ORIGINAL ARTICLE

HYBRID AORTIC ARCH SURGERY TO CREATE A LANDING ZONE IN THE ASCENDING AORTA

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Abstract

Introduction: *Thoracic Endovascular Aortic Repair (TEVAR) has enabled the treatment of aortic pathology that previously required open surgery, with higher morbidity and mortality. The need for a favorable landing zone (Lz), without compromising the patency of the supra-aortic vessels meant that Ishimaru Lz 2 was the most proximal technically feasible Lz. We developed a hybrid technique for the creation of a more proximal Lz in high risk patients - in the first stage, debranching/rerouting of the supra-aortic vessels, with or without ascending aorta replacement, was performed; a few weeks later, a TEVAR with a LZ in the distal ascending aorta was performed. This technique allowed the avoidance of the more aggressive total arch and proximal descending aorta replacement (Elephant Trunk or Frozen Elephant Trunk - FET) in high risk patients.*

We reviewed all patients who underwent hybrid arch surgery in our Department to create a more proximal Lz that allowed safe TEVAR stent placement.

From November 2007 to October 2019, 15 patients required hybrid surgery to achieve treatment - 9 by replacing the ascending aorta and debranching supra-aortic vessels and 6 by debranching and re-routing supra-aortic vessels to the native ascending aorta. All underwent computed tomography angiography within 30 days of surgery and had follow-up with annual appointments and imaging control.

Patients' average age was 65.5 (+/- 11.5) years, 73.3% being male. Average follow-up was 54.7 (+/- 46.2) months. The most common diagnosis was thoracic aortic aneurysm (66.7%), followed by chronic type B aortic dissection (20.0%), penetrating atherosclerotic ulcer (6.7%) and reintervention due to endoleak (EL, 6.7%). No in-hospital mortality was registered. ICU and hospital stay was 1.3 (0.8) days and 9.8 (10.3) days, respectively. Survival at 1- and 5- years was 84.6% and 65.8%, respectively. No EL was detected in 66.7% (n=10) of patients. Incidence of early EL was 20.0% (n=3), of which two-thirds had spontaneous resolution, and late EL was 13.3% (n=2). Endovascular reintervention was required in one patient.

TEVAR in the context of hybrid surgery is associated with low morbidity and mortality, with a low incidence of EL and good early and long term survival.

INTRODUCTION

Thoracic Endovascular Aortic Repair (TEVAR) has enabled the treatment of aortic pathology that previously could only be addressed with open surgery, an aggressive approach with higher morbidity and mortality. However, for TEVAR, the existence of a favorable landing zone (Lz), without compromising the patency of the supra-aortic vessels is mandatory. This meant that initially, Lz 2 of the Ishimaru classification was the most proximal technically feasible Lz in the endovascular treatment of thoracic aortic pathology.

Over the last years, the evolution in treating complex aortic disease culminated with the appearance of

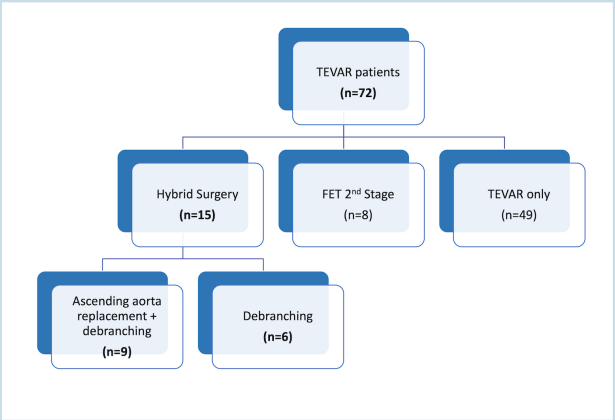

Figure 1 *TEVAR patients sorted by surgical strategy.*

the Frozen Elephant Trunk technique (FET), that potentially treated the arch and proximal thoracic aortic pathology in a single-stage[1]. However, this technique still carries a considerable in-hospital mortality (14,9%)[1] and spinal cord injury is as high as 21%[2]. Therefore, a hybrid approach combining open surgery and TEVAR may be a valid option for the elderly high-risk patients or those with many comorbidities[3].

OBJECTIVE

The authors proposed to review all patients who underwent hybrid surgery in their Department in order to create a more proximal Lz for second stage TEVAR.

