International Journal of Cardiology 271 (2018) 31–35

Contents lists available at ScienceDirect

International Journal of Cardiology

journal homepage: www.elsevier.com/locate/ijcard

Hybrid repair of thoracoabdominal aneurysm: An alternative strategy for preventing major complications in high risk patients ☆

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ARTICLE INFO

Article history:
Received 13 February 2018
Received in revised form 11 April 2018
Accepted 30 April 2018

Keywords:
Thoracoabdominal
Spinal cord
Aneurysm
Aortic
TEVAR

ABSTRACT

Background: Nowadays, less invasive endovascular procedures have been employed in high risk patients for thoracoabdominal aortic aneurysm (TAAA) in order to try to reduce the risk of major complications. The aim of the study was to analyze the results of our hybrid 2-stage approach for TAAA repair.
Methods: Between July 2011 and September 2016, 17 consecutive high-risk patients received a hybrid 2-stage procedure for TAAA repair. Mean age of the population was 58.9 ± 9.0 years and 16 (94.1%) were male. Of them, 7 (41.2%) suffered of chronic obstructive pulmonary disease and 15 (88.2%) had a previous history of aortic operation. Three patients had Marfan syndrome (17.6%). The preoperative anatomy of the aneurysms was classified according to "Crawford classification" in type II (n = 6, 35.3%), type III (n = 10, 58.8%) and type IV (n = 1, 5.9%). All patients were followed up with an angio CT-scan at 1, 3 months and yearly thereafter.
Results: In-hospital mortality was 11.8% (2 patient). None of the patients experienced paraplegia and paraparesis. Major post-operative complications were pancreatitis 17.6% (3/17). At follow-up (mean time of 23.3 ± 21.7 months) 2 patient died (12.5%) waiting for the second stage endovascular completion. Median interval time between the 2 steps was 35 days. Overall survival at 1- and 3-years was 75.6 ± 1.0. One type Ib and 1 type III endoleak were noted and successfully treated with an additional stent graft.
Conclusions: The results of hybrid 2-stage TAAA repair on high-risk patients are satisfactory and therefore encouraging. The extremely low incidence of spinal cord injury could make this technique the technique of choice for this type of pathology in selected high-risk patients. At follow-up, residual endoleaks occur although surgical reoperations are not often needed.

1. Introduction

The surgical treatment of thoracoabdominal aortic aneurysm (TAAA) is often associated with major complications such as permanent stroke, paraplegia, respiratory insufficiency and renal failure necessitating dialysis. In the last decade the use of endografts for the treatment of thoracic aortic aneurysms has increasingly taken the field [1–3]. Its application is now indicated for extensive TAAA using fenestrated and branched endoprosthesis [4,5]. Surgeons interested in this aortic field have tried to take advantage of these less invasive procedures and attempted to find applicability in traditional open surgery [6–8].

In this initial short series we propose what is now known as the "hybrid 2-stage approach" for TAAA repair, which consists, of a first open visceral rerouting followed by a second stage procedure where the aneurysm is excluded using endografts [9,10].

The end points of the study were the following: procedural success, spinal cord injury and morbidity/mortality during in-hospital stay, whereas, overall survival, type I/III endoleaks, and freedom from reinterventions during follow-up.

2. Patients and methods

2.1. Patients' characteristics

Medical records and available aortic data sets were retrospectively reviewed to identify patients who underwent hybrid repair of TAAA at Sant'Orsola-Malpighi Hospital (Bologna, Italy). Between July 2011 and September 2016, a total of 39 patients were treated at our Institution for TAAA. Patients who had previously undergone complete open thoracoabdominal aortic aneurysm repair (10) and abdominal endovascular repair (12) (including those who had a previous extranatomic bypass) were excluded from the study. Thus, 17 consecutive patients have met the criteria for hybrid 2-stage TAAA repair at our Institution.

