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Management of Blunt Thoracic Aortic Injury

Evidence Based Medicine Guideline

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SUMMARY

Blunt thoracic aortic injury (BTAI) may be managed with observation, thoracic endovascular aortic repair (TEVAR), or open repair depending upon the severity of injury, hemodynamic status of the patient, presence of concomitant injury, and medical comorbidities. Critically ill patients with concomitant injuries may benefit from delayed repair. Improvements in computed tomography (CT) capabilities provide better vascular injury characterization and allow increased non-operative management of low-grade aortic injuries.

RECOMMENDATIONS

- **Level 1**
  - **Suspected blunt thoracic aortic injury (BTAI) based on initial chest radiograph or mechanism of injury should be evaluated using CT arteriogram (CTA) of the chest.**
  - **Grade IV and select Grade III BTAI should undergo endovascular repair.**
- **Level 2**
  - **Grades I & II BTAI should receive non-operative management using an esmolol infusion titrated to maintain a systolic blood pressure (SBP) of 100-120 mmHg. Nicardipine (followed by diltiazem) may be used for elevated blood pressure refractory to beta-blockade or in patients where a beta-blocker is contraindicated.**
- **Level 3**
  - **Stable Grade III and select Grade II injuries may be treated with delayed repair.**

INTRODUCTION

Blunt thoracic aortic injury (BTAI) remains the second most common cause of death in blunt trauma, exceeded only by head injury (1). These cases are characterized by high energy trauma that is associated with rapid deceleration due to motor vehicle collision, motorcycle crash, and falls from height. Approximately 80% of such patients die in the pre-hospital setting. Nearly 40% of those patients that make it to the hospital succumb to their injuries within the first 24 hours. These injuries are thought to occur because of a shearing force applied near the aortic isthmus during rapid deceleration where the aorta becomes pinched between the chest wall and spine (2).

Previously, these injuries required open repair, as originally performed by Dr. Debakey, but this was associated with high morbidity and mortality. The advent of endovascular surgery led to development of thoracic endovascular aortic repair **(**TEVAR**)**, first successfully performed by Kato et al. in 1997 (3). Studies have demonstrated that TEVAR is the approach of choice when feasible. Current data suggests that low grade BTAI may successfully be treated with nonoperative management.

LEVEL OF RECOMMENDATION DEFINITIONS

- **Level 1:** Convincingly justifiable based on available scientific information alone. Usually based on Class I data or strong Class II evidence if randomized testing is inappropriate. Conversely, low quality or contradictory Class I data may be insufficient to support a Level I recommendation.
- **Level 2:** Reasonably justifiable based on available scientific evidence and strongly supported by expert opinion. Usually supported by Class II data or a preponderance of Class III evidence.
- **Level 3:** Supported by available data, but scientific evidence is lacking. Generally supported by Class III data. Useful for educational purposes and in guiding future clinical research.

The most popular BTAI grading scale was proposed by the Society of Vascular Surgery (SVS) in 2009 (4).

- Grade I: intimal tear
- Grade II: intramural hematoma or intimal flap
- Grade III: pseudoaneurysm
- Grade IV: rupture

Treatment has historically been based upon the grade of injury at time of presentation. Given the dynamic process of these injuries, it is possible to progress or regress to a different grade during workup. Per the Society for Vascular Surgery, Grade I injuries are recommended to undergo non-operative management with blood pressure and impulse control. Grade II-IV injuries, although a gray zone, are currently recommended to undergo repair. Repair is typically performed by endovascular repair unless there are concomitant injuries or extenuating circumstances that warrant an open repair (5).

LITERATURE REVIEW

BTAI is characterized by a rapid deceleration injury due to high-speed motor vehicle collision, motorcycle crash, or falls from significant height (2). The most common location is the level of the aortic isthmus near the left subclavian artery (LSA) followed by the aortic arch and diaphragmatic thoracic aorta. The pathophysiology is believed to revolve around stretching of the aorta due to extrinsic forces acting upon the tethered isthmus and free-floating descending aorta (6). Additional proposed theories include the “water-hammer” effect in which a concomitant increase in abdominal pressure causes frank rupture of the weakest portion near the tethered aorta and the osseous pinch effect where the entrapped aorta is compressed by the anterior thoracic bones and vertebrae (6).

