

Blunt traumatic injuries of thoracic aorta and supra-aortic trunks - a narrative review

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ABSTRACT

INTRODUCTION: Blunt thoracic aortic injuries (BTAI) are defined as a tear in the thoracic aorta caused by a high energy blunt trauma. The most common reported mechanism of injury is motor vehicle accidents, and it can be potentially lethal. The Society for Vascular Surgery (SVS) and the European Society for Vascular Surgery (ESVS) guidelines recommend thoracic endovascular aortic repair (TEVAR) as the first line treatment for BTAI. Other controversies regarding BTAI management were reported in the literature, such as the best treatment for minimal aortic injuries with intimal tear, ideal stent graft oversizing, best timing for treatment and necessity to cover the left subclavian artery (LSA). The purpose of this review is to identify and analyze appropriate studies published so far about the management of BTAI.

METHODS: We performed a thorough electronic search of the literature using PubMed and Embase databases. We used the following combination of key words in our search strategy ((aortic injury) AND (blunt thoracic trauma)) AND (vascular surgery* OR treatment* OR TEVAR*). Articles not in English were excluded. The primary subject was results of endovascular treatment. Secondary subjects were indications and results of OSR, best timing for intervention, ideal graft oversizing, need for left subclavian artery (LSA) coverage, and management of BTAI grade I (intimal tear).

RESULTS: Data related to our primary and secondary subjects were extracted from the selected articles. TEVAR is considered the primary treatment for BTAI, if the patient has suitable anatomy, with good short and mid-term outcomes, with lower mortality and paraplegia rates at short and mid-term follow-up, compared to OSR. Despite good term results at short-term follow-up after TEVAR, long-term outcomes are still a concern. OSR is still a valid option in selected cases, and it should be considered for patients whose injury location is unsuitable for the endovascular approach. In most patients with BTAI, it is recommended around 10% of graft oversizing. However, a more aggressive approach with oversizing between 10-20% should be considered for patients with considerable hypotension and even >20% for patients presenting with severe hypotensive hemorrhagic shock. A necessity of LSA coverage has been reported in 30% of TEVAR for urgent treatment of BTAI, and it seems to be well tolerated. We should considered expectant approach with serial follow-up CT scans in patients with BTAI grade I injuries with asymptomatic intimal aortic tear.

CONCLUSIONS: This literature review reports and synthesizes published data about the management strategies for BTAI. TEVAR seems to be effective in the treatment of BTAI, with few complications and good outcomes at short and mid-term follow-up, and it should be the first-line treatment for these patients. OSR should be an option when a patient's injury is not suitable for endovascular approach.

Keywords: Aortic injury; Blunt thoracic trauma; TEVAR; Thoracic aorta; Supra-aortic trunks



INTRODUCTION

AbLunt thoracic aortic injuries (BTAI) are defined as a tear in the thoracic aorta caused by a high energy blunt trauma with sudden deceleration.^[1] They are the second most common cause of death in high-energy accidents, after traumatic brain injury.^[2,3] The most common reported mechanism of injury is motor vehicle accidents, with falls from a high height coming as second.^[4] The lesion is typically located at the aortic isthmus, which is the portion of the thoracic aorta more susceptible to the excessive stretching.

The initial diagnosis of BTAI can be difficult because these patients usually have other concomitant traumatic injuries^[5] and they can have a wide range of presentations, from no related symptoms, in case of a asymptomatic intimal tear, to a hemorrhagic shock from an aortic rupture.^[5] In fact, BTAI is potentially lethal, with some studies reporting up to 80% mortality before hospitalization and 46% in hospital mortality.^[2,3,6]

The severity classification system for BTAI divide them in 4 grades based on computed tomography angiography (CTA) imaging: grade I (intimal tear), grade II (intramural hematoma), grade III (pseudoaneurysm), and grade IV (rupture).^[7,8]

The Society for Vascular Surgery (SVS) and the European Society for Vascular Surgery (ESVS) guidelines recommend thoracic endovascular aortic repair (TEVAR) as the first line treatment for BTAI grade II-IV.^[7,9] TEVAR is considered the primary treatment approach for BTAI if the patients anatomy and injury location is suitable for the endovascular procedure,^[10-12] because it has lower postoperative mortality and paraplegia rates, compared to open surgery repair (OSR).^[8,13,14] Despite good term results at short-term follow-up after TEVAR, long-term outcomes are still a concern.

