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Single-Center Clinical Analysis of Traumatic Thoracic Aortic Injuries: A Retrospective Observational Study

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Purpose: This study investigated the clinical outcomes of trauma patients with blunt thoracic aortic injuries at a single institution.
Methods: During the study period, 9,501 patients with traumatic aortic injuries presented to Trauma Center of Gil Medical Center. Among them, 1,594 patients had severe trauma, with an Injury Severity Score (ISS) of >15. Demographics, physiological data, injury mechanism, hemodynamic parameters associated with the thoracic injury according to chest computed tomography (CT) findings, the timing of the intervention, and clinical outcomes were reviewed.
Results: Twenty-eight patients had blunt aortic injuries (75% male, mean age, 45.9±16.3 years). The majority (82.1%, n=23/28) of these patients were involved in traffic accidents. The median ISS was 35.0 (interquartile range 21.0–41.0). The injuries were found in the ascending aorta (n=1, 3.6%) aortic arch (n=8, 28.6%) aortic isthmus (n=18, 64.3%), and descending aorta (n=1, 3.6%). The severity of aortic injuries on chest CT was categorized as intramural hematoma (n=1, 3.6%), dissection (n=3, 10.7%), transection (n=9, 32.2%), pseudoaneurysm (n=12, 42.8%), and rupture (n=3, 10.7%). Endovascular repair was performed in 71.4% of patients (45% within 24 hours), and two patients received surgical management. The mortality rate was 25% (n=7).
Conclusions: Traumatic thoracic aortic injuries are life-threatening. In our experience, however, if there is no rupture and extravasation from an aortic injury, resuscitation and stabilization of vital signs are more important than an intervention for an aortic injury in patients with multiple traumas. Further study is required to optimize the timing of the intervention and explore management strategies for blunt thoracic aortic injuries in severe trauma patients needing resuscitation.

Keywords: Aorta, thoracic; Aneurysm, false; Traumatic; Multiple trauma

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INTRODUCTION

In 1968, according to their landmark study based on autopsy reports, Parmley et al. [1] found that 85% (237/275) of patients died before arriving at the hospital. In addition, a study by Teixeira et al. [2] in 2011, reported that in 35% (n=304) of cases, thoracic aortic rupture was the cause of death. Blunt thoracic aortic injury (BTAI) is the leading cause of trauma-related death.

According to two multicenter studies of the American Association for the Surgery of Trauma (AAST) published in 1997 and 2007, the overall in-hospital mortality rate has decreased from 22% (53 of 241) to 13.0% (25 of 193), provided that patients receive immediate care at the hospital [3]. From the perspective of medicine's achievements, the development of diagnostic technology, especially computed tomography (CT), is vital for the immediate diagnosis of BTAI. Antihypertensive therapy is given to slow the lesion's progression before fatal complications occur [4]. Acceptance of the grading system of BTAI, treatment strategies, and the development and application of revolutionary endovascular devices have enabled more reliable management, thereby increasing the survival rate of BTAI patients [5].

Due to the mechanism of injury, the majority of BTAI have concomitant injuries. In some cases, concomitant injuries may need to be prioritized for treatment. In total, 29% of patients presented with major abdominal injuries and 31% presented with major head injuries, with implications for the choice of a proper strategy for management of BTAI with severe concomitant injuries [6]. Rabin et al. [7] reported that an early intervention (within 24 hours) for BTAI with a traumatic brain injury (TBI), regardless of the treatment modality, may worsen the TBI if it is not managed right away (after 24 hours). The study by Osgood et al. [8] showed that in grade I and II BTAI, 95% of the patients presented complete resolution or maintained a stable status. Only 5% of them showed progression of the lesion.

However, treatment strategies have not been sufficiently standardized given the multidisciplinary aspect of the mechanism of BTAI and associated injuries. According to a systematic review of 7,768 patients that was commissioned by the Society of Vascular Surgery of the United States in 2011, non-operative management had a significantly higher mortality rate than endovascular repair and even open repair (46%, 9%, and 19%, respectively) [9].

The management and strategy for BTAI treatment may vary depending on the institution's composition of specialists and faculty members in the initial management of trauma patients. Our institution was designed and operated by dedicated cardiothoracic surgeons specializing in trauma who participated in the initial management of trauma patients. Our goal was to review our experience in treating BTAIs during a 4-year period and to publish our center's data according to radiographic and clinical examinations.

METHODS

This is a retrospective clinical analysis of patients with traumatic thoracic aortic injuries, admitted to a trauma center between January 2014 and December 2016. This study was approved by the Institutional Review Board (IRB) of the Gil Medical Center of Gachon University College of Medicine (IRB No. GFIRB 2018-425). Informed consent was waived by IRB of Gil Medical Center of Gachon University College of Medicine. Our work does not infringe on any rights of others, including privacy rights, and intellectual property rights. There is no human rights violation in our manuscript.

A total of 9,501 patients with traumatic injuries presented to our center during the study period. Among them, 1,594 patients were classified as having severe trauma, with an Injury Severity Score (ISS) of >15. On reviewing the trauma registry and radiological studies, 28 patients with blunt traumatic thoracic aortic injuries were identified.

