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ARTYKUŁ ORYGINALNY / *ORIGINAL ARTICLE*

Endovascular repair of traumatic thoracic aortic rupture: a single centre experience

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Abstract

Background: Thoracic aortic rupture is usually the result of a sudden deceleration caused by a traffic accident, fall or some other misfortune. Before the endovascular era, there was only one treatment option: open repair, burdened by high morbidity and significant mortality. Now, we have the ability to treat it with a stent graft. The advantages of this method include avoiding a thoracotomy or aorta cross-clamping and their associated complications.

Aim: To present our experience and results of endovascular treatment of thoracic aortic ruptures.

Methods: Since 1998, we have performed endovascular treatment for aortic lesions in 1,598 patients. From this group, the indication for stent graft implantation in 31 patients was a traumatic aortic rupture or pseudoaneurysm caused by an injury. All patients had a history of blunt chest trauma. The sequence of injury treatment depended on the severity of each. In all but two patients, the first was an aortic stent graft implantation. The length of thoracic aorta covered ranged from 100–200 mm (mean 123 mm). We did not use any method of spinal cord ischaemia protection. Final angiography showed complete exclusion of the aortic disruption in all patients.

Results: All but one operation was successful. One patient died intraoperatively due to concomitant injuries. After the operation, none of the patients had signs of spinal cord ischaemia or any other complications through a follow-up period ranging from 12 to 96 months (mean 40 months).

Conclusions: Our experience with traumatic thoracic aortic ruptures suggests that endovascular treatment should be the method of choice, especially in unstable multi-trauma patients. However, long-term studies are required to assess the durability of this technique after many years.

Key words: traumatic aortic rupture, endovascular repair, stent graft

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INTRODUCTION

Thoracic aortic rupture is usually the result of a sudden deceleration caused by a traffic accident, fall or some other misfortune. The most common location of rupture is at the aortic isthmus, the region between the fixed arch and the mobile thoracic aorta, but the pathogenesis is still controversial [1, 2]. Despite progress made in the field of rescue medicine, the majority of cases are still lethal, just as they were many years ago [3, 4]. The natural history of this condition is sudden haemorrhage, hypovolemic shock, and death in 85% of patients. The remaining minority of patients develop a self-limiting haematoma and pseudoaneurysm with a high risk of sudden rupture [5].

In those cases, before the endovascular era, there was only one treatment option: open repair, which was burdened by high morbidity and significant mortality, even in experienced vascular wards [6]. Now, we have the ability to treat thoracic aortic ruptures with a stent graft. The advantages of this method include avoiding a thoracotomy or aorta cross-clamping and their associated complications.

The aim of our study was to present our experience and results of endovascular treatment of thoracic traumatic aortic ruptures.

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Table 1. Patient preoperative data

		Acute group	Delayed group
Number		22	9
Gender (male/female)		19/3	7/2
Mean age (range)		39.3 (14–81)	49.4 (31–84)
Mechanism of injury:	Vehicle accident	21	7
	Fall from height	1	2
Mean time from injury to operation (range)		11 (6–28) hours	26 (4–58) months
No. (%) of patients with concomitant injuries:	Head	20 (91%)	–
	Neck	9 (41%)	–
	Extremities	18 (82%)	–
	Abdomen included:	7 (32%)	–
	Spleen	5 (23%)	–
	Liver	2 (9%)	–
	Pancreas	1 (5%)	–
No. (%) of patients with GCS < 8		13 (59%)	0

GCS — Glasgow Coma Scale

METHODS

Study group

Since 1998, we have performed endovascular treatment for aortic lesions in 1,598 patients, including 382 thoracic stent grafts. From this group, the indication for stent graft implantation in 31 (8.7%) patients was a traumatic aortic rupture or pseudoaneurysm caused by an injury within nine years from 2003 to 2012. Those 31 consecutive patients comprised our study group. Twenty-two were admitted directly after the accident with multi-organ trauma and shock or referred from another hospital with the diagnosis or suspicion of an aortic rupture (this is the acute group). The remaining nine patients were admitted a varying amount of time (4–58 months) after their injury due to the presence of a pseudoaneurysm (this is the delayed group). All patients had a history of blunt chest trauma (28 vehicle accidents and three falls from heights). Table 1 shows the preoperative data of all patients.