MATERIAL AND METHODS

From November 2007 to October 2019, 80 TEVAR were performed at Santa Marta Hospital´s Cardiothoracic Department to 72 patients (figure 1). Of those, 15 required a hybrid, two-stage strategy (surgical followed by endovascular procedure), in order to achieve treatment.

All patients underwent their first postoperative computed tomography angiography (CTA) within 30 days of surgery and follow-up consisted of presential appointments and annual imaging control. Statistical analysis was performed with SPSS™ 25 (©IBM).

RESULTS

Two different techniques were used for the first (surgical) stage. Nine patients required replacement of the ascending aorta and debranching of supra-aortic vessels under cardiopulmonary bypass (CPB, figure 2) while the remaining 6 patients only required debranching of the supra-aortic vessels and re-routing to the native ascending aorta, which was done with partial clamping without the need for CPB (figure 3). The second stage – TEVAR deployment - was performed similarly regardless of the technique used for first stage.

Patients' average age was 65.5 (+/- 11.5) years, with 73.3% being male (n=11). The average follow-up was 54.7 (+/- 46.2) months. The most common indication (figure 4) was thoracic aortic aneurysm (66.7%), followed by chronic type B aortic dissection (20.0%), penetrating aortic ulcer (6.7%) and reintervention due to endoleak (EL, 6.7%). Surgery was urgent in only one patient.

There was no in-hospital mortality recorded. The average ICU stay and hospital stay was 1.3 (+/- 0.8) days and 9.8 (+/- 10.3) days, respectively. Morbidity consisted of: cerebellar infarction (n=1), central retinal artery occlusion (n=1) and femoral access complication (n=1), all after the second stage TEVAR. Survival at 1- and 5- years was 84.6% and 65.8%, respectively (figure 5).

Throughout the entire follow-up, no EL was detected in 66.7% (n=10) of patients (figure 4). The incidence of early EL was 20.0% (n=3), of which two-thirds (n=2) had spontaneous and complete resolution documented on the following CTA. Late EL rate was 13.3% (n=2), and persisted over time. Endovascular reintervention was required in only one patient with late EL due

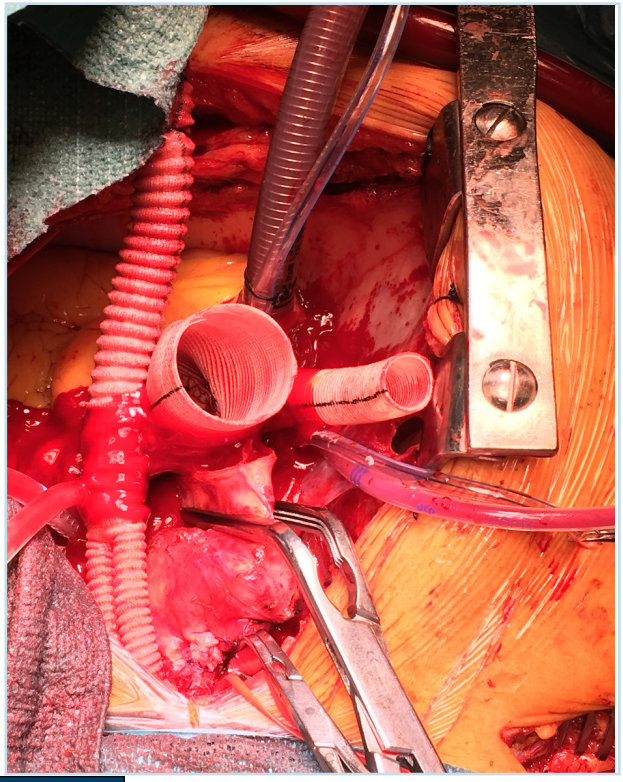

Figure 2 *Replacement of the ascending aorta and debranching of supra-aortic vessels under cardiopulmonary bypass.*

to its increasing size over time. In this case, a good and uneventful surgical result was obtained after deployment of a new stentgraft.

DISCUSSION

The use of a hybrid strategy in our Department is nowadays reserved for high-risk patients, unfit for the Frozen Elephant Trunk (FET) procedure. Patients over 80 years or younger but with many comorbidities like COPD or chronic kidney disease are offered this hybrid option. Thus, we spare these patients from undergoing deep hypothermic circulatory arrest, in order to keep surgical risk as low as possible.

