

Our Experience with Endovascular Repair of Descending Thoracic Aortic Injury after Blunt Trauma

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ABSTRACT

Background: Thoracic endovascular aneurysm repair (TEVAR) allows minimally invasive efficient and rapid management of patients with traumatic aortic injury. In the past surgery was the only management option till the first stent was done in 1994, and nowadays TEVAR became the treatment of choice.

Objective: This study aimed to share our experience and show how TEVAR is efficient and safe in traumatic descending aortic injury.

Patients and Methods: A prospective study that was done in multicentre in Egypt and KSA. A total number of 49 patients had emergent TEVAR for traumatic descending thoracic aortic injury.

Results: 58 patients presented to our centers with blunt traumatic descending aortic injury, out of them, 9 (15.52%) patients had grade 1 and were treated by conservative management, and 49 (84.48%) patients had emergent TEVAR for Grades II and III traumatic (no patient presented by grade IV) in the first 24 hours from trauma except 2 patients had TEVAR in the 2nd day after stabilization of their general condition due to associated injuries. In forty-six (93.88%) patients the aortic injury was in the vicinity of the origin of the left Subclavian artery, however, three (6.12%) of the injuries occurred at mid descending Thoracic aorta. In the study group, forty-four (89.8%) patients had concomitant injuries. In all our patients, one stent graft of 10 cm in length was enough to exclude the injured part of the aorta and the width was variable according to aortic diameter.

Conclusion: TEVAR is safe, easy, and practical management of traumatic descending thoracic aortic injury.

Keywords: Traumatic aortic injury, TEVAR, Outcome, Complications, endoleak, mortality.

INTRODUCTION

The Global status report on road safety in 2018, which was launched by World Health Organization (WHO) in December 2018, highlights that the number of annual road traffic deaths has reached 1.35 million. Nowadays road traffic accidents are the main cause of death in people in the age group between (5-29) especially in developing countries. Non-fatal injuries affect between 20-50 million causing disabilities to them from their injuries⁽¹⁾.

Thoracic aortic injuries are associated with very high mortality, they are the second most common cause of death in trauma patients after intracranial hemorrhage⁽¹⁾. Descending Thoracic aortic injuries happen after trauma causing acceleration-deceleration injury as in road traffic accident (RTA) and fall from height (FFH). The most common site of aortic injury is the aortic isthmus as it lies between the fixed aortic arch and mobile descending thoracic aorta^(1, 2).

Since 1959 surgical repair was considered the main line of treatment for Blunt traumatic thoracic aortic injury (BTAI). Later on, with the new technology TEVAR became an excellent substitute. It was first used in 1994 when descending thoracic aorta aneurysm stenting was done, and by time TEVAR starts to gain an advantage over surgery and now it became the treatment of choice as it is safer and less invasive for the patients who are already unstable because of the trauma and the associated injuries. The golden advantage and benefit of TEVAR are that it can be done without using heparin so avoiding bleeding from associated trauma injuries. In

some studies, surgical repair is still associated with high mortality and morbidity⁽³⁾, and TEVAR is associated with better morbidity and mortality than surgical repair^(4,5,6).

This study aimed to share our experience and show how TEVAR is efficient and safe in traumatic descending aortic transection.

PATIENTS AND METHODS

Between June 2017 and September 2021, a total number of 58 patients presented to our centers with a blunt traumatic descending aortic injury. They were properly investigated and radiologically classified into four grades 1-4 according to the severity of the aortic injury. Grade 1 with an intimal tear, grade 2 with intramural hematoma, grade 3 with pseudoaneurysm with intact adventitia, and grade 4 with rupture free wall. Out of them, 9 (15.52%) patients had grade 1 and were treated by conservative management, and 49 (84.48%) patients had emergent TEVAR for Grades II and III traumatic (no patient presented by grade IV) descending thoracic aortic injury/transaction in the first 24 hours from trauma except 2 patients had TEVAR in the 2nd day after stabilization of their general condition due to associated injuries. For those who had TEVAR their medical data were collected which include age, sex, mechanism of injury, associated injuries, type of anesthesia or sedation given, procedure-related complications, need for blood transfusion, need for re-intervention, ICU stay and hospital stay, then follow up for thirty days after discharge and if there are any

complications, need for readmission, reintervention, survival, and mortality.