Computed tomography scan

The diagnosis was made in all acute patients with a computed tomography (CT) scan performed immediately after admission due to multi-organ trauma. In delayed patients, the initial diagnosis was achieved by routine chest X-ray in eight cases and echocardiography in one case, followed by confirmation with a contrast-enhanced CT scan. In all cases, by using various CT reconstructions (Fig. 1), we measured:

— the diameter of the aorta:
  - between the left subclavian artery (LSA) and left common carotid artery (LCCA)
  - between the LSA and the site of rupture
  - 2 cm below the site of rupture

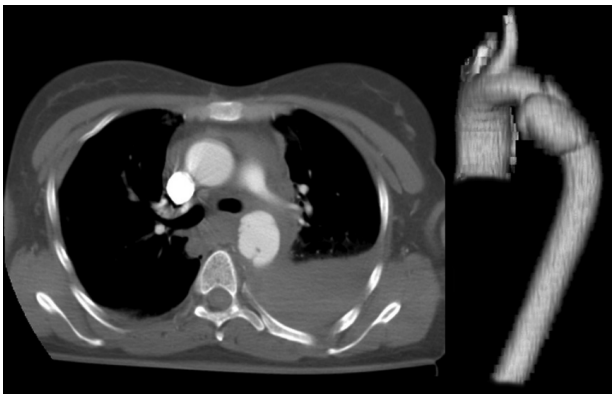

Figure 1. Preoperative computed tomography scan — thoracic aortic rupture

— the distance:
  - between the LSA and the LCCA
  - between the LCCA and the site of rupture.

Stent graft implantation

The sequence of injury treatment depended on the severity of each. In all but two patients, the first treatment was an aortic stent graft. One patient required a splenectomy, and one required a segmentectomy of the liver (due to massive abdominal haemorrhage) before the endovascular treatment. Stent graft implantation was performed in an operating room equipped with C-arm through a femoral artery approach. Patients were treated with either general (19/31 patients, 61%) or regional (12/31 patients, 39%) anaesthesia with sedation. Ten (32%) patients were heparinised before stent

graft implantation (eight from the delayed group and two from the acute group). The remaining patients had significant contraindications to heparin administration due to concomitant injuries and the risk of bleeding. All patients received antibiotic prophylaxis. In 16 cases, we used a Zenith (Cook), in four cases we used a Tag (Gore), and in 11 cases we used a Relay or Talent (Medtronic) stent graft. The stent graft selection depended upon availability and the required size. We oversized the stent graft by 10–20% in diameter and the sizes ranged from 22 mm to 34 mm (mean 27 mm). The length of thoracic aorta covered ranged from 100 mm to 200 mm (mean 123 mm). We did not use any method of spinal cord ischaemia (SCI) protection. At deployment, no pharmacological methods were used to reduce systemic pressure. We always tried to spare the blood flow to the LSA, but if the length between its origin and the rupture site (proximal neck) was less than 1 cm, we intentionally covered it with the stent graft; this was required in six patients. After stent graft implantation, angiography showed a type I endoleak in eight patients. Balloon angioplasty of the proximal seal was performed in all cases, with 5/8 (62.5%) being effective. The remaining three cases required an additional segment of stent graft during the procedure. Final angiography showed complete exclusion of the aortic disruption in all patients.

In one patient, due to a concomitant aortic wall dissection close to the rupture site, there was difficulty with the guidewire passage to the ascending aorta. The solution to the problem was right brachial access and antegrade passage of the guidewire through the brachiocephalic trunk to the descending aorta resulting in standard stent graft implantation. In all remaining patients, one common femoral artery was the only vascular access required. Table 2 shows the operative details for all patients.