While in the beginning of our series there were patients left with their native ascending aorta, which had a normal diameter at the time of surgery, we now tend to replace the ascending aorta in all patients. This change in our first stage technique is due to acknowledging both the risk of retrograde dissection after partially cross clamping the aorta or deploying the stent graft[4] and the risk of disease progression, that might lead to a type IA EL over time. Although we didn't register neither of these complications in our series, we would only consider to keep the native aorta in very high-risk patients, in whom CPB would be contra-indicated.

The second stage, endovascular, was performed within 2 months after the first stage. Stent graft deployment has some particularities, since the proximal Lz is in Ishimaru zone 0. It is fundamental to assure enough graft length during the first stage to have a proper proximal Lz. This can be achieved by anastomosing the rerouted supra-aortic vessels as close to the sinotubular junction as possible, which in turn provides a straight, lengthy enough ascending segment, that will ensure a proper overlap (> 25mm) between the two grafts. This concern combined with a generous oversize (>15%) should be taken to avoid a type IA EL.

Two-thirds of patients in our series had no EL during the entire follow-up. If we add to this number the patients with spontaneous resolution of early EL, then 80% of patients are EL free at long-term. Regarding early EL, only one patient had a persistent EL. This was a patient with a type IIB EL from intercostal arteries, in whom we opted for a conservative approach, keeping the usual annual follow-up with CTA. Late EL was observed in two patients. The first patient had a type III EL with aneurysmal sac growing that required reintervention with a new TEVAR. The second patient had

Figure 3 *Debranching of the supra-aortic vessels and re-routing to the proximal native ascending aorta.*

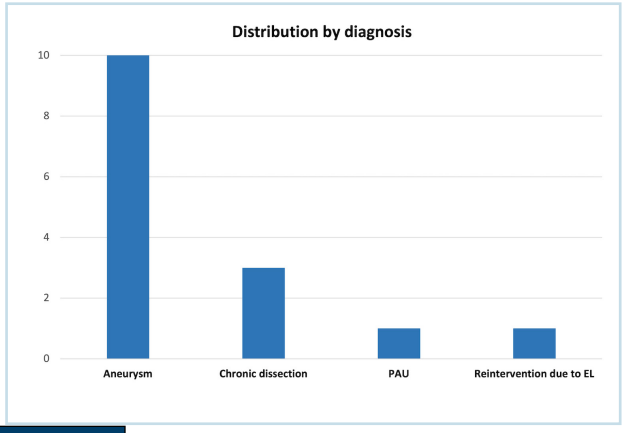

Figure 4 *Distribution by diagnosis.*

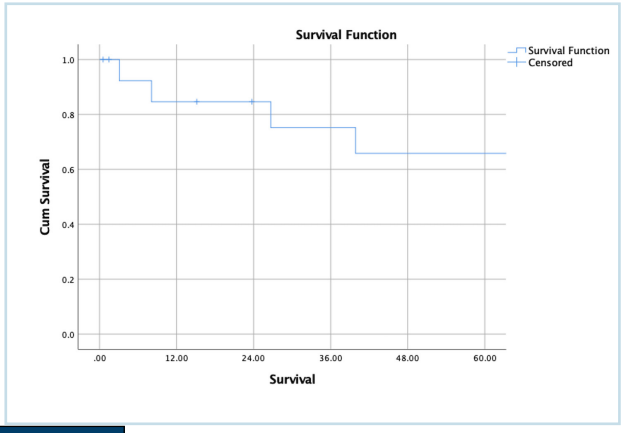

Figure 5 *Cumulative survival curve (in months).*

a type IA EL that remained stable over time without aneurysmal sac perfusion, so we also opted for a conservative approach. These cases of late EL emphasize the importance of a rigorous imaging follow-up that must be continued throughout the patients' life.

Overall, this hybrid strategy revealed to be safe and effective, as noted by the absence of in-hospital mortality, short hospital stay, good surgical results and excellent survival curves if we consider this sub-group of high-risk patients.

CONCLUSION

TEVAR in the context of hybrid surgery is associated with low morbidity and mortality, with a relatively low incidence of EL and good survival. The hybrid strategy is a good alternative in high-risk patients for classical surgery, allowing its treatment in a phased approach. Hybrid procedures, similarly to other aortic surgery strategies, require rigorous clinical and imaging follow-up throughout the patients' entire life.

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