

The Society for Vascular Surgery clinical practice guideline on the management of blunt thoracic aortic injury: Focused update

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ABSTRACT

Blunt thoracic aortic injury (BTAI) remains a devastating and potentially fatal complication of major trauma that requires expedient diagnosis and management by a collaborative team of trauma and vascular specialists. Trauma patients with BTAI commonly have multiple associated injuries, including intracranial or truncal hemorrhage, that increase the complexity of factors related to timing and conduct of repair. Optimal outcomes for these patients require consideration of these factors and updated knowledge of the available evidence by all stakeholders of care in a collaborative fashion. In 2011, the Society for Vascular Surgery published its clinical practice guidelines on the management of BTAI. Based on the available evidence from published research at the time, seven specific key questions were formulated spanning areas including patient selection, timing and conduct of repair, considerations in the setting of specific high-risk associated injuries, and surveillance. A systematic review and evidence synthesis of each question was conducted by a dedicated methodology team. The Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) approach was used to describe the strength of each recommendation and the level of certainty of evidence. The review identified major gaps in evidence across most of the questions posed, highlighting opportunities for additional research. Since that publication in 2011, the cumulative experience in the diagnosis and management of BTAI has grown significantly. This provided an opportunity for a focused update based on the current evidence. We assembled a panel of experts who identified seven specific areas of investigation and commissioned a systematic review of the published literature. Thirteen recommendations are provided in the current update. They address indications for and timing of definitive treatment, use of perioperative anticoagulation, management of the left subclavian artery, and imaging surveillance. In addition, we discuss the use of anti-impulse therapy for medical management as well as BTAI management for patients with concomitant injuries such as traumatic brain injury and solid organ injury. The collaborative engagement of all

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Disclaimer: The Society for Vascular Surgery develops evidence-based clinical practice guidelines as a resource to assist members in the practice of vascular surgery. The guideline recommendations contained herein are based on a recent review of published evidence. They reflect the available body of evidence, and their applicability reflects the limitations of

that data and is subject to reassessment and revision as new knowledge emerges. Given these limitations, clinical practice guidelines do not represent a statement of the standard of care, nor do they substitute for clinician judgment or supplant patient preference or shared decision-making. The Society of Vascular Surgery recognizes that departure from guidelines may be warranted when, in the reasonable judgment of the treating clinician, such a course of action is indicated by the clinical presentation of the patient, limitations of available resources, advances in knowledge or technology, or patient preference. The reader must rely solely on their own judgment to determine what practices and procedures, whether included in this practice guideline or not, are appropriate for them, their patient, their institution, or their practice.

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stakeholders in care of these complex patients is considered fundamental to optimal care. Significant unmet research needs in the field are also outlined. (J Vasc Surg 2026;83:1281-90.)

Keywords: Aorta; Blunt thoracic aortic injury; Trauma; Vascular injury

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Summary of recommendations

- (1) In patients with grade 1 and 2 blunt thoracic aortic injury (BTAI) (minimal aortic injury [MAI]), we recommend definitive nonoperative management (NOM) over thoracic endovascular aortic repair (TEVAR) or open repair (Fig 1). (1C) Grade 1 injuries require no routine follow-up imaging. We suggest grade 2 injuries undergo one follow-up computed tomography angiography (CTA) to ensure resolution.
- (2) In patients with hemodynamically stable grade 3 BTAI, we suggest delayed TEVAR (>24 hours) to allow for management of other associated traumatic injuries if needed. (2C) In an unstable patient in whom there is a concern that the BTAI is the specific cause of the patient's instability, we recommend urgent (<24 hours) or emergent intervention. (1B)
- (3) Among patients requiring left subclavian artery (LSA) coverage for TEVAR after BTAI, we suggest that the decision regarding LSA revascularization be based on feasibility and factors such as a patent prior left internal mammary to coronary bypass, detection of a dominant left vertebral artery on preoperative or intraoperative imaging, or an aortic origin of the left vertebral artery. (2C)
- (4) In patients with BTAI undergoing TEVAR, we suggest that intraoperative anticoagulation can be used at the surgeon's discretion after considering the risk of bleeding and thrombotic complications. (2C)
- (5a) In all patients with grade 1 BTAI treated nonoperatively, we suggest against routine surveillance imaging. (2C)
- (5b) In patients with grade 2 BTAI treated nonoperatively, we suggest at least one follow-up surveillance imaging study. We suggest repeat imaging at 1 to 3 months after injury. (2C)
- (5c) In patients who had TEVAR for BTAI, we suggest postoperative surveillance imaging. (2C)
- (6a) In patients with grade 1 or 2 BTAI (MAI) and concomitant traumatic brain injury (TBI), we suggest against anti-impulse therapy for BTAI. Management of blood pressure should prioritize TBI over BTAI. (2C)
- (6b) In patients with grade 3 BTAI and concomitant TBI, we suggest that the decision to use anti-impulse therapy should be individualized based

on collaborative management with other surgical and medical specialties. (2C)

