

Blunt Thoracic Aortic Injury:

Current Issues and Endovascular Treatment Paradigms

The 2011 SVS TEVAR for BTAI clinical guidelines raised a number of unanswered questions. How have they been resolved since then?

BY JOSHUA D. ADAMS, MD, AND JOHN A. KERN, MD

Blunt thoracic aortic injury (BTAI) remains the second most common cause of mortality among all nonpenetrating traumatically injured patients, second only to intracranial hemorrhage.^{1,2} Historically, it has been estimated that < 25% of patients survive the prehospital setting, and of those who do, up to 50% do not survive 24 hours.³ Current data suggest that approximately 4% of patients die during transport from the scene, and an additional 19% die during the initial trauma evaluation.⁴ Of the remaining survivors, 29% demonstrate concomitant major abdominal injury, and 31% present with a major head injury, which creates significant challenges in the management of BTAI.

Since the first endovascular thoracic aortic device became commercially available in the United States in 2005, the treatment of BTAI has rapidly evolved as high-volume trauma centers applied the principles of endovascular aneurysm repair to BTAI in an off-label manner. With the growing shift from open repair to thoracic endovascular aortic repair (TEVAR) as the primary treatment in patients with BTAI, outcomes have improved with significantly reduced mortality and morbidity, including procedure-related paraplegia.⁵⁻⁹

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Aortic-specific complications were most often related to exaggerated device oversizing and first-generation devices that did not conform well to variable aortic anatomy. This widespread adoption of TEVAR as the primary treatment choice for BTAI led to the release of clinical practice guidelines from the Society for Vascular Surgery (SVS) in 2011, which raised a number of specific unresolved issues.¹⁰ It is the goal of this article to examine the current state of these previously identified issues and look toward the future of TEVAR for patients with BTAI.

ISSUES RELATED TO TEVAR FOR BTAI

Off-Label Use of Thoracic Aortic Devices

At publication time of the SVS guidelines, there were no commercially available thoracic aortic devices with an on-label indication for traumatic aortic injury. That has since changed. Currently, two second-generation thoracic endovascular devices have been approved by the US Food and Drug Administration (FDA) for the treatment of BTAI. In January 2012, the indications for the Conformable TAG (C-TAG) device (Gore & Associates) were expanded to include BTAI in patients with adequate access vessels and aortic diameters measuring from 16 to 42 mm in diameter (Figure 1). In January of 2014, following the report of the RESCUE trial,¹¹ the FDA approved the Valiant Captivia system (Medtronic, Inc.) to treat traumatic aortic disruption in patients with aortic diameters ranging from 18 to 44 mm (Figure 2).

The expanded on-label indication and the smaller-diameter, second-generation devices allow more patients in this typically younger population to benefit from TEVAR.

Suitability and Unmet Needs of Current FDA-Approved Thoracic Endografts

The single greatest unmet need identified among the first-generation devices in 2011 was lack of arch conformation, given the often tight radius of the curvature in a younger subset of trauma patients. Lack of proximal wall apposition has been associated with endoleak and endograft collapse.^{12,13} Manufacturers of the latest generation of commercially available thoracic stent grafts have modified devices and the proximal deployment system to address this issue. A recent study by Canaud et al¹⁴ compared the conformability of the four commercially available thoracic devices with increasing aortic arch angulation and oversizing. All second-generation devices performed significantly better than their respective predecessors. Both the Valiant and the C-TAG devices performed well, with complete wall apposition and arch angulation up to 140° and 120°, respectively.

Management of Minimal Aortic Injury

The classification scheme for grading the severity of BTAI has been widely accepted and is shown in Figure 3.¹⁵ Grade I demonstrates an intimal tear or flap. Grade II demonstrates an intramural hematoma without significant change in the external contour of the aorta. Grade III demonstrates a contained pseudoaneurysm with extension beyond the normal contours of the aorta. Grade IV involves full-thickness aortic

injury with extravasation. SVS guidelines recommend TEVAR for grade II through IV BTAIs, given that grade I injuries typically heal spontaneously.

A recent retrospective review of 41 patients with grade I or II injuries that were conservatively managed demonstrated that at mean follow-up of 86 days, 55% had complete resolution of injury, 40% had no change in aortic injury, and 5% had progression from grade I to grade III injury.¹⁶ When progression did occur, it tended to occur early, at a mean of 16 days from injury. Given the mounting evidence, conservative management of grade I and II injuries is recommended with appropriate observation and follow-up imaging, usually at a short interval (2–7 days) and then at 30 days, 6 months, and 1 year or until the lesion resolves.

