Blunt thoracic aortic injury with small pseudoaneurysm may be managed by nonoperative treatment

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Objective: **The efficacy of nonoperative management of blunt thoracic aortic injury (BTAI) was evaluated in patients with pseudoaneurysm.**
Methods: **A retrospective review was done for patients with BTAI at Fukui Prefectural Hospital during a 9-year period. Charts were reviewed for age, gender, Injury Severity Score, Abbreviated Injury Scale for each body area, initial type of aortic injury, site of aortic injury, type of definitive management, complications, and outcomes.**
Results: **Eighteen patients with BTAI were treated at Fukui Prefectural Hospital. Of 18 patients with pseudoaneurysm, seven patients were hemodynamically unstable and four patients died because of associated injuries; there were no aortic-related deaths. All 14 surviving patients were followed up for an average of 40.9 months. Only two patients with pseudoaneurysm required operative management because of the progression of the pseudoaneurysm. The pseudoaneurysm/normal aortic diameter ratio of those with any intervention was higher than that of those with nonoperative management.**
Conclusions: **BTAI with pseudoaneurysm can be managed nonoperatively, with about 10% risk of progression to require surgical repair. (J Vasc Surg 2016;63:341-4.)**

Blunt thoracic aortic injury (BTAI) is the leading cause of death after blunt multiple trauma.[1] Since the classic autopsy series by Parmley et al[2] in 1958, prompt diagnosis and early operative repair, often with cardiopulmonary bypass, have been the standard of care. This strategy was associated with significant morbidity and mortality. Rabin et al[3] reported that early aortic repair in patients with concurrent BTAI and traumatic brain injury is associated with progressive head injury regardless of repair modality. Alternative management of this injury has evolved, including thoracic endovascular aortic repair (TEVAR), delayed surgical repair, and nonoperative management in select cases. In multiply injured patients, BTAI may not be an isolated injury but rather associated with other significant life-threatening injuries. In these patients, the timing of operative intervention must be considered with the associated injuries.

Nonoperative management has traditionally been reserved for those patients who have contraindications to open repair, primarily to temporize until definitive surgical repair or TEVAR could be undertaken. Little is known about the outcomes of deliberate nonoperative management except through subgroup analysis of nonsurgical candidates. Nonoperative management of patients with minimal aortic injuries[4-8] or with major concurrent injuries has recently been reported.[9-12] However, appropriate selection of patients remains challenging and must balance poorer outcome associated with emergency repair against the risk of aortic rupture.

The safety of conservative management of patients with more severe aortic injuries, including pseudoaneurysm, and its effect on outcomes are poorly documented. Our institution has practiced nonoperative management of BTAI during the past couple of decades. Treatment of BTAI in our institution has been considered to be of relatively low priority in multiple trauma patients. The institutional paradigm has not shifted during this time. Injuries are managed medically with surveillance imaging with computed tomography (CT) to evaluate progression. Therefore, the purpose of this study was to evaluate the efficacy of nonoperative management of the patients with pseudoaneurysms.

METHODS

The Institutional Review Board of Fukui Prefectural Hospital approved this retrospective study, with the need for patient consent waived given the retrospective design. We reviewed a consecutive series of 18 patients with BTAI admitted to Fukui Prefectural Hospital from April 1, 2006, through March 31, 2015. Patient data were obtained from hospital records, and all patients with BTAI were included in this study. There were no patients who were automatically excluded from BTAI. The starting date for this retrospective study was 2006 as sufficient clinical records before 2006 were not obtained because of the change of the hospital's record system. Patients with injuries limited to a major branch of the aorta, such as the innominate or subclavian arteries, were also excluded