- (6c) In patients with grade 3 BTAI and concomitant TBI or solid organ injury (SOI), we suggest that timing for TEVAR should be determined in a collaborative fashion in consultation with other stakeholders, including trauma and neurosurgery. (2C)
- (6d) In patients with grade 4 BTAI, we recommend emergent repair. (1C)
- (6e) For patients with BTAI and concomitant TBI or SOI, we suggest a collaborative approach for intraprocedural anticoagulation during TEVAR. Although current observational studies do provide some reassurance that heparinization is not associated with worse intracranial bleeding or neurologic outcomes, the certainty in this evidence is very low. Decisions about intraoperative anticoagulation in patients with TBI should be individualized based on multidisciplinary collaboration. (best practice statement)
- (7) In patients with grade 3 BTAI, we suggest anti-impulse therapy as a stabilizing measure until TEVAR is performed if the concomitant injuries do not preclude this approach. (2C)

INTRODUCTION AND RATIONALE

In 2011, the Society for Vascular Surgery (SVS) published comprehensive clinical practice guidelines (CPG) on the management of BTAI with TEVAR.¹ BTAI remains an infrequent but potentially lethal sequela of major trauma—most commonly encountered after major deceleration events, including major motor vehicle, auto vs pedestrian or fall-related injuries. Because of the nature of the kinetic energy exerted on the human body in these mechanisms of injury, isolated BTAI is exceedingly rare. Commonly associated injuries including TBI, SOI, and pelvic fracture represent major risk for hemorrhagic complications, including death. Accordingly, these injuries often take precedence over initial BTAI management depending on a complex assessment of factors that must be conducted rapidly and in a collaborative fashion with the key stakeholders of care for these patients. This CPG was undertaken to provide clinicians caring for victims of trauma with the best available contemporary data on the diagnosis, initial management, definitive care, and follow-up for these patients.

In planning this update, the committee considered the scope of clinical research advances in the management of BTAI since the prior publication in 2011.¹ The areas for focus concern primarily the role and conduct of TEVAR in the management of BTAI. Comparative effectiveness studies and large-scale randomized trials in this specific population of patients remain severely lacking. The published literature on the selection for, timing of, and conduct of TEVAR for patients with BTAI relies on retrospective data and multicenter registry collaborations. These limitations

were highlighted during the systematic data review undertaken, impacting the strength of recommendations.

METHODS

The SVS appointed the chair and approved members of the writing committee with specific expertise in the management of BTAI. Committee members' conflicts of interest were declared and reviewed on a regular basis in accordance with SVS policies. Methodological support was provided by the Mayo Clinic Evidence-based Practice Center, which included facilitation of developing structured clinical questions using the PICOS format (population, intervention, comparison, outcomes, subgroups), identification of patient-important outcomes, conducting systematic reviews, and support in the evidence-to-decision (EtD) process. The committee used expert consensus to prioritize seven clinical questions deemed to be of highest importance to current practice.

Conducting systematic reviews and rating certainty of evidence. Search strategies were developed by the methodology team and medical librarians. The strategies used structured controlled vocabulary terms and text words to search multiple databases from each database's inception to April 15, 2024. Eligible studies were selected by two independent reviewers based on prior established inclusion criteria consistent with each PICO question. Meta-analyses were conducted when two or more studies addressed the same outcome. Risk of bias was assessed using items selected from the Newcastle Ottawa Scale.² The certainty in the estimates was assessed using the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) approach, consistent with SVS adoption of GRADE in 2007.^{3,4}

The GRADE approach starts with a provisional high certainty rating for outcomes derived from randomized trials and low certainty from nonrandomized studies. This level of certainty can be reduced or increased based on several domains, such as the risk of bias, imprecision, inconsistency, indirectness, publication bias, and magnitude of effect. SVS assigns the labels of A, B, and C to high, moderate, and low/very low certainty.

Developing recommendations. SVS uses the GRADE EtD framework to transform evidence to recommendations.⁵ These actionable statements are based on certainty of the evidence, balance of effects, values and preferences, feasibility (eg, availability of surgical expertise), acceptability by stakeholders, and other contextual factors. Recommendations are either strong or conditional, denoted with the verbs "recommend" and "suggest," respectively. The rationale for the recommendations is provided in EtD worksheets (see the [Appendix](#), online only). Strong recommendations imply that the desirable consequences clearly outweigh the undesirable consequences in most settings and that most patients in this situation would want the recommended course of action.

Treatment Algorithm: SVS CPG 2.0

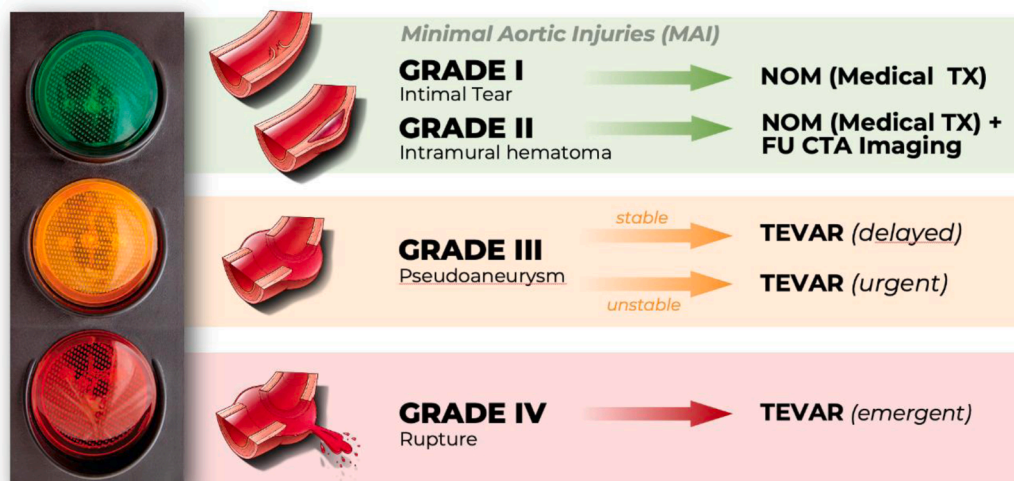


Fig 1. Summary of current clinical practice guideline for management of blunt thoracic aortic injury (BTAI). CPG, Clinical practice guideline; CTA, computed tomography angiography; FU, follow-up; NOM, nonoperative management; SVS, Society for Vascular Surgery; TEVAR, thoracic endovascular aortic repair.

