

CASE REPORT

## Intragraft Obstructive Thrombus Two Years After Endovascular Repair of Traumatic Aortic Injury: A Case Report and Review of the Literature

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**Introduction:** Thoracic endovascular aortic repair (TEVAR) is the treatment of choice for blunt thoracic aortic injury (BTAI) and has proven to be a good alternative to open surgery. TEVAR requires less operation time, has fewer complications, can be used for relatively unstable patients, and is associated with a significantly lower mortality rate. Moreover, long term follow up data demonstrate low re-intervention rates and stentgraft failure.

**Report:** The case of a 21 year old man who sustained severe trauma, including a traumatic pseudoaneurysm of the descending thoracic aorta distal to the left subclavian artery in 2016, is presented. The patient was treated by TEVAR. Two years later, he presented with progressive paraplegia due to stentgraft occlusion occurring four days after a new high velocity motor vehicle accident. An axillofemoral bypass was performed to assure blood flow to the lower body. Two days later the stentgraft was removed via left thoracotomy and replaced by a Dacron graft. Gross examination showed severe thrombus formation at the proximal edge, and a thrombotic occlusion in the middle and distal third of the stent. After three months of hospitalisation the patient was discharged to a rehabilitation clinic with partial recovery of his paraplegia. As of June 2020, the patient was able to walk without assistance and his paraplegia improved with only loss of sensation of his lower legs.

**Conclusion:** A serious thrombotic complication two years after TEVAR is described. Although TEVAR is the currently preferred treatment for BTAI, more research is needed to examine the mechanisms behind this thrombotic complication and to elucidate whether TEVAR is definitive treatment or a “bridge to further surgery”. Smaller diameter stentgrafts, anticoagulation, regular (lifelong) follow up imaging, and prophylactic surgical conversion in (selected) patients might help to prevent this serious complication.

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**Abbreviations:** BTAI Blunt Thoracic Aortic Injury, TEVAR Thoracic Endovascular Aortic Repair

**Keywords:** BTAI (Blunt Thoracic Aortic Injury), Obstruction, Occlusion, Paraplegia, TEVAR (Thoracic Endovascular Aortic Repair), Thrombus

### INTRODUCTION

Thoracic endovascular aortic repair (TEVAR) is the treatment of choice for blunt thoracic aortic injury (BTAI). BTAI is relatively rare and often lethal.<sup>1</sup> TEVAR has been proven to be a good alternative to open surgery for the treatment of BTAI. TEVAR requires less operating time, has fewer complications, can be used for relatively unstable patients, and is associated with a significantly lower mortality rate.<sup>2</sup> Next to the overt short term advantages of TEVAR, the mid- and long term outcomes are good, with low incidences of stentgraft related complications or re-interventions.<sup>3,4</sup>

The case of a patient with thoracic stentgraft occlusion with progressive paraplegia two years after TEVAR is described.

### CASE REPORT

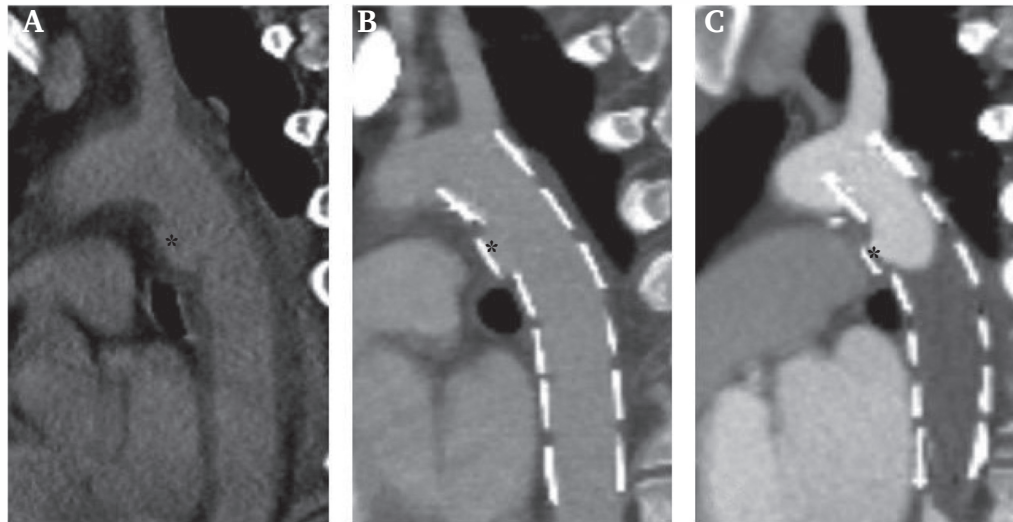
In June 2016, a 21 year old man was severely injured after his scooter collided with a stationary truck. He had multiple injuries, including a traumatic grade III pseudoaneurysm of the descending thoracic aorta, at the level of the ligamentum arteriosum (Fig. 1A). The patient was brought to the operating room for a TEVAR. The aortic diameters were 20 mm proximal and distal to the lesion, with a blood pressure at the time of arrival of 180/130 mmHg. To treat the patient, a 24–115 mm stentgraft (Zenith TX2; Cook Medical, Limerick, Ireland) was selected and deployed (20% oversizing). The patient fully recovered and was discharged after 27 days and was instructed to take 80 mg acetylsalicylic acid (ASA) daily for the next six months. The patient returned for surveillance computed tomography angiography (CTA) in February 2017 (T = 6 months) and in