The mean age of the study cohort was 58.9 ± 9.0 years and 16 (94.1%) were male. All patients were considered high risk for conventional open repair, according to the

☆ This author takes responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

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https://doi.org/10.1016/j.ijcard.2018.04.130
0167-5273/

classification of the American Society of Anesthesiologists (class 3 or 4) [11] and the endovascular treatment (branched or fenestrated endoprosthesis) was excluded for clinical and anatomical reasons after collegial discussion with interventional radiologists.

Hypertension and chronic pulmonary disease were the most common risk factors (88% and 41%, respectively). Three patients (17.6%) suffered from Marfan syndrome. The primary indication for the treatment were chronic post-dissection aortic aneurysm (CPDA, n = 15; 88.2%) and degenerative aneurysm (DA, n = 2; 11.8%) with a maximum aneurysm size ≥6 cm. Among 15 chronic post dissection aortic aneurysm, 10 patients had diagnosis of type A dissection and 5 type B. In the subgroup of Type A dissection, 6 patients underwent aortic arch replacement according to Frozen Elephant Trunk Technique, in two patients the arch was replaced with Elelphant Trunk Technique, 1 patient received only arch replacement and one modified Bentall procedure. In the subgroup of Type B dissection, one patient underwent previous modified Bentall procedure and 4 patients received carotid-subclavian by-pass and TEVAR positioning. The preoperative anatomy of the aneurysms was classified according to "Crawford classification" in type II (n = 6, 35.3%), type III (n = 10, 58.8%) and type IV (n = 1, 5.9%). Fifteen patients had undergone previous aortic open procedures (88.2%). All patient demographics are reported in Table 1.

The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki as reflected in a priori approval by the institute's human research committee and was approved by the Ethics Committee of Bologna Medical University.

All patient data were entered into a patient dataset; approval to conduct this retrospective study without individual patient consent was provided by our institutional review board.

2.2. Operative technique

Our hybrid TAAA repair has been previously illustrated and consists of a two-stage (surgical plus endovascular) procedures, as described below [9,10].

2.2.1. First stage: infrarenal abdominal aorta replacement (Fig. 1- left side)

A median transperitoneal approach is used to expose the abdominal aorta until the iliac arteries. The procedure begins with the isolation of the visceral arteries (the celiac trunk is isolated passing through the retroepiploic cavity). Once the exposure is completed, systemic heparin at a dose of 100 U/kg is administered. The aorta is cross-clamped proximally (infra-renal) and distally on the iliac arteries. The aneurysm is opened and the thrombus is removed. We routinely reinforce the fragile and weak aortic wall with two strips of Teflon felt (inside and outside) especially the proximal portion. Finally the infrarenal aorta is entirely replaced using a multi-branched graft; we usually prefer the Coselli vascular prosthesis (Vascutek, Renfrewshire, Scotland UK) as showed in Fig. 1, which is sutured in an end-to-end anastomosis to the proximal aorta using 5/0 polypropylene suture. After that, clamps are removed and blood flow is restored. Visceral rerouting usually starts from the right renal artery followed by the left renal artery, the SMA, and the celiac trunk [9]. The end-to-end anastomosis with the side branch of the Coselli prosthesis are performed using a 6–0 polypropylene suture. The last right side branch of the graft is used for the celiac trunk but is always tunneled behind and posterior to the pancreas. In case of fragile and small visceral arteries we prefer to use an extra graft like the gore-tex hybrid prosthesis (W. L. Gore and associates, Flagstaff, Arizona USA) because it simplifies the reimplantation [12,13]. Renal artery protection is always achieved with the infusion of five-hundred milliliters of Custodiol HTK solution (Essential Pharmaceuticals, Newtown, PA) for each kidney detachment. All grafts were covered with the residual aortic wall and an extension of pericardial patch to avoid adhesion with the bowel and constriction of the branches.