Conditional recommendations imply that the desirable consequences likely outweigh the undesirable consequences and that although most patients would still want the suggested course of action, some would not. Good practice statements were made when direct evidence was not available, but indirect evidence overwhelmingly supported an action.⁶

PICO QUESTIONS

- (1) Should patients with MAIs (grade 1 and 2 BTAI) be treated with NOM alone or TEVAR?
- (2) Should patients with grade 3 BTAI undergo early or delayed TEVAR?
- (3) Do patients undergoing LSA coverage (zone 2) for TEVAR after BTAI require left subclavian revascularization?
- (4) What is the optimal role of intraoperative systemic anticoagulation in patients with BTAI undergoing TEVAR?
- (5) What is the optimal imaging surveillance protocol for patients with BTAI after TEVAR or NOM?
- (6) What is the optimal treatment of BTAI patients with concomitant SOI or TBI?
- (7) What is the role of anti-impulse therapy in the NOM of BTAI?

RESPONSES TO PICO QUESTIONS, DATA REVIEW, AND RECOMMENDATIONS

PICO question #1: should patients with SVS grade 1 and 2 (MAIs) be treated with NOM alone or TEVAR?

Background and rationale. The previous SVS guidelines¹ recommended that NOM be used as definitive

care for SVS grade 1 injuries (see Fig 2).⁷ Since this 2011 publication, several studies have suggested that both grade 1 and 2, together referred to as MAIs, may be safely treated with NOM.⁸⁻¹⁴

Evidence. Several observational studies have demonstrated no difference in aortic-related mortality or outcomes when SVS grade 1 and 2 injuries (MAIs) receive NOM. These studies demonstrated that MAIs were associated with low aortic-related mortality and excellent intermediate-term outcomes. One study followed MAIs with surveillance CTA imaging and showed that the majority resolve within 8 weeks.⁸ An approach using NOM with follow-up imaging of grade 2 injuries allows for detection of the injury progression in these patients and avoids the potential complications that can result from the conduct of TEVAR, including access complications.

Multiple studies suggest that follow-up imaging for grade 1 injuries may not be required. Most notably, Jinadasa et al¹⁵ found that more than 93% of patients with grade I injuries demonstrated achievement of resolution or stability of their injury by median postinjury day 11; an additional 6% showed resolution by median postinjury day 31. Of the minority that showed initial worsening of their injury, 85% went on to show injury resolution. Sandhu et al⁸ found that grade I injuries had a median resolution time of 39 days.

Although one retrospective review of the Aortic Trauma Foundation (ATF) Registry from 2016 to 2021 showed a difference between NOM and TEVAR with regard to mortality,¹⁴ the SVS commissioned systematic review combining multiple studies showed no

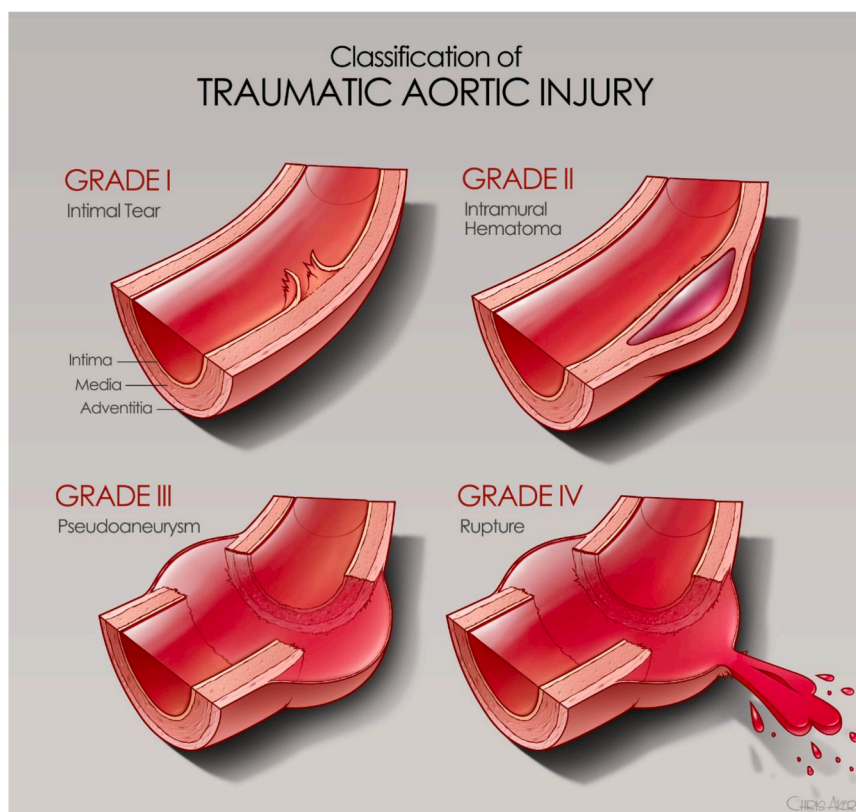


Fig 2. Classification of traumatic aortic injury. Reprinted from *Journal of Vascular Surgery*,⁷ Copyright (2009), with permission from Elsevier.

difference in mortality, with an increased aortic-related mortality with TEVAR.²

The weight of present data favors NOM for SVS grade 1 and 2 injuries, despite the need for additional research on this topic. The committee made a strong recommendation considering the feasibility, availability, and resource use associated with NOM.