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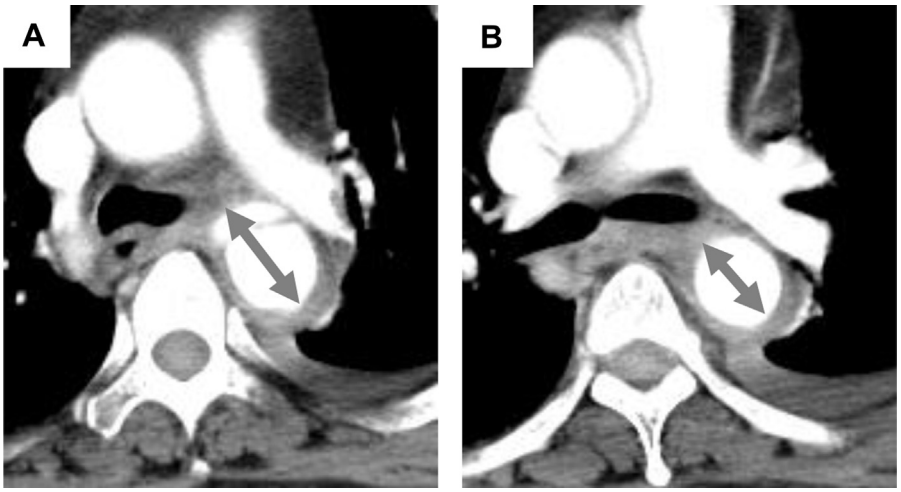

Fig 1. Radiographic findings included **(A)** pseudoaneurysm maximal width and **(B)** normal aortic diameter (*double arrowhead*).

from the review. Data examined were age, gender, Injury Severity Score, and Abbreviated Injury Scale for each body area (head, abdomen, and pelvis). Additional data regarding initial type of aortic injury, site of aortic injury (ascending aorta, aortic arch, aortic isthmus, or descending thoracic aorta), type of definitive management (conservative, open repair, or endovascular repair), and complications and outcomes were recorded.

All CT scans were reviewed together with two radiologists and a cardiovascular surgeon. Aortic injuries were classified as follows by the Society for Vascular Surgery: grade I indicated an intimal tear, grade II indicated an intramural hematoma, grade III indicated pseudoaneurysm, and grade IV indicated rupture or transection.[10] The pseudoaneurysm maximal width/normal aortic diameter (P/N) ratio was calculated on arrival (Fig 1). The normal aortic size was defined as the diameter of the aorta just distal to the injury. The treatment of the BTAI patients was based on the severity of the aortic injury, the concomitant associated injuries, and the hemodynamic status. Treatment of life-threatening injuries took precedence.

Dedicated chest CT angiography was used as the follow-up imaging modality. Serial CT was performed at 24 hours and then every 48 to 72 hours until the aortic injury was unchanged for 7 days. Absence of imaging characteristics of aortic instability (ie, pseudoaneurysm progression) prompted continued nonoperative management. Any increase in size of the pseudoaneurysm was used to switch to surgical management. Regular radiographic follow-up was indicated after discharge with a control thoracic CT scan at 1 month, 3 months, 6 months, and 12 months. Subsequent imaging would be annual unless the condition resolved or evolved into a lesion requiring repair. There was no concern about long-term radiation effects. Other imaging, such as magnetic resonance angiography, was not considered to reduce radiation. If nonoperative management was unsuccessful, open repair through a left thoracotomy with cardiopulmonary bypass support or TEVAR was performed in the operating room with general anesthesia. An open procedure was performed before the introduction of TEVAR. The decision for the management of BTAI in this series was based on the judgment of the attending vascular surgeon.

Continuous variables were presented as mean ± standard deviation. Continuous variables were compared using Student *t*-test. Significance was defined as $P < .05$.

