Parameters for successful nonoperative management of traumatic aortic injury

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Objective: Blunt traumatic aortic injury is associated with significant mortality, and increased computed tomography use identifies injuries not previously detected. This study sought to define parameters identifying patients who can benefit from medical management.

Methods: We reviewed 4.5 years of blunt traumatic aortic injuries. Injury was classified as grade I (intimal flap or intramural hematoma), II (small pseudoaneurysm <50% circumference), III (large pseudoaneurysm >50% circumference), and IV (rupture/transection). Secondary signs of injury included pseudocoarctation, extensive mediastinal hematoma, and large left hemothorax. Follow-up, including computed tomography, was reviewed.

Results: We identified 97 patients: 31 grade I, 35 grade II, 24 grade III, and 7 grade IV; 67(69%) male; mean age 47 ± 18.8 years, mean Injury Severity Score 38.8 ± 14.6; overall survival 76 (78.4%). Secondary signs of injury were found in 30 patients. Overall, 52 (53.6%) underwent repair, 45 undergoing thoracic endovascular aortic repair, with 2 (2.22%) procedure-related deaths, and 7 undergoing open repair. Five patients undergoing thoracic endovascular aortic repair required 7 additional procedures. In 45 medically managed patients, there were 14 deaths (31%), all secondary to associated injuries. Injury Severity Scores of survivors and nonsurvivors were 33 ± 10.8 and 48.6 ± 12.8, respectively ($P < .001$). Follow-up showed resolution or no change in 21 (91%) and a small increase in 2 grade I injuries.

Conclusions: All blunt traumatic aortic injury does not necessitate repair. Stratification by injury grade and secondary signs of injury identifies patients appropriate for medical management. Grade IV injury necessitates emergency procedures and carries high mortality. Grade III injury with secondary signs of injury should be urgently repaired; patients without secondary signs of injury may undergo delayed repair. Grade I and II injuries are amenable to medical management. (J Thorac Cardiovasc Surg 2014;147:143-50)

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The natural history of blunt traumatic aortic injury (BTAI) was described in a landmark article by Parmley and colleagues[1] defining early operative repair, often with cardiopulmonary bypass, as the standard of care.[1] This strategy, however, was associated with significant morbidity and mortality. Alternative management strategies have evolved, including medical management, delayed operative repair, and thoracic endovascular aortic repair (TEVAR).

BTAI is a spectrum from minimal to severe injury. Because of the increased resolution of the newer generation of computed tomographic (CT) scans, the initial trauma evaluation can now identify aortic injuries that previously would have not been detected. In multiply injured patients, BTAI may not be an isolated finding but rather associated with other significant, potentially life-threatening injuries. In these patients the treatment and the timing of operative intervention if indicated must be considered in light of the associated injuries. Treatment of BTAI may be of relatively low priority and best delayed until other injuries have been stabilized.

A number of grading systems for BTAI exist. It would be ideal if the grade of injury were related to injury severity and predicted the need for therapy. This study therefore sought to define a clinically useful grading system for BTAI and demonstrate its use to guide therapy.

MATERIALS AND METHODS

The institutional review board of the University of Maryland approved this retrospective study. All patients admitted with BTAI to the University of Maryland Shock Trauma Center between June 2007 and December 2011 were identified through the trauma registry. Exclusion criteria included age younger than 15 years, arrival in extremis precluding imaging, and initial operation at another facility with subsequent transfer. Medical records, imaging, and operative reports were reviewed. Demographic data, mechanism of injury, Injury Severity Score (ISS), admission vital signs, and associated injuries were abstracted. Additional data regarding management of the aortic injury, including time to intervention if performed, treatment of associated traumatic injuries, and complications and outcomes, were recorded.

All CT scans were reviewed with a faculty trauma radiologist. Aortic injuries were classified as follows: grade I indicated an intimal tear or intramural hematoma, grade II indicated a small pseudoaneurysm (<50% of the

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Abbreviations and Acronyms

AAST	= American Association for the Surgery of Trauma
BTAI	= blunt traumatic aortic injury
CT	= computed tomography
ISS	= Injury Severity Score
SSI	= secondary signs of injury
TEVAR	= thoracic endovascular aortic repair
TBI	= traumatic brain injury

aortic circumference), grade III indicated a large pseudoaneurysm (>50% of the aortic circumference), and grade IV indicated rupture or transection (Figure 1).

Secondary signs of injury (SSI) on chest CT, defined as pseudocoarctation, mediastinal hematoma with mass effect, and large left hemothorax, were identified and recorded (Figure 2). The presence of a mediastinal hematoma, regardless of size, without mass effect was not considered to represent SSI.

