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(s)INE: (soft-graft)-induced new entry tear after elephant trunk procedure

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Abstract

Elephant trunk and frozen elephant trunk are established procedures for the treatment of aortic arch pathologies, such as aneurysm or dissection. The aim of open surgery is to re-expand the true lumen, favouring correct organ perfusion and the thrombosis of the false lumen. Frozen elephant trunk, with its stented endovascular portion, is sometimes associated with a life-threatening complication: the stent graft-induced new entry. In the literature, many studies reported the incidence of such issue after thoracic endovascular prosthesis or frozen elephant trunk, but in our knowledge, there are no case studies about the occurrence of stent graft-induced new entry with the use of soft grafts. For this reason, we decided to report our experience, highlighting how the use of a Dacron graft can cause distal intimal tears. We decided to coin the term soft-graft-induced new entry to indicate the development of an intimal tear induced by the soft prosthesis in the arch and proximal descending aorta.

Keywords: Aortic dissection • Elephant trunk • Stent graft-induced new entry • Cardia surgery • Aortic surgery • Thoracic endovascular prosthesis

INTRODUCTION

One of the purposes of using elephant trunk (ET) or frozen elephant trunk (FET) procedure is to replace the aneurysmal or dissected arch and reduce the late dilatation of the descending aorta, caused by the false lumen (FL). In this manner, we might induce the thrombosis of the FL, favouring the aortic remodelling with re-expansion of the true lumen (TL) [1].

This favourable aortic remodelling leads to an improved survival and freedom from re-interventions. However, one of the complications associated with the use of FET is the development of stent graft-induced new entry (SINE) tears, typically described after the implant of thoracic endovascular prosthesis (TEVAR).

SINE is the acronym for 'stent-induced new entry', a term coined in 2010 from Dong *et al.* [2]. It was defined as 'a new tear caused by the stent graft itself', excluding those created by natural disease progression or any iatrogenic injury from the endovascular manipulation.

In this article, we aim to demonstrate that SINE can also occur after the implant of a soft Dacron ET.

Since in the literature the development of SINE after ET has never been reported yet, we have decided to use the acronym soft-graft-induced new entry ((s)INE).

Moreover, in 1 patient out of the 2 described, after the endovascular treatment of the complication, a second new entry tear occurred distally to the TEVAR. We would like to highlight how the fragility of the aortic wall represents the main risk factor for the development of such complication.

PATIENT 1

The first patient was 67-year-old male. He had a biological Bentall 3 years earlier in another institution for emergency treatment of type A acute aortic dissection. He was followed up with serial computed tomography (CT) images.

After 3 years, he was referred to our aortic unit for a progression of the aneurysmal pathology at the level of the aortic arch, with intimal tear just above the distal anastomosis and expansion of the FL at the origin of the supra-aortic trunks. The 2 carotids were intact, while the dissection expanded into both subclavian arteries. The proximal descending aorta was dilated at the level of the isthmus, due to the expansion of the FL.

Given the relative young age of the patient and the good general conditions, a decision was made to proceed with surgical arch replacement. We performed the ET with the soft Gelweave Siena Graft prosthesis (Terumo Aortic; Inchinnan, Glasgow, UK), with separated supra-aortic trunks implant.

The postoperative course was free of medical or surgical complications and the patient was discharged in excellent conditions.

The predischarge CT scan showed a smooth surgical outcome, with complete thrombosis of the FL at the level of the thoracic

descending aorta and residual distal FL below the diaphragm due to aorta-iliac re-entries.

One-year CT control showed the shrinking of the thrombosed false channel at the thoracic level, witnessing the positive remodelling induced by the ET (Fig. 1).

The patient was temporarily lost for follow-up during COVID pandemic with poor blood pressure control.

However, at 3-year follow-up, the thoracic FL appeared re-perfused again at the level of the distal arch and proximal descending aorta. This originated from a new tear at the distal end of the ET, with the prosthesis straddling the (s)INE. The Dacron prosthesis appeared shortened and folded back to itself. Therefore, the patient underwent the implant of a Relay NBS pro (Terumo Aortic, Sunrise, FL, USA).

The 1-year follow-up showed the optimal adaptation of the prosthesis with no endoleak or other complications and thus restoration of the remodelling process.