Pre-TEVAR Assessment:

All patients in the study group had:

1. Full detailed history and detailed clinical examination with emphasis on type, the mood of trauma, and any other associated injuries.
2. Routine laboratory investigations including CBC, liver, and kidney function tests, and coagulation profile with emphasis on the presence of anemia and impaired kidney function.
3. Chest X-ray posteroanterior for associated lung injury, pneumothorax, hemothorax, and rib fracture.
4. Transthoracic echo for associated cardiac injury
5. MSCT aortography for proper assessment of the size of the descending aorta and site, extent, and degree of the dissection.
6. Proper assessment of other body injuries by specialized doctors according to the specialty and according to trauma protocol.

Type of anesthesia used:

Forty-four patients were performed by local anesthesia and five patients received general anesthesia two of them started with local anesthesia and then converted to general due to hemodynamic instability and irritability.

Technique:

The most important point in TEVAR is the strategy by deciding the proper size (length and diameter) and the layout of the stent and its relation to great vessels.

All TEVAR were done in a hybrid room with the full equipment ready for conversion to open surgery at any time or any stage.

With the patients in a supine position, the chest, abdomen, and groin were prepped and draped.

The access site used in our patients was through femoral exposure or percutaneously through the right common femoral artery (**Figure 1**).



Figure (1): The right common femoral artery as an access site, and after finishing no hematoma or bleeder We gave heparin to the patient, if no contraindication, with a target of activated clotting time ≥ 300 seconds keeping that level although the time of TEVAR. Sheath and guidewire were used under fluoroscopic guidance into ascending aorta, an aortogram was done to see the lesion (**Figure 2**) then device deployment, with systolic pressure around 100 mm Hg.

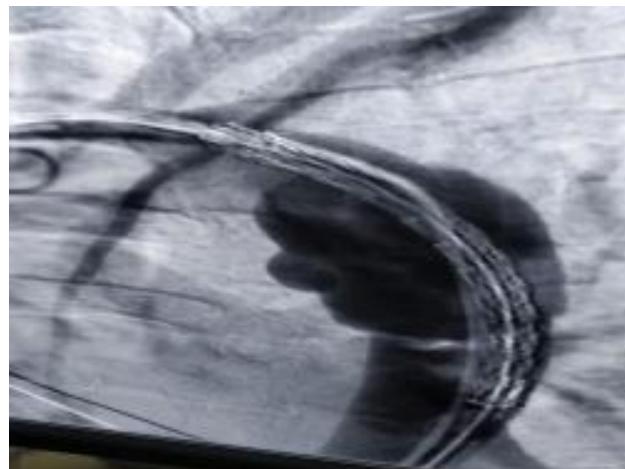


Figure (2): Aortogram before deployment of the stent in the proximal descending thoracic aorta with an aneurysm.

Then stent graft was ballooned and an aortogram was performed to confirm no endoleak (**Figure 3**), then the wire and sheath were removed. We checked the femoral site for bleeding or hematoma and we confirmed intact distal pulsations then heparin was reversed.



Figure (3): Aortogram after deployment of the stent in the proximal descending thoracic aorta no endoleak

Postoperative assessment:

Our protocol for follow up post-TEVAR was close follow up of the hemodynamics in the ICU for the first 24 hours, at least, follow up full labs particularly kidney function test and CBC, follow up daily chest x-ray in the first 48 hours, follow up CT chest with contrast after 24 hours, before discharge and after one month.

Ethical consent:

Approval of the study was obtained from Cairo University Academic and Ethical Committee. Every patient signed informed written consent for the acceptance of participation in the study. This work has been carried out following The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

The collected data were coded, processed, and analyzed using the SPSS (Statistical Package for Social Sciences) version 22 for Windows® (IBM SPSS Inc, Chicago, IL, USA). Data were tested for normal distribution using the Shapiro-Wilk test. Qualitative data were represented as frequencies and relative percentages. Chi-square test (χ^2) to calculate the difference between two or more groups of qualitative variables. Quantitative data were expressed as mean \pm SD (Standard deviation). Independent samples t-test was used to compare two independent groups of normally distributed variables (parametric data). P-value < 0.05 was considered significant.

