PANEL DISCUSSION

Applying the SVS Blunt Thoracic Aortic Injury Guidelines in Practice

Translating evolving evidence to inform patient selection, timing of TEVAR, left subclavian artery revascularization, decision-making for concomitant injuries, and long-term surveillance.



Ali Azizzadeh, MD, FACS
Lee and Harold Kapelovitz Distinguished Chair in Cardiovascular Biology
Professor & Director, Division of Vascular Surgery
Vice Chair, Jim and Eleanor Randall Department of Surgery
Associate Director, Smidt Heart Institute
Associate Dean, Faculty Affairs
Cedars-Sinai Medical Center
Los Angeles, California
ali.azizzadeh@csmc.edu



Erica L. Mitchell, MD, EdM SE, DFSVS, FACS, MAMSE
Professor & Chief, Vascular & Endovascular Surgery
Vice Chair, Academic Affairs
The University of Tennessee Health & Science University
Medical Director, Vascular & Endovascular Surgery
The Elvis Presley Trauma Center, Regional One Health
Memphis, Tennessee
emitch61@uthsc.edu

The previous Society for Vascular Surgery (SVS) guidelines for blunt thoracic aortic injury (BTAI) were published in 2011. What has changed in our understanding and management of BTAI since then, and what were the key evidence gaps or areas of evolving practice that prompted this SVS focused update for the management of BTAI?[1]

Dr. Azizzadeh: The biggest change since 2011 is that we now understand BTAI as a spectrum of disease rather than an injury for which the default response is repair. Thoracic endovascular aortic repair (TEVAR) has largely replaced open repair for patients who require intervention, but at the same time, we have accumulated considerably more natural history data showing that minimal aortic injuries (grade 1 and 2) frequently heal without intervention. The contemporary question is therefore not simply how to repair BTAI but who actually needs repair and when.

An important development has been the establishment of the Aortic Trauma Foundation (ATF) international BTAI registry, a prospective, multicenter database dedicated to aortic trauma. BTAI is relatively uncommon, and meaningful progress is difficult when the evidence consists primarily of small, retrospective, single-center series. The ATF registry has allowed us to examine contemporary practice across centers and address questions involving nonoperative management, timing of TEVAR, and left subclavian artery (LSA) management. Those efforts have helped refine—and in some cases challenge—long-standing assumptions about BTAI care.

The focused update reflects that evolution. The evidence review addressed seven key clinical questions using the PICOS (population, intervention, comparison, outcomes, subgroups) framework and informed 13 recommendations involving injury grade, timing of intervention, LSA management, anticoagulation, concomitant injuries, and surveillance. Importantly, much of the evidence remains observational. The guideline should therefore be viewed as a framework for decision-making rather than an algorithm that replaces clinical judgment.

Dr. Mitchell: Contemporary data reveal that TEVAR is now standard for the surgical repair of BTAIs, low-grade (SVS grades 1 and 2) injuries do not need surgical intervention, and medical management with anti-impulse control

allows for delayed repair of SVS grade 3 injuries (preventing immediate progression of the thoracic arterial injury). We have a much better understanding of who needs/does not need surgical intervention and who needs/does not need surveillance, and we have some data to support delayed TEVAR for patients needing further resuscitation. The new recommendations guide BTAI care but also allow for point-of-care surgical decision-making to be made based on concomitant patient factors.

One of the most notable changes in the updated guidelines is the recommendation for definitive nonoperative management of both grade 1 and 2 BTAI. How has this changed your threshold for intervention, particularly for grade 2 injuries? Are there clinical or imaging features that might still prompt you to consider intervention rather than observation?

Dr. Mitchell: The guidelines serve to inform all practitioners managing BTAI that evidence no longer supports the use of TEVAR in patients presenting with SVS grade 2 BTAI. We have not routinely employed TEVAR for grade 2 BTAI for several years now, and it is well understood amongst our surgical trainees, trauma surgeons, and vascular surgeons that TEVAR is no longer recommended here. The caveat of course is that TEVAR may be necessary for these patients if anti-impulse control goals cannot be achieved for patients with concomitant BTAI and traumatic brain injury (TBI).

Regarding clinical or imaging features that prompt further intervention, we have seen several cases where the aortic injury on CTA appeared concerning enough to warrant further investigation. In these cases, we employ digital subtraction angiography and intravascular ultrasound to better elucidate the injury. Examples include ductus diverticulum in a patient with severe chest trauma and/or BTAI with severe intimal tearing. Seeing no thoracic aortic external wall contour abnormality on further imaging is reassuring. Patients with abnormal external wall contour, which is considered a grade 2 injury using the European Society for Vascular Surgery (ESVS) clinical practice guidelines, should undergo repair per ESVS guidelines. This is not as well elucidated by the SVS guidelines.