PATIENT 2

A 61-year-old male was referred to our institution for type A acute aortic dissection. CT scan showed an intimal tear from the non-coronary sinus, with dissection extended distally to iliac arteries. The patient underwent the replacement of the ascending aorta and the aortic arch in emergency with an ET procedure with the soft Gelweave Dacron Graft with the intimal relayering technique [3].

The postoperative course was simple and the CT scan showed a smooth repair of the aortic arch, with the presence of FL in the distal thoracic and abdominal aorta, with no signs of malperfusion.

At the postoperative 3-month CT control, we observed the complete thrombosis of the FL in the proximal descending thoracic aorta. However, the distal FL remained patent starting from the middle descending aorta, perfused retrogradely by sub-diaphragmatic entries.

The patient was scheduled for elective TEVAR completion. A week before the planned procedure, he was admitted with thoracic pain and a CT scan was repeated. This showed a significant modification of the aortic anatomy, with a complete re-perfusion of the distal arch and proximal descending aorta (previously thrombosed) due to (s)INE at the end of the ET.

We proceeded in emergency with the positioning of a thoracic endoprosthesis Relay NBS pro, between the ET and the distal thoracic aorta. The coeliac portion remained perfused by aorta-iliac re-entries. The imaging control showed the correct positioning of the prosthesis, with the exclusion of the FL and no entry flow.

Three-month CT scan was regular, but, 1 year later, the CT control revealed a classical SINE at the end of the stent graft with retrograde partial re-perfusion of the FL. For this reason, the patient underwent the positioning of another TEVAR (Relay NBS pro). The control documented the excellent adaptation of the prosthesis without signs of further perfusion of the FL (Fig. 2).

DISCUSSION

Postoperative SINE may result in acute FL pressurization and expansion or malperfusion. If left untreated, it has a mortality rate of up to 25% following endovascular aortic interventions [4]. The growing use of hybrid endoprosthesis for both acute and chronic aortic dissection has placed the accent on this, life-threatening, complication.

In the literature, it is widely reported that FET has an optimal rate of TL expansion and FL thrombosis [5]. However, the risk of secondary aortic re-interventions following FET remains significant.

It has been estimated that SINE occurs in about 15–18% of cases after FET [6].

Moreover, SINE can develop even years after the procedure [7].

In conventional TEVAR, the stent graft should have enough radial force, derived from oversizing, to re-expand the TL preventing stent graft migration. In the FET procedure, due to the design of the hybrid graft, the stent migration is impossible. Thus, oversizing of the stent graft portion of an FET graft is unnecessary.

The are many studies comparing the risk of developing SINE, albeit these always concern the use of prosthesis for FET [6, 8]. No studies have evaluated the occurrence of SINE with the use of soft graft.

Furutachi *et al.* [6] compared ET with FET: after 1 year from intervention in the FET group, the incidence of SINE was 15.8%. However, for the ET group, the authors wrote 'not applicable', probably meaning that SINE could not occur after ET.

In our practice, the use of FET in the case of acute aortic dissection is not the first choice, preferring a soft approach given the fragility of the dissected membrane and the need for reduced diameters to avoid SINE.

The Siena graft is a soft Dacron prosthesis, developed in our institution [9], that can achieve adequate force with the blood flow to re-expand the TL. Normally, this force should not cause a