RESULTS

Between June 2017 and September 2021, 49 patients underwent emergency TEVAR for a traumatic aortic injury, and their demographic data and mode of trauma are shown in (Table 1).

The patient's ages ranged from 14-to 59 years (mean \pm SD 27 ± 13.15 years), forty-five (91.84%) patients were men and four (8.16%) were females. Forty-seven (95.91%) patients were involved in road traffic accidents (RTA) and the other two (4.08%) presented after falling from height.

Table (1): Demographics and mode of trauma data

Age	Range	14-59
	Mean \pm SD	27 ± 13.15
Sex	Male	45 (91.84%)
	Female	4 (8.16%)
Mode of trauma	RTA	47 (95.91%)
	FFH	2 (4.08%)

In the majority of cases (forty-six patients) (93.88%), the aortic injury was located near the origin of the left subclavian artery (juxta-isthmus), however, three (6.12%) of the injuries occurred at the mid descending thoracic aorta. Forty-four (89.8%) patients had concomitant injuries (Table 2).

Associated injuries were divided according to the spatiality involved. Of them, thirty-seven (75.5 %) need other interventions than TEVAR that differ according to the associated injuries from cast and chest tube insertion to abdominal exploration, neurosurgery operation, and orthopedic and spine surgical fixation.

Table (2): Aortic injury site and associated injuries

		Concomitant injury		Percentage
Aortic injury site	Juxta-isthmus		46	93.88%
	Mid descending Thoracic aorta		3	6.12%
Associated injuries	With associated injuries		44	89.8%
	Free off Other injuries		5	10.2%
	Other intervention		37	75.5 %
	Neuro-surgery	Brain contusion	7	14.28%
		Cerebral hge	3	6.12%
		Spine injury	5	10.2%
	Cardio-thoracic	Fracture ribs	25	51.02%
		Hemothorax	10	20.41%
		pneumothorax	2	4.08%
	GS	Liver injury	5	10.2%
		Kidney injury	3	6.12%
		Abdominal hge	8	16.32%
	Orthopedic	Long bone fractures	11 (mainly femur)	22.45%

In all patients, one stent graft of 10 cm in length was enough to exclude the injured part of the aorta and the width was variable according to aortic diameter. The blood loss from stenting was non-significant in forty-seven patients but two patients had a right femoral injury that required vascular intervention one by direct repair and the other one needed interposition graft, these two (4.08%) patients had blood loss of 300-350 ml (Mean \pm SD 325 ± 25) (Table 3).

Table (3): Stenting time, graft size, and blood loss from stenting

Stenting time (min)	Range in 47 patients Mean \pm SD	70-94 79.3 ± 6.798
	2 patients with vascular injury Mean \pm SD	169-180 174.5 ± 5.5
Graft size (mm)	21*10	15 (30.61%)
	26*10	14 (28.57%)
	28*10	20 (40.82%)
Blood loss (ml)	Range in 47 patients Mean \pm SD	20-50 34.898 ± 11.09
	2 patients with vascular injury Mean \pm SD	300-350 325 ± 25

Regarding blood transfusion, patients with hemoglobin below 8 gm/dl received a blood transfusion and that happened in twelve (24.49%) patients and they received from 2-4 units/patient (Mean \pm SD 3.17 \pm 0.86), and the cause of transfusion was associated injuries and bleeding in nine (18.37%) patients and left hemothorax in three (6.12%) patients.

There were eight(16.33%) procedure-related complications, four (8.16%) had femoral site superficial wound infections that were treated medically, two (4.08%) had right femoral artery injuries that were repaired by the vascular surgeon and two patients had endoleaks type 1 that were presented back to the hospital during the first month of TEVAR (one in the second week and the other one in the third week) both of them have TEVAR again one of them survived and the other died later in the ICU, although follow up CT aorta before discharge was done for all patients confirmed absence of endoleak. No patient needed any kind of reintervention in the same admission.