Clinicians ordered whole-body computed tomography for traumatic injury patients after triage based on the trauma-alert protocols. When a patient was suspected of or identified as having a BTAI on the initial radiologic evaluation, the strategy for the treatment and resuscitation of the patient was planned by the cardiothoracic surgeon in the trauma team. CT angiography was performed before the intervention or during follow-up within 2 weeks. The results were read by the radiologists, and the traumatic aortic injury was classified according to the simplified Vancouver grading system.

We reviewed patients' demographics, mechanism of injuries, Glasgow Coma Scale score, hemodynamic parameters at the time of admission and in the resuscitation room, shock index, associated thoracic injury according to chest CT findings, the timing of the intervention and amount of transfusion within 4 hours and 24 hours, the ISS, and clinical outcomes, including in-hospital mortality and cause of death.

Statistical analyses were performed using SPSS version 22 (IBM Corp., Armonk, NY, USA). Continuous variables are expressed as the mean and standard deviation, and categorical data are expressed as observations (percentages). The student *t*-test for data with a normal distribution and the Wilcoxon rank-sum test for data with a non-normal distribution were performed as appropriate. Categorical data were analyzed using the chi-square test and the Fisher test. A *p*-value less than 0.05 was considered to indicate statistical significance.

Table 1. Demographic data of the patients

Characteristics	Total (n=28)
Age (years)	45.9±16.3
Male	21 (75.0)
Injury Severity Score	35.0 (21.0–41.0)
Location of aortic injuries	
Ascending aorta	1 (3.6)
Aortic arch	8 (28.6)
Aortic isthmus	18(64.2)
Descending aorta	1 (3.6)
CT finding of aortic injuries	
Dissection	3 (10.7)
IMH	1 (3.6)
Pseudoaneurysm	12 (42.8)
Rupture	3 (10.7)
Transection	9 (32.2)

Values are presented as mean±standard deviation or number (%) or median (interquartile range).
CT: computed tomography, IMH: intramural hematoma.

RESULTS

Blunt aortic injuries accounted for 1.7% (28/1,594) of severe trauma cases at our institution during the study period. The demographic and clinical details of patients are shown in Table 1. Regarding the injury mechanism, a majority of the patients were involved in traffic accidents (TA), 82.1% (n=23): occupant TA, 46.3% (n=13); pedestrian TA, 14.3% (n=4); and motorbike TA, 21.4% (n=6). The remaining patients (17.9%; n=5) had injuries due to falls from a height. Slightly over half (53.6%) of the patients were transported directly from the accident location, while 46.4% of the patients were transferred from other hospitals.

The following concomitant thoracic injuries were found: intramural hematoma (IMH) in the thoracic aorta, 42.9% (n=12); mediastinal hematoma, 64.3% (n=18); hemopericardium, 14.3% (n=4); pulmonary contusion, 46.4% (n=13); hemothorax of the left hemithorax, 53.6% (n=15); multiple rib fracture, 60.7% (n=17); sternum fracture, 10.7% (n=3); and fracture of the thoracic spine, 28.6% (n=8). Three of the 28 patients underwent an emergency operation before intervention for the aortic injury, one patient underwent laparotomy, and two underwent orthopedic surgery.

Table 2. The distribution of management for BTAI according to the Vancouver simplified classification

Grade	No.	Shock index	ISS	Non-intervention	Intervention	
					Early (within 24 hours)	Delayed (over 24 hours)
I	1	1.3	41.0	1 (3.8)	0	0
III	23	0.8 (0.7–1.1)	36.0 (21.0–41.0)	4 (15.3)	8 (30.7)	11 (42.3)
IV	2	0.6 (0.5–0.6)	24.5 (20.0–29.0)	1 (3.8)	1 (3.8)	0

Values are presented number (%) or median (interquartile ranges).
BTAI: blunt thoracic aortic injury, ISS: Injury Severity Score.

To manage the aortic injuries, 77% (n=20/26) underwent a surgical intervention and 23% (n=6/26) were managed non-surgically. Thoracic endovascular aortic repair (TEVAR) was performed in 69.2% of patients (n=18/26). Two patients underwent open repair or hybrid repair, and a patient with a traumatic pseudoaneurysm in the ascending aorta, concomitant with traumatic brain injury, underwent ascending aortic replacement 3 days later. The other patient with a traumatic pseudoaneurysm near the subclavian artery underwent staged TEVAR after debranching of the left common carotid artery and the left subclavian artery bypass. Among the patients who underwent TEVAR, 50% (n=9/18) underwent early surgery (within 24 hours from admission), while the procedure was delayed in 50% (over 24 hours from admission). Table 2 shows the distribution of management according to the simplified Vancouver classification (n=26).

The mortality rate was 25% (n=7), of which two deaths resulted from aortic rupture in the emergency room before the intervention. Three deaths were related to a traumatic brain injury, one death resulted from trauma-related multi-organ failure. Four of the patients died within 48 hours after admission. One was hospitalized for 107 days and died from pneumonia and sepsis. Among the five patients who died after the intervention, only one was classified as grade IV and underwent TEVAR. Table 3 shows the hemodynamic findings and injury severity according to survival.