OSR should be considered for patients whose injury location is unsuitable for the endovascular approach, despite the already described higher postoperative morbidity and mortality rates.^[13,15,16]

Other controversies regarding BTAI management have been reported in the literature, such as the best treatment for minimal aortic injuries with intimal tear, ideal graft oversizing, best timing for treatment and necessity to cover the left subclavian artery (LSA).

The purpose of this review is to identify and analyze appropriate studies published so far about the management of BTAI.

METHODS

We performed a thorough electronic search of the literature using PubMed and Embase databases. We used the following combination of key words in our search strategy ((aortic injury) AND (blunt thoracic trauma)) AND (vascular surgery* OR treatment* OR TEVAR*). Articles not in English were excluded. No time restrictions were applied.

The primary subject was results of endovascular treatment. Secondary subjects were indications and results of OSR, best timing for intervention, ideal graft oversizing, need for left subclavian artery (LSA) coverage, and management of BTAI grade I (intimal tear).

Articles retrieved from the search were selected by title and abstract by the first author. Only full-length articles were considered for inclusion in this non-systematic, narrative review.

RESULTS

TEVAR is considered the primary treatment for BTAI, if the patient has suitable anatomy, with good short and mid-term outcomes.^[6,17-19] Lower mortality and paraplegia rates have been reported with TEVAR at short and mid-term follow-up, compared to OSR.^[20,21] However, long-term complications and patency of TEVAR remains unclear. Cheng et al studied a population of 287 patients in Taiwan, and they reported better long-term outcomes for TEVAR compared with OSR in perioperative morbidity and mortality rates, despite similar survival and reintervention rates after hospital discharge.^[15]

There are no certainties across published data about the ideal stent graft oversizing. In most patients with BTAI, it is recommended around 10% of graft oversizing. However, in patients presenting with significant hypotension, it should be considered around 0-20% of oversizing to decrease the risk of endoleak and graft migration after full resuscitation.^[22] Finally, in patients with severe hypotensive hemorrhagic shock due to aortic rupture from BTAI, an oversizing of >20% can be an option, but it has a risk of device collapse if the oversizing proves to be excessive.^[23]

There are different findings in the literature regarding the ideal timing for treatment of BTAI. In the past, some studies found evidence that in most patients who progressed to aortic rupture, it happened mostly in the first 24 hours.^[24] For that reason and because most diagnosed lesions were BTAI grade III and IV, immediate treatment was recommended for all patients with BTAI for many years. On the other hand, nowadays, with more diagnostic accuracy from CTA, it is possible to diagnose more patients with BTAI grade I and II. In fact, recently published studies found better outcomes for delayed intervention (after 24 hours), with lower morbidity and mortality rates, compared to early treatment (within 24 hours).^[17,25] Accordingly, Demetriades et al showed better results with delayed intervention, after 24h of presentation, in patients with BTAI and other major traumatic lesions requiring treatment.^[9] In the ESVS guidelines it is recommended emergent repair in patients with BTAI and free aortic rupture or patients with peri-aortic hematoma with 15mm or more. In all the other cases, it should be considered delayed intervention to allow treatment of other life-threatening injuries.^[9] Delayed intervention also allows proper stabilization of these patients. Therefore, the stent graft's measurements on CT imaging can be more accurate.