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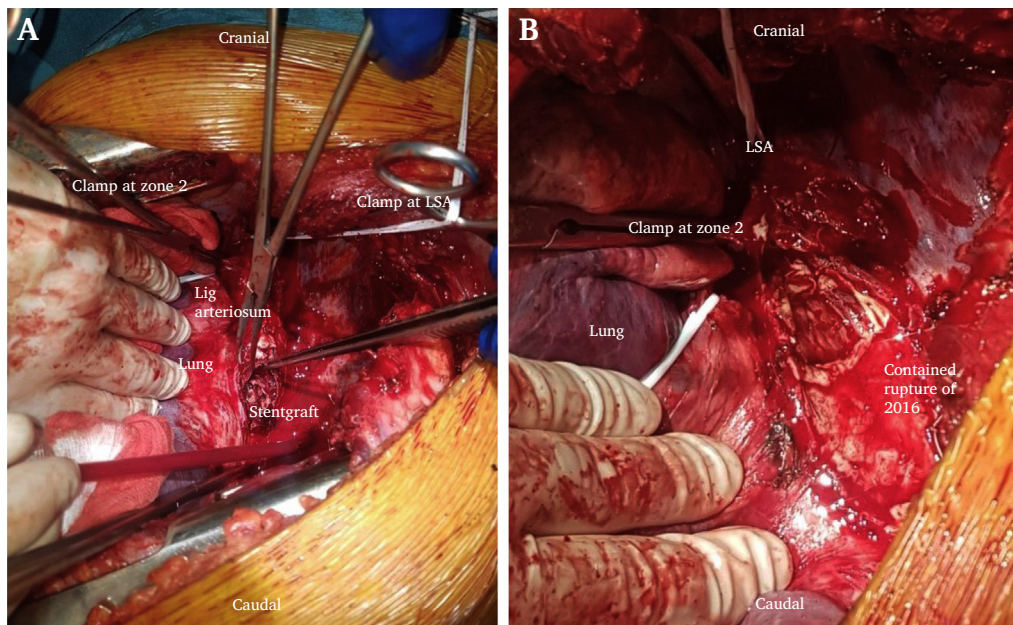


**Figure 1. Sagittal views of the descending aorta at different times.** Panel A demonstrates sagittal view of the thoracic aorta at the time of the first trauma. The Asterix (\*) demonstrates the location of the grade III rupture distal to the LSA near the ligamentum arteriosum. Panel B demonstrates the CTA scan image 20 days after TEVAR with very subtle thrombus formation, which resulted in continuation of the anticoagulation. Panel C shows the CTA at the time of thrombotic occlusion of distal two thirds of the stentgraft.

