Nonoperative management rather than endovascular repair may be safe for grade II blunt traumatic aortic injuries: An 11-year retrospective analysis

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Author Disclosures

The authors declare no conflicts of interest.

The present work did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Reviewer Disclosures

The reviewers have nothing to disclose.

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BACKGROUND: The Society of Vascular Surgery (SVS) guidelines currently suggest thoracic endovascular aortic repair (TEVAR) for grade II–IV and nonoperative management (NOM) for grade I blunt traumatic aortic injury (BTAI). However, there is increasing evidence that grade II may also be observed safely. The purpose of this study was to compare the outcome of TEVAR and NOM for grade I–IV BTAI and determine if grade II can be safely observed with NOM.

METHODS: The records of patients with BTAI from 2004 to 2015 at a Level I trauma center were retrospectively reviewed. Patients were separated into two groups: TEVAR versus NOM. All BTAIs were graded according to the SVS guidelines. Minimal aortic injury (MAI) was defined as BTAI grade I and II. Failure of NOM was defined as aortic rupture after admission or progression on subsequent computed tomography (CT) imaging requiring TEVAR or open thoracotomy repair (OTR). Statistical analysis was performed using Mann–Whitney U and χ^2 tests.

RESULTS: A total of 105 adult patients (≥16 years) with BTAI were identified over the 11-year period. Of these, 17 patients who died soon after arrival and 17 who underwent OTR were excluded. Of the remaining 71 patients, 30 had MAI (14 TEVAR vs. 16 NOM). There were no failures in either group. No patients with MAI in either group died from complications of aortic lesions. Follow-up CT imaging was performed on all MAI patients. Follow-up CT scans for all TEVAR patients showed stable stents with no leak. Follow-up CT in the NOM group showed progression in two patients neither required subsequent OTR or TEVAR.

CONCLUSIONS: Although the SVS guidelines suggest TEVAR for grade II–IV and NOM for grade I BTAI, NOM may be safely used in grade II BTAI. (*J Trauma Acute Care Surg.* 2018;84: 133–138. Copyright © 2017 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Therapeutic study, level IV.

KEY WORDS: NOM of BTAI grade I–II; blunt traumatic aortic injury; nonoperative management.

Blunt traumatic aortic injury (BTAI) is associated with significant mortality. Although it occurs in less than 1% of motor vehicle crashes (MVCs), it is the second leading cause of mortality for this mechanism of injury.[1] It is estimated that up to 80% of patients with BTAI will die before hospital arrival, and another 50% of those hospitalized will die within the first 24 hours after injury.[1–3] Therefore, early and accurate identification of patients with BTAI is imperative. The traditional screening method for BTAI was the portable anterior–posterior (AP) chest x-ray (CXR). However, the sensitivity of a CXR in identifying BTAI is as low as 41%.[4] As a result, computed tomography (CT) imaging of the chest has been increasingly used to screen for BTAI. As the efficiency of CT imaging has improved, more patients with minimal aortic injury (MAI) are being identified. The Society of Vascular Surgery (SVS) categorizes BTAI from grade I to grade IV: grade I, intimal tear; grade II, intramural hematoma; grade III, pseudoaneurysm; and grade IV, rupture. The SVS guidelines currently suggest thoracic endovascular aortic repair (TEVAR) for grade II–IV and nonoperative management (NOM) for grade I BTAI. However, there is limited but increasing evidence that grade II may be observed safely without TEVAR. This may in part be a result of the fact that the quality of evidence for the SVS recommendations is C (low or very low). The experience with NOM of grade I–II injuries is limited to small retrospective case series with short follow-up.[5–15] The purpose of this study is to compare the outcomes of TEVAR and NOM for grade I–IV BTAI and determine if grade II can be safely observed with NOM.

Submitted: March 6, 2017, Revised: May 17, 2017, Accepted: May 29, 2017, Published online: June 20, 2017.

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The study was presented at the 75th annual meeting of the American Association for the Surgery of Trauma, September 14–17, 2016, in Waikoloa, Hawaii.

