



## Thoracic endovascular aortic repair with left subclavian artery reconstruction for blunt traumatic aortic injury in elderly patients

Li Zhang<sup>a</sup>, Huaping Wu<sup>a</sup>, Xiang Li<sup>a</sup>, Kaiping Lv<sup>a</sup>, Huanhuan Song<sup>a</sup>, Cunliang Zeng<sup>a</sup>, Jianlin Liu<sup>b,\*</sup>

<sup>a</sup> Department of Vascular Surgery, Dazhou Central Hospital, Dazhou, 635000, PR China

<sup>b</sup> Department of Vascular Surgery, The First Affiliated Hospital of Xi'an Jiaotong University, Xi'an, 710000, PR China

### ARTICLE INFO

#### Keywords:

Blunt traumatic aortic injury  
Thoracic endovascular repair  
Reconstruction of left subclavian artery

### ABSTRACT

**Introduction:** Blunt thoracic aortic injury (BTAI) is rare in elderly patients. As the population ages and life expectancy increases, the frequency of this injury will increase, while the treatment and outcomes remain unclear. **Methods:** We retrospectively analyzed the collected data of patients >60 years old with BTAI to investigate the mechanism of trauma; time interval from injury to diagnosis; type and timing of surgical intervention; aortic arch pattern; choice of left subclavian artery reconstruction; endograft to treat BTAI; length of the endovascular procedure; endoleaks; complications including stroke, paraplegia, and renal failure; length of hospital stay (LOS) and intensive care unit stay (L.ICUS); and 30-day mortality.

**Results:** Five elderly trauma patients were found to have BTAI. Four (80%) were males, the cohort mean age was 68 years, the major mechanism of trauma was fall injury, and the associated injury was thoracic trauma. All patients were transferred to our hospital, and emergency computed tomography angiography showed BTAI in each patient. The average time interval from injury to diagnosis was 2.7 days. Two patients suddenly showed signs of instability in their vital signs and underwent immediate endovascular repair, while 3 patients underwent delayed endovascular repair. The injury site was located in the aortic isthmus just distal to the origin of the left subclavian artery; the aortic arch pattern was II (80.0%) in 4 cases and III in 1 case (20.0%). The choice of left subclavian artery reconstruction included chimney, double chimney, fenestration, and chimney combined with in situ fenestration. Endografts to treat BTAI included the Ankura (Lifetech Scientific, Shenzhen, China) and the C-TAG (W.L. Gore & Associates, Flagstaff, AZ USA). The length of the endovascular procedure was 75.4 min; there were no endoleaks and no complications including stroke, paraplegia, or renal failure. The average LOS was 25 days, and the average L.ICUS of 2 patients was 15 days, with no 30-day mortality.

**Conclusion:** Elderly patients with fall injury should promptly exclude BTAI. Thoracic endovascular aortic repair (TEVAR) with a left subclavian artery reconstruction technique provided good results without procedure-related or neurological complications. Because of the low incidence of this type of injury, we are unable to provide any evidence to guide the treatment option for this life-threatening condition.

### Introduction

Blunt traumatic aortic injury (BTAI) is a life-threatening emergency associated with high mortality, most commonly caused by a rapid acceleration/deceleration injury sustained through a motor vehicle accident, falls from height, and/or blunt thoracic trauma. Open surgical repair had remained the standard treatment option for BTAI since it was successfully introduced in 1959. However, with technological advances, thoracic endovascular aortic repair (TEVAR) offers an alternative

treatment option for BTAI. TEVAR is a less invasive surgical approach for the management of these already critical patients. The incidence of vascular injuries in patients aged 65 years or older is approximately 0.7% according to Konstantinidis and colleagues.<sup>1</sup> As the population ages and life expectancy increases, the frequency of this injury will increase in the elderly and thus it behooves us to understand the treatments and outcomes in this patient population. Recently, Malgor et al. analyzed data from the US Trauma National Registry and found that BTAI was the most common vascular injury in that subset of elderly patients. The length of

\* Corresponding author.