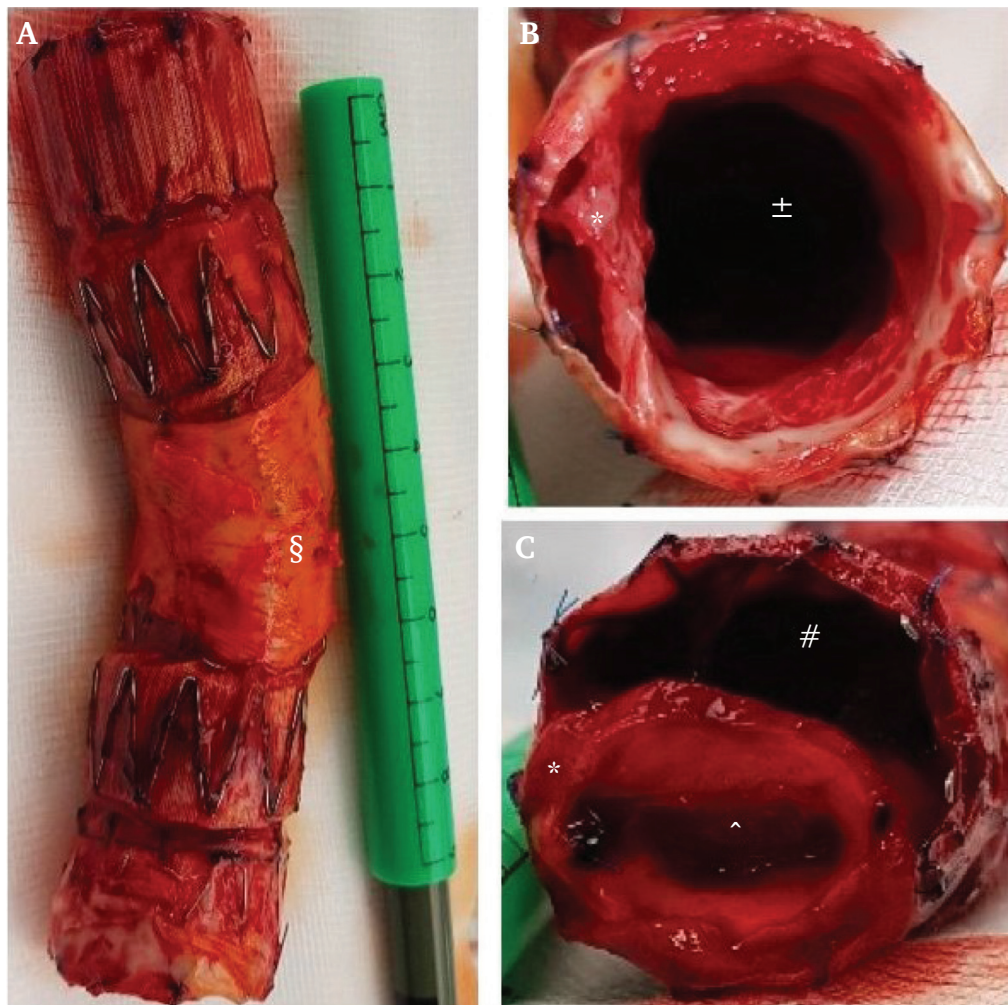
September 2017 (T = 12 months). The CTAs showed limited amounts of intragraft wall mounted thrombus, mainly involving the distal third of the stentgraft (Fig. S1). A follow up scan was scheduled for September 2018 (T = 24 months) and because of the intragraft thrombus, the patient was instructed to continue antiplatelet therapy (ASA).

In July 2018, the patient was involved in a second high velocity rollover motor vehicle accident and was

hospitalised in a rural hospital for one night. He left the hospital in a good clinical condition. For the next four days he stayed at home, recovering from the car crash, bruised and painful, but without neurological symptoms. On the fifth day, he woke up with profound paraplegia. There was a delay in transportation to hospital, owing to the fact that the patient lived on an island. He was first transported to another hospital and finally referred to the authors' centre.



**Figure 2. A. Peri-operative image after a left thoracotomy.** The zone two aortic arch and at left subclavian artery clamps can be seen. The stentgraft is removed from the descending aorta. **B. Image following removal of the stentgraft.** The clamp at the aortic arch/zone 2 can be seen. The LSA clamp has been exchanged for a vessel loop. Please note the white arrow showing the old contained rupture/pseudoaneurysm of the descending aorta, just around the ligamentum arteriosum.



**Figure 3. Removed stentgraft.** Removed stentgraft with a part of the thoracic aortic wall (§) demonstrated at panel A. Panel B demonstrates the proximal part of the stentgraft with thrombus formation (\*) and the true lumen (±). Panel C demonstrates the distal part with occlusive thrombus formation of almost the entire lumen (-), and a false lumen (#) due to re-expansion of the endograft outside the body.