Dr. Azizzadeh: This is probably the most significant change from the previous guideline. We now have enough accumulated experience to recognize that uncomplicated grade 2 injuries often behave more like grade 1 injuries than grade 3 pseudoaneurysms. Accordingly, I no longer consider an uncomplicated intramural hematoma an indication for TEVAR. The supporting systematic review found that for grades 1 and 2 combined, TEVAR was associated with higher aortic-related mortality than nonoperative management, although the underlying evidence remains limited.[2] Prospective, multicenter ATF registry experience has also supported definitive medical management of minimal aortic injuries (grades 1 and 2 BTAI).[3]

I still carefully review the imaging, particularly for evidence of progression to pseudoaneurysm formation on interval imaging. Classification is useful, but morphology and clinical context still matter.

For hemodynamically stable patients with grade 3 BTAI, the guidelines now favor delaying TEVAR beyond 24 hours to allow treatment of other traumatic injuries. In practice, how do you decide when it is safe to wait versus when the aortic injury needs to take priority? Which high-risk features most influence that decision?

Dr. Azizzadeh: The key word is *stable*. Delayed TEVAR should not be interpreted as waiting simply to cross a 24-hour threshold. It means taking advantage of a period of aortic stability to resuscitate the patient and address injuries that pose a more immediate threat.

The evidence synthesis found higher mortality with TEVAR performed within 24 hours compared with delayed intervention.[2] However, in practice, timing is driven by physiology and competing injuries. A patient with significant TBI, active intra-abdominal or pelvic hemorrhage, or major orthopedic trauma may benefit substantially from stabilization before TEVAR.

Conversely, I would not delay treatment when there is concern for impending rupture or when the aortic injury appears responsible for hemodynamic instability. Rapid morphologic progression, enlarging periaortic hematoma, or other concerning imaging changes also lower my threshold for earlier repair. The principle is not to delay every grade 3 injury; rather, it is to not allow a stable aortic injury to distract from more urgent components of polytrauma.

Dr. Mitchell: The diagnosis of grade 3 BTAI alone does not mandate urgent or emergent TEVAR. Essentially, the guidelines reinforce that delayed TEVAR for SVS grade 3 BTAI is acceptable when other life-threatening injuries demand more pressing attention. If a BTAI patient is unstable from other injuries, management of these injuries should supersede TEVAR. However, if a patient is hemodynamically unstable because of their aortic injury, then this patient should undergo expedited aortic repair. Timing of TEVAR should depend on the patient's condition rather than a fixed time point.[4]

It is also important to understand that not all SVS grade 3 BTAIs are the same and that some demand immediate repair. BTAI with traumatic thoracic aortic coarctation (TTAC) and associated aortic malperfusion syndrome must undergo emergent aortic repair.[5] These injuries do not present with rupture but instead present with clinical exam findings (upper extremity hypertension, absent femoral/distal pulses, and/or spinal cord ischemia), concerning physiology, and/or imaging findings consistent with acute aortic luminal narrowing. Without immediate treatment, these patients develop spinal cord, visceral, and limb-threatening ischemia. Even with expedited treatment, death may result from massive and unrecoverable reperfusion sequelae. TEVAR can be challenging, as crossing the zone of injury may not be achievable from standard femoral access. Wire access across the transection may have to be gained from brachial/axillary access (and snared to gain groin access). Regardless, a TTAC injury is akin to having a supraceliac clamp, which cannot be tolerated for an extended period of time.

When zone 2 coverage is required during TEVAR for BTAI, what factors guide your decision for LSA revascularization, and how has branched endovascular technology influenced your approach?

Dr. Azizzadeh: This remains an individualized decision. The guideline recognizes that unrevascularized LSA coverage may increase ischemic complications, but the certainty of that evidence is low.[2] Importantly, ATF registry data identified increased ischemic neurologic events when the LSA was covered without revascularization.[6]

I place particular importance on vertebral anatomy, a patent left internal mammary artery (LIMA)–to–coronary artery bypass, dependence on left arm inflow, and the overall extent of aortic coverage. Urgency matters equally. In a patient who requires immediate exclusion of a life-threatening injury, LSA preservation should not unnecessarily delay definitive aortic treatment.

Branched endografts have changed the equation because LSA preservation can now be incorporated into a completely endovascular repair in anatomically suitable patients. They expand our options, but the availability of a branched device does not mean that every LSA must be preserved. The relevant question remains whether a particular patient is likely to derive meaningful benefit from preservation.

Dr. Mitchell: We all understand that LSA coverage may be essential for some zone 2 BTAIs. Management thereafter has not been well defined. Data show that LSA coverage without revascularization is associated with increased neurologic ischemic complications.[6] However, what the data do not tell us is when LSA revascularization should be performed (ie, the ideal time frame after TEVAR). Unlike dissection or aortic aneurysm patients requiring LSA coverage after TEVAR, patients with BTAI after trauma may have concomitant injuries requiring prolonged intubation or surgical treatments that make elective LSA revascularization risky or low priority. This is particularly true for patients with concomitant TBI.