E-mail address: [jlliu@mail.xjtu.edu.cn](mailto:jlliu@mail.xjtu.edu.cn) (J. Liu).

<https://doi.org/10.1016/j.jimed.2019.10.002>

Available online 23 October 2019

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**Table 1**  
Patient demographics and characteristics.

Variables	Mean (range) or percentage (n = 5)
Age (years)	68 (62–77)
Male	4 (80.0%)
Mechanism of trauma	
Fall injury	4 (80.0%)
Motor vehicle accidents	1 (20.0%)
Associated injures	
Rib fracture	5 (100%)
Clavicle fractures	2 (40.0%)
Vertebral fracture	5 (100%)
Pleural effusion	4 (80.0%)
Pulmonary contusion	4 (80.0%)
Brain injury	1 (20.0%)
Vital signs stable	3 (60.0%)
ICU admission	2 (40.0%)
Mechanical ventilation	2 (40.0%)
Closed thoracic drainage	2 (40.0%)
Blood transfusion	2 (40.0%)

hospital stay (LOS), length of intensive care unit stay (L.ICUS), and mortality was significantly higher in geriatric patients sustaining any vascular injury compared with a general nongeriatric adult trauma population.<sup>2</sup>

## Methods

Data of patients with BTAI were retrospectively reviewed at our regional medical center from the records of patients treated from August 2016 to September 2018. Patients >60 years with BTAI were included, and the data recorded included the patient demographics, mechanism of trauma, associated injures, vital signs, the choice of diagnostic imaging, the time interval from injury to diagnosis, the type of surgical intervention (endovascular vs. open), the timing of surgical intervention (immediate vs. delayed), aortic arch pattern, the choice of left subclavian artery reconstruction, the endograft used to treat the BTAI, the length of the endovascular procedure, endoleaks, complications including stroke, paraplegia, and renal failure, length of hospital stay (LOS), length of intensive care unit stay (L.ICUS), and 30-day mortality.

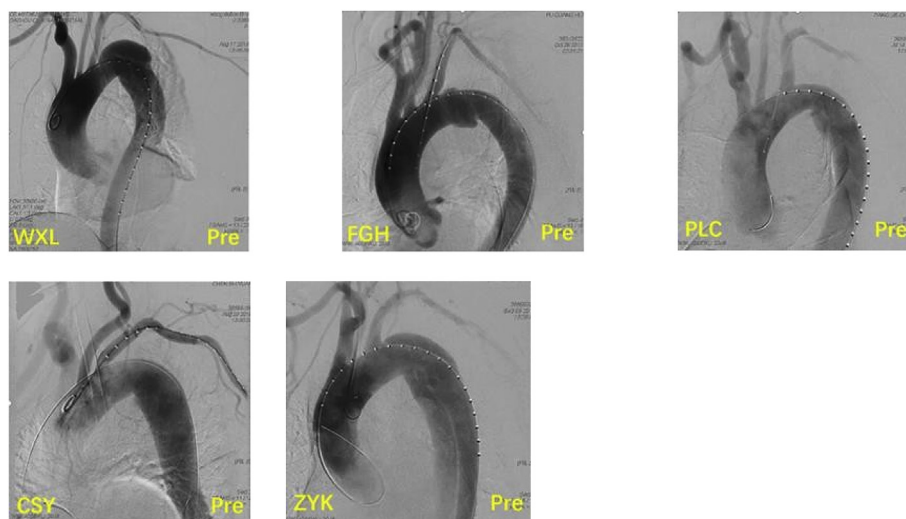
## Results

Over the past 2 years, only 5 elderly trauma patients were found to have BTAI. Four (80%) were males and 1 (20%) was female. The cohort mean age was 68 years (range: 62 to 77). All but one patient (in a motor

