Blunt thoracic aortic injury: A Western Trauma Association critical decisions algorithm

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This is a recommended evaluation and management algorithm from the Western Trauma Association (WTA) Algorithms Committee addressing the management of adult patients with blunt thoracic aortic injury (BTAI). Because there is a paucity of published prospective randomized clinical trials that have generated class I data, these recommendations are based primarily on published prospective and retrospective cohort studies, and expert opinion of the WTA members. The final algorithm is the result of an iterative process including an initial internal review and revision by the WTA Algorithm Committee members and then final revisions based on input during and after presentation of the algorithm to the full WTA membership.

Blunt thoracic aortic injury is an uncommon but highly lethal injury and most commonly occurs at the descending aorta, just distal to the takeoff of the left subclavian artery. Understanding patients at risk for BTAI, as well as an efficient trauma evaluation, will lead to timely diagnosis and treatment. With the widespread use of computed tomography (CT) scan and the advent of endovascular treatment options, the diagnosis and treatment of BTAI have changed significantly over the past two decades. These changes have led to a more nuanced approach to the management of patients with BTAI, progressing from diagnosis, medical management, surgical repair, and postrepair management. The currently published guidelines have not kept up with recent changes in management, and this algorithm intends to present an updated and reliable tool for the care of most patients with BTAI.

The algorithm (Fig. 1) and accompanying comments represent a safe and sensible approach to the evaluation of the patient with BTAI. We recognize that there will be multiple factors that may warrant or require deviation from any single recommended algorithm and that no algorithm can completely replace expert bedside clinical judgment. We encourage institutions to use this as a general framework in the approach to these patients and to customize and adapt the algorithm to better suit the specifics of that program or location.

ALGORITHM

The following lettered sections correspond to the letters identifying specific sections of the algorithm shown in Figure 1. In each section, we provide a brief summary of the important aspects and options that should be considered at that point in the evaluation and management process.

A. Screening

Blunt thoracic aortic injury is caused by a high-energy mechanism resulting in rapid deceleration, most commonly a high-speed motor vehicle crash (~80%), followed by fall from significant height, motorcycle crash, or pedestrian struck by auto.[1] Mechanisms of injury with little or no energy transmission to the chest (assault, fall from standing) do not require additional evaluation for BTAI. Chest x-ray (CXR) has been traditionally used as a screening tool for BTAI. Findings on CXR associated with BTAI include widened mediastinum, left hemothorax, loss of aortic nob, and left apical cap, among others. While these CXR findings may be seen in patients with BTAI, a significant number of patients with BTAI will have a completely normal CXR, making CXR unreliable to rule out BTAI.[2,3] Blunt trauma patients with a high-energy mechanism of injury, regardless of CXR findings, require further diagnostic evaluation to identify or rule out BTAI. In addition, further diagnostic imaging should be obtained in any trauma patient without a clear high-energy mechanism but with CXR findings concerning for possible BTAI.

B. Diagnosis

The current criterion standard for diagnosis of BTAI is a computed tomographic angiogram (CTA) of the chest, with a

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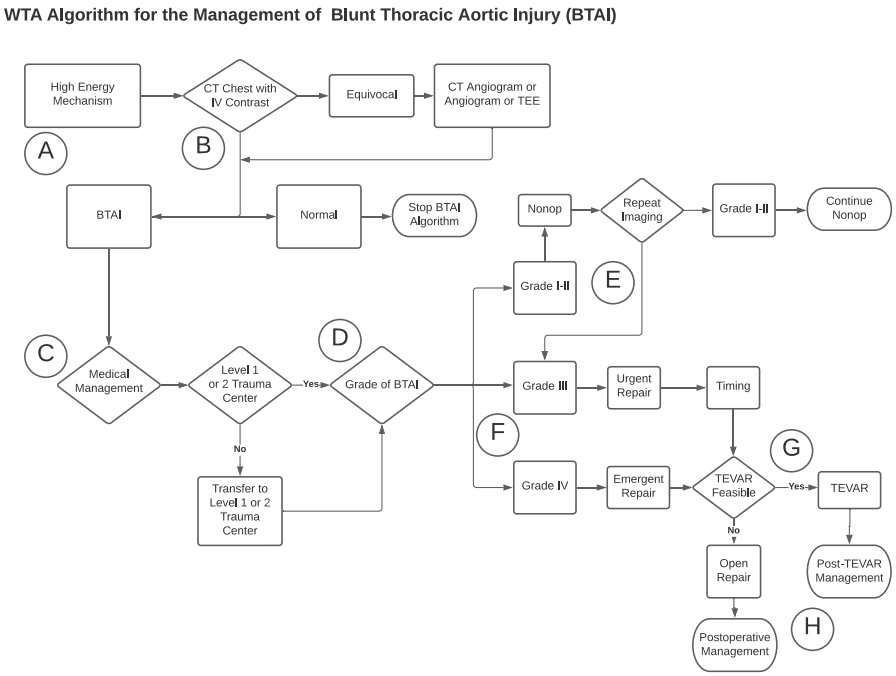

