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Hybrid Endovascular Repair of Thoracoabdominal Aorta: Early Results

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ABSTRACT

Background: Thoracoabdominal aortic aneurysms (TAAA) present a significant clinical challenge, as they are complex and require invasive surgery. In an attempt to prevent considerably high mortality and morbidity in open repair, hybrid endovascular repair has been developed by many authors. In this study, we evaluated the early-term results obtained from this procedure.

Methods: From November 2010 to February 2013, we performed thoracoabdominal hybrid aortic repair in 18 patients. The mean age was 68 years (12 men, 6 women). All of the patients had significant comorbidities. Follow-up computed tomography (CT) scans were performed at 1 week, 3 months, 6 months, and annually thereafter.

Results: All patients were operated on in a staged procedure and stent graft deployment was achieved. Procedural success was achieved in all cases. All patients were discharged with complete recovery. No endoleaks weres detected in further CT examination.

Conclusion: Our results suggests that hybrid debranching and endovascular repair of extensive thoracoabdominal aneurysms represents a suitable therapeutic option to reduce the morbidity and mortality of TAAA repair, particularly in those typically considered at high risk for standard repair.

INTRODUCTION

Thoracoabdominal aortic aneurysms (TAAA) present a significant clinical challenge, as they are complex and require invasive surgery [Svensson 1993; Coselli 2000; Piazza 2012]. Data from the Nationwide Inpatient Sample (NIS) database in the United States suggest a mortality rate approaching 22.3% [Cowan 2003]. Advances in the technique for open repair of the aortic arch include inducing hypothermia and circulatory arrest, cerebrospinal fluid drainage, retrograde cerebral perfusion, and selective antegrade perfusion, which have improved the outcomes and reduced morbidity. However, conventional open repair is associated with substantial morbidity and mortality, despite these improvements and refinements of open procedures and significant advances in perioperative care. In addition to this, many patients with severe comorbities or unfavorable anatomy are less suited to open repair [Svensson 1993; Coselli 2000; Cowan 2003; Piazza 2012]. In an attempt to prevent considerably high mortality and morbidity in open repair, hybrid endovascular repair has been developed by many authors.

In the present study, we evaluated the early-term results obtained from this procedure in our single-center experiment.

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MATERIALS AND METHODS

From November 2010 to February 2013, we performed thoracoabdominal hybrid aortic repair in 18 patients at a single center. The mean age was 68 years (6 men, 3 women). All of the patients had significant comorbidities (Table 1). Ten patients had proximal aneurysm of the descending thoracic aorta. Four had ascending, arcus, and proximal descending aortic aneurysm with third-degree aortic insufficiency. Four other patients had distal descending and abdominal aortic aneurysm extending to the infrarenal region (Table 2). Prior

Table 1. Demographic and Clinical Characteristics of the Patients

Characteristic	No. (%) or Mean ± Standard Deviation
Patients, total	18
Men	12
Age, years	68 ± 9.4
Diabetes mellitus	6
Tobacco (history or current)	12
Coronary artery disease/myocardial infarction	6
Congestive heart failure	—
Hypertension	12
Chronic obstructive pulmonary disease	8
Home oxygen	—
Renal insufficiency	4
Dialysis dependent	—
Modified Society for Vascular Surgery risk score	4.8 ± 2.0
Prior aortic surgery	—
Follow-up, months	21.4 ± 18.3

Table 2. Preoperative Anatomy and Clinical Features

Variable	No (%) or Mean ± Standard Deviation
Patients	18
Thoracic	14
Arch	4
Proximal descending thoracic aorta*	10
Thoracoabdominal	
TAAA extent†	4
Types I-III	4
Type IV	—
Type V	—
Associated chronic dissection	—
Aneurysm diameter, cm (minor axis)	7.9 ± 1.5
Clinical presentation	
Symptomatic	6
Elective	12
Urgent nonruptured	—
Ruptured	—

*Left subclavian artery revascularization only.
†Crawford classification modified by Safi [Svensson 1993].

to the procedure, thin-slice computed tomography (CT) with radiocontrast material was obtained of the entire thoracoabdominal aorta to establish the appropriateness of endovascular intervention and for stent graft sizing purposes. The range for thoracic and thoracoabdominal aneurysm diameter was 6.1 to 9.3 cm. A length of at least 15 mm along the aorta and a maximum diameter of the proximal aortic neck of 38 mm were regarded as safe anatomical criteria for stent grafting alone. Preprocedure planning was conducted using CT angiograms of the thoracic/abdominal aorta and iliac arteries. The operative and endovascular procedures were performed staged and all patients provided informed consent for both parts of the treatment.