RESULTS

All but one operation was successful. One patient died intraoperatively due to concomitant injuries (cerebral contusion and oedema, multiple fractures, two cardiac arrests on the operating table). After the operation, none of the patients had signs of SCI.

We performed a postoperative CT scan in all survivors that showed complete exclusion of the aortic disruption (Fig. 2). The follow-up period ranged from 12 to 96 months (mean 40 months). We followed patients with a CT scan in the 3rd, 6th, and 12th postoperative months and annually thereafter, and found complete healing of the rupture location in all 'acute' cases and shrinkage of the pseudoaneurysm in 'delayed' cases (Fig. 3). During the observation period, there were no signs of left hand ischaemia or subclavian steal syndrome in patients with a covered LSA ostium. There were also no stent graft-related complications such as migration, fracture, collapse, false aneurysm expansion or rupture.

DISCUSSION

Blunt aortic injury is the most common cause of death in trauma patients, with an overall incidence of 0.3% [7]. Open aortic surgery is burdened with a high incidence of complications primarily due to comorbidities in this specific group of multi-organ trauma patients. Therefore, since the first report of endovascular treatment for traumatic aortic rupture by Semba [8], this method has appeared to be superior to open surgery due to the minor operative trauma. There is also no need for systemic heparinisation, which can be dangerous due to potential post-traumatic bleeding. Moreover, the surgery is not time-consuming and can be performed before managing most of the other injuries. Most importantly, the complication rate is lower [9, 10]. Because we believe that the endovascular method is better than open surgery due to the above mentioned reasons, it is the only method we use for our patients. In our opinion, this is the best solution for every vascular centre, even ones that are not experienced in cardiothoracic surgery. These results prove that our protocol is efficient.

The main concern associated with endovascular treatment is the lack of long-term observational results for this relatively new method. In our study, as reported in another study [9], the majority of patients were young with a life expectancy over 35 years, and we still do not know how the stent graft will behave after such a long time. Early results using the withdrawn Stentor and Vanguard stent grafts that broke [11] or resulted in an aneurysm rupture a few years after the endovascular treatment [12] were not optimistic.

The unsolved problem during the treatment of thoracic aorta lesions is the risk of SCI, which is estimated to be up to 21% after an open method and 0–12% after an endovascular method [13, 14]. The risk of SCI depends on the length of the thoracic aorta covered during the endovascular treatment, with 205 mm being the threshold for increased risk [15]. In traumatic rupture patients, it is usually not necessary to cover a long section of the aorta; therefore, the risk of SCI is low. In our cohort, even though we did not use any method of SCI protection, we did not notice this complication in any case, probably due to the short stent grafts used (mean length of the stent graft was 123 mm).

The site of rupture is usually at the aortic isthmus, so the distance from the LSA usually allows for proximal stent graft fixation. Nevertheless, in our series, six patients required intentional coverage of the LSA ostium. Most authors have reported the need for LSA revascularisation only for specific indications, including long aortic segment coverage, prior or concomitant infrarenal aortic replacement, hypoplastic right vertebral artery, a patent left internal mammary artery graft, renal insufficiency or a functioning dialysis fistula in the left arm [16]. We did not have any indications for LSA revascularisation in our patients and have not yet observed any symptoms of subclavian steal syndrome or hand ischaemia.