The ICU stay was ranging from 1-2 days with 3-4 days of hospital stay in isolated TEVAR patients and variable in the other patients according to the associated lesions and procedures they have. There were four (8.16%) in-hospital mortality during the same admission and the cause was the associated injuries and one mortality during the first month in his second admission due to Endoleak (**Table 4**).

Table (4): Complications and mortality

Complications	Patients	Percentage
femoral site superficial wound infection	4	8.16%
Stent complications	2 (endoleak within 1 st month)	4.08%
Vascular complications	2	4.08%
Blood loss	2 (because of vascular injury)	4.08%
Mortality	5	10.2%
In the same admission	4 (from associated injuries)	8.16%
Within first month	One from endoleak	2.04%

DISCUSSION

Traumatic aortic injuries are not common but very fatal and are associated with very high mortality if not managed properly, up to 50% die in the first seventy-two hours ⁽⁷⁾. Another study showed that 88% of the patients with traumatic aortic injuries died in the first hour and 10 % died within two weeks ⁽⁸⁾.

Blunt traumatic aortic injuries occur after trauma associated with acceleration-deceleration injuries like road traffic accidents (RTA) and fall from height (FFH).

It usually happens at the isthmus as it is the junction between the fixed descending thoracic aorta and the mobile aortic arch. The incidence of aortic injuries is 50-70% at the isthmus, 18% in the ascending aorta and arch, and 14% in the descending thoracic aorta ⁽⁷⁾.

It usually happens after RTA (96.7%) or FFH (3.3%) ^(9, 10), with overall incidence of (0.3%) ⁽¹¹⁾. It is commonly and easily missed and it needs a very high suspicion and well orientation of it to be diagnosed.

According to the society of vascular committee in 2011, the best time for TEVAR is in the first 24hours after trauma, grade I aortic injury is for conservative management ⁽¹²⁾.

In our study group 58 patients presented to our centers with blunt traumatic descending aortic injury, out of them, 9 (15.52%) patients had grade 1 and were treated by conservative management, and 49 (84.48%) patients had emergent TEVAR for Grades II and III traumatic (no patient presented by grade IV) in the first 24 hours from trauma except 2 patients had TEVAR in the 2nd day after stabilization of their general condition due to associated injuries. Of those who had TEVAR and aged between 14 and 59 years (mean \pm SD 27 \pm 13.15 years), forty-five (91.84%) patients were men and four (8.16%) were females. Forty-seven (95.91%) patients were involved in RTA and the other two (4.08%) presented after falling from height.

In forty-six (93.88%) patients, the aortic injury was located near the origin of the left subclavian artery (juxta-isthmus), however, three (6.12%) of the injuries occurred at the mid descending thoracic aorta. Out of them, forty-four patients (89.8%) had concomitant injuries.

With **Brenner et al.** ⁽¹³⁾, 88 patients had TEVAR all presented after blunt trauma, with a median age of 47 (19.7), 72.7% were men, 2 % had grade II, 90 % had grade III and 8 % had grade IV.

But with **Fujikawa et al.** ⁽¹⁴⁾, 6 patients age (mean \pm SD 48.8 \pm 19.8), all of them had an injury at the aortic isthmus, of them 5 patients had TEVAR within the first 8 hours of trauma and the last one had it within the 48 hours.

With **Azizzadeh et al.** ⁽¹⁵⁾, they had 71 patients with blunt traumatic aortic injury their mean age was 39.8 years, and 50 of them were males. Out of them, Nineteen (27%) patients died shortly after arrival before any vascular intervention, in the others ten (14%) patients had grade 1 injuries and were managed medically. The remaining 42 (59%) patients with grade 2 and 3 injuries had an intervention. The median interval time between admission and repair was 4.3 days (range, 0-109 days). Of the 42 patients who had intervention fifteen (21%) patients, underwent surgery, and twenty-seven (38%) patients had TEVAR.