Recently, a necessity of LSA coverage has been reported in 30% of TEVAR for urgent treatment of BTAI.^[21] The recommendation of an ideal 20mm of proximal seal zone can be a reason for the need of LSA coverage. An article published in 2021 with a population of 61 patients who underwent TEVAR for BTAI treatment, showed that LSA coverage was well tolerated, but long-term consequences of LSA coverage are still uncertain.^[26] The decision of revascularization in these patients needing LSA coverage in an urgent TEVAR should be individualized, but it should be

strongly considered particularly when there is a dominant left vertebral artery, a previous left internal mammary coronary artery bypass graft, or the distal right vertebral segment is absent.^[27]

BTAI grade I injuries with asymptomatic intimal aortic tear should be treated with expectant approach with serial follow-up CT scans.^[2]

CONCLUSION

This literature review reports and synthesizes relevant published data on the management strategies for BTAI. TEVAR should generally be considered the first-line treatment for BTAI whenever invasive treatment is necessary, because it has lower morbidity and mortality rates and good short and mid-term postoperative results. However, long-term outcomes are still unclear. OSR can be a valid option in a patient whose injury location is unsuitable for endovascular treatment. Conservative management is an acceptable alternative for lesions limited to the intima (Grade 1).

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REFERENCES

- Gaffey AC, Zhang J, Saka E, Quatromoni JG, Glaser J, Kim P, et al. Natural History of Nonoperative Management of Grade II Blunt Thoracic Aortic Injury. *Ann Vasc Surg.* 2020;65:124-9
- Teixeira PG, Inaba K, Barmparas G, Georgiou C, Toms C, Noguchi TT, Rogers C, Sathyavagiswaran L, Demetriades D. Blunt thoracic aortic injuries: an autopsy study. *J Trauma.* 2011;70:197-202
- de Mestral C, Dueck A, Sharma SS, Haas B, Gomez D, Hsiao M, Hill A, Nathens AB. Evolution of the incidence, management, and mortality of blunt thoracic aortic injury: a population-based analysis. *J Am Coll Surg.* 2013;216:1110-5
- Hiller RJ, Mikocka-Walus AA, Cameron PA. Aortic transection: demographics, treatment and outcomes in Victoria, Australia. *Emerg Med J.* 2010;27:368-71
- Jahromi AS, Kazemi K, Safar HA, Doobay B, Cinà CS. Traumatic rupture of the thoracic aorta: cohort study and systematic review. *J Vasc Surg.* 2001;34:1029-34
- Sevitt S. The mechanisms of traumatic rupture of the thoracic aorta. *Br J Surg.* 1977;64:166-73
- Lee WA, Matsumura JS, Mitchell RS, Farber MA, Greenberg RK, Azizzadeh A, Murad MH, Fairman RM. Endovascular repair of traumatic thoracic aortic injury: clinical practice guidelines of the Society for Vascular Surgery. *J Vasc Surg.* 2011;53:187-92
- Azizzadeh A, Keyhani K, Miller CC 3rd, Coogan SM, Safi HJ, Estrera AL. Blunt traumatic aortic injury: initial experience with endovascular repair. *J Vasc Surg.* 2009;49:1403-8
- Riambau V, Böckler D, Brunkwall J, Cao P, Chiesa R, Coppi G, et al. Editor's Choice - Management of Descending Thoracic Aorta Diseases: Clinical Practice Guidelines of the European Society for Vascular Surgery (ESVS). *Eur J Vasc Endovasc Surg.* 2017;53:4-52.
- Scalea TM, Feliciano DV, DuBose JJ, Ottochian M, O'Connor JV, Morrison JJ. Blunt Thoracic Aortic Injury: Endovascular Repair Is Now the Standard. *J Am Coll Surg.* 2019;228:605-10
- Agostinelli A, Carino D, Borrello B, Marcato C, Volpi A, Gherli T, et al. Blunt traumatic injury to the thoracic aorta treated with thoracic endovascular aortic repair: a single-centre 20-year experience. *Interact Cardiovasc Thorac Surg.* 2019;28:17-22.