Figure 1. Western Trauma Association algorithm for the evaluation and management of patients with BTAI. Circled letters correspond to sections in the associated manuscript.

sensitivity of 95% to 100% and a negative predictive value of 99% to 100%.[4–6] However, many trauma patients will initially undergo a "pan-scan" that includes a CT of the chest, but the contrast load may not be timed appropriately to produce a formal CTA of the chest. This initial CT scan of the chest may identify a BTAI, but if the diagnosis remains in question, further evaluation is required with a formal CTA, transesophageal echocardiogram, intravascular ultrasound, or conventional aortography. Transesophageal echocardiogram has similar sensitivity to CTA,[7,8] but its application may depend on institutional availability and expertise. Conventional aortography, while previously the standard diagnostic modality for BTAI, is not usually necessary in current practice. In fact, conventional aortography is an invasive procedure that requires additional resource mobilization and has a lower sensitivity than CTA,[1,9] particularly for lower-grade injuries.[10] Intravascular ultrasound may be more accurate than conventional angiography when CTA is equivocal.[11]

C. Medical Management

The medical management of BTAI begins as soon as the injury is identified and should begin in the emergency department in preparation for admission to the intensive care unit. Medical management, also known as anti-impulse therapy, decreases the risk of injury progression and free rupture of a contained BTAI by lowering blood pressure and heart rate to reduce aortic wall stress.[12] Anti-impulse therapy is typically achieved using a short-acting β blocker infusion (e.g., esmolol) as first line therapy, with goals of systolic blood pressure of <100 mm Hg and heart rate of <100 beats per minute.[13,14] If goals are not achieved with a β blocker alone, a calcium channel blocker (e.g., diltiazem) or vasodilator (e.g., nitroprusside) may be introduced. However, pure vasodilator agents should be avoided as first-line therapy in patients with BTAI because they can actually increase aortic wall stress and shearing forces despite lowering the systolic blood pressure. Blood pressure management should be performed in the context of associated injuries, particularly with severe traumatic brain injury (TBI), where hypotension should be avoided to prevent secondary TBI. In patients with concomitant TBI, there should be a multidisciplinary discussion to determine the optimal goals of anti-impulse therapy for both the BTAI and the TBI. If the BTAI is identified at a lower-level or nontrauma center, medical management should be started, and the patient should be transferred to a higher-level trauma center for ongoing management.

D. Grading

After initiation of medical management, grading of BTAI places an important role in the subsequent management. The most common grading system was published in 2009.[15] This system grades injuries from I to IV, with increasing levels of BTAI injury severity. Injuries are classified as grade I (intimal tear), grade II (intramural hematoma), grade III (pseudoaneurysm), and grade IV (rupture). For the purposes of this algorithm, grades I and II are considered low-grade injuries, while grade III and IV are considered high-grade injuries.

E. Management of Low-Grade Injuries

The majority of low-grade injuries (grades I and II) can be managed with anti-impulse therapy alone.[16–18] After initiation of intravenous anti-impulse therapy, patients should have a plan for repeat CTA 48 to 72 hours after admission to evaluate for injury progression, which may occur in up to 10% to 15% of cases.[19] If the injury remains stable on repeat imaging, patients should be transitioned to an oral antihypertensive medication regimen. In addition, patients should have interval outpatient imaging to confirm healing of the injury, which should occur in most cases within 8 weeks of injury.[16] Once the injury has resolved, antihypertensive

medications may be stopped. If at any point a low-grade injury progresses to a high-grade injury, patients should undergo repair of their BTAI. In addition, if a patient has a contraindication for anti-impulse therapy (e.g., associated severe TBI), they may be considered a candidate for endovascular repair of a low-grade injury.

F. Management of High-Grade Injuries

High-grade injuries (grades III and IV) also receive initial medical management but require subsequent surgical intervention for definitive repair of BTAI. Timing of repair of high-grade injuries depends on the grade of injury and associated injuries. Patients with a grade III injury and no associated injury, an uncommon situation, may be taken directly for aortic repair without delay. However, if patients with a grade III BTAI have significant associated injuries, repair of the BTAI may be delayed, while continuing anti-impulse therapy and addressing other higher-priority injuries. Delayed repaired of BTAI, as late as 48 to 72 hours after admission, has been found to be safe and may be the preferred approach in patients with severe concomitant injuries.[12,20–22] Patients with a grade IV (ruptured) BTAI require an emergent repair of the aortic injury, regardless of associated injuries. Repair of grade IV BTAI should be performed in the same emergent fashion as any other hemorrhage control procedure for trauma, such as laparotomy or angioembolization.

G. Endovascular Versus Open Repair

While open repair of BTAI via left posterolateral thoracotomy, with or without cardiopulmonary bypass, was the standard approach for decades, thoracic endovascular aortic repair (TEVAR) has become the treatment of choice for patients with BTAI.[20,23] While there are no prospective, randomized trials available, TEVAR has been associated with improved outcomes, particularly related to mortality and paraplegia.[21,24,25] Although TEVAR is the preferred approach for BTAI repair, there are certain situations, primarily anatomic, that may still require open BTAI repair. Anatomic conditions that may limit the ability to use TEVAR include the diameter of the proximal landing zone, length of proximal and distal landing zones, calcification at fixation sites, aortic tortuosity, intraluminal thrombus, and diameter and quality of access vessels.[26] While most BTAIs are in the descending aorta, more proximal injuries of the arch or ascending aorta may also require open repair.