Alsac et al. ⁽¹⁶⁾, had 28 patients, of them 20 were males with a mean age of 45 \pm 18.8 years, they were managed within a median time of 5 hours (range 2 to 10 hours) from trauma.

In all patients, one stent graft of 10 cm in length was enough to exclude the injured part of the aorta and the width was variable according to aortic diameter. Aortogram at time of intervention and CT chest with contrast after 24 hours were performed to confirm no endoleak and hematoma disappearance.

The blood loss from stenting was non-significant in forty-seven patients but two patients had a right femoral injury that required vascular intervention one by direct repair and the other one needed interposition graft, these two (4.08%) patients had blood loss of 300-350ml (Mean \pm SD 325 \pm 25).

Regarding blood transfusion, patients with hemoglobin below 8 gm/dl received a blood transfusion and that happened in twelve (24.49%) patients and they received from 2-4 units/patient (Mean \pm SD 3.17 \pm 0.86), and the cause of transfusion was associated injuries and bleeding in nine (18.37%) patients and left hemothorax in three (6.12%) patients.

With **Fujikawa et al.** (14), TEVAR time was 159.5 \pm 21.1 minutes and blood loss was 105 \pm 26.6 mL with no leakage at the time of TEVAR, and follow-up CT showed hematoma disappearance.

There were eight (16.33%) procedure-related complications, four (8.16%) had femoral site superficial wound infections that were treated medically, two (4.08%) had right femoral artery injuries that were repaired by a vascular surgeon and two patients had endoleaks type 1 that were presented back to the hospital during the first month of TEVAR (one in the second week and the other one in the third week) both of them have TEVAR again one of them survived and the other died later in the ICU, although follow up CT aorta before discharge was done for all patients confirmed absence of endoleak. No patient needed any kind of reintervention in the same admission.

With **Brenner et al.** (13), overall hospital morbidity was 57 %, where TEVAR-related complications were 9.1 %, four had type 1 endoleak, two had type 2, and two had type 3. For type 1 endoleak all patients required reintervention while type 2 and 3 were resolved on subsequent imaging.

With **Azizzadeh et al.** (15), there was no paraplegia only one patient had a stroke, left subclavian artery was covered in 13 (48%) patients. In **Alsac et al.** (16), no intervention-related morbidity.

The ICU stay was ranging from 1-2 days with 3-4 days of hospital stay in isolated TEVAR patients and variable in the other patients according to the associated lesions and procedures they have.

In **Alsac et al.** (16) all TEVAR were successful with a mean intervention time of 94 \pm 35.8 minutes, coverage of the origin of left subclavian happened in 13 cases, and of the left common carotid in one case, they had a median of hospital stay of 27 days (range 9 to 127 days).

There were four (8.16%) in-hospital mortality during the same admission and the cause was the associated injuries and one mortality during the first

month in his second admission due to Endoleak (2.04%).

With **Brenner et al.** (13), TEVAR related mortality was 0 % and overall mortality was 6.8%, and in **Azizzadeh et al.** (15), nineteen (27%) patients died shortly after arrival before any vascular intervention, in intervention group 42 patients there was no mortality from surgery or TEVAR.

With **Fujikawa et al.** (14), one patient died on day 6 due to ascending aorta rupture; however, his autopsy showed a healing process at the injury site where there is the stent. And in **Alsac et al.** (16), overall hospital mortality was 17.9% all were not related to the aortic rupture or TEVAR, and no intervention-related morbidity or mortality.

Hundersmarck et al. (17), had 31 patients presented with blunt traumatic aortic injuries of them 10 died before TEVAR from associated injuries, 2 did not require TEVAR, and 19 had TEVAR that was successful in the all (100%) the patients. Of those who had TEVAR, three died in hospital due to aorta unrelated causes.

The outcome of TEVAR was good in our study and it is safe in traumatic descending aortic dissection also with other studies, as in **Fujikawa et al.** (14), as they concluded that it is a valid therapeutic option with minimal surgical invasion for patients with acute aortic injury. Also, **Alsac et al.** (16), concluded that TEVAR allows immediate efficient repair for acute traumatic thoracic aortic injuries, and also **Hundersmarck et al.** (17), showed that TEVAR had good long term radiographic outcomes in blunt traumatic aortic injuries.