Recommendation

1. In patients with grades 1 and 2 BTAI (MAI), we recommend definitive NOM over TEVAR or open repair. (1C) Grade 1 injuries require no routine follow-up imaging. We suggest grade 2 injuries undergo one follow-up CTA to ensure resolution.

PICO question #2: should SVS grade 3 BTAI undergo early or delayed TEVAR?

Background and rationale. The previous SVS CPG suggested urgent repair (<24 hours) for all SVS grade 3 injuries.¹ Since this 2011 guideline, several studies have examined outcomes among both early and delayed TEVAR in these patients. Patients presenting with SVS grade 3 injuries rarely have isolated BTAI. There is frequently a question of which injury should be

addressed first, and often, significant time in the operating room is required to address all of the associated traumatic injuries. The rationale of a delayed approach would allow for patient stabilization and permit management of coexisting traumatic injuries that may represent a greater threat to a detrimental outcome.¹⁶⁻²⁰

Evidence. Updated review since the previous CPG yields additional research suggesting that early TEVAR (<24 hours) is associated with increased overall mortality in SVS grade 3 BTAI. In addition, there was no difference in aortic-related mortality in the early vs late cohorts.¹⁶⁻²⁰

Despite these findings favoring delayed TEVAR for grade 3 BTAI, it is important to consider that several factors may provide solid indication for earlier timing of TEVAR in select patients. Early TEVAR is advised in unstable patients with SVS grade 3 BTAI where the BTAI is deemed the specific cause for the patient's instability. In addition, if the aortic injury demonstrates certain high-risk features, urgent (<24 hours) intervention would be necessary, because indirect evidence implies that delay in the presence of such features may be associated with a higher risk of complications, including death. Such reported high-risk features include hemothorax, mediastinal hematoma, aortic coarctation, lesion/normal aortic diameter ratio >1.4, and admission lactate >4 mM.^{21,22}

Taken in total, these existing data suggest that early TEVAR is associated with worse outcomes than a more delayed approach. Additional study is required to further define the optimal timing of TEVAR within the context of specific global injury patterns, hemodynamic parameters, and patient-specific risk factors.

Recommendation

2. In patients with hemodynamically stable grade 3 BTAI, we suggest delayed TEVAR (>24 hours) to allow for management of other associated traumatic injuries if needed. (2C) In an unstable patient in whom there is a concern that the BTAI is the specific cause of the patient's instability, we recommend urgent (<24 hours) or emergent intervention. (1B)

PICO question #3: do patients undergoing left subclavian artery coverage (zone 2) for TEVAR after BTAI require left subclavian revascularization?

Background and rationale. The previous SVS CPG favored selective revascularization (either before or after TEVAR) depending on the status of the vertebral anatomy, with a minority of experts favoring revascularization.¹ The rationale of revascularization approaches has included (1) the preservation of antegrade perfusion to the cerebrovascular system to specifically decrease the risk of posterior circulation strokes and (2) to mitigate the risk of left arm ischemia.¹ Early revascularization is reasonably of particular importance in the setting of prior left internal mammary to coronary artery bypass or left arm dialysis access.

Evidence. Several studies have been conducted on this topic since the previous guidelines,²³⁻²⁹ although not all met criteria for inclusion in our analysis because populations that included non-BTAI patients. One included study from the ATF International BTAI registry examined 364 patients undergoing TEVAR for BTAI; 26.6% of whom underwent left subclavian artery (LSCA) coverage without revascularization and 2.7% (10) underwent coverage with subsequent LSCA revascularization. These investigators found a lower incidence of stroke or paralysis with revascularization during the index TEVAR procedure compared with those patients who did not require LSCA coverage.²⁷

Recommendation

3. Among patients requiring LSA coverage for TEVAR after BTAI, we suggest that the decision about LSA revascularization be based on feasibility and factors such as a patent prior left internal mammary to coronary bypass, detection of a dominant left vertebral artery on preoperative or intraoperative imaging, or an aortic origin of the left vertebral artery. (2C)

Revascularization should be considered in (1) circumstances of a patent prior left internal mammary to coronary bypass to prevent a major cardiac event, (2) when a dominant left vertebral artery is detected (a diminutive or occluded right vertebral artery, or an end posterior inferior cerebellar artery) on preoperative or intraoperative imaging to mitigate the risk of posterior circulation stroke, and (3) in the case of an aortic origin of the left vertebral artery to avoid limb-threatening left arm ischemia.³⁰ Multiple LSA revascularization options exist, each with its own unique risks and procedural considerations, including but not limited to branched devices, open bypass, or transposition.^{31,32} The urgency of repair (injury grade), the condition of the patient, the availability of devices, and expertise may impact the feasibility and timing of revascularization.

PICO question #4: what is the optimal role of intraoperative systemic anticoagulation in patients with BTAI undergoing TEVAR?