Table 2. The operative details for all patients

No.	Initials	Age	Stent graft used	Acute	LSA coverage	Stent graft length	Stent graft diameter	No. of stent graft elements	Comment
1.	RK	19	Talent	Yes	No	120	30	2	Additional stent graft due to intraoperative endoleak
2.	AM	31	Talent	No	No	115	30	1	
3.	MJ	54	Talent	Yes	No	140	24	2	Additional stent graft due to intraoperative endoleak
4.	WT	52	Talent	No	No	100	28	1	
5.	WC	38	Talent	No	No	120	30	1	
6.	MO	44	TAG	No	No	100	26	1	
7.	CT	56	Zenith	No	No	115	22	1	
8.	KZ	52	Zenith	Yes	No	115	24	1	
9.	PP	14	Talent	Yes	Yes	140	24	1	Intraoperative effective balloon angioplasty due to EL type I
10	KL	49	Zenith	Yes	Yes	115	24	1	
11.	JB	40	Relay	No	No	100	26	1	
12.	CD	47	Zenith	Yes	No	120	28	1	
13.	JC	43	Relay	Yes	No	100	26	1	
14.	WP	35	Relay	Yes	Yes	100	30	1	Intraoperative effective balloon angioplasty due to EL type I
15.	SS	35	Relay	Yes	No	100	26	1	
16.	LC	22	Zenith	Yes	No	115	22	1	
17.	TG	61	Talent	No	No	115	30	1	Intraoperative effective balloon angioplasty due to EL type I
18.	HG	46	Zenith	Yes	Yes	120	28	1	
19.	KK	21	Zenith	Yes	No	115	22	1	
20.	MW	58	Zenith	Yes	No	140	28	2	Additional stent graft due to intraoperative endoleak
21.	MK	39	Zenith	No	No	115	24	1	
22.	PA	41	Zenith	Yes	Yes	140	28	1	
23.	JA	81	Zenith	Yes	No	200	34	1	Intraoperative effective balloon angioplasty due to EL type I
24.	MP	39	Zenith	Yes	No	140	28	1	
25.	ZS	52	TAG	Yes	Yes	200	34	1	Died intraoperatively
26.	MS	40	TAG	Yes	No	100	26	1	
27.	NG	33	Zenith	Yes	No	115	24	1	
28.	KK	47	Zenith	Yes	No	140	32	1	
29.	KK	19	Zenith	Yes	No	115	24	1	
30.	MW	84	TAG	No	No	120	30	1	
31.	MS	18	Zenith	Yes	No	134	26	1	Intraoperative effective balloon angioplasty due to EL type I

LSA — left subclavian artery

A few years ago, there was a debate regarding the timing of aortic surgery for stable trauma patients [17], but this debate occurred in the era when open treatment was preferred. Currently, the only indication to delay aortic rupture treatment is clinical instability of the patient from injuries other than aortic lesions [18]. In our group of patients, only in two 'acute' cases was there an indication to delay aortic surgery due to a massive abdominal haemorrhage. We also treated nine patients in the 'delayed' group 4–58 months after their injury. This proves that a sustained rupture of the thoracic aorta is possible, but Holmes et al. [5] found that during the first six hours of admission, approximately 5% of patients deteriorate due to haemorrhage. Therefore, immediate repair seems to be justified even in stable patients.

On the other hand, there is still a deficiency of vascular centres with on-stock availability of different endoprosthesis sizes and a team experienced in endovascular procedures. Moreover, in young patients, the size of the aorta is

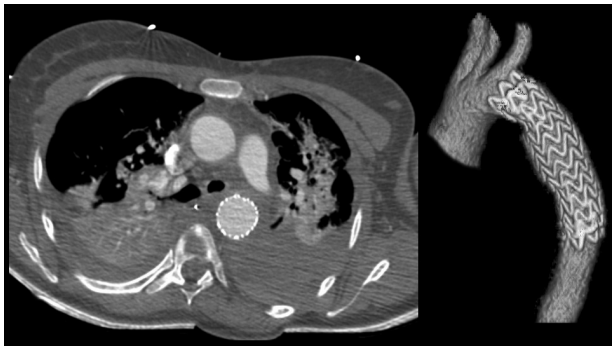

Figure 2. Direct postoperative computed tomography scan — complete exclusion of the aortic disruption

Figure 3. Computed tomography scan three months (left) and 12 months (right) after stent graft implantation in 'delayed' case — shrinkage of the pseudoaneurysm

usually small, thereby making it difficult to find a stent graft of the proper size. We always try to oversize the stent graft by no more than 20% due to reports of collapsed endoprostheses with greater oversizing [19].