CTA has been demonstrated to be the premiere standard for diagnosis and grading of BTAI over conventional aortography (3,7). The presence of additional thoracic injuries, which can require more immediate attention, may limit injury interpretation. In addition, investigation of the vertebral anatomy, arch involvement, iliofemoral sizes, and flap/pseudoaneurysm characteristics are paramount for detailed grading and perioperative planning (7).

In 2011, Lee et al. updated the SVS clinical practice guidelines using the GRADE methodology given the shift to endovascular repair and significant morbidity associated with open approaches (5). They suggested endovascular repair over open repair or nonoperative repair for grade II-IV injuries after performing a systematic review of over 7500 patients. The authors concluded that mortality was substantially decreased with endovascular repair (9%) compared to open (19%) and non-operative repair (46%). They also noted a clinically significant increased association with spinal cord ischemia and end-stage renal disease in open repairs when compared to TEVAR (p=0.01). They also concluded that urgent repair (within 24 hours, immediately after other injuries were addressed, or prior to discharge) was associated with a decreased risk of mortality compared to those managed non-operatively. At the time of publication, there was no FDA on-label approval for endovascular grafts. As a result, there was no expert consensus on the effect of oversized grafts typically used in aneurysm repair. Using their data, they found that 30% of cases had coverage of the LSA resulting in potential compromise to the posterior cerebral collateral circulation. Therefore, they recommended intraoperative angiography for evaluation and selective revascularization of the LSA if necessary. Finally, they recommended lower doses of systemic heparinization with no routine spinal drainage and open femoral exposure. These conclusions from the expert consensus panel were all found to be Grade 2 Level C recommendations.

In 2014, Fox et al. updated the practice guideline for the evaluation and management of BTAI for the Eastern Association for the Surgery of Trauma committee using the GRADE framework. The authors sought to evaluate the ideal imaging modality, the operative approach, and the timing of repair. A non-pooled analysis of data from 1998-2013 evaluating the use of CTA vs. catheter-based angiography found that CTA had an increased sensitivity and lower specificity compared to aortography in all six articles analyzed. As a result, they strongly recommended the use of CTA for diagnosis of BTAI. With regard to endovascular vs. open approaches, they identified a total of 37 studies that met their inclusion criteria. They demonstrated that mortality and paraplegia rates were significantly lower with endovascular repair than with open repair (8% vs. 19%, RR 0.56 and 0.5 vs. 3%, RR 0.36 respectively). Tthey found a comparable stroke rate with TEVAR compared to open repair (2.5% vs. 1%, RR 1.48). Given these findings, they strongly recommended endovascular repair in patients without the following contraindications: aortic diameter < 15 mm, involvement of left common carotid, and left vertebral origin with no posterior cerebral collateral flow. Their final analysis investigated delayed vs. immediate repair. Using data from seven studies, they identified a decreased mortality (9% vs. 21%), paraplegia rate (0.6% vs. 5.5%), and stroke incidence (7% vs. 9%) among

TEVAR patients compared to open repair. The quality of evidence for delayed repair was low preventing strong recommendations for its application (8).

Since that time, there has been a shift in the paradigm of proposed management for Grade II-III BTAI injuries. Grade I injuries can be managed medically to maintain a SBP of 100-120 mmHg using continuous beta-blocker infusions as first -line therapy followed by vasodilators as needed (1). Mouawad et al. recommended the use of esmolol due to its rapid onset of action and quick titration with intravenous calcium channel blockers or nitrates added for refractive hypertension.