Background and rationale. The rationale for heparinization in the context of TEVAR is to mitigate the risk of thrombotic complications, particularly of the lower extremities, in the setting of larger-bore sheath requirements. The safety of systemic intravenous heparinization during TEVAR in a polytrauma patient with a TBI or SOI, however, remains a significant area of concern for all clinical stakeholders caring for these patients.

In the 2011 SVS CPG, the majority of experts suggested that heparin be used routinely, but at lower doses than used in the context of elective TEVAR. The previous CPG group also yielded a minority opinion expressing that heparin may not be necessary, given that the rapidity with which TEVAR can be performed in these cases mitigates the risk for thrombotic events. In the final analysis of the 2011 CPG writing group, they concluded that the decision for heparinization must be individualized based on the balance of the perceived risks of bleeding for the specific patient.¹

Evidence. Two recently published nonrandomized studies have investigated the use of heparin vs no systemic heparinization during TEVAR.^{33,34} Full heparinization did not increase mortality, and analysis of the Vascular Quality Initiative database indicated a mortality benefit associated with the practice.³³ Further, the risks pertaining to the use of heparin during TEVAR were demonstrated to be similar across all grades of aortic injury.³³ There was no difference in stroke, thrombotic events, spinal cord ischemia, hematoma, or endoleak related to systemic heparinization during TEVAR.^{33,34}

In one study including patients with SVS grade 3 BTAI, the use of heparin decreased the risk of acute lower extremity ischemia.³³ However, in another single-center study, timing to repair in patients who were not

heparinized was found to be more expeditious compared with patients with heparinization.³⁴

Recommendation

4. In patients with BTAI undergoing TEVAR, we suggest that intraoperative anticoagulation can be used at the surgeon's discretion after considering the risk of bleeding and thrombotic complications. (2C)

PICO question #5: what is the optimal imaging surveillance protocol for patients with BTAI after TEVAR or NOM?

Background and rationale. Although the indications for surveillance imaging after BTAI treated with NOM are generally recognized as including detection of injury progression or resolution, the optimal frequency, duration, and modality of that imaging have not been clearly defined. Previous SVS guidelines lacked sufficient data to justify substantive guidelines.¹

Since that time, conservative management of grade 1 and 2 BTAI (MAI) has been proposed by investigators,³⁵ making the need for diligent and standardized surveillance practices of these injuries more pressing.

Similarly, guidelines for postoperative surveillance of patients with BTAI treated with TEVAR have not been clearly established. Surveillance practices for TEVAR after aneurysm or dissection are predicated on pathology-specific risks that may not pertain to patients with BTAI. Moreover, the relative youth of the trauma population attaches substantially higher cumulative radiation exposure and cost to that surveillance protocol. On the other hand, the long-term durability and effectiveness of endografts placed for trauma are largely unknown.

Evidence. Gharai et al³⁶ performed a retrospective review of 17,579 patients who underwent chest CT angiography as part of their blunt trauma admission workup, of whom 113 were found to have MAIs. Of these patients, 93% had at least one follow-up scan. Forty-three percent of these showed resolution on their first follow-up scan at a median of 2 days. By the third follow-up scan at a median of 28 days, 64% of the patients' injuries had resolved. By the final scan (median 261 days), 69% of injuries had completely resolved, 11% had improved, and 20% were stable.

Jinadasa et al¹⁵ reported on the natural history of 83 patients with grade I BTAI and follow-up imaging. Seventy-eight percent of these patients had improvement or resolution demonstrated by median day 5. Seven patients showed worsening that was demonstrated on median day 3, six of whom went on to show resolution or improvement, with the last undergoing TEVAR that would not have been performed under current practice patterns.

Among patients who undergo TEVAR for BTAI, evidence is sparse but encouraging. Spiliotopoulos et al³⁷ investigated the optimal follow-up imaging schedule based on 76 patients who underwent TEVAR for BTAI over 11 years, all but six of whom underwent follow-up imaging. No differences were seen in survival, graft-related complications, or need for reintervention between those patients who were first reimaged at 12 to 18 months and those who had their first follow-up scans after 18 months.

Recommendations

- (5a) In all patients with grade 1 BTAI treated nonoperatively, we suggest against routine surveillance imaging. (2C)
- (5b) In patients with grade 2 BTAI treated nonoperatively, we suggest at least one follow-up surveillance imaging study. We suggest repeat imaging at 1 to 3 months after injury. (2C)
- (5c) In patients who had TEVAR for BTAI, we suggest postoperative surveillance imaging. (2C)

Considering the scarcity of evidence, the committee suggests choosing surveillance schedules based on clinical experience, surgeon judgment, and patient-specific factors, including the device used for repair. The individualized protocol should balance the low risk of long-term device complications compared with other burdens, including the cumulative radiation exposure to the patient.

PICO question #6: what is the optimal treatment of patients with BTAI with concomitant solid organ injury or traumatic brain injury?

Background and rationale. Often, the injured patient has concomitant injuries, each of which is life-threatening. The challenge of caring for such patients is particularly complex when the optimal treatments for these injuries are in direct conflict with each other. For instance, TBI is often treated with permissive hypertension; in the presence of a BTAI for which relative hypotension is desirable, the physician is ostensibly faced with a critical choice. Moreover, although TEVAR for BTAI may enable permissive hypertension, the procedure itself may carry additional risks, including stroke and reduced cerebral perfusion if LSA coverage is required. In addition, the risks of procedural anticoagulation during TEVAR are not only relevant to concomitant intracranial hemorrhage but any significant SOI or musculoskeletal injury.