RESULTS

During the 9-year study period, 18 patients with BTAI were identified (Fig 2). Of the 18 patients, 12 were male and 6 were female (Table I). The average age and Injury Severity Score were 58.2 years (range, 24-88 years) and 32.8 years (range, 16-50 years), respectively. Associated injuries were common; five had traumatic brain injury, five had pelvic trauma, and five had abdominal solid organ injuries. The distribution of injuries by location was as follows: aortic isthmus (n = 17); descending thoracic aorta (n = 1). Seven patients were hemodynamically unstable because of trauma other than aortic injury: two splenic injuries, one hepatic injury, three pelvic fractures, and one right femur amputation.

There were only grade III injuries. The grade of BTAI showed a good interobserver variability of 0.75 (95% confidence interval, 0.520-0.979). Of the 18 patients with grade III injuries, 16 were managed nonoperatively, 1 underwent TEVAR, and 1 underwent an open procedure. There were no patients who were managed with either TEVAR or open repair as initial management. There were no procedural complications and no deaths in the two patients who underwent TEVAR or open surgery. Of the 16 patients managed nonoperatively, 4 patients died because of associated injuries, 3 died because of severe brain injury after 2 days, and 1 died because of severe lung injury after 7 days. In-hospital mortality in this group was

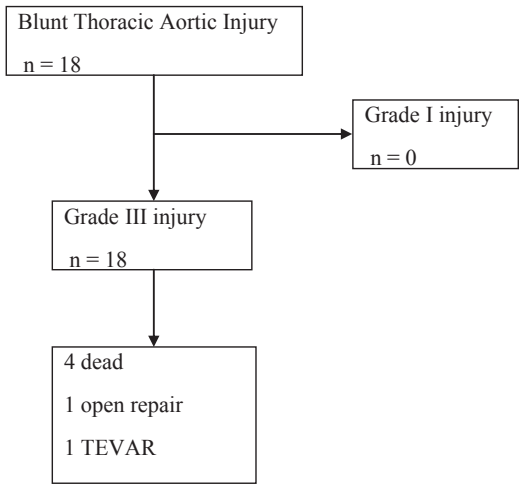

Fig 2. Patient selection and study groups. *TEVAR*, Thoracic endovascular aortic repair.

Table I. Demographic characteristics of 18 patients with blunt thoracic aortic injury (BTAI)

Characteristic	
Age (range), years	58.2 (24-88)
Male	12
ISS (range)	32.8 (16-50)
Associated injuries, No.	
Major head injury (AIS > 3)	5
Major abdominal injury (AIS > 3)	5
Major pelvic injury (AIS > 3)	5

AIS, Abbreviated Injury Scale; *ISS*, Injury Severity Score.

22%, with no aortic-related mortality. No deaths were the result of aortic injury or procedure.

Fourteen surviving patients were followed up for an average of 40.9 months (range, 3.1-79 months). One patient died because of brain hemorrhage in another medical facility after 3.1 months of injury. All other patients had longer duration of follow-up than 12 months (Table II). Six grade III injuries were resolved. Six grade III injuries were unchanged but did not require intervention. Two patients in grade III had progression of pseudoaneurysm. One patient required open surgery 3 months after injury, and another patient underwent TEVAR 7 days after injury. Of 18 patients with grade III BTAI managed nonoperatively, only 2 eventually required repair. Patients with grade III BTAI managed nonoperatively had an 11% risk of progressing to require surgical repair.

The P/N ratio of the patients with nonoperative management was 1.41; the P/N ratio of those with open surgery or TEVAR was 1.99 ($P < .001$; Table II).

Table II. Actual numerical values of pseudoaneurysm/normal aortic diameter (*P/N*) ratios, actual duration of follow-up, and number of computed tomography (*CT*) scans for all 18 patients

	P/N ratio	*Duration of follow-up, months*	*No. of CT scans performed*
Surgical repair (−)	1.31	0.1	1
	1.18	3.1	5
	1.19	15	8
	1.22	41	10
	1.23	72	13
	1.25	47	11
	1.33	32	10
	1.36	72	13
	1.43	18	8
	1.51	75	13
	1.52	15	8
	1.53	79	14
	1.56	14	8
	1.61	0.1	1
	1.65	0.5	3
	1.69	0.1	1
Surgical repair (+)	1.8	15	8
	2.18	75	13
	$P < .001$		

DISCUSSION

This study represents a 9-year experience with nonoperative management of BTAI with pseudoaneurysm. The outcome of patients with BTAI with pseudoaneurysm in whom a definitive nonoperative approach was selected remains obscure. With an average follow-up of 40 months, it was found that there were no aortic-related complications or death.