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DOI: 10.1097/TA.0000000000001630

METHODS

This was a retrospective cohort study where the records of patients with BTAI from 2004 to 2015 at a Level I trauma center were reviewed. All patients with BTAI were evaluated in a multidisciplinary approach with the initial evaluation completed by the trauma team. Subsequent consultations were placed to cardiothoracic surgery, vascular surgery, and surgical critical care as needed. Based on the hemodynamic status of the patient and grade of injury, as determined by CT imaging of the chest, patients were taken either to the operating room for open thoracotomy repair (OTR), interventional radiology (IR) suite for TEVAR by either IR physicians or vascular surgery, or to the Surgical Intensive Care Unit for NOM. The method of repair, either OTR or TEVAR, was determined based on patient's hemodynamic status, associated injuries, and aortic anatomy in a joint effort by the IR and vascular surgery team. NOM patients were treated with short-acting intravenous beta-blocker infusion titrated to maintain systolic blood pressure less than 140 mm Hg and heart rate less than 80 bpm. Additional agents such as calcium channel blockers or vasodilators were added as needed. A majority of the patients underwent follow-up CT of the chest imaging before discharge to document resolution or stability of their injuries. Failure of NOM was defined as aortic rupture after admission or progression on follow-up CT imaging of the chest undergoing TEVAR or OTR. Aortic injury grade was determined by a single investigator (lead author) who was blinded to the readings of the radiologist; the designations were then verified by a separate investigator also blinded to the radiologist readings. Patients with MAI (grade I–II) were divided into two groups (TEVAR vs. NOM) comparing hospital length of stay (HLOS) and mortality as primary endpoints, and progression of grade of injury on follow-up CT scan and complications as secondary endpoints. Post-procedure follow-up care of the patients who had TEVAR and in-hospital follow-up care of the patients who had NOM were performed jointly by vascular surgery, IR, and the surgical critical care and acute care surgery teams.

Demographics, mechanism of injury, grade and location of thoracic aortic injury, method of repair, complications, HLOS, discharge disposition, and mortality were collected.

The detailed CT scan description of the BTAI documented by a board-certified radiologist was used to extrapolate the appropriate grade of injury based on the standard SVS grading system. All patients were followed through their hospital course until discharge. The majority of these patients had follow-up CT imaging of the chest before discharge. Post-discharge follow-up data were not available for review; all data presented are limited to in-hospital course until discharge.

The Institutional Review Board reviewed and approved the study protocol. Statistical analysis was performed using Mann–Whitney U and χ^2 tests. Data are reported as median with interquartile range or percentage. A value of $p < 0.05$ was considered statistically significant.

RESULTS

A total of 105 adult patients (age ≥16 years) with BTAI were identified over the 11-year period. Of these, 34 (32%) patients were excluded. Seventeen died soon after arrival from associated injuries before addressing their thoracic aortic injury and 17 underwent OTR. Intraoperative mortality from aortic rupture and uncontrolled hemorrhage was 3 (18%). The median time for all grade (I–IV) injuries from admission to completion of OTR was 10.2 (9–14) hours. The median HLOS for these patients was 12 (3–30) days with 30% mortality. OTR was rare, performed primarily in the early years of the study from 2004 to 2009. From 2009 to 2015, all BTAIs were managed with TEVAR or NOM.

Of the remaining 71 patients, 48 (68%) had TEVAR and 23 (32%) underwent NOM. Patient demographics along with the distribution of BTAI by grade is listed in Table 1. There were no differences between the groups with regard to age, gender, overall Injury Severity Score (ISS), or mechanism of injury. However, both groups consisted predominantly of men and the primary mechanism of injury was MVC. It is not surprising there was an inverse relationship of the BTAI grades between the two groups. TEVAR had a significant higher number of grade IV whereas NOM had a higher number of grade I and grade II BTAI. The Abbreviated Injury Score (AIS)–chest was significantly higher in the TEVAR group (Table 1). The failure rate after TEVAR and NOM was 0%. There was no difference in HLOS [18 (8–24) vs. 11 (6–31) days; $p = 0.44$], discharge disposition, or mortality between the groups.

In Table 2, patients with only MAI (grade I–II) were selected for comparison; TEVAR (n = 14) versus NOM (n = 16). MAI (grade I–II) was present in 14 of the TEVAR patients and 16 NOM patients (Fig. 1). Patient demographics for these two groups are listed in Table 1. The groups were well matched in age, gender, ISS, AIS–chest, and mechanism of injury. The primary mechanism of injury in both groups was MVC. There was no difference between the groups in the number of grade I or II BTAI. There were no isolated BTAIs in either group. BTAI receiving TEVAR had a higher incidence of associated traumatic brain injury (TBI) and orthopedic fractures where BTAI receiving NOM had more rib and spinal fractures. There was no difference between the groups from emergency room admission until completion of the first CT imaging of the chest. The most common location of aortic injury in the TEVAR group was descending aorta and the isthmus in the NOM group (Table 2). The median time from admission to the completion of the TEVAR procedure was 10 (6–26) hours. Two patients (one grade I and one grade II) had their TEVAR procedures delayed for 11 and 18 days, respectively, until significant infections were cleared.

