreement from the neurosurgery team. A repeat CT scan seven days later demonstrated progression to a Grade 3 BTAI, with a 1 cm pseudoaneurysm extending into Zone 2 on the inner curve of the aortic arch, as well as a codominant left vertebral artery (Supplementary Video 1; Supplementary Digital Content is available online at https://doi.org/10.26676/jevtm.33826). Due to the presence of the codominant vertebral artery and in the setting of TBI, it was felt that a Zone 2 TEVAR without subclavian revascularization was not appropriate. It was also felt that the presence of a surgical airway significantly increased the risk of a bypass graft infection with a left carotid-subclavian bypass. A Gore TBE device was immediatetly acquired.

The patient was brought urgently to the operating room. Using ultrasound guidance, percutaneous arterial and venous access was obtained. Systemic heparin was administered. A 12 F Gore dryseal sheath was advanced from the right femoral vein to the cavoatrial junction. A pigtail catheter was positioned in the ascending aorta from the left common femoral artery. A Lunderquist wire was positioned at the aortic root of the right common femoral artery and a 22 F Gore Dryseal sheath was advanced to the descending thoracic aorta. A snare sheath was advanced in a coaxial fashion from the right common femoral artery within the 22 F sheath and positioned in the descending thoracic aorta. From the left radial access, a 6F Terumo R2P sheath was advanced retrograde into the LSA. The descending thoracic aorta was cannulated from the LSA with a hydrophilic glide wire, which was subsequently snared. A 26 mm by 15 cm Gore TBE Aortic Component was advanced into the aortic arch, the C-arm was positioned with an extreme cross-table angulation, and an angiogram was performed. A cava balloon was advanced into the right atrium and inflated to induce systolic hypotension, allowing for precise deployment of the device. Final positioning of the graft was confirmed to be in Zone 2, just distal to the left common carotid artery as desired. The cava balloon was deflated, and a 12 mm by 6 cm long subclavian branch was then advanced, deployed, and post-dilated. Completion aortography demonstrated wide patency of the carotid and subclavian arteries. All devices and wires were subsequently removed, and all access sites were closed. A CT Angiogram obtained on post- operative day 4 demonstrated widely patent stent grafts with no endoleaks (Supplementary Video 2). The patient was discharged home on post-operative day 10. A 3-month follow-up CT demonstrated exclusion of the traumatic pseudoaneurysm and patent aortic and LSA stents.

Case Report 2

The second case is that of a 65-year-old male who fell 10 m off scaffolding. The patient had loss of consciousness at the time of the event. His concomitant injuries included bilateral wrist fractures, rib fractures, and a right-sided pneumothorax. A CT scan was performed that demonstrated an aberrant right subclavian artery (RSA) and a Grade 3 BTAI, with a focal pseudoaneurysm at the origin of the aberrant RSA that projected superomedially and was surrounded by a mediastinal hematoma (Supplementary Video 3). The patient was transferred to our level 1 trauma center and anti-impulse therapy was initiated.

Upon arrival, the patient was taken to the operating room for a combined cervical debranching procedure and placement of the Gore TBE. It was determined that bilateral carotid subclavian bypasses would not be appropriate given the increased risk of airway compromise due to neck edema post-operatively, and a plan to revascularize his RSA with an open bypass and concomitant endovascular repair of his LSA was undertaken.

Appropriate exposure of the second portion of the aberrant RSA was obtained. The dissection was then extended medially allowing for exposure of the carotid sheath; the common carotid artery was proximally and distally controlled. In this case, the left axillary artery was exposed for direct placement of the LSA stent to avoid the use of radial access at the left wrist fracture.

After ultrasound-guided arterial and venous access was obtained, the patient was systemically heparinized. A bypass was then performed using a 6 mm polytetra-flouroethylene propaten graft from the right common carotid artery to the second portion of the RSA.

After completion of the right carotid to subclavian bypass, the same procedure as described above was performed for deployment of the 34 mm × 15 cm TBE Aortic Component with a 15 mm × 6 cm LSA stent over a "through and through" wire passed from the left axillary artery. A aortography on completion demonstrated wide patency of the left subclavian branch and no signs of an endoleak. A CT angiogram obtained on post-operative day 1 demonstrated the expected persistent type II endoleak from retrograde flow related to the aberrant RSA (Supplementary Video 4). On post-operative day 2 the patient underwent the planned second stage of the intervention: successful coil embolization of the remnant pseudoaneurysm along the origin of the aberrant RSA. The patient was discharged home on post-operative day 9.