At the time of presentation to the authors' hospital he had a blood pressure of 202/115 and a lack of sensation starting at level Th10/11 with no reflexes in his lower extremities. Both femoral pulses were absent and his legs were cold. CTA demonstrated occlusion of the middle and distal third of the thoracic stentgraft without signs of endoleak, collapse, migration, or structural device alterations (Fig. 1).

To restore perfusion to the lower body an immediate right axillofemoral bypass (10 mm Dacron; Braun Medical, Melsungen, Germany) was performed. After surgery his systolic arterial blood pressure, measured in the left femoral artery, increased from 30 mmHg to 60 mmHg. Femoral pulses were present but weak. Cerebrospinal drainage was performed by placement of a spinal drainage catheter, in order to optimise perfusion of the spinal cord. The day after surgery, the clinical condition of the patient deteriorated: an exploratory laparotomy demonstrated an ischaemic right colon, most likely caused by systemic hypoperfusion. A right sided hemicolectomy was performed. The next day a second look was performed with formation of a terminal ileostomy and in order to improve peripheral perfusion it was decided

to replace the occluded stentgraft with an aortic interposition graft through a left thoracotomy. After clamping on the aorta proximal and distal to the stentgraft (Fig. 2A), the stentgraft was removed (Fig. 2B) and replaced by a 22 mm Dacron graft (Braun Medical). Finally, the axillofemoral bypass was removed during the same operation. Gross examination of the removed stentgraft showed intraluminal thrombus formation in the entire graft with occlusion in the middle and distal third of the endograft (Fig. 3).

The patient was transferred to the intensive care unit and developed acute kidney failure necessitating haemodialysis. He was tetraplegic after the cessation of anaesthesia due to spinal cord ischaemia and critical illness polyneuropathy. He had severe electrolyte disturbances due to an intestinal ischaemic injury in combination with a high output ileostomy requiring total parental nutrition. Furthermore, he developed severe neuropathic pain in both legs. He was discharged on post-operative day 83, still paraplegic at the level of Th10. In December 2018 (post-operative day 155) an ileotransversostomy was performed. In January 2019 the patient was still recovering: both the power and sensitivity



**Table 1.** Ten cases of acute thrombotic (near) occlusion of a TEVAR stentgraft.

Author	Year	Patient Age/Sex	Stentgraft	Ø Aorta	% Oversizing	Anti-coagulation	Time between TEVAR and occlusion (months)	Thrombosis	Symptomatic	Treatment	Outcome
Alvarez <sup>5</sup>	2009	17 ♂	24 × 66 mm Zenith Tx2 (Cook) <sup>a</sup>	18 mm	33%	Ascal	11	Nearly obstructive	Yes	Planned EAB, aorto-aortic bypass	Uneventful
Marone <sup>6</sup>	2012	32 ♂	24 × 104 mm Relay (Bolton)	21 mm	14%	Ascal	30	Partial obstructive	No	Planned thoracotomy, tube replacement	Uneventful
Reich <sup>7</sup>	2014	24 ♂	24 × 116 mm Talent (Medtronic)	23 mm	4%	No	14	Nearly obstructive	Yes	Acute thoracotomy, tube replacement	Paraplegic
Marino <sup>8</sup>	2014	38 ♂	Valiant (Medtronic)	24 mm	27%	Ascal	6	Partial obstructive	No	Change to warfarin for 18 months due to progression and re-fusion open surgery, endovascular endograft relining was performed	Asymptomatic
Abdoli <sup>9</sup>	2017	29 ♂	22 × 100 mm Valiant (Medtronic)	22 mm	22%	No	9	Nearly obstructive	Yes	Acute axillobifemoral bypass	Asymptomatic → planned endograft explant and replacement of the descending thoracic aorta
García Reyes <sup>10</sup>	2018	—	—	—	—	—	12	Total obstruction	Yes	EAB, aorto-aortic bypass	Asymptomatic
Liesdek <sup>11</sup>	2019	24 ♂	Valiant (Medtronic)	—	—	Carbasalate calcium	23	Total obstruction	Yes	Acute thoracotomy, tube replacement	Improvement of paraplegia
Hostalrich <sup>12</sup>	2019	15 ♀	22 × 109 mm Zenith (Cook)	15 mm	32%	No	10	Nearly obstructive	Yes	Acute primary endovascular stenting (OPTIMED)	Asymptomatic
Martinelli <sup>13</sup>	2020	22 ♂	22 × 100 mm Zenith (Cook)	19 mm	15%	Antiplatelet therapy	6	Total obstruction	Yes	Emergency endovascular relining of the endograft	8 months later, asymptomatic recurrent partial occlusion of the second graft was present → planned thoracotomy, tube replacement → final outcome: paraplegic
Beijer	2020	21 ♂	24 × 115 mm Zenith Tx2 (Cook)	20 mm	20%	Ascal <sup>b</sup>	24	Total obstruction	Yes	Acute EAB followed by thoracotomy, tube replacement	Improvement of paraplegia