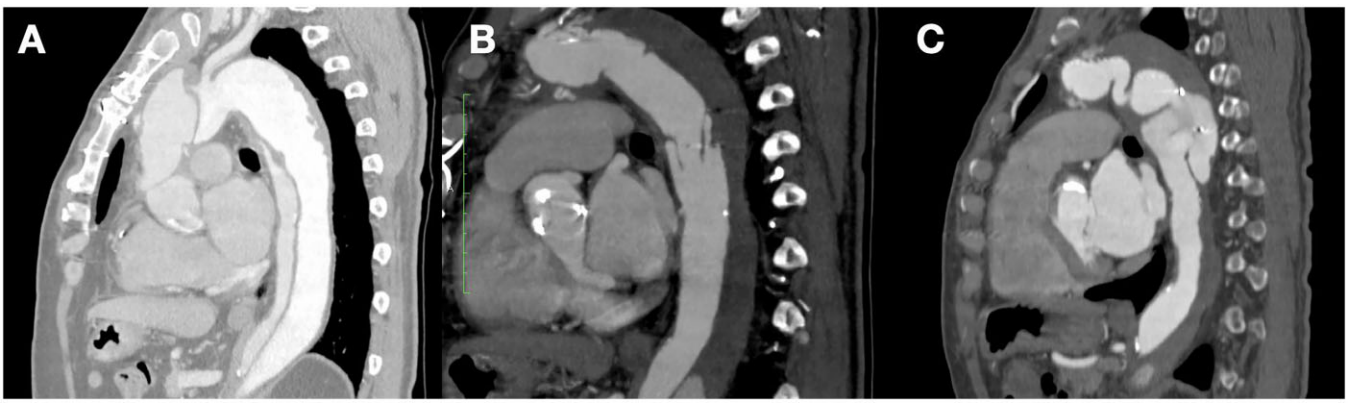

Figure 1: (**A**) Aneurysmal pathology of the aortic arch with aortic dissection. (**B**) Predischarge computed tomography scan of the elephant trunk with Siena Graft, showing complete thrombosis of the false lumen at the level of the thoracic descending aorta. (**C**) One-year computed tomography control: the Dacron prosthesis appears retracted and crumpled due to the soft-graft-induced new entry.

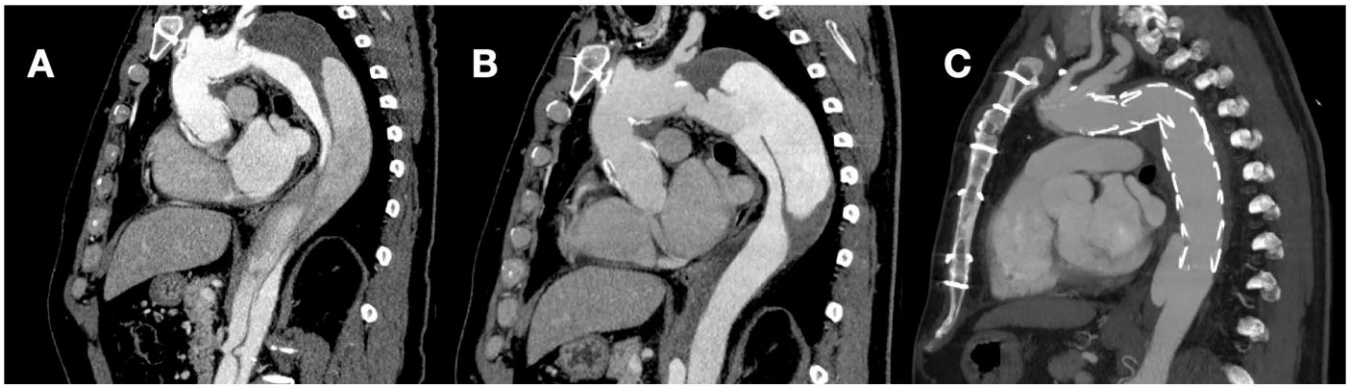

Figure 2: (**A**) Computed tomography image 3 months after elephant trunk with intimal relayering technique. (**B**) Re-perfusion of the false lumen in the distal arch due to soft-graft-induced new entry. (**C**) One-year computed tomography image after thoracic endovascular prosthesis: classical stent graft-induced new entry at the end of the endoprosthesis.

stress to the vessel. We observed that the re-expansion of the TL in the case of soft ET is comparable to the FET in the thoracic tract and that both techniques are equivalent.

As described by Wada *et al.* [8], the mechanisms behind developing distal SINE are complex. Our 2 cases lead us to think that one of the main factors in the development of SINE lies in the tissue fragility, which manifests itself both as a consequence of haemodynamic jets and as a mechanical action of the endoprosthetic graft, regardless of the type of prosthesis used, whether it is rigid or soft. In fact, the lesion appears exactly at the distal transition zone between the graft-covered aorta and the not-covered aorta, following normal postoperative CT imaging without evidence of FL flow in the descending aorta.

Neither of our 2 patients had tissue connective disease, which certainly could represent a risk factor. Anyways, the results of aortic dissection represent '*per se*' the cause of vascular fragility, especially at the level of the flap, which is the structure involved in the SINE.

CONCLUSION

The classical 'soft' ET remains an important treatment option for different pathologies providing useful solutions for the surgeon and patient; however, it also exposes to the risk of SINE.

In the case of both SINE or (s)INE, additional endovascular intervention is recommended and can be successfully performed with the implantation of a TEVAR.

SINE can develop several years after the procedure; therefore, close and lifelong follow-up is mandatory after any kind of prosthesis positioned in the thoracic aorta.

Conflict of interest: none declared.

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