BTAI has traditionally been treated as a surgical emergency. Multiple studies, however, have reported the safety of delayed repair (open surgery or TEVAR) in polytrauma patients. In high-risk patients with multiple severe associated injuries or severe premorbid conditions, a deliberate nonoperative management may be a reasonable option.

In a study by Holmes et al,[11] 30 BTAI patients were treated with either delayed surgery or nonoperative management with a median follow-up of 2.5 years. Results showed that one third of patients from the nonoperative group died because of severe traumatic brain injury. Caffarelli et al[12] reported the preliminary outcomes of 29 patients who underwent planned nonoperative management. This study showed a survival rate of 97% at a median of 1.8 years. Furthermore, it is evident that nonoperative management has evolved from being a bridging strategy toward a definitive surgical repair or TEVAR to one that remains expectant observation in many patients. It was concluded that deliberate, nonoperative management might be a reasonable alternative in polytrauma patients. These reports provided no information about a spectrum of BTAI.

Starnes et al[13] reviewed their experience in treating BTAI to create a new classification scheme based on radiographic and clinical data. Of 23 patients with intimal tears, 20 were managed nonoperatively. Of 100 patients with pseudoaneurysm, 14 patients were managed nonoperatively.

Of patients with grade III injuries, 66% were managed nonoperatively, 22% died because of severe associated injuries, and 11% required delayed repair. Harris et al[14] developed an aortic injury risk score to evaluate aortic stability and to predict early rupture based on patient physiology and lesion characteristics. In that report, a P/N ratio >1.4 was independently associated with aortic rupture. As the Rabin group and the Caffarelli group reported,[10,11] the size of pseudoaneurysms is an important factor for optimal management, and smaller grade III BTAI may be managed by nonoperative treatment. The present study reported that the P/N ratio of the patients receiving nonoperative management was smaller than the P/N ratio of patients who received open surgery or TEVAR. Unfortunately, there were no sufficient data in our study to indicate that patients with a certain P/N ratio must undergo repair.

The inferences drawn from these observations are limited by small sample size and uncontrolled bias with its being a retrospective report. Many patients could not be reached because of the rural location of the institution. It was also possible that grade I and II injuries were overlooked in the setting of multiple trauma. It is unclear whether our data could change our observational approach to BTAI in regard to intervention, in particular for patients with P/N ratios of >1.9, because the present report was a retrospective study with a small sample size. In addition, a follow-up of 40 months was short concerning the potential for pseudoaneurysm expansion because the natural history of this lesion is not yet known. Therefore, much further work about size of pseudoaneurysm selection or duration of follow-up is needed.

CONCLUSIONS

This study proposes the use of nonoperative management for aortic injuries with pseudoaneurysm as an alternative to traditional prompt operative treatment. Nonoperative management was safe during the short term, with a survival rate of 77% without any aortic ruptures; 66% of grade III injuries did not require intervention, and 11% of grade III injuries with larger pseudoaneurysm required operative management because of progression. This study suggests that BTAI with pseudoaneurysm can be managed nonoperatively, with about 10% risk of progression to require surgical repair.

AUTHOR CONTRIBUTIONS

Conception and design: ST, SM, HM, MS, HN, TN, HI
Analysis and interpretation: ST
Data collection: ST
Writing the article: ST
Critical revision of the article: ST
Final approval of the article: ST
Statistical analysis: ST
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Overall responsibility: ST

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