The management of higher-grade injuries is less clear. Per the SVS guidelines, Grade II-IV injuries should undergo urgent repair endovascularly, if amenable. However, the need to address more life-threatening injuries in some BTAI patients has identified that Grade II-IV BTAI may be managed in a delayed fashion in select patients. Harris et al. proposed the need for lesion specific BTAI management. They noted the number of additional classification systems that have been developed, including the Stanford, Presley, and Shock Trauma classifiers, which have been aimed at further evaluation of the length and circumferential involvement of Grade III aortic lesions. Both the Stanford and Shock Trauma systems use a cut-off of 50% circumferential involvement to stratify Grade III aortic pseudoaneurysms. The Presley system used the length and location of pseudoaneurysms with a cutoff of 1 cm and location relative to the LSA. Based on the combination of these systems and hemodynamic status, the authors proposed an algorithm to better classify Grade III pseudoaneurysms as low risk or high-risk lesions. Low risk lesions are further classified depending upon size with small low-risk lesions being managed non-operatively and large low-risk lesions undergoing a delayed repair (9).

Spencer et al., at Orlando Regional Medical Center, retrospectively reviewed data from 71 BTAI patients and found that there was no progression of injury among Grade I-II BTAI patients with intramural aortic hematomas and that these patients could safely be managed non-operatively with appropriate follow-up CT scans (10).

Gandhi et al. retrospectively evaluated complications, mortality, and pseudoaneurysm imaging characteristics in 18 patients that underwent non-operative management (NOM) vs. 17 patients who underwent operative management using TEVAR (11). The TEVAR group had a higher number of procedural complications and similar rates of hospital complications. They concluded that certain Grade III pseudoaneurysms may be amenable to observation with continued imaging and short-term follow-up. Tanizaki et al. evaluated 18 Grade III pseudoaneurysm patients over a 9-year period and found no deaths were related to the aortic injury with a median follow-up of 41 months (12). Interestingly, they used a pseudoaneurysm to normal aortic diameter (P/N) ratio and found that an increased P/N ratio was associated with need for surgical repair.

A systematic review of 74 studies by the Canadian Society for Vascular Surgery in 2019 found that NOM was justified in Grade I-II BTAI due to relatively low rates of injury progression (7.8%) and need for operative intervention (3.4%) (13). Despite this, they found that only 40% of these injuries do not resolve over time with the caveat of having suboptimal follow-up. With regard to Grade III-IV injuries, they concluded that there were significantly higher rates of injury progression (23%) and need for operative intervention (9%). Of those studies with aortic-related death as an endpoint, they found that Grade I-II injuries had a 1% chance of aortic-related death while Grade III-IV had an 18% progression to death from their BTAI. Harleen et al. published a single-institution retrospective review evaluating determinants and outcomes of NOM (14). They found that later admission dates in younger patients and patients with a lower Injury Severity Score (ISS) were associated with need for TEVAR. As a result, they also recommended NOM of Grade I-II BTAI with need for additional investigation regarding appropriate follow-up. De mestral et al. demonstrated that there continues to be an increase in the number of patients who undergo NOM and a subsequent decrease in mortality (15). Delayed repair has also been shown to be associated with a reduced mortality compared to early repair (even after adjusting for confounding factors including ISS and admission physiology) advocating for re-evaluation of the current practice guidelines (16).

Given the relative paucity of data regarding follow-up and novelty of TEVAR, the RESCUE Trial was created to identify the outcomes related to endovascular repair. Using pre-selected grafts, the one-year results found that TEVAR had favorable outcomes in this short period. However, they also recommended continued studies to evaluate long-term outcomes associated with endovascular repair (17).

CONCLUSION

The management of BTAI remains a complex issue for which no universally accepted algorithm exists. The current SVS guidelines appear to be dated and there has been a shift away from operative repair in low grade injuries. TEVAR remains the standard of care in the appropriate clinical setting in patients with favorable anatomy. In all patients, stringent blood pressure management with impulse control is paramount. Given the recent shift in trends towards novel endovascular repair, close patient follow-up is required to investigate potential long-term complications associated with TEVAR compared to open repair. As a result, the Aortic Trauma Foundation was formed as a multicenter, multidisciplinary approach to investigate the management of BTAI (18).