Evidence. It is estimated that 30% to 50% of patients who have BTAI also have coincident TBI or SOI, and the combination of these injuries is associated with significantly greater mortality.³⁸ An analysis of data from the Trauma Quality Improvement Program found that 28% of patients with BTAI had simultaneous TBI³⁹; these patients predictably exhibited more severe shock, a greater

injury severity score, and a worse Glasgow Coma Scale. They were significantly more likely to develop acute respiratory distress syndrome, stroke, and cardiac arrest, and had a higher overall mortality than patients with BTAI alone. This group found that patients with TBI were less likely to undergo TEVAR than patients with BTAI without brain injury. In addition, patients with TBI who did undergo aortic repair had a higher Glasgow Coma Scale and lower injury severity score than patients with BTAI/TBI managed nonoperatively.

Patients with BTAI/TBI undergoing TEVAR were more likely to develop acute renal failure, acute respiratory distress syndrome, pulmonary embolism, and stroke than those managed nonoperatively, yet had a lower incidence of in-hospital cardiac arrest and had a substantial and significant reduction in mortality.

Emergent, rather than urgent, TEVAR in the presence of TBI is often justified by the allowance of a shorter period of anti-impulse control; the sooner TEVAR is performed, the more rapidly the blood pressure may be increased for the treatment of TBI. Indeed, the use of antihypertensive agents has been identified as a risk factor for mortality in TBI.⁴⁰

The optimal timing for TEVAR in the setting of concomitant TBI has been examined by several groups. In one single-center study of 20 patients with combined BTAI/TBI, Zambetti et al⁴¹ identified a possible increase in mortality associated with TEVAR performed before 14 hours. In a subsequent examination of 100 patients with BTAI/TBI from the multicenter ATF Registry, however, Arbabi et al³⁸ found that emergent vs urgent TEVAR for BTAI in patients with TBI showed no difference in the outcomes of delayed cerebral ischemic events, in-hospital mortality, or aortic-related mortality, and found zero incidence of delayed hemorrhagic stroke. In patients with grade 4 BTAI, emergent repair, even in the presence of TBI, is recommended.⁴²

Data regarding intraoperative anticoagulation during TEVAR for BTAI in the setting of other injuries are inconclusive. Zambetti et al⁴¹ evaluated TEVAR timing and procedural anticoagulation in patients with TBI and found that universal intraprocedural heparinization was not associated with any change in neurologic function.

Recommendations

- 6a. In patients with grade 1 or 2 BTAI (MAI) and concomitant TBI, we suggest against anti-impulse therapy for BTAI. Management of blood pressure should prioritize TBI over BTAI. (2C)
- 6b. In patients with grade 3 BTAI and concomitant TBI, we suggest that the decision to use anti-impulse therapy should be individualized based on collaborative management with other surgical and medical specialties. (2C)

- 6c. In patients with grade 3 BTAI and concomitant TBI or SOI, we suggest that timing for TEVAR should be determined in a collaborative fashion in consultation with other stakeholders, including trauma and neurosurgery. (2C)
- 6d. In patients with grade 4 BTAI, we recommend emergent repair. (1C)
- 6e. For patients with BTAI and concomitant TBI or SOI, we suggest a collaborative approach for intraprocedural anticoagulation during TEVAR. Although current observational studies do provide some reassurance that heparinization is not associated with worse intracranial bleeding or neurologic outcomes, the certainty in this evidence is very low. Decisions about intraoperative anticoagulation in patients with TBI should be individualized based on multidisciplinary collaboration. (best practice statement)

PICO question #7: what is the role of anti-impulse therapy in the nonoperative management of BTAI?

Background and rationale. Anti-impulse therapy has been advocated in a variety of acute aortic pathologies, including BTAI, to decrease shear wall stress on the compromised aortic architecture and mitigate against injury progression. The therapeutic foundation of anti-impulse approaches consists of antihypertensive and negative inotropic therapy and, when needed, supplementation with a vasodilator.

The effective use of anti-impulse therapy strategies in some trauma patients may, however, be problematic. Specifically, associated brain and spinal cord injuries have been shown to benefit from pharmacologic elevation of blood pressure to optimize perfusion of recovering neurologic tissues. Such a conflict of potential strategies between BTAI and neurologic injuries in the same patient requires multidisciplinary collaboration to resolve.

Evidence. Data examining the optimal use of anti-impulse therapy are lacking.⁸ In the largest pertinent review reporting practice and outcomes from the ATF Registry,⁴³ continuous titratable infusion of antihypertensive medication was used in 49.1% of patients with BTAI, with β -blockers proving the most used class of medications (74.6%). In this study, the most often cited target objective was a systolic blood pressure goal of <120 mm Hg. This was only documented as achieved, however, in 64% of patients with BTAI.

Recommendation

7. In patients with grade 3 BTAI, we suggest anti-impulse therapy as a stabilizing measure until TEVAR is performed if the concomitant injuries do not preclude this approach. (2C)

Limitations

This guideline represents the diligent work of our methodology team and a committee of dedicated SVS expert volunteers and staff. As outlined in the disclaimer at the beginning of this document, the recommendations included herein are based on a diligent review of the available body of evidence. The applicability of these guidelines is subject to reassessment and revision as new data emerge and highlights a clear need for ongoing research into a host of variables pertinent to optimal care of patients sustaining BTAI. Individualized consideration of the specific patient and the clinical environment by capable clinicians will continue to be of critical importance in advancing the care of BTAI.