♂ male.

♀ female.

Ø diameter.

% percentage.

- not reported.

TEVAR: Thoracic endovascular aortic repair, mm: millimetre, EAB: extra anatomic bypass.

<sup>a</sup> The stentgraft was implanted 7 weeks following trauma.<sup>b</sup> After 24 months switch to warfarin due to thrombus formation.

of his legs were increasing and the patient was continent for faeces. In June 2020 the patient was doing quite well. After intensive rehabilitation and physiotherapy, he had almost fully recovered from his paraplegia and was able to walk without adjuncts and only had loss of sensation of his lower legs. He also returned to his former job.

## DISCUSSION

The short term advantages of TEVAR, such as lower initial mortality, have been acknowledged by various studies and clinical observations.<sup>1,2</sup> The long term outcomes of TEVAR are also good, with low re-intervention rates or stentgraft failures.<sup>3,4,10</sup> A rare but serious complication has been described that has been scarcely reported in long term follow up studies. In reviewing the literature, nine case reports of acute thrombotic (near) occlusion of a thoracic stentgraft were found (Table 1).<sup>5–13</sup>

Most patients were young males treated by TEVAR for a blunt traumatic injury of the descending aorta. The age of patients ranged from 15 to 38 years, their aortic diameters ranged from 15 to 24 mm, and stentgraft oversizing ranged from 4% to 33%. At least six of ten patients were placed on antiplatelet therapy. In all cases, no significant structural modifications of the stentgraft could be detected at follow up scans. Finally, the (near) occlusion of the stentgraft developed between six and 30 months post-operatively.

Specific to the present case is the total occlusion of the stentgraft occurring after a second trauma. Trauma patients develop a hypercoagulable state.<sup>14</sup> It is probable that the patient in this case had already developed asymptomatic thrombus formation inside his stentgraft. Following the second trauma, a state of hypercoagulability combined with the existing thrombus could have prompted acute occlusion of the remaining lumen. Another explanation is that the second trauma might have caused initiation of separation of the thrombus layer from the graft, which might then have behaved like a dissection flap and caused occlusion within the stentgraft. Unfortunately, the exact pathophysiological mechanism, using histological examination of the explanted, stentgraft could not be investigated.

TEVAR is frequently used in aneurysmal aortic diseases (AADs). This patient population is different in several ways from those with BTAI. Firstly, patients with a BTAI are often younger and consequently have a narrower aortic diameter. Secondly, the aortic arch is more angulated in patients with a BTAI. Stentgraft size is usually based on AAD, and therefore excessive oversizing is often inevitable in patients with a BTAI owing to the limited availability of smaller stentgraft diameters. Oversizing in TEVAR might play an important role in the formation of intragraft thrombus, as it leads to a higher risk of collapse and thus occlusion of the stentgraft.<sup>10</sup> Fernandez et al. retrospectively reviewed 20 cases of acute or subacute TEVAR for BTAI with a mean follow up of 40 months.<sup>1</sup> Seven of 20 (35%) of the patients developed detectable intragraft mural thrombus, all within six months of TEVAR placement. No evidence of significant progression was found during further follow up in this group and no major complications were observed.<sup>1</sup> Importantly, the 17

year old patient with a nearly occlusive thrombus described by Alvarez et al.<sup>5</sup> was part of this cohort and the thrombus was not observed on post-operative scans before the occlusion occurred.