2.2.2. Second stage: endovascular stent graft completion (Fig. 1- right side)

Two to four weeks after the first procedure, the endovascular procedure completes the TAAA repair [10]. It consists of a percutaneous stent graft coverage of the remaining thoracoabdominal aortic aneurysm (usually through a femoral artery access) using the Coselli prosthesis as distal landing zone. Lumbar cerebrospinal fluid catheter is always placed before the procedure and kept for 72 h. We routinely use a traditional non-automatic system of cerebrospinal flui drainage, "the FlexTip Plus Epidural Catheterization Set, Arrow, Teleflex, United States" and we usually maintain liquor pressure < 11 mmHg. In case of neurologic symptoms nad pressure > 11 mmHg CSF is drained manually. Before hospital discharge, an angio CT-scan is warrented to check for endoleak or other vascular complications.

2.3. Statistical analysis and follow-up

Continuous variables were expressed as the mean ± SD and were analyzed by using the unpaired two-tailed *t*-test. Categorical variables were presented as percentages and were analyzed with Pearson's Chi-Square test or Fisher's exact test when appropriate. A two-tailed *p* value <0.05 was considered statistically significant.

Outpatient follow-up of all hospital survivors (15 patients) included computed tomography/magnetic resonance imaging (CT/MRI) review, direct telephone interview of the patient or a close relative, and civil registry. Survival curves (taking into account perioperative deaths) were estimated at 1-, 2-, and 3 years using the Kaplan-Meier method. Statistical analysis was performed using Statistical Package for Social Sciences version 22.0 (IBM SPSS Inc., Chicago, IL, USA).

Table 1
Patients' demographics (n = 17).

Variable	Frequency	%
Male	16	94.1
Age (years, mean ± SD)	58.9	9.3
Hypertension	15	88.2
Diabetes	2	11.8
BMI (mean ± SD)	30	17.3
COPD	7	41.2
Chronic renal insufficency	5	29.4
Previous aortic operation	15	88.2
Marfan	3	17.6
Etiology		
• Degenerative aneurysm	2	11.8
• Chronic post-dissection aneurysm	15	88.2
Crawford classification		
• Type I	0	
• Type II	6	35.3
• Type III	10	58.8
• Type IV	1	5.9

SD: standard deviation; BMI: body mass index; COPD: chronic obstructive pulmonary disease.

3. Results

3.1. Early results

Overall, hospital mortality was 11.8% (n = 2). There was no intraoperative mortality. Causes of death were aortic rupture and visceral ischemia, which occurred one and four days after the first stage procedure, respectively.

None of the patients experienced early or late paraplegia and paraparesis. Major post-operative complications were gastrointestinal: pancreatitis in three patients (17.6%) and bowel ischemias (11.8%, resulting in hemicolectomy and colostomy in both cases) in two patients. Both complications greatly prolonged the hospital stay. Other severe postoperative complications were kidney related (transient serum creatinine elevation ≥200 μM/l was observed n = 10, 58.8%) although only 1 patient needed permanent dialysis after hospital discharge. Overall mean ICU stay was 5.7 ± 6.0 days. All post-operative morbidities are listed in Table 2.

First step technical success was achieved in all cases. Second stage completion was possible in 15/17 patients (88.2%), since two patients died waiting for the procedure. Median and mean interval time between the 2 steps was 35 and 90.5 ± 169 days, respectively.

3.2. Long-term results

Follow-up was 100% complete at a mean time of 23.3 ± 21.7 months (ranging from 1 month to 66 months). Two patients died after hospital discharge for unknown reasons most probably from sudden aortic rupture. Kaplan-Meier estimate of survival (%) at 1-, 2- and 3-years was 75.6 ± 1.0.

Two cases of endoleak were noted in the follow-up, at 5 and 26 months, respectively, after TAAA repair. In the first case, a type Ib endoleak developed early after the aneurysm exclusion (caused by the incomplete sealing of the stent graft to the vascular prosthesis) and it required an additional stent graft release (Fig. 2A and B). In the second patient a type III endoleak showed later after the hybrid repair and it was also successfully treated with further stent graft coverage (Fig. 2C and D).

None of the patients required an open aortic procedure at follow-up. A summary of the follow-up outcomes of each patient discharge from the hospital is decribed in Table 2.