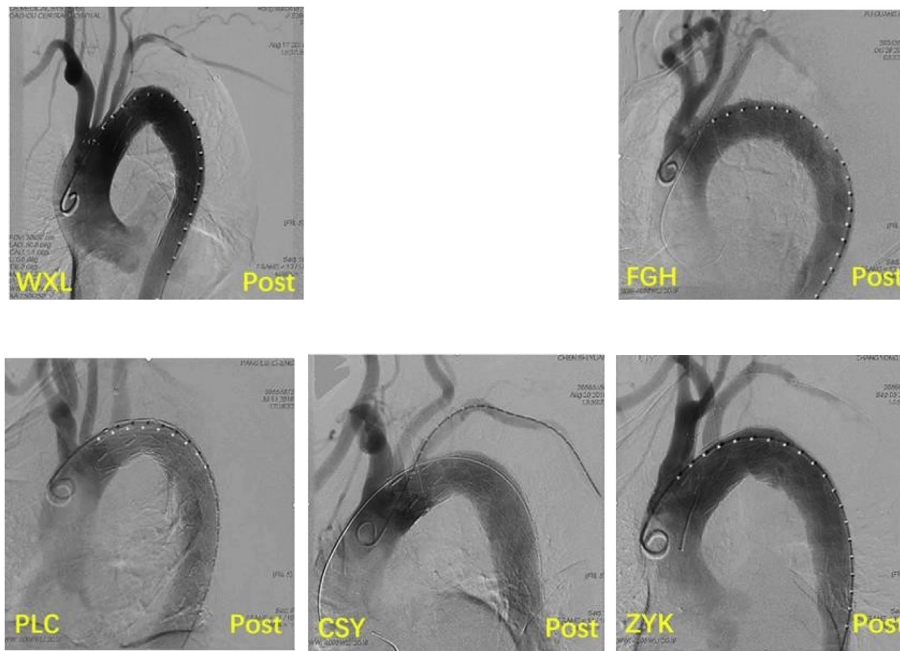
vehicle accident) were involved in a fall injury. The most significant component of the associated injures was thoracic trauma. Computed tomography showed mediastinum widening and suspected aortic dissection in all cases. All patients were transferred to our hospital and emergency computed tomography (CT) angiography showed a BTAI for all patients. The average time interval from injury to diagnosis was 2.7 days (range: 6 h to 10 days), 2 patients suddenly showed signs of instability in their vital signs and underwent immediate endovascular repair and postoperatively entered the intensive care unit for mechanical ventilation, closed thoracic drainage, and blood transfusion. Three patients underwent delayed endovascular repair (Table 1). The injury site was located in the aortic isthmus just distal to the origin of the left subclavian artery (Fig. 1), the aortic arch pattern was II in 4 cases (80.0%) and III in 1 case (20.0%). The choices of left subclavian artery reconstruction were chimney (20.0%), double chimney (20.0%), pre-fenestration (40.0%), chimney combined with in situ fenestration (20.0%). Endografts used to treat the BTAI included Ankura (Lifetech Scientific, Shenzhen, China) and the C-TAG (W.L. Gore & Associates, Flagstaff, AZ USA) (Fig. 2). The length of the endovascular procedure was 75.4 min (range: 17–118 min); there were no endoleaks and no complications including stroke, paraplegia, and renal failure. The average length of hospital stay (LOS) was 25 days (range: 10–45 days), the average length of intensive care unit stay (L.ICUS) of 2 patients was 15 days (range: 10–20 days) and there was no 30-day mortality (Table 2).