CONCLUSIONS

The understanding of BTAI and its optimal management, both medical and surgical, continues to evolve as data accumulate and as endovascular technology advances. Moreover, the presence and nature of associated injuries can substantially impact treatment strategies. Although this contextual variability precludes comprehensive evidence that applies to all possible presentations, sufficient data exist to support the above recommendations and help guide the care teams who treat patients with BTAI.

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Additional material for this article may be found online at www.jvascsurg.org.

APPENDIX (online only).

Evidence to Decision Framework Worksheets

Strategy/treatment/test/intervention: Nonoperative

management of low-grade BTAI (grade 1 and 2)

Alternative strategy: Operative repair

Domain	The effects		Judgment
How substantial are the desirable anticipated effects of the strategy?	No increase in aortic-related mortality was reported with NOM in low-grade BTAI		Trivial Small Moderate Large Unknown
How substantial are the undesirable anticipated effects?	No difference was noted in mortality, stroke, or mediastinal hematoma between NOM and TEVAR for low-grade BTAI. The rate of acute renal failure (ARF) of 9% noted in the literature was not encountered in the clinical practice of the expert panel.		Trivial Small Moderate Large Unknown
Do the desirable effects outweigh the undesirable effects?	Yes		No Probably no Probably yes Yes Unknown
	Studies about the topic	Panel input	
Is there important uncertainty or variability about how much people value the main outcomes?			Important uncertainty or variability Possibly important uncertainty or variability Probably no important uncertainty or variability No important uncertainty or variability
What is the overall certainty of the evidence of effects?			Very low Low Moderate High
How large are the resource requirements associated with the intervention?	Low compared with operative repair		Large costs Moderate costs Small costs Unknown
How large is the incremental cost relative to the net benefit?	Low cost of NOM with evident benefit		Large ICER Moderate ICER Small ICER Savings Unknown
What would be the impact on health inequities?	No evidence	Likely lower disparities (surgery may be inaccessible to under/uninsured (rural areas))	Worsened Probably worsened Probably improved Improved Unknown
Is the option acceptable to key stakeholders?	Yes, there seems to be relative buy-in to nonoperative management of low-grade injuries.		No Probably no Probably yes Yes Unknown

(Continued on next page)

Continued.

Domain	The effects				Judgment
Is the option feasible to implement?	Yes, already done at most centers				No Probably no Probably yes Yes Unknown
Type of recommendation	We recommend against the option or for the alternative	We suggest not to use the option or to use the alternative	We suggest using either the option or the alternative	We suggest using the option	We recommend the option

Strategy/treatment/test/intervention: Delayed (>24 hours)
 repair of grade 3 BTAI
 Alternative strategy: Urgent (<24 hours) repair of grade
 3 BTAI

Domain	The effects		Judgment
How substantial are the desirable anticipated effects of the strategy?	Significant; reduction in mortality (4.3% late vs 9.7% early)		Trivial Small Moderate Large Unknown
How substantial are the undesirable anticipated effects?	Potential risk of interval rupture or complications (low) Potential increase in length of stay (low)		Trivial Small Moderate Large Unknown
Do the desirable effects outweigh the undesirable effects?	Yes		No Probably no Probably yes Yes Unknown
	Studies about the topic		Panel input
Is there important uncertainty or variability about how much people value the main outcomes?			Important uncertainty or variability Possibly important uncertainty or variability Probably no important uncertainty or variability No important uncertainty or variability
What is the overall certainty of the evidence of effects?			Very low Low Moderate High
How large are the resource requirements associated with the intervention?	Moderate; potential small increase in length of stay		Large costs Moderate costs Small costs Unknown
How large is the incremental cost relative to the net benefit?	Unknown		Large ICER Moderate ICER Small ICER Savings Unknown

Continued.

Domain		The effects			Judgment	
What would be the impact on health inequities?		Not studied			Worsened Probably worsened Probably improved Improved Unknown	
Is the option acceptable to key stakeholders?		Seems to be agreeable to multiple parties			No Probably no Probably yes Yes Unknown	
Is the option feasible to implement?		Already done in major centers			No Probably no Probably yes Yes Unknown	
Type of recommendation	We recommend against the option or for the alternative	We suggest not to use the option or to use the alternative	We suggest using either the option or the alternative	We suggest using the option	We recommend the option	

Strategy/treatment/test/intervention: Cover the left subclavian artery (LSA) without revascularization during thoracic endovascular aortic repair (TEVAR) for trauma