- van der Zee CP, Vainas T, van Brussel FA, Tielliu IF, Zeebregts CJ, van der Laan MJ. Endovascular treatment of traumatic thoracic aortic lesions: a systematic review and meta-analysis. *J Cardiovasc Surg (Torino).* 2019;60:100-10
- Tang GL, Tehrani HY, Usman A, Katariya K, Otero C, Perez E, Eskandari MK. Reduced mortality, paraplegia, and stroke with stent graft repair of blunt aortic transections: a modern meta-analysis. *J Vasc Surg.* 2008;47:671-5
- DuBose JJ, Charlton-Ouw K, Starnes B, Saqib N, Quiroga E, Morrison J, Gewertz B, Azizzadeh A; AAST/Aortic Trauma Foundation Study Group. Do patients with minimal blunt thoracic aortic injury require thoracic endovascular repair? *J Trauma Acute Care Surg.* 2021;90:384-7
- Cheng YT, Cheng CT, Wang SY, Wu VC, Chu PH, Chou AH, Chen CC, Ko PJ, Liu KS, Chen SW. Long-term Outcomes of Endovascular and Open Repair for Traumatic Thoracic Aortic Injury. *JAMA Netw Open.* 2019;2:e187861
- Mousa AY, Dombrovskiy VY, Haser PB, Graham AM, Vogel TR. Thoracic aortic trauma: outcomes and hospital resource utilization after endovascular and open repair. *Vascular.* 2010;18:250-5
- Estrera AL, Gochmour DC, Azizzadeh A, Miller CC 3rd, Coogan S, Charlton-Ouw K, et al. Progress in the treatment of blunt thoracic aortic injury: 12-year single-institution experience. *Ann Thorac Surg.* 2010;90:64-71
- Demetriades D, Velmahos GC, Scalea TM, Jurkovich GJ, Karmy-Jones R, Teixeira PG, et al. Operative repair or endovascular stent graft in blunt traumatic thoracic aortic injuries: results of an American Association for the Surgery of Trauma Multicenter Study. *J Trauma.* 2008;64:561-70
- Steuer J, Björck M, Sonesson B, Resch T, Dias N, Hultgren R, et al. Editor's Choice - Durability of Endovascular Repair in Blunt Traumatic Thoracic Aortic Injury: Long-Term Outcome from Four Tertiary Referral Centers. *Eur J Vasc Endovasc Surg.* 2015;50:460-5.
- Karmy-Jones R, Ferrigno L, Teso D, Long WB 3rd, Shackford S. Endovascular repair compared with operative repair of traumatic rupture of the thoracic aorta: a nonsystematic review and a plea for trauma-specific reporting guidelines. *J Trauma.* 2011;71:1059-72
- Hoffer EK, Forauer AR, Silas AM, Gemery JM. Endovascular stent-graft or open surgical repair for blunt thoracic aortic trauma: systematic review. *J Vasc Interv Radiol.* 2008;19:1153-64.
- Jonker FH, Verhagen HJ, Mojibian H, Davis KA, Moll FL, Muhs BE. Aortic endograft sizing in trauma patients with hemodynamic instability. *J Vasc Surg.* 2010;52:39-44
- Muhs BE, Balm R, White GH, Verhagen HJ. Anatomic factors associated with acute endograft collapse after Gore TAG treatment of thoracic aortic dissection or traumatic rupture. *J Vasc Surg.* 2007;45:655-61
- Fabian TC, Richardson JD, Croce MA, Smith JS Jr, Rodman G Jr, Kearney PA, et al. Prospective study of blunt aortic injury: Multicenter Trial of the American Association for the Surgery of Trauma. *J Trauma.* 1997;42:374-80
- Hemmila MR, Arbabi S, Rowe SA, Brandt MM, Wang SC, Taheri PA, et al. Delayed repair for blunt thoracic aortic injury: is it really equivalent to early repair? *J Trauma.* 2004;56:13-23
- Stafforini NA, Singh N, Hemingway J, Starnes B, Tran N, Quiroga E. Reevaluating the Need for Routine Coverage of the Left Subclavian Artery in Thoracic Blunt Aortic Injury. *Ann Vasc Surg.* 2021;73:22-6
- Matsumura JS, Lee WA, Mitchell RS, Farber MA, Murad MH, Lumsden AB, et al. The Society for Vascular Surgery Practice Guidelines: management of the left subclavian artery with thoracic endovascular aortic repair. *J Vasc Surg.* 2009;50:1155-8