Factors that guide my decision for LSA revascularization include the overall neurologic and physiologic condition of the patient, dependency on left-sided vertebral anatomy for basilar perfusion, a LIMA-to–coronary artery bypass requiring higher perfusion pressures than experienced after TEVAR, and evidence of symptomatic malperfusion of the patient's left upper extremity. Patients may not experience symptoms initially, particularly if they are intubated. Young, left hand–dominant patients are more prone to symptoms, and we certainly offer LSA revascularization for symptomatic patients. We typically try to revascularize young and/or left hand–dominant patients as soon as physiologically possible, certainly within the same hospital stay. Obviously, we do not perform LSA revascularization in patients still requiring ventilatory support. Establishing a pre-reconstruction neurologic exam is essential.

As Dr. Azizzadeh alluded to, branched endografts are now available for TEVAR in patients requiring LSA coverage; however, the devices were not designed for traumatic thoracic aortic injuries, and we have found that these devices are not always suitable for young BTAI patients, as the majority of these patients do not have great vessel branch anatomy to support the device. Regardless, new technologies, including laser fenestration, are increasingly being used in trauma patients, and this is a good thing.

How do concomitant injuries, particularly TBI or solid organ injury (SOI), influence the timing of BTAI treatment and the use of anti-impulse therapy? How do you approach multidisciplinary decision-making in these patients?

Dr. Azizzadeh: BTAI management is inherently multidisciplinary. These patients rarely have an isolated aortic injury, and the competing risks often determine both timing and treatment.

TBI is particularly important. The evidence reviewed by the guideline suggests higher mortality with very early TEVAR in patients with concomitant TBI, although certainty is low.[2] If the aorta is stable, I generally prioritize neurologic stabilization and treatment of active hemorrhage before TEVAR.

Anti-impulse therapy is useful when tolerated, but it cannot be applied without considering cerebral and systemic perfusion. A patient with severe TBI or ongoing hemorrhage may require a different hemodynamic strategy than an otherwise stable patient with isolated BTAI. These decisions are best made by a multidisciplinary team including trauma surgery, vascular surgery, neurosurgery, and critical care. The goal is not a particular number in isolation; it is a reduction of aortic wall stress without compromising perfusion of injured organs.

Dr. Mitchell: I agree with Dr. Azizzadeh. Patients with concomitant BTAI and TBI do require a different strategy for anti-impulse therapy. Higher systolic blood pressures are needed to maintain cerebral perfusion for patients with TBI. The guidelines recommend collaborative management of these patients. We work closely with our trauma and neurosurgery colleagues to optimize treatment of these patients. For patients with severe and life-threatening TBIs, we delay TEVAR for TBI treatment. Generally, these patients do not survive to benefit from TEVAR. For non-severe TBIs, we generally expeditiously prioritize TEVAR so that these patients can receive optimal medical management (higher mean arterial perfusion pressures) of their TBIs.

For patients with concomitant BTAI and SOI, we prioritize the most life-threatening condition first after a multidisciplinary discussion with the trauma and vascular surgeons. Even patients with severe BTAI and SOI can undergo TEVAR, with low-dose systemic heparinization and reversal, without progression of their SOI.

The guideline leaves intraoperative anticoagulation during TEVAR largely to surgeon discretion after weighing bleeding and thrombotic risks. What does that decision look like in your practice?

Dr. Mitchell: The guidelines support institutional prerogative for intraoperative anticoagulation during TEVAR, considering the risk and benefits to our patients being treated for their traumatic injuries. In our practice, we work in concert with our trauma and neurosurgeons to mitigate risk for our BTAI patients with concomitant TBI and SOI. We have found that we can safely offer TEVAR with low-dose systemic heparin (3,000-5,000 U bolus) for patients with concomitant TBI and SOI. Procedural times are short and typically < 45 minutes. We routinely reverse the heparin with protamine at the time of sheath removal. We have not seen progression of either TBI or SOI, but we have seen one periprocedural stroke that occurred during TEVAR without systemic heparinization. This patient was aged > 65 years. Consideration must be given to patient age and atherosclerotic burden in the aortic arch as well as concomitant injury burden.

Dr. Azizzadeh: I individualize heparinization according to bleeding risk. In a patient without a major contraindication, I generally favor systemic anticoagulation during TEVAR because we are introducing large-bore sheaths, wires, and an endograft. The evidence review found an association between intraoperative heparin use and lower mortality, but the certainty was low and the observational data cannot establish causation.[2]

The decision changes with significant intracranial hemorrhage, uncontrolled solid organ bleeding, or another major bleeding risk. In those circumstances, reduced anticoagulation or proceeding without systemic heparin can be reasonable. I make that decision collaboratively with the trauma and neurosurgical teams when appropriate. The updated guideline appropriately leaves room for judgment because the consequences of both thrombosis and hemorrhage can be substantial.