Debranching procedures were performed under general anesthesia in an operating room. Ten patients had left carotid-subclavian bypass with a 7-mm polytetrafluoroethylene (PTFE) graft (Vascutec Co, Scotland, UK). Patients with ascending, arcus, and descending aneurysms with aortic insufficiency had a Bentall procedure with arcus debranching with a 3-branched dacron graft (Hemashield gold, 12 × 8 × 8 mm; Maquet Cardiopulmonary AG, Hirrlingen, Germany). The other patients having TAAA had a total abdominal debranching with a similar dacron graft. Abdominal vessels were debranched, including the truncus cheliacus, superior and inferior mesenteric, and both of the renal arteries, with an inflow of the left common iliac artery. All patients had suitable proximal and distal landing zones for endovascular graft implantation except patients with a previous Bentall operation. In 4 patients, proximal parts of the stent grafts were deployed into dacron grafts used for the replacement of the ascending aorta. Before the stent graft deployment, selective use of preoperative cerebrospinal fluid drainage was performed with a drainage system (EDM Lomber Drainage Kit; Medtronic, Minneapolis, MN, USA) in 2 of the patients, who underwent Crawford Type III TAAA to minimize the risk of paraplegia. Cerebrospinal fluid was allowed to drain freely with gravity with a target pressure of 10 mmHg, as cited in the literature [Cambria 2000; Kuratani 2010]. During the procedures and 2 days postoperatively, 85 and 230 mL cerebrospinal fluid was drained from these patients, respectively. The thoracic aortic stent graft was an E-vita thoracic 3G Stentgraft System (Jotec GmbH, Hechingen, Germany). Follow-up CT scans were performed at 1 week, 3 months, 6 months, and annually after discharge.

RESULTS

Over a 2-year period, 18 consecutive patients underwent hybrid treatment of thoracoabdominal aorta. All patients were operated on in a staged procedure, and stent graft deployment was technically successful in all of them. The mean interval between bypass and thoracic endovascular aortic repair (TEVAR) was 1.1 days (range, 3 hours to 7 days).

A total of 42 arterial bypasses were performed. Four patients underwent bypass of 3 main arcus arteries for arcus debranching in addition to replacement of the aortic valve and ascending aorta (Figure 1). Four patients received total abdominal debranching (truncus celiacus, 2 to renal arteries, 1 to the superior and 1 to the inferior mesenteric arteries) (Figure 2). Ten patients had left subclavian artery debranching with left carotid bypass of this artery.

Procedural success was achieved in all cases. All patients were discharged with complete recovery except 1 patient, who underwent aortic valve and ascending aorta replacement.

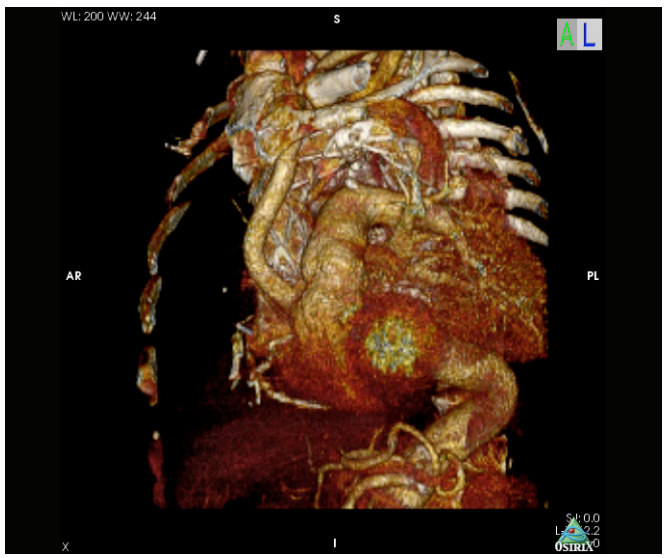

Figure 1. Completion of the hybrid procedure with antegrade inflow bypass to the innominate, left carotid, and left subclavian arteries.

