Patency of renal and visceral vessels after open thoracoabdominal aortic replacement

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Objective: **In thoracoabdominal aortic aneurysms (TAAAs), a paradigm shift is observed from open surgery toward total endovascular aortic repair using fenestrated and branched endografts. Whereas outcome after open replacement in terms of mortality and paraplegia has been evaluated extensively, no studies exist addressing long-term patency of visceral and renal vessels. To enable comparison of target vessel patency between open and endovascular treatment, we analyzed our series of open TAAA replacements.**

Methods: **Our vascular surgery database was screened for patients who received open TAAA replacement between 1998 and 2012, and patient records were analyzed retrospectively. All available imaging scans (computed tomography and magnetic resonance angiography: preoperative, postoperative, and follow-up) were evaluated for graft and vessel patency.**

Results: **We identified 62 patients (mean age, 66 ± 10 years; 40 men) who had been operated on for aneurysms of Crawford types I (8), II (13), III (13), and IV (24) and Safi type V (4). A total of 181 vessels were revascularized by either patch inclusion (n = 147) or selective revascularization (bypass or transposition, n = 34); 48 survived the procedure, resulting in a number of vessels available for follow-up of 154 (patch, 126; selective revascularization, 28). The respective patency rates for overall, patch, and selective revascularization were 95.2%, 94.2%, and 100% at 5 years and 83.7%, 81.3%, and 100% at 10 years, respectively. In addition, a trend for better performance of selective revascularization (bypass or transposition) was evident as all vessel occlusions were observed in cases of patch inclusion, whereas all selectively revascularized vessels were patent. The respective patency rates for the celiac trunk, superior mesenteric artery, and left and right renal artery were 100%, 97.5%, 92.3%, and 90.3% at 5 years.**

Conclusions: **In our series of open thoracoabdominal aortic replacement, excellent patency rates for revascularized renal and visceral vessels were observed during long-term follow-up. We were able to provide a reference value of long-term target vessel patency that can and should be taken into account to judge the efficacy of endovascular repair in TAAA. (J Vasc Surg 2015;62:594-9.)**

Thoracoabdominal aortic aneurysm (TAAA) has been seen as a rare entity with an estimated incidence of 5.9 cases per 100,000 person-years affecting elderly patients (average age, 65 years) with an almost equal gender distribution (male:female, 1.7:1) in historical analysis.[1] More recent studies, however, report an increasing incidence of 10.4 cases per 100,000 in the United States [2] and up to 16.3 cases per 100,000 in Sweden.[3] The natural history of TAAA is sobering, with a survival rate of only 24% at 2 years and half of deaths due to aneurysm rupture.[4]

There are three options available to treat TAAA: conventional open surgery, hybrid approach combining endografting with renovisceral rerouting, and total endovascular repair; no significant difference in the incidence of mortality or spinal cord ischemia was found between total endovascular repair and open repair in a landmark study by Greenberg et al[5] in 2008. However, a paradigm shift in treatment of extensive type II and type III TAAAs from open to total endovascular repair is proposed because of its lower risk and potential benefits.[6] Hybrid repair as an alternative treatment method for TAAA was introduced in 1999 by Quiñones-Baldrich et al[7] with the aim of reducing operative invasiveness by avoiding the need for thoracotomy. Contemporary results of larger multicenter series, however, show considerable mortality and morbidity of hybrid repair, and it has been postulated that hybrid repair will be replaced by total endovascular repair in the future.[8] For total endovascular repair of TAAA, first performed by Chuter et al[9] in 2001 with a custom-made graft, treatment is now based on fenestrated and branched endografts, and robust outcome data with favorable results have been accumulated.

Surprisingly, for conventional open repair of TAAA, none of the large series has evaluated target vessel patency so far, and only one study is available reporting the results of a presewn branched graft in 41 patients.[10] In hybrid and total endovascular repairs, patency of renovisceral target vessels has been analyzed only on a short-term and midterm basis (1-3 years).

Therefore, the objective of this study was to perform an analysis of long-term target vessel patency after open TAAA surgery in our cohort of patients to provide a

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Table I. Patient and aortic characteristics (N = 62)

Patient characteristics	
Age, years	66 ± 10
Male gender	40 (65)
Risk factors	
HTN	61 (99)
DM	3 (5)
Smoking	48 (77)
CAD	16 (26)
Renal dysfunction	14 (23)
ASA class	
2	9 (15)
≥3	53 (85)
EF, %	57 ± 7
PAD	10 (16)
Aortic characteristics	
TAAA class	
I	8 (13)
II	13 (21)
III	13 (21)
IV	24 (39)
V	4 (7)
Diameter, cm	7 ± 1.4
Aneurysm	45 (73)
Dissection	17 (27)
Previous aortic surgery	14 (23)
Marfan syndrome	5 (8)

ASA, American Society of Anesthesiologists; *