Once the diagnosis of an aortic injury was made, hemodynamically stable patients were treated with β-blockers, usually intravenous esmolol hydrochloride (INN esmolol). Although there was no rigidly defined algorithm, in general the treatment of the BTAI was based on the severity of the aortic injury, the concomitant associated injuries, and the hemodynamic stability. Treatment of life-threatening injuries took precedence. One of two approaches was chosen to repair BTAI. An open procedure was performed through a left thoracotomy with cardiopulmonary bypass support, or TEVAR was performed with general anesthesia in the operating room with real-time fluoroscopic control. A dedicated chest CT angiogram was used as the follow-up imaging modality.

Data are presented as mean ± SD. The Student *t* test was used to compare groups.

RESULTS

Ninety-seven patients met inclusion criteria. The average age and ISS were 47 ± 18.8 years and 38.8 ± 14.6, respectively. Sixty-seven (69%) were male. The mechanism of injury included motor vehicle collisions (69%), motorcycle or all-terrain vehicle collisions (11%), falls (10%), pedestrians struck by a vehicle (8%), and crush injuries (1%). Seventy-eight patients were transported from the field, with the remainder transferred to our facility before operative therapy for BTAI. Associated injuries were common; 34% had a pelvic fracture, 30% had traumatic brain injury (TBI), and 23% required laparotomy (Table 1).

There were 31 grade I injuries, 35 grade II injuries, 24 grade III injuries, and 7 grade IV injuries. Twenty patients (21%) were hypotensive (systolic blood pressure <90 mm Hg) on arrival to our facility. Four patients who had sustained multiple injuries and presented in cardiac arrest were resuscitated but subsequently died of associated injuries. SSI included a large left hemothorax in 7 patients, pseudocoarctation in 15, and a large mediastinal hematoma with mass effect in 26 patients. Overall, 30 patients (31%) had SSI, with 13 exhibiting 2 or more SSI findings. Findings of SSI (and multiple SSI) were more common in patients with higher-grade aortic injury (Table 2). Anatomic aortic variants were identified in 39 patients (40%). Bovine arch was the most common variant, followed by an anomalous origin of the arch vasculature. There was no correlation between the grade of aortic injury and the incidence of anatomic aortic variants.

Twenty-eight patients with grade I injuries (90%) were treated medically, and 3 underwent TEVAR. The mortality for grade I injuries was 13%, with no aortic-related mortality. Among those with grade II injuries, 13 patients were managed medically, with the remainder undergoing TEVAR. The mortality for grade II injuries was 20%, with 1 aortic-related death occurring after TEVAR. Of the 24 patients with a grade III BTAI, 4 were managed nonoperatively, 18 underwent TEVAR, and 2 underwent an open procedure. Mortality in this group was 21%. No deaths were the result of the aortic injury or its treatment. Seven patients sustained grade IV injuries, with a 71% mortality, all the result of the aortic injury. Interestingly, the 4 patients with grade IV injuries who were normotensive on arrival died, whereas 2 of the remaining 3 arriving in shock survived. All 7 of the grade IV injuries were repaired, 5 open and 2 with TEVAR (Table 2).

Stratifying patients by treatment regimen, 45 (46%) were managed medically and 52 (54%) had either an open procedure (n = 7) or TEVAR (n = 45). Among those managed medically, there were 14 deaths (31%), all the result of associated injuries, including severe TBI, abdominal injury, or pelvic trauma. Among those managed medically, nonsurvivors had a significantly higher ISS than did survivors (48.6 ± 12.8 vs 33.0 ± 10.8; $P < .0001$). There were no aortic-related deaths, ruptures, complications, or emergency interventions among those managed medically.

Fifty-two patients were treated with either TEVAR or an open procedure, with an overall survival of 87%. TEVAR was used in 45 patients (87%), with a 93% survival. There were 2 potentially aortic-related mortalities, 1 each among those with grade II and IV lesions. One patient with a previous left internal thoracic artery bypass graft to his left anterior descending coronary artery had a cardiac arrest and died after a very challenging TEVAR procedure in which the left subclavian artery was covered by the stent graft. Another patient with an isolated BTAI had acute renal failure and ventricular fibrillation develop within 24 hours of TEVAR. Neither could be resuscitated. One additional death occurred on hospital day 5 from intra-abdominal sepsis after damage-control laparotomy.

There were 13 procedural complications in 11 patients after TEVAR, for a total complication rate of 24%. These included 3 endoleaks, 3 vascular site complications, and a retained guidewire in 5 patients who required 7 additional interventions, including 1 open aortic repair on bypass.

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