REFERENCES

1. Mouawad NJ, Paulisin J, Hofmeister S, Thomas MB. Blunt thoracic aortic injury - concepts and management. J Cardiothorac Surg 2020; 15(1):62.
2. Sevitt S. The mechanisms of traumatic rupture of the thoracic aorta. Br J Surg 1977; 64(3):166-173.
3. Kato N, Hirano T, Ishida M, Shimono T, Cheng SH, Yada I, Takeda K. Acute and contained rupture of the descending thoracic aorta: treatment with endovascular stent grafts. J Vasc Surg 2003; 37(1):100-105.
4. Azizzadeh, A., et al. Blunt traumatic aortic injury: initial experience with endovascular repair. J Vasc Surg 2009; 49(6):1403-1408.
5. Lee WA, Matsumura JS, Mitchell RS, et al. Endovascular repair of traumatic thoracic aortic injury: clinical practice guidelines of the Society for Vascular Surgery. J Vasc Surg 2011; 53(1):187-192.
6. Baqué P, Serre T, Cheynel N, et al. An experimental cadaveric study for a better understanding of blunt traumatic aortic rupture. J Trauma 2006; 61(3):586-591.
7. Patel NR, Dick E, Batrick N, Jenkins M, Kashef E. Pearls and pitfalls in imaging of blunt traumatic thoracic aortic injury: a pictorial review. Br J Radiol 2018; 91:20180130.
8. Fox N, Schwartz D, Salazar JH, et al. Evaluation and management of blunt traumatic aortic injury: a practice management guideline from the Eastern Association for the Surgery of Trauma. J Trauma Acute Care Surg 2015; 78(1):136-146.
9. Harris DG, Rabin J, Starnes BW, et al. Evolution of lesion-specific management of blunt thoracic aortic injury. J Vasc Surg 2016; 64(2):500-505.
10. Spencer SM, Safcsak K, Smith CP, Cheatham ML, Bhullar IS. Nonoperative management rather than endovascular repair may be safe for grade II blunt traumatic aortic injuries: An 11-year retrospective analysis. J Trauma Acute Care Surg 2018 ;84(1):133-138.
11. Gandhi SS, Blas JV, Lee S, Eidt JF, Carsten CG. Nonoperative management of grade III blunt thoracic aortic injuries. J Vasc Surg 2016; 64(6):1580-1586.
12. Tanizaki S, Maeda S, Matano H, et al. Blunt thoracic aortic injury with small pseudoaneurysm may be managed by nonoperative treatment. J Vasc Surg 2016; 63(2):341-344.
13. Jacob-brassard J, Salata K, Kayssi A, et al. A systematic review of nonoperative management in blunt thoracic aortic injury. J Vasc Surg 2019; 70(5):1675-1681.
14. Harleen SK, Leonard SD, Perlick A, et al. Determinants and outcomes of nonoperative management for blunt traumatic aortic injuries. J Vasc Surg 2018; 67(2): 389-398.
15. De mestral C, Dueck A, Sharma SS, et al. Evolution of the incidence, management, and mortality of blunt thoracic aortic injury: a population-based analysis. J Am Coll Surg 2013; 216(6):1110-1115.
16. Marcaccio CL, Dumas RP, Huang Y, Yang W, Wang GJ, Holena DN. Delayed endovascular aortic repair is associated with reduced in-hospital mortality in patients with blunt thoracic aortic injury. J Vasc Surg 2018; 68(1):64-73.
17. Khoynezhad A, Donayre CE, Azizzadeh A, White R. One-year results of thoracic endovascular aortic repair for blunt thoracic aortic injury (RESCUE trial). J Thorac Cardiovasc Surg 2015; 149(1):155-161.
18. Challoumas D, Dimitrakakis G. Blunt Thoracic Aortic Injuries: New Perspectives in Management. Open Cardiovasc Med J 2015; 9:69-72.