TABLE 1. Demographics for TEVAR Versus NOM With BTAI Grade I–II

	TEVAR	NOM	*p*
Patients (n)	14	16	
Men	11 (79%)	8 (50%)	0.21
Women	3 (21%)	8 (50%)	0.21
Age, y	52 (32–65)	43 (37–66)	0.88
ISS	35 (25–44)	29 (17–29)	0.14
AIS–chest	4 (4–4)	4 (2–4)	1.0
Overall mortality	2 (14%)	1 (6%)	0.90
D/C home	2 (14%)	4 (25%)	0.78
D/C rehab/SNF	10 (72%)	11 (69%)	0.87
Grade of injury			
Grade I	8 (57%)	8 (50%)	0.81
Grade II	6 (43%)	8 (50%)	0.98
Mechanism of injury			
MVC	10 (71%)	11 (69%)	0.87
MCC	0 (0%)	2 (13%)	0.52
Peds	4 (29%)	2 (13%)	0.25
Fall	0 (0%)	1 (5%)	0.34
Associated injury*			
Rib fractures	57%	63%	1.00
TBI	71%	25%	0.19
Orthopedic fractures	71%	63%	1.00
Spine fractures	36%	44%	1.00
PTX, HTX	36%	25%	0.72
Solid organ (liver, spleen, kidney)	33%	31%	1.00

Data reported as median with (interquartile range) or total count with (percentage).

TEVAR, thoracic endovascular aortic repair; NOM, nonoperative management; BTAI, blunt traumatic aortic injury; ISS, Injury Severity Score; AIS, Abbreviated Injury Score; D/C, discharge; Rehab, rehabilitation facility; SNF, skilled nursing facility; MVC, motor vehicle crash; MCC, motorcycle crash; Peds, pedestrian vs. automobile crash; TBI, traumatic brain injury; PTX, pneumothorax; HTX, hemothorax.

*Totals will not equal 100%. Each patient may have one or more associated injury.

No patients with MAI died from complications related to their aortic lesion. Two patients who underwent TEVAR and one patient who underwent NOM died from devastating TBI and subsequent withdrawal of care. There was no difference in mortality between the two groups. Of the remaining patients, there was no significant difference in discharge disposition. Although our data did not reach significance, patients requiring a TEVAR had a HLOS nearly twice as long as the NOM group [20 (9–33) vs. 11 (5–24) days, $p = 0.20$].

Follow-up CT imaging of the chest was performed before discharge on the majority of MAI patients (14/16 [88%] NOM and 13/14 [93%] TEVAR). There was no difference between the two groups for median time from admission to first CT or from admission to follow-up CT (Table 2). Follow-up CT imaging of all patients in the TEVAR group showed stable stents with no leak. Follow-up CT imaging in the NOM group showed progression in two patients (one from grade I to II, and one from grade II to III), no change in 11, and resolution in three grade I injuries (Table 2). None of the progressions required OTR or TEVAR.

TABLE 2. TEVAR Versus NOM With BTAI Grade I–II: CT Imaging Results

	TEVAR	NOM	*p*
Patients (n)	14	16	
Location of injury			
Ascending aorta	0%	0%	1.0
Aortic arch	2 (14%)	2 (12%)	0.89
Isthmus	5 (36%)	8 (50%)	0.68
Descending aorta	7 (50%)	6 (38%)	0.75
Time from admission to first CT, min	64 (37–103)	52 (35–73)	0.27
Time from admission to F/U CT during hospitalization, d	2 (2–7)	3 (2–7)	0.66
Resolution of injury		19%	
No change in injury		69%	
Progression of injury		12%	
Stable stent with no leak	100%		

Data reported as median with (interquartile range) or total count with (percentage).
F/U, follow-up; CT, computed tomography; TBI, traumatic brain injury.

Complications in the NOM group included one pulmonary embolism and one myocardial infarction. Both patients had a grade I injury and recovered without sequela. In the TEVAR group, one patient (grade I) had atrial fibrillation, which responded to medical management and another patient (grade I) required repair of a collapsing stent at the proximal end. Both patients were discharged to a rehabilitation center. Neither group had patients who suffered paralysis resulting from BTAI treatment.