Timing of TEVAR in the Injured Patient

In patients with stable aortic injuries (grade II or III), the timing of intervention is usually dictated by the severity of associated nonaortic injuries. With proper anti-impulse control, delayed management of BTAI until life-threatening nonaortic injuries have been treated has been shown to be a safe and beneficial approach.^{17,18} The optimal timing of aortic repair has continued to evolve as the treatment of BTAI has shifted from open aortic repair to TEVAR. The minimally invasive nature of TEVAR has allowed for earlier aortic repair in stable patients, emergent treatment of unstable patients, and easier concomitant management of both aortic and nonaortic injuries. In patients without other serious injuries, the trend has been to treat grade II or III injuries within 24 hours of admission to avoid progression to rupture (grade IV) and the potential deleterious effects of aggressive impulse control in certain patient populations.

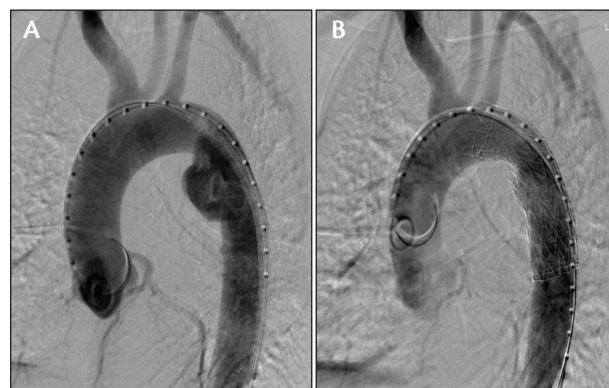


Figure 1. The C-TAG endovascular prosthesis. Digital subtraction angiogram before placement (A) and after deployment (B) of the C-TAG endovascular prosthesis. Note the bare stents only across the origin of the LSA.

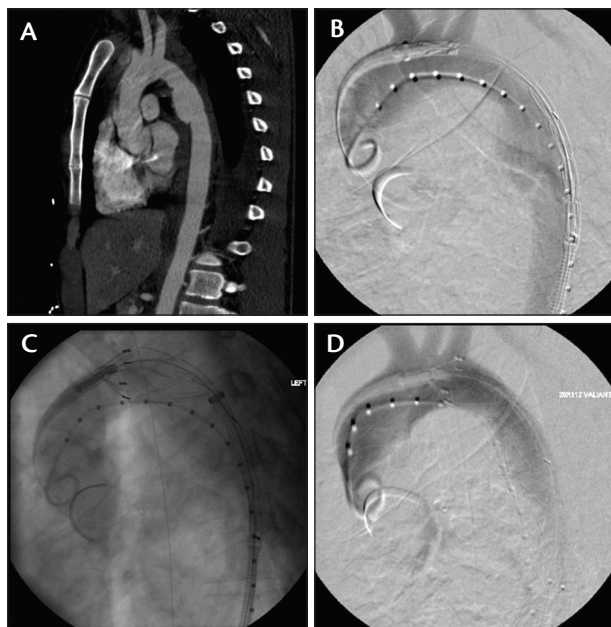


Figure 2. The Valiant with the Captivia device. Multiplanar reconstruction of a patient with a BTAI (A). Digital subtraction angiogram showing placement of the Valiant device before deployment (B). The Captivia proximal deployment system (C) allows repositioning after partial deployment. A digital subtraction angiogram shows the proximal aspect of the covered device partially across the origin of the LSA (D).

Treatment of Pediatric Patients With BTAI

BTAI rarely occurs in the pediatric and adolescent population; however, TEVAR still offers significant benefits over open repair for patients with suitable aortic anatomy. Currently, the C-TAG and Valiant devices are available in 21- and 22-mm configurations and are indicated to treat down to 16- and 18-mm-diameter aortas, respectively. Unfortunately, these devices are only available in lengths of 10 cm and 112 mm at these diameters, which requires a relatively larger proportion of coverage of the descending thoracic aorta. Considerations for treating BTAI in young patients must also take into account allowance for continued somatic growth. For these reasons, some centers advocate the use of covered balloon-expandable stents because they are shorter in length and can be further dilated in the future as the patient's aorta grows.¹⁹ Although no large-diameter, covered, balloon-expandable stent is FDA approved in the United States, the covered Cheatham platinum balloon-expandable stent (NuMed, Inc.), is widely used to treat aortic coarctation outside of the United States and is available in centers participating in the Coarctation of the Aorta Stent

Trial (COAST) and the Pulmonary Artery Repair With Covered Stents Trial (PARCS).