Ethical Approval and Informed Consent

Ethical approval was not required. Informed consent was obtained from both patients in this case series.

DISCUSSION

The surgical management of BTAI continues to evolve. Historic management of BTAI prior to the endovascular era involved open repair via thoracotomy, aortic cross-clamping, and left-heart bypass, or deep hypothermic circulatory arrest. The advent of TEVAR ushered in a new era of management of BTAI with substantially reduced mortality and morbidity for patients [7]. Ongoing challenges with the surgical management of BTAI involve patients with injuries extending proximal to Zone 3 that have contraindications to primary LSA coverage where revascularization of the LSA is required (Table 3) [8].

Non-revascularization of the LSA in TEVAR is associated with increased risk of stroke and spinal cord ischemia [9–10]. Literature specific to BTAI supports additional considerations for LSA revascularization as trauma patients are at significantly higher risk of developing ischemic symptoms of the left upper extremity than non-trauma patients after coverage of the LSA [11].

In trauma patients where proximal TEVAR and LSA revascularization is required, cervical debranching has been the intervention of choice. Complications due to cervical debranching procedures are not insignificant and can be observed in up to 30% of patients [12]. These complications include phrenic nerve injury, brachial plexus trauma, thoracic duct injury with chylothorax or prolonged wound drainage, swallowing dysfunction with aspiration, graft thrombosis, graft infection, and wound complications [12–14]. In addition, cervical debranching remains a challenge in patients with concomitant neck trauma, lacerations, C-spine injury and immobilization, or tracheostomy. TBE offers a minimally invasive operation in these patients that may avoid many of the complications associated with debranching.

Table 3 Contraindications to left subclavian artery coverage in thoracic endovascular aortic repair (TEVAR) [8].

Contraindications to left subclavian artery coverage in TEVAR
1. Presence of left internal mammary artery coronary artery bypass graft
2. Termination of the left vertebral artery in a posterior inferior cerebellar artery (PICA)
3. Dominant left vertebral artery or occlusion of the right vertebral artery
4. Functioning left arm arteriovenous fistula
5. Prior infrarenal aortic repair with ligation or coverage of lumbar arteries
6. Planned long-segment (20 cm) coverage of the descending thoracic aorta
7. Hypogastric artery occlusion

The TBE device has allowed vascular surgeons to electively treat proximal aortic arch pathology while maintaining perfusion to the LSA with excellent results to date in experienced centers [15]. Additionally, results from a non-randomized trial performed in the United States across 34 sites suggest TBE in BTAI has favorable outcomes [16]. The wider availability of this device will allow for the application of this technology in the hyperacute setting for patients with BTAI, the most lethal of the thoracic traumatic injuries. Careful patient consideration is required with respect to anatomic suitability; a retrospective review evaluating various anatomical features in patients undergoing TEVAR found that only 32% of patients are suitable candidates for theoretical TBE intervention [17]. We have demonstrated the clinical utility of this emerging technology in the setting of acute BTAI and will continue to use this device in appropriately selected patients.

CONCLUSION

This report demonstrates two successful percutaneous endovascular repairs of BTAI using the Gore TBE device to preserve left subclavian perfusion. Off-the-shelf branched thoracic endografts in BTAI should be considered by experienced TEVAR trauma centers in patients requiring LSA revascularization with appropriate anatomy who are at increased risk of complications from either Zone 2 TEVAR coverage alone or cervical debranching procedures. Widespread access to these devices will allow for further review of outcomes in this challenging patient population.

Ethics Statement

(1) All the authors mentioned in the manuscript have agreed to authorship, read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.
(2) The authors declare that they have read and abided by the JEVTM statement of ethical standards including rules of informed consent and ethical committee approval as stated in the article.

Conflicts of Interest

Dr. Kenton Rommens serves as a consultant for Gore Medical and Terumo Aortic. The remaining authors have no other disclosures or conflicts of interest.

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SUPPLEMENTARY DIGITAL CONTENT

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Supplementary Video 1. Video of pre-operative computed tomography scan for case report 1.

Supplementary Video 2. Video of post-operative computed tomography scan for case report 1.

Supplementary Video 3. Video of pre-operative computed tomography scan for case report 2.

Supplementary Video 4. Video of post-operative computed tomography scan for case report 2.

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