Alternative strategy: Revascularize the LSA during TEVAR for trauma

Domain	The effects		Judgment
How substantial are the desirable anticipated effects of the strategy?	Decreased operative time Decreased blood loss Decreased need for anticoagulation (evidence predates approval of branched TEVAR [TBE] device)		Trivial Small Moderate Large Unknown
How substantial are the undesirable anticipated effects?	Left arm pain Left arm ischemia Romagnoli data Late stroke – 1/10 w revascularization vs 6/97 NR and early stroke 0/10 vs 2/97 Paralysis 0/10 w/R vs 3/97 w/NR Arm ischemia. Emboli – 0/10 vs 2/97		Trivial Small Moderate Large Unknown
Do the desirable effects outweigh the undesirable effects?	Can save a large percentage of patients from needing revascularization.		No Probably no Probably yes Yes Unknown
	Studies about the topic	Panel input	
Is there important uncertainty or variability about how much people value the main outcomes?	Uchida 2019 ²³ Romagnoli		Important uncertainty or variability Possibly important uncertainty or variability Probably no important uncertainty or variability No important uncertainty or variability
What is the overall certainty of the evidence of effects?			Very low Low Moderate High
How large are the resource requirements associated with the intervention?			Large costs Moderate costs Small costs Unknown
How large is the incremental cost relative to the net benefit?			Large ICER Moderate ICER Small ICER Savings Unknown
What would be the impact on health inequities?			Worsened Probably worsened Probably improved Improved Unknown
Is the option acceptable to key stakeholders?			No Probably no Probably yes Yes Unknown

Continued.

Domain		The effects			Judgment
Is the option feasible to implement?					No Probably no Probably yes Yes Unknown
Type of recommendation	We recommend against the option or for the alternative	We suggest not to use the option or to use the alternative	We suggest using either the option or the alternative	We suggest using the option	We recommend the option

Strategy/treatment/test/intervention: Anticoagulation during TEVAR

Alternative strategy: No anticoagulation during TEVAR

Domain	The effects		Judgment
How substantial are the desirable anticipated effects of the strategy?	The use of anticoagulation during the performance of TEVAR is thought to reduce the risk of stroke and access site thromboembolic events (event rates of access complication potentially as high as 8%, PMID 20644131). The risk of stroke directly attributable to the performance of TEVAR without the use of anticoagulation in this setting is not known. The risk reduction of either stroke or access site complications is not specifically known.		Trivial Small Moderate Large Unknown
How substantial are the undesirable anticipated effects?	The undesirable effects of using anticoagulation during the performance of TEVAR for BTAI in the setting of TBI are likely small, although the data are observational and limited. Data related to the use of anticoagulation in the setting of TEVAR in the early presentation of TBI associated with ICH are very limited. Observational studies demonstrating its use in more delayed repairs suggest that the risks are small or trivial (PMID: 33359706)		Trivial Small Moderate Large Unknown
Do the desirable effects outweigh the undesirable effects?	Reduced mortality signal; two observational studies (potential confounding bias/patient selection impact unknown)		No Probably no Probably yes Yes Unknown
	Studies about the topic	Panel input	
Is there important uncertainty or variability about how much people value the main outcomes?	Quiroga (PMID 33359706) Garcia-Toca (PMID 20644131)		Important uncertainty or variability Possibly important uncertainty or variability Probably no important uncertainty or variability No important uncertainty or variability
What is the overall certainty of the evidence of effects?			Very low Low Moderate High
How large are the resource requirements associated with the intervention?			Large costs Moderate costs Small costs Unknown
How large is the incremental cost-effectiveness relative to the net benefit?			Large ICER Moderate ICER Small ICER Savings Unknown
What would be the impact on health inequities?			Worsened Probably worsened Probably improved Improved Unknown
Is the option acceptable to key stakeholders?	All decisions regarding anticoagulation for the individual patient should be made in consultation with all stakeholders (including the multidisciplinary trauma team)		No Probably no Probably yes Yes Unknown

Continued.

Domain		The effects			Judgment	
Is the option feasible to implement?					No Probably no Probably yes Yes Unknown	
Type of recommendation	We recommend against the option or for the alternative	We suggest not to use the option or to use the alternative	We suggest using either the option or the alternative	We suggest using the option	We suggest using the option	We recommend the option

Strategy/treatment/test/intervention: Post-TEVAR 1, 6, and 12 months, then annual computed tomography angiography (CTA), nonoperative injuries; grade 1 no follow-up imaging, grade 2 1-month CTA

Alternative strategy: Less frequent imaging and noncontrast low-dose CT after 2 years for post-TEVAR patients

Domain		The effects		Judgment	
How substantial are the desirable anticipated effects of the strategy?	Finding an actionable complication of stent grafting			Trivial Small Moderate Large Unknown	
How substantial are the undesirable anticipated effects?	Radiation exposure, contrast nephropathy, and cost			Trivial Small Moderate Large Unknown	
Do the desirable effects outweigh the undesirable effects?	Identification of radiographic complications before clinical events			No Probably no Probably yes Yes Unknown	
	Studies about the topic	Panel input			
Is there important uncertainty or variability about how much people value the main outcomes?	None	Consensus/expert opinion		Important uncertainty or variability Possibly important uncertainty or variability Probably no important uncertainty or variability No important uncertainty or variability	
What is the overall certainty of the evidence of effects?				Very low Low Moderate High	
How large are the resource requirements associated with the intervention?				Large costs Moderate costs Small costs Unknown	
How large is the incremental cost relative to the net benefit?				Large ICER Moderate ICER Small ICER Savings Unknown	
What would be the impact on health inequities?				Worsened Probably worsened Probably improved Improved Unknown	
Is the option acceptable to key stakeholders?				No Probably no Probably yes Yes Unknown	
Is the option feasible to implement?				No Probably no Probably yes Yes Unknown	
Type of recommendation	We recommend against the option or for the alternative	We suggest not to use the option or to use the alternative	We suggest using either the option or the alternative	We suggest using the option	We recommend the option