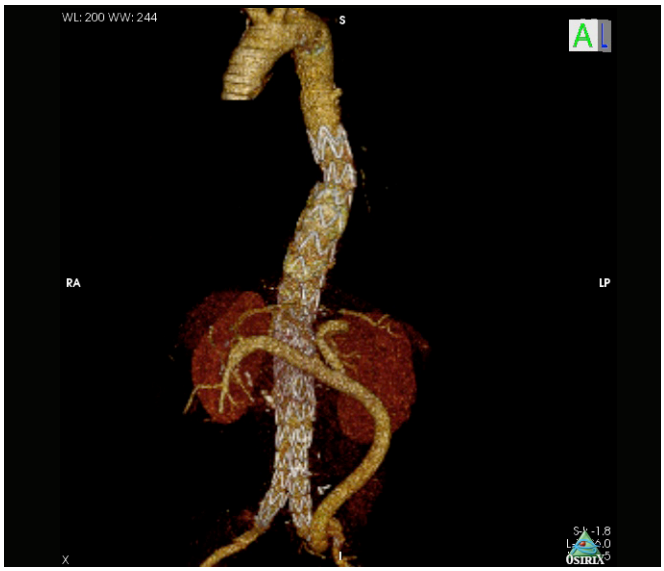

Figure 2. Postoperative CT scan of patient with a 3-dimensional reconstruction of a Crawford Type III. Stent graft repair of the thoracoabdominal aorta and retrograde visceral bypass from left common iliac artery are shown.

This patient developed a transient ischemic attack after the debranching procedure but recovered completely on the 19th day postoperatively.

Postoperative complications included acute renal failure without hemodialysis in 1 patient. We observed no incidences of paraplegia, and all patients were discharged after achieving independent gait. The median duration of the hospital stay was 18 days (range, 12-56 days). One type I endoleak due to heavy aortic plaque was detected by CT scan in 1 patient at the time of discharge. After failure of an endoluminal intervention, a left thoracotomy was performed and the proximal descending aorta was snared with 6 mm of cotton tape over the endograft. No endoleaks were detected in further CT examination.

DISCUSSION

Although open surgical repair is considered the treatment of choice for thoracoabdominal aortic disease in low-risk patients, such invasive surgery was accompanied by significant in-hospital mortality and morbidity rates in several large series [Svensson 1993; Cambria 2000; Coselli 2000; Cowan 2003; Piazza 2012]. Favorable results have been achieved in many centers, with operative mortality of 3.9% to 13% for open arch replacement and 4.8% to 10% for open TAAA repair [Svensson 1993; Coselli 2000; Strauch 2005; Kouchoukos 2008; Sundt 2008; Wong 2011; Piazza 2012]. However, despite these reports, real-world operative mortality remains significant, >20% for open TAAA repair, based on the American National Inpatient Sample database [Cowan 2003]. Furthermore, these procedures are associated with high frequencies of transient or permanent neurological and cognitive deficits, whose rates range between 2.6% and 16% [Svensson 1993; Cambria 2000; Coselli 2000; Cowan 2003; Strauch 2005; Kouchoukos 2008; Sundt 2008; Kuratani 2010; Wong 2011; Piazza 2012].