## Discussion

BTAI is a life-threatening event associated with deceleration injuries. The incidence of BTAI is estimated between 1.5% and 2%,<sup>3</sup> but the mortality rate is high. Eighty percent of patients with BTAI die before reaching a trauma center. For patients who survive till hospital arrival, 50% die within 24 h. Normal vital signs do not rule out aortic injury.<sup>4</sup> A high degree of clinical suspicion and liberal use of imaging is necessary to prevent missed or delayed diagnoses. CT of the chest with intravenous contrast is strongly recommended to diagnose clinically significant BTAI.<sup>5</sup> A study from Japan revealed that a longer time interval from hospital arrival to CT scan was associated with higher mortality in the emergency department in patients with BTAI.<sup>6</sup> Besides surgical therapy, conservative treatment and endovascular therapy have been described. With the evolution of endovascular management of BTAI, there has been a transition from open repair to TEVAR. The rate of open repair decreased from 7.4% in 2007 to 1.9% in 2015, while TEVAR increased from 12.1% to 25.7% during the same period. We confirmed previous findings that endovascular repair is associated with decreased mortality, length of



**Fig. 1.** Aortic angiography pre-TEVAR shows aortic isthmus injury.



**Fig. 2.** Aortic angiography post-TEVAR showed no endoleak with good patency of the left subclavian artery

WXL:TEVAR + double chimney, Ankura;

PLC:TEVAR + prefenestration, Ankura

CSY:TEVAR + prefenestration, Ankura

ZYK:TEVAR + chimney+in situ fenestration, Ankura.

**Table 2**  
Imaging diagnostic and intervention data.

Patient series	WXL	FGH	PLC	CSY	ZYK
The time interval from injury to diagnosis	10 days	6 h	8 h	1 day	2 days
Aortic arch pattern	III	II	II	II	II
Left subclavian artery reconstruction	double chimney	chimney	pre-fenestration	pre-fenestration	chimney+in situ fenestration
The length of endovascular procedure (75.4min)	109 min	118 min	17 min	33 min	100 min
Endograft	ANKURA	C-TAG	ANKURA	ANKURA	ANKURA
LOS (25 days)	41 days	45 days	17 days	12 days	10 days
L.ICUS (15 days)		20 days	10 days		

stay, and major complications including acute kidney injury. Single-center and multicenter studies demonstrated the feasibility of this technique with few post-procedural complications and reduced mortality rates.<sup>7,8</sup> Despite the lack of randomized controlled trial evidence, clinicians are moving forward with endovascular treatment of BTAI based on meta-analyses of cohort studies and large clinical series.<sup>9</sup>

TEVAR for aortic isthmus injury just distal to the origin of the left subclavian artery (SCA) commonly requires covering the left subclavian artery to prevent an endoleak. Coverage of the left SCA showed a low incidence of complications in the follow-up period and revascularization of the left SCA seemed to be dispensable in most of these patients. However, in the patient cohort, the Disabilities of the Arm Shoulder and Hand (DASH) score increased with age.<sup>10</sup> In elderly patients with BTAI combined with anemia and hypotension, an adequate and a favorable proximal sealing zone with the left subclavian artery reconstruction to prevent stroke, paraplegia, and left upper limb ischemia is optimal. In this study, the major mechanism of trauma for BTAI was a fall injury, and chest CT scanning with intravenous contrast as soon as possible can confirm the diagnosis and avoid treatment delay. Once the vital signs become unstable, endovascular repair should be expedited, but LOS and L.ICUS are significantly prolonged. TEVAR with several methods for reconstruction of the left subclavian artery have achieved satisfactory clinical results, no endoleak and no other complications including stroke, paraplegia, and renal failure. The length of prefenestration endovascular procedure is shorter than for the chimney procedure.

## Conclusion

Elderly patients with a fall injury, especially those with unstable vital signs, should promptly exclude BTAI. TEVAR with a left subclavian artery reconstruction technique provided good results without procedure-related or neurological complications in elderly patients who had a BTAI located in the aortic arch. Because of the low incidence of this type of injury only a coordinated multicenter effort will be able to clarify the optimal management of BTAI, and this would be highly challenging due to the natural history of the condition.

## Funding

None.

## Declaration of competing interest

None.

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