DISCUSSION

BTAI is a lethal clinical problem and prompt diagnosis and treatment is imperative. CT imaging of the chest is frequently used to screen for BTAI based on mechanism of injury.[4] This shift in practice is in part caused by the poor sensitivity of the AP CXR to diagnose BTAI. Increased CT imaging use and quality have led to more frequent diagnoses of MAI, grade I–II. SVS guidelines suggest TEVAR for grade II–IV BTAI and NOM for grade I.[6] However, there is limited but increasing evidence that grade II may also be observed safely without TEVAR (Table 3). In this study, we demonstrated that 16 patients with MAI (8 grade I and 8 grade II) were safely observed with NOM and none required operative intervention before discharge from the hospital. Follow-up CT before discharge from the hospital in the NOM group showed progression in 2 patients (one from grade I to II, and one from grade II to III), no change in 11, and resolution in 3 grade I injuries (Table 2). None of the progressions required OTR or TEVAR. However, this study is limited by its lack of power, small numbers, and no long-term follow-up beyond hospital course. Long-term follow-up is critical before any conclusions regarding safety of NOM of grade II injuries.

The decision for TEVAR versus NOM was determined based on patient's hemodynamic status, associated injuries, and aortic anatomy in a joint effort by the IR and vascular surgery team. One of the associated injuries that would greatly benefit from TEVAR as opposed to NOM was TBI. Patients with NOM required tight blood pressure control and avoidance of hypertension, which was achieved with short-acting intravenous beta-blocker infusions, calcium channel blockers, or vasodilators as needed. However, this end point is in direct contradiction with cerebral perfusion pressure goals that need to be maintained, at times with the addition of inotropic support, in patients with TBI. TEVAR would remove such conflicts and allow cerebral perfusion pressure goals to be achieved without risk of rupture. This may have contributed to the much higher rate of TEVAR versus NOM noted in patients with associated TBI (71% vs. 25%, $p = 0.19$) (Table 1).

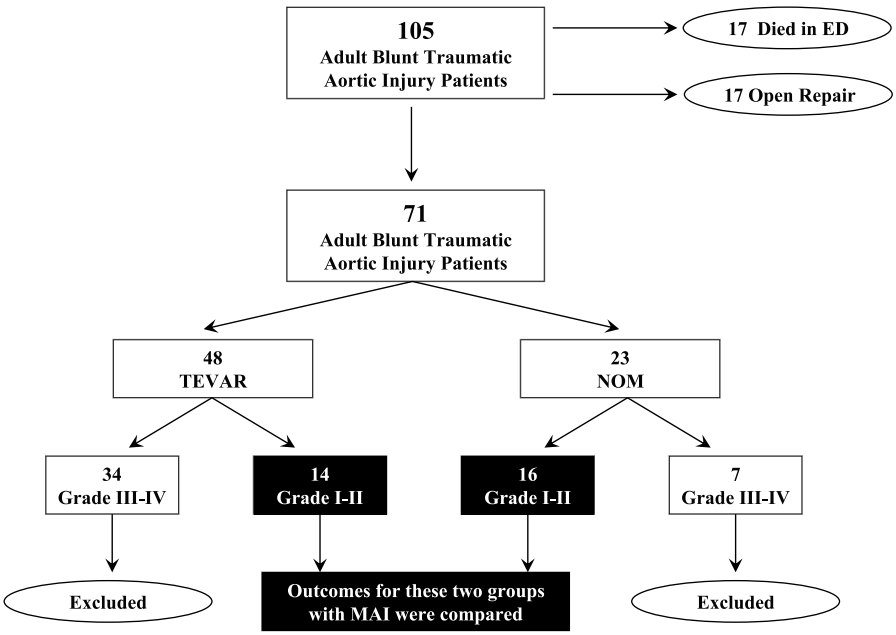

Figure 1. Flow chart of the patient groups with MAI (grade I–II) compared in the study. ED, emergency department; TEVAR, thoracic endovascular aortic repair; NOM, nonoperative management; MAI, minimal aortic injury.

TABLE 3. Retrospective Studies With NOM of MAI (Grade I–II)

Author	Year	NOM Grade I (n)	NOM Grade II (n)	Resolution n (%)	Progression of Injury Requiring TEVAR or Operative Repair
Malhotra et al.	2001	6		2 (33%)	
Kepros et al.	2002	5		5 (100%)	
Holmes et al.	2002	10		5 (50%)	
Caffarelli et al.	2010	6	2	5 (19%)	1 grade III progressed and required OTR
Starnes et al.	2012	16	2	14 (44%)	
Shalhub et al.	2012	6	3	6 (67%)	

TEVAR, thoracic endovascular aortic repair; NOM, nonoperative management; MAI, minimal aortic injury; OTR, open thoracotomy repair.