The smallest available stent graft diameter is 21 mm. Because of a maximum 20% oversize, the question remains what to do with patients with aorta diameters smaller than 18 mm. In our series, we did not encounter this scenario, but the only solution is probably open thoracic aorta surgery. A similar problem could apply to juvenile patients with growing aortas. In such cases, the oversizing must be maximal. The youngest patient treated in our department for traumatic aorta rupture was 14 years old, and the diameter of the aorta was 20.5 mm. The stent graft we used was 24 mm (17% oversize). We have not yet observed any complications related to the growing aorta during our five-year follow-up period. Nevertheless, there is a necessity for a wider stent graft diameter range for acute indications.

Another technical problem during endovascular treatment of thoracic aorta lesions is the acute angle of the aortic arch. This especially concerns traumatic aortic ruptures that are usually close to the tortuous region of the aorta. In such circumstances, the stent graft may not adhere to the inner curve of the arch resulting in an endoleak or collapse. In 2008, Kölbel et al. [20] proposed a novel technique of bending a thoracic stent graft. We have not used this technique, but we did not notice any problems in two cases with a protruding stent as seen on the CT scan. Those two cases were performed with a Talent stent graft with proximal 'free flow'.

CONCLUSIONS

Our results of traumatic thoracic aortic ruptures suggest that endovascular treatment should be the method of choice, especially in unstable multi-trauma patients. It allows for fast management of the potentially lethal condition and, therefore, provides additional time to manage other injuries. Moreover, the morbidity and mortality rates are low. However, long-term studies are required to assess the durability of this technique after many years.

Conflict of interest: *none declared*

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Wewnątrznaczyniowe leczenie urazowych pęknięć aorty: doświadczenie jednego ośrodka

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Streszczenie

Wstęp: Pęknięcie aorty piersiowej jest zwykle efektem nagłego, ujemnego przyspieszenia (opóźnienia) spowodowanego wypadkiem komunikacyjnym, upadkiem z wysokości lub innym urazem. W przeszłości jedyną możliwością leczenia była operacja otwarta, obarczona wysoką śmiertelnością i dużym odsetkiem powikłań. Aktualnie w takich przypadkach istenieje możliwość implantacji stentgraftu do aorty piersiowej. Zaletą tej metody jest uniknięcie torakotomii i klemowania aorty oraz związanych z nimi powikłań.

Cel: Celem pracy była ocena wyników wewnątrznaczyniowego leczenia urazowych pęknięć aorty piersiowej.

Metody: Od 1998 r. w Klinice autorów metody wewnątrznaczyniowe w leczeniu patologii aorty zastosowano u 1598 chorych. Wśród nich było 31 osób, u których wskazaniem do implantacji stentgraftu było pęknięcie aorty piersiowej lub tętniak rzekomy spowodowany urazem. Kolejność leczenia obrażeń zależała od ich istotności. Poza 2 przypadkami rozpoczynano od implantacji stentgraftu. Długość pokrytej aorty wynosiła 100–200 mm (śr. 123 mm). Nie stosowano żadnej metody protekcji niedokrwienia rdzenia kręgowego. Końcowa arteriografia we wszystkich przypadkach wykazała całkowite wyłączenie z krążenia obszaru pęknięcia aorty.

Wyniki: Poza 1 przypadkiem wszystkie operacje zakończyły się powodzeniem. Jeden chory zmarł z powodu towarzyszących urazów. Po operacji u żadnego pacjenta nie stwierdzono objawów niedokrwienia rdzenia kręgowego ani innych powikłań związanych z implantacją stentgraftu. Okres obserwacji wynosił 12–96 miesięcy (śr. 40 miesięcy).

Wnioski: Zastosowanie stentgraftów w leczeniu urazowych pęknięć aorty piersiowej powinno być uznawane za metodę z wyboru, zwłaszcza u niestabilnych chorych po urazach wielonarządowych. Konieczne są jednak badania nad trwałością tego sposobu terapii w długoletniej obserwacji.

Słowa kluczowe: stentgraft, leczenie wewnątrznaczyniowe, urazowe pęknięcie aorty

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