In conclusion, although TEVAR is the first choice treatment for BTAI, a serious thrombotic complication two years after treatment has been described herein and elsewhere. More research is needed, especially within young patients, to elucidate the mechanism of thrombus formation and stentgraft occlusion, in order to determine whether TEVAR is definitive treatment or a “bridge to further surgery”. Smaller diameter stentgrafts should be accessible in the emergency setting to prevent excessive oversizing. Moreover, regular (lifelong) follow up imaging, possibly prolonged anticoagulation, and prophylactic surgical conversion in selected patients might help prevent this serious complication.

## FUNDING

None.

## CONFLICT OF INTEREST

None.

## APPENDIX A. SUPPLEMENTARY DATA

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ejvsf.2021.10.018>.

## REFERENCES

- 1 Fernandez V, Mestres G, Maeso J, Domínguez JM, Aloy MC, Matas M. Endovascular treatment of traumatic thoracic aortic injuries: short- and medium-term follow-up. *Ann Vasc Surg* 2010;**24**:160–6.
- 2 Tang GL, Tehrani HY, Usman A, Katariya K, Otero C, Perez E, et al. Reduced mortality, paraplegia, and stroke with stent graft repair of blunt aortic transections: a modern meta-analysis. *J Vasc Surg* 2008;**47**:671–5.
- 3 Hundersmarck D, van der Vliet QMJ, Winterink LM, Leenen LPH, van Herwaarden JA, Hazenberg CEVB, et al. Blunt thoracic aortic injury and TEVAR: long-term outcomes and health-related quality of life. *Eur J Trauma Emerg Surg* 2020. <https://doi.org/10.1007/s00068-020-01432-y> [Epub ahead of print].
- 4 Cheng YT, Cheng CT, Wang SY, Wu VC, Chu PH, Chou AH, et al. Long-term outcomes of endovascular and open repair for traumatic thoracic aortic injury. *JAMA Netw Open* 2019;**2**:e187861.
- 5 Alvarez B, Constenla I, Maeso J, Matas M. Late thrombosis of a thoracic aorta stent graft: therapeutic management. *J Vasc Surg* 2009;**49**:774–7.
- 6 Marone EM, Kahlberg A, Tshomba Y, Logaldo D, Chiesa R. Surgical conversion for intragraft thrombosis following endovascular repair of traumatic aortic injury. *J Vasc Surg* 2012;**55**:538–41.
- 7 Reich HJ, Margulies DR, Khoynezhad A. Catastrophic outcome of de novo aortic thrombus after stent grafting for blunt thoracic aortic injury. *Ann Thorac Surg* 2014;**98**:e139–41.
- 8 Marino M, Kasemi H, Martinelli O, Bresadola L, Salvatori FM, Irace L. Re-TEVAR for complications after blunt aortic traumatic injury stenting. *Cardiovasc Intervent Radiol* 2014;**37**:519–22.

- 9 Abdoli S, Ham SW, Wilcox AG, Fleischman F, Lam L. Symptomatic intragraft thrombus following endovascular repair of blunt thoracic aortic injury. *Ann Vasc Surg* 2017;**42**:305.
- 10 García Reyes ME, Martins GG, Valenzuela VF, González JMD, Lebrun JM, Montoya SB. Long-term outcomes of thoracic endovascular aortic repair focused on bird beak and oversizing in blunt traumatic thoracic aortic injury. *Ann Vasc Surg* 2018;**50**:140–7.
- 11 Liesdek OCD, Jacob KA, Vink A, Vermeulen MA, Hazenberg CEVB, Suyker WJL. Surgical treatment of acute thoracic stent graft occlusion. *Ann Thorac Surg* 2019;**107**:e127–9.
- 12 Hostalrich A, Canaud L, Ozdemir BA, Chaufour X. Severe thoracic aorta stenosis after endovascular treatment of blunt thoracic aortic injury. *Semin Thorac Cardiovasc Surg* 2019;**31**: 227–9.
- 13 Martinelli O, Malaj A, Faccenna F, Ruberto F, Alunno A, Totaro M, et al. Open conversion for recurrent endograft occlusion after endovascular treatment of blunt traumatic aortic injury: a peculiar case report. *Ann Vasc Surg* 2020;**67**:568.
- 14 Previtali E, Bucciarelli P, Passamonti SM, Martinelli I. Risk factors for venous and arterial thrombosis. *Blood Transfus* 2011;**9**: 120–38.