From 2001 to 2002, three retrospective studies observed a total of 21 patients with grade I BTAI with NOM.[7,10,15] None of the patients died from causes related to the BTAI. Subsequent CT imaging of the chest reported resolution of the injury in 33–50%, no change in 0–17%, and progression to stable pseudoaneurysm in 0–50%. None of the patients progressed to a point that required operative intervention. In 2012, Shalhub et al. observed nine (six grade I and three grade II) BTAI patients with NOM.[14] Follow-up CT imaging of the chest in the nine patients showed resolution of six (67%) (five grade I and one grade II) and stable findings in three (one grade I and two grade II). None of the grade I or II injuries progressed to a point that required TEVAR or OTR. Our results corroborate the previous findings. Two studies have attempted NOM of grade I–III injuries. In 2010, Caffarelli et al. reported 27 patients with BTAI (6 grade I, 2 grade II, and 19 grade III) that were observed with NOM.[13] Follow-up CT imaging of the chest found a 19% (5 patients) resolution rate, 78% (21 patients) stable injury rate, and 4% (1 patient) progression rate. One of the grade III patients did fail NOM by demonstrating progression of the initial pseudoaneurysm to a larger, more unstable lesion that required OTR. None of the grade I or II failed NOM. In the second study by Starnes et al. in 2012, NOM was performed for 26 patients who survived (17 grade I, 2 grade II, and 7 grade III).[9] Five of the seven grade III had an average follow-up 75 days, and all remained stable with no progressions. None of the grade II failed NOM requiring TEVAR or OTR. We also had seven grade III patients in our study who underwent NOM. These patients had concomitant injuries that precluded vascular intervention or anatomy that was not compatible with available stents. All of them had stable injuries on follow-up CT imaging of the chest and none required TEVAR or OTR.

Long-term follow-up data have been provided by a limited number of studies. In 2002, Holmes et al. reported the results of 15 patients with MAI who underwent NOM and were followed long term (up to 5 years).[15] Five died because of TBI and causes not related to the BTAI. The remaining 10 survivors were alive at a median of 2.5 years (range 6 months to 5 years) without progression of injury or the need for operation. Five of the 10 had complete radiographic resolution of their injuries and 5 had asymptomatic and radiographically stable pseudoaneurysms. In the study by Caffarelli et al. discussed above, serial long-term imaging was performed an average of 107 days after injury.[13] Stanes et al. performed follow-up imaging an average 71 days (2–196 days) after grade I, 745 days (6–1840 days) after grade II, and 75 days (12–68) after grade III injuries that had NOM.[9]

In 2015, a multicenter study by DuBose et al. incorporated nine American College of Surgeons–verified Level I centers to report the largest series of BTAI outcomes.[16] Of the 123 patients (32%) who had NOM (72 grade I, 19 grade II, 25 grade III, and 7 grade 4), 1 grade I (1.4%) and 1 grade IV (14.2%) required salvage TEVAR. Univariate analysis against patients undergoing repair indicated that those undergoing NOM were significantly older, more likely to be grade I, and less likely to have associated mediastinal hematoma. As a group, they had shorter hospital and intensive care unit stays and fewer ventilator days. Although our data did not reach significance, we also found that patients who underwent TEVAR had a HLOS nearly twice as long as the NOM group [20 (9–33) vs. 11 (5–24) days; $p = 0.20$]. Eight patients with grade I BTAI had TEVAR. Two patients (one grade I and one grade II) had their TEVAR procedures delayed for 11 and 18 days, respectively, until significant infections could be cleared. This raises the question of whether TEVAR was even necessary in these patients. Given the small numbers in each of the above studies, including our own, further multicenter studies are needed to answer the question regarding NOM of MAI. Future studies need to also determine the need for TEVAR in patients with grade I because avoiding this procedure may significantly decrease cost and risk to patients.

Advancements in CT scan technology have led to faster, higher quality images with 3D reconstructions that were not previously possible. This greater sensitivity may in part be contributing to the higher incidence of MAI noted in recent years.

CONCLUSIONS

Although SVS guidelines suggest TEVAR for grade II–IV BTAI and NOM only for grade I injuries, grade II injuries may be safely managed using NOM. Given the small patient population, future multicenter studies with long-term follow-up will be needed to evaluate which grades can be safely observed with NOM.

AUTHORSHIP

S.S.: literature search, study design, data collection, writing. K.S.: study design, data collection, data analysis, data interpretation, writing, figure, tables, editing, corrections, and submission. C.P.S.: study design, data collection, editing. M.L.C.: study design, data analysis, data interpretation, writing, figure, tables, and editing. I.S.B.: literature search, study design, data collection, data analysis, data interpretation, writing, figure, tables, editing, corrections, and submission.

DISCLOSURE

The authors declare no conflicts of interest.

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