How do the updated surveillance recommendations affect your follow-up of patients with grades 1 and 2 BTAI and those who undergo TEVAR? How do you individualize surveillance while considering the risks and burden of repeated imaging, particularly in a younger trauma population?

Dr. Mitchell: The 2018 SVS guidelines state that follow-up after vascular surgery (including trauma repairs) is aimed at detecting clinically significant problems early, before symptoms appear.[7] Real-world data using Medicare claims found that recommended postprocedural surveillance imaging studies were performed at a surprisingly low frequency. During the 6-year study period, only 50% to 53% of endovascular aneurysm repair (EVAR), 52% to 58% of lower extremity bypass or peripheral vascular intervention, and 74% to 78% of carotid endarterectomy or carotid artery stenting patients underwent recommended postprocedure surveillance imaging.[8]

For major trauma patients, there are wide variations in how follow-up services are provided, and limited data exist for patients undergoing TEVAR, EVAR, or peripheral reconstruction for trauma. Regardless, surveillance is a cornerstone to vascular surgical practices and essential after TEVAR after BTAI. We apply standard SVS guidelines for surveillance for all trauma, including after TEVAR, whether this is for adult or pediatric patients. We have found higher than expected surveillance rates for our vascular trauma patients than reported for "general"

trauma patients. Our long-term surveillance adherence rates are higher in our pediatric versus adult trauma patients and highest in our pediatric trauma patients who are treated and surveilled at our pediatric hospital. Knowing that trauma patients traditionally have lower adherence to surveillance rates must be considered when holding discussions with them regarding future surveillance strategies. We try our best to get our patients back for their surveillance studies, while also considering that yearly CTAs are not appropriate for pediatric patients. It is a balance.

Dr. Azizzadeh: Surveillance should reflect the natural history of the injury and the intervention performed. For grade 1 BTAI treated nonoperatively, the updated guideline moves away from routine surveillance imaging. For grade 2 injury, follow-up imaging remains useful to document resolution or stability. The evidence supporting nonoperative management is reassuring: Grade 2 injuries generally have favorable intermediate-term outcome, and many resolve relatively early.[2]

After TEVAR, surveillance remains important, particularly because these patients are often young and may live with an endograft for decades. At the same time, repeated CTA carries cumulative radiation and contrast burden, and long-term follow-up in trauma populations is notoriously difficult. Therefore, I individualize imaging according to device findings, anatomy, and prior stability and consider modalities that reduce cumulative radiation when appropriate.

The broader goal should be clinically meaningful surveillance rather than imaging simply because a calendar says it is due.

Where is available evidence lacking in BTAI management, and where is further research most needed to inform future recommendations?

Dr. Azizzadeh: Despite major progress, most BTAI recommendations are still based on observational data. The ATF registry has demonstrated what can be accomplished through prospective, multicenter collaboration in a relatively uncommon injury. The next step is to expand that model with more granular imaging, physiologic findings, associated injury, treatment, and long-term follow-up data.

Several questions stand out. We need better predictors of which grade 3 injuries can safely be treated with delayed repair—or potentially selected nonoperative management—and which are at genuine risk of progression or rupture. We need stronger trauma-specific evidence defining when LSA revascularization improves outcomes and whether branched endografts provide a clinical advantage over selective coverage or surgical revascularization. We also need better evidence regarding anticoagulation in patients with TBI or active hemorrhage.

Finally, long-term surveillance remains unresolved. BTAI patients are often young, yet our knowledge of endograft behavior over several decades remains incomplete. Emerging data also suggest that TEVAR-induced aortic stiffening may increase left ventricular afterload and contribute to hypertension and adverse cardiac remodeling.[9] These potential physiologic consequences deserve further study in young trauma patients with decades of expected survival.

Dr. Mitchell: Dr. Azizzadeh has highlighted the major areas for BTAI inquiry. I will add that significant research and data are lacking for pediatric aortic injuries, whether iatrogenic, traumatic, or resulting from some other cause (eg, aortoesophageal fistula after swallowing a button battery).

I believe we need to work with industry to advance technology for the management of both adult and pediatric traumatic aortic injuries. Distinct thoracic branched endoprostheses need to be designed for BTAI, as current models are not suitable for the average traumatic aortic injury. Devices also need to be designed for pediatric patients with aortic emergencies. We need appropriately sized grafts, dissolvable devices, and devices that can adapt to the growth of the injured child. Further research and development in this area is essential. ■

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Disclosures
Dr. Azizzadeh: None.
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