H. Postrepair Management

After TEVAR, patients should be admitted to the intensive care unit for monitoring of bleeding, neurologic changes, and vascular insults related to the procedure. Blood pressure and heart rate goals can be normalized, and anti-impulse therapy can be discontinued. Specific to TEVAR, femoral access complications (femoral artery hematoma, thrombosis, embolization, dissection, pseudoaneurysm) should be considered and monitored in the postoperative period. After initial recovery, patients will need surveillance imaging of the endograft, with serial chest CT, to monitor for aortic dilatation at the site of implantation and development of subsequent endoleak.[27,28] Timing and length of surveillance are controversial, because of the radiation exposure risk associated with annual surveillance. The pros and cons of lifelong graft surveillance must be weighed by the patient and surgeon to make an informed decision for each individual patient.[29,30] Postoperative management for open repair of BTAI is similar to other cardiopulmonary bypass patients.

AREAS OF CONTROVERSY AND EXISTING KNOWLEDGE/RESEARCH GAPS

It is also important to note that there are many areas of this algorithm that lack high-quality evidentiary support and where further focused research is required. Table 1 provides a list of the most important specific topics or existing research "gaps" related to this topic that were identified by the authors during the development of this algorithm. Screening criteria for BTAI are not defined. However, in the era of widespread CT scan for most blunt trauma patients, this is likely a question that will remain unanswered. The challenge of managing a patient with BTAI and concomitant TBI brings nuance to titration of anti-impulse therapy. This should be a multidisciplinary decision that leads to agreed upon goals in this setting of competing priorities. The role of antiplatelet agents in the management of BTAI, either nonoperative or TEVAR, has been recommended by some, but its efficacy has not been established. The last two gaps in knowledge relate to follow-up imaging of BTAI. Patients with low-grade injuries who are managed nonoperatively require repeat imaging to assess for injury progression, but the timing and frequency are not known. There is also controversy about the role of nonoperative management for low-grade injuries, with some recommending TEVAR for grade II BTAI and others recommending medical management alone. Similarly, there are little available data about whether nonoperative management strategies can be extended to select higher grade injuries. Finally, patients who require TEVAR for repair of BTAI require serial imaging to evaluate for aortic diameter changes and endoleak, but the timing, frequency, and longevity of these repeat scans are not standardized or based on high-quality evidence and require further study.

SUMMARY AND CONCLUSION

Blunt thoracic aortic injury is uncommon and most often occurs after high-speed motor vehicle crashes. Early medical management with anti-impulse therapy to control heart rate and blood pressure are essential to prevent injury progression and rupture. Patients who arrive at hospitals without the ability to repair BTAI should be transferred to higher level trauma centers, but medical management should begin at the referring hospital. Low-grade injuries (grades I and II) should be treated with medical management

TABLE 1. Top Identified Knowledge and Research Gaps Related to the Management of BTAI

Topic or Research Gap	Algorithm Section
1. Screening criteria for BTAI	A
2. Optimal anti-impulse therapy in patient with BTAI and concomitant TBI	C
3. Antiplatelet therapy in the management of BTAI	C
4. Timing of repeat imaging for low-grade BTAI	E
5. Role of nonoperative management for low-grade and high-grade injuries	E and F
6. Length and timing of endograft surveillance	H

alone, while high-grade injuries (grades III and IV) require repair after initial medical management. Timing of repair of high-grade injuries is determined by grade of injury and any associated injuries. The majority of BTAI can be repaired by TEVAR, but open repair may be required in situations where aortic anatomy precludes TEVAR. After repair, patients with TEVAR require long-term graft surveillance, although the optimal timing, frequency, and length of surveillance are unknown.

AUTHORSHIP

C.V.R.B., M.d.M., K.J.B., J.L.H., K.I., E.J.L., E.E.M., K.A.P., A.G.R., N.G.R., J.L.S., J.A.W., A.M.M., J.J.D., R.C., and M.J.M. contributed in the conception and design. C.V.R.B. contributed in the acquisition of data. C.V.R.B., M.d.M., K.J.B., J.L.H., K.I., E.J.L., E.E.M., K.A.P., A.G.R., N.G.R., J.L.S., J.A.W., A.M.M., J.J.D., R.C., and M.J.M. contributed in the analysis and interpretation of data. C.V.R.B. contributed in the drafting of the manuscript. C.V.R.B., M.d.M., K.J.B., J.L.H., K.I., E.J.L., E.E.M., K.A.P., A.G.R., N.G.R., J.L.S., J.A.W., A.M.M., J.J.D., R.C., and M.J.M. contributed in the critical revision of the manuscript. C.V.R.B. and M.J.M. performed the supervision. All authors have seen and approved the final manuscript as submitted. The first author (C.V.R.B.) had full access to all data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

DISCLOSURE

The authors declare no conflicts of interest.
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