Details of Operative Management for TEVAR in BTAI

A number of specific management details remain somewhat controversial, or at least surgeon or institution specific. These issues include management of revascularization for left subclavian artery (LSA) coverage, intraprocedural systemic heparinization, routine placement of spinal drainage, and choice of open or percutaneous access. Depending on nonaortic injury severity, it is our practice to selectively revascularize the LSA. As our experience with TEVAR for BTAI has grown, the frequency with which we have needed to cover the LSA has steadily decreased due to our acceptance of a shorter proximal landing zone in nonaneurysmal traumatic aortic pathology. We prefer to systemically heparinize patients when there is no associated intracranial hemorrhage or solid-organ injury. Given the usual location of the injury in the proximal descending thoracic aorta and the usually short treatment length, we do not routinely place lumbar spinal drains in patients undergoing TEVAR for BTAI. Finally, our approach to access has evolved to a routinely percutaneous-first strategy, using the widely accepted preclose technique for delivery of the thoracic aortic device. Access remains a very important issue in patients with small iliac arteries, including women and older patients with atherosclerotic disease. Smaller delivery profiles for next-generation devices, the development of the SoloPath recollapsible balloon access system (Terumo Interventional Systems), and various "endoconduit" techniques facilitate a safe and minimally invasive manner for treating these often severely injured patients.

Optimal Follow-Up Strategy

The optimal follow-up strategy continues to evolve as imaging technology continues to improve and long-term experience grows. While the concerns of cumulative radiation and iodinated contrast exposure persist, newer-generation, dual-source CT scanners, such as the Somatom Force (Siemens Healthcare), provide significant reductions in radiation dose and volume of iodinated contrast needed without compromising image quality. Although the individual follow-up strategy is usually tailored to the patient, in general, CT angiography is utilized at 1, 3, and 12 months. In the absence of endoleak or endograft collapse or migration on those initial studies, repeat imaging is usually performed every 3 to 5 years. Alternative follow-up strategies include the use of multiview chest x-ray and magnetic resonance angiography to avoid the previously discussed risks.

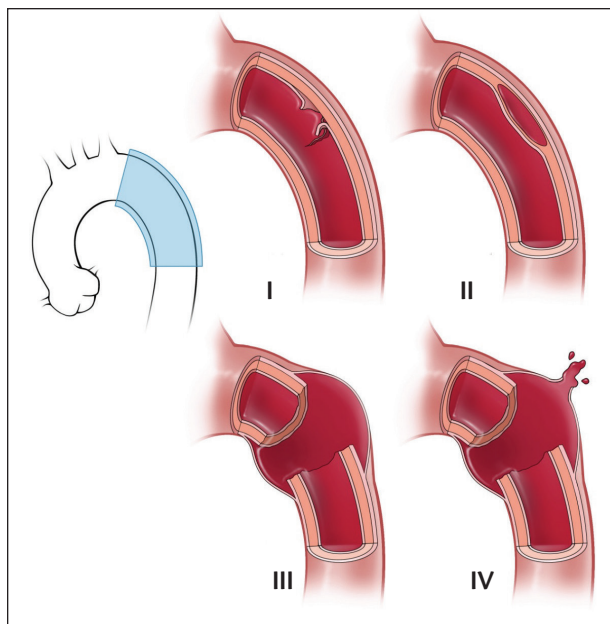


Figure 3. Classification system for BTAI. Illustration showing the different grades of BTAI including grade I (intimal tear/flap), grade II (intramural hematoma), grade III (pseudoaneurysm), and grade IV (rupture). This figure was adapted from the *Journal of Vascular Surgery*, Vol 49, Azizzadeh A, et al, *Blunt traumatic aortic injury: initial experience with endovascular repair*, Page 1403–1408, Copyright Society for Vascular Surgery 2009.

Future of TEVAR for BTAI

With the development of newer-generation devices leading to improved outcomes and less endograft-related complications, TEVAR has established itself as the primary treatment for most patients with BTAI. Future iterations of devices should include shorter lengths to minimize the coverage of normal aorta and intercostal arteries in this focal aortic pathology, more precise deployment mechanisms, and potentially the ability to reconstrain and redeploy the endograft. In the pediatric population, where continued somatic growth of the aorta is a consideration, a more conformable balloon-expandable covered stent may provide better wall apposition to the curve of the proximal descending aorta's radius while still allowing further balloon dilation at a later date.

CONCLUSION

The use of TEVAR in traumatically injured patients continues to evolve, and TEVAR has supplanted open surgical repair as the primary treatment for BTAI in most centers. In the nearly 4 years since the release of the SVS clinical guidelines, many of the issues raised

by the committee have been resolved, while others continue to evolve as we accrue experience with the improved newer-generation devices, fine-tune endovascular techniques, and accumulate follow-up data. ■

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