CONCLUSION

TEVAR is safe, easy, and practical management of traumatic descending thoracic aortic transection.

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Conflict of interest: Nil.

REFERENCES

1. Richens D, Field M, Neale M et al. (2002): The mechanism of injury in blunt traumatic rupture of the aorta. Eur J Cardiothorac Surg., 21:288-93.
2. Fattori R, Russo V, Lovato L et al. (2009): Optimal management of traumatic aortic injury. Eur J Vasc Endovasc Surg., 37:8-14.
3. Schmoker J, Lee C, Taylor R et al. (2008): A novel model of blunt thoracic aortic injury: a mechanism confirmed? J Trauma, 46(5): 920-27.
4. Jonker F, Giacovelli J, Muhs B et al. (2010): Trends and outcomes of endovascular and open treatment for traumatic thoracic aortic injury. J Vasc Surg., 61(6):681-96.
5. Xenos E, Bietz G, Davenport D (2011): Endoluminal versus open repair of descending thoracic aortic rupture: a review of the national trauma databank. Ther Adv Cardiovasc Dis., 5(5): 221-25.
6. Tang G, Tehrani H, Usman A et al. (2008): Reduced mortality, paraplegia, and stroke with stent-graft repair

- of blunt aortic transactions: A modern meta-analysis. *J Vasc Surg.*, 47(3):671-75.
7. **Demers P, Miller C, Scott Mitchell R et al. (2004):** Chronic traumatic aneurysms of the descending thoracic aorta: mid-term results of endovascular repair using first and second-generation stent-grafts. *Eur J Cardiothorac Surg.*, 25:394-400.
8. **Parmley L, Mattingly T, Manion W et al. (1958):** Nonpenetrating traumatic injury of the aorta. *Circulation*, 17:1086-101.
9. **Lee W, Matsumura J, Mitchell R et al. (2011):** Endovascular repair of traumatic thoracic aortic injury: clinical practice guidelines of the Society for Vascular Surgery. *J Vasc Surg.*, 53: 187-92.
10. **Propper B, Clouse W (2010):** Thoracic aortic endografting for trauma: a current appraisal. *Arch Surg.*, 145: 1006-11.
11. **Arthurs Z, Starnes B, Sohn V et al. (2009):** Functional and survival outcomes in traumatic blunt thoracic aortic injuries: An analysis of the National Trauma Databank. *J Vasc Surg.*, 49: 988-94.
12. **White R, Miller D, Criado F et al. (2011):** Report on the results of thoracic endovascular aortic repair for acute, complicated, type B aortic dissection at 30 days and 1 year from a multidisciplinary subcommittee of the Society for Vascular Surgery Outcomes Committee. *J Vasc Surg.*, 53(4):1082-90.
13. **Brenner M, Teeter W, Hadud M et al. (2017):** Long-term outcomes of thoracic endovascular aortic repair: A single institution's 11-year experience. *J Trauma Acute Care Surg.*, 82(4):687-693.
14. **Fujikawa T, Yukioka T, Ishimaru S et al. (2001):** Endovascular stent grafting for the treatment of blunt thoracic aortic injury. *J Trauma*, 50: 223-229.
15. **Azizzadeh A, Keyhani K, Miller C et al. (2009):** Blunt traumatic aortic injury: initial experience with endovascular repair. *J Vasc Surg.*, 49(6):1403-8.
16. **Alsac J, Boura B, Desgranges P et al. (2008):** Immediate endovascular repair for acute traumatic injuries of the thoracic aorta: a multicenter analysis of 28 cases. *Comparative Study J Vasc Surg.*, 48(6): 1369-74.
17. **Hundersmarck D, van der Vliet Q, Winterink L et al. (2020):** Blunt thoracic aortic injury and TEVAR: long-term outcomes and health-related quality of life. <https://europepmc.org/article/MED/32632630>