After the introduction of thoracic endovascular devices, a hybrid approach to arch and TAAA disease has been adopted as an alternative technique with potentially less morbidity. Single-institution series have reported early to medium-term outcomes with varying but favorable results. Generally, institutional reports have shown that aortic debranching, followed by endovascular aneurysm exclusion, is effective and feasible for the treatment of arch and TAAA. The most significant advantage of this procedure is the considerably low incidence of neurologic complications (paraplegia and stroke) and mortality compared with open procedures [Hughes 2009; Antoniou 2010; Donas 2010; Eagleton 2010; Campbell 2011; Ham 2011; Kirkwood 2011; Lee 2011; Milewski 2010; Ferrero 2012; Vallejo 2012; Michler 2013]. Kuratani et al [Kuratani 2010] reported a recent experience using hybrid techniques in 86 cases with varying extents of TAAA. Reported operative mortality and neurologic complications have been acceptable and mostly superior to those occurring with conventional open repair. All patients had significant comorbidities, making them high -risk for open repair. Long-term survival was 94.8% and 70.8% at 2 and 10 years, respectively. There was no paraplegia or stroke. Other studies of hybrid TAAA procedures had similar results [Antoniou 2010; Donas 2010; Eagleton 2010; Campbell 2011; Ham 2011; Kirkwood 2011; Lee 2011; Milewski 2010; Ferrero 2012; Vallejo 2012]. To minimize the risk of paraplegia, selective use of preoperative spinal drainage was performed in 2 of the patients who underwent Crawford Type III TAAA at our institution. This procedure may have prevented our patients from suffering paraplegia.

To allow for patient hemodynamic stabilization, we generally stage the repairs by a few hours to a few days rather than performing simultaneous procedures. Although a simultaneous hybrid procedure is preferred in emergent settings, it increases the injected contrast load, which is nephrotoxic, potentially causing acute renal failure postoperatively. Furthermore, combined repairs prolong operative time, and in this patient population with significant comorbidities, extended anesthesia time as well as potential time for additional blood loss may negatively influence patient outcomes. However, an obvious disadvantage for staging the hybrid procedure is aneurysm rupture during the interval. Currently, both approaches have been used by many authors with no obvious differences in outcome [Kouchoukos 2008; Hughes 2009; Kuratani 2010; Ham 2011; Kirkwood 2011]. Nevertheless, we have had a relatively positive experience using a 2-stage approach, with no interval aneurysm rupture.

Hybrid repair of the thoracoabdominal aorta with supra-aortic and/or visceral debranching prior to stent-graft deployment provides the advantage of reducing invasiveness by avoiding aortic cross-clamping and circulatory arrest [Hughes 2009; Milewski 2010; Michler 2013]. With our alternative hybrid approach for combined aneurysm of the ascending, arcus and descending aorta in 4 patients, cardiopulmonary bypass allowed replacement of the diseased ascending aorta

and aortic valve, which provided a robust landing zone for stent graft deployment and a superior proximal seal to minimize the risk of endoleak. This procedure was less invasive than conventional arch replacement with the elephant trunk procedure. Potential advantages include eliminating the risk of bleeding from aortic anostomoses, recurrent laryngeal nerve injury, hypothermia-related coagulopathy, and ischemic injury to the nervous system and visceral organs from prolonged circulatory arrest, especially in elderly patients older than 75 years [Hughes 2009; Milewski 2010].

The present study describes our experience of a considerably limited series of patients comparing with previously published reports. However, in this study we focused on hybrid repair and enrolled only high-risk patients with significant comorbidities, who were excluded from conventional open repair. This study was also interesting because it revealed results of a single center in a relatively short period of time with lower mortality and morbidity than other studies reported in the literature, although evaluating our results is difficult because of the limited series of patients. One reason for our good results was our close follow-up system during the postoperative period. During the follow-up period, all patients received CT scans at the time of discharge and once every year to prevent serious issues such as stent migration, endoleak, and aortic rupture.

In this study, our early results suggest that hybrid debranching and endovascular repair of extensive thoracoabdominal aneurysms represents a suitable therapeutic option to reduce the morbidity and mortality of TAAA repair, particularly in those patients typically considered at high risk for standard repair. These results support the growing use of hybrid procedures in the treatment of complex aortic aneurysms. Prior to broad application of these methods in all patients, further evaluation and follow-up are required to determine what role this approach will have in the future treatment of complex aortic aneurysm disease.

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