Table 3. Hemodynamic finding and injury severity according to survival

Variable	Survivors (n=21)	Non-survivors (n=7)	*p*-value
AIS			
Head and neck	0.0 (0.0–2.0)	3.0 (0.5–5.0)	0.048
Face	0.0 (0.0–1.0)	0.0 (0.0–1.0)	0.879
Thorax	4.0 (4.0–4.0)	5.0 (4.0–5.0)	0.002
Abdomen	0.0 (0.0–2.0)	3.0 (1.0–3.5)	0.190
Extremities	2.0 (0.0–3.0)	2.0 (0.0–2.0)	0.778
External	1.0 (0.0–1.0)	0.0 (0.0–1.0)	0.630
ISS	29.0 (21.0–41.0)	42.0 (41.0–50.0)	0.009
SBP	120.0 (95.0–132.0)	83.0 (61.5–120.5)	0.059
DBP	76.0 (52.0–84.0)	59.0 (41.0–68.5)	0.130
MAP	93.3 (66.0–99.7)	69.0 (47.8–84.8)	0.060
HR	98.0 (87.0–102.0)	102.0 (79.0–109.0)	0.873

Values are presented number (%) or median (interquartile ranges).
ISS: Injury Severity Score, AIS: Abbreviated Injury Scale, SBP: systolic blood pressure, DBP: diastolic blood pressure, MAP: mean arterial pressure, HR: heart rate per minute.

DISCUSSION

Thoracic aortic injury in trauma cases has been recognized as a landmark of severe traumatic injury [1,10]. In the past, as surgical repair was the only treatment option for blunt aortic injuries, it resulted in high mortality and morbidity. However, the management strategy of blunt aortic injuries has dramatically changed owing to a better understanding of traumatic aortic injuries, diagnostic approaches, and pathophysiology. CT has enabled the early detection of aortic injuries, helping clinicians to make early decisions on the treatment plan [4]. Additionally, a categorical classification of aortic injuries on the basis of CT has made it possible to determine a treatment plan according to the severity of the aortic injury [11,12]. TEVAR has emerged as a more reliable method to repair injured aortas [13,14].

The ISS, which assesses the combined effects of injuries in patients with multiple injuries, was high (median 35.0; interquartile range 21.0–41.0) in our study. Several other studies reported similar results, such as those by Fabian et al. [4] (31±11 in those who lived and 39±13 in those who died), Lamarche et al. [12] (41.9±13.0), and Rabin et al. [7] (54±13 in those who underwent early repair and 42±8 in those who underwent delayed repair). It is clear that BTAIs frequently occur with concomitant injuries; therefore, the presence of other concomitant injuries should be considered while planning injury management [15,16].

Some researchers reported that surgical management was more effective in BTAI patients who underwent delayed repair than in those who underwent immediate repair [17]. Early diagnosis and presumptive treatment with an antihypertensive regimen were reported to be effective in the prevention of in-hospital aortic rupture [4]. Endovascular management has been reported to be more efficient and to have fewer complications than surgical management [3,13,18]. In trauma patients with blunt aortic injuries, especially concomitant traumatic brain injuries, early repair of the blunt aortic injury, regardless of the repair modality, resulted in worsening of the traumatic brain injury [7]. However, there is a difference in outcomes depending on the classification system; injuries classified as grade I and grade II are minimal, and progression of the injury is rare; therefore, these patients respond well to medical management. Grade I-II injuries may be treated with non-operative management [8,19].

In our study, two patients died due to aortic-related mortality. Their aortic injuries were classified as grade IV according to the Vancouver classification. Both their initial chest CT scans revealed extravasation from aortic injuries. Their survival times were 1 hour and 2 hours after trauma, respectively. TEVAR for BTAI is being practiced as a common treatment, which is consistent with this study. In this study, TEVAR was performed in 90% (18/20) of the patients. The use of TEVAR has increased and replaced open aortic repair for the treatment of BTAI. Similar results have been reported in other countries [13,20].

This study had several limitations, including inherent limitations associated with the retrospective design. Additionally, the sample size was small and the study was conducted in a single institution. This study only included the proportion of patients with BTAIs who could reach the hospital and could be diagnosed via chest CT. The management of BTAIs could not be standardized, as it was dependent on the attending physician who was present, the timing and severity of presentation, and associated injuries. Despite these limitations, it is important to note that TEVAR is an acceptable treatment modality for BTAIs without impending rupture and that BTAIs are not an absolute priority in cases of multiple trauma.

CONCLUSION

Traumatic thoracic aortic injuries are life-threatening. In our experience, however, if there is no rupture or extravasation from the aortic injury, resuscitation and stabilization of vital signs are more important than an intervention for the aortic injury in patients with multiple traumas. Further study is required to optimize the timing and explore management strategies for BTAIs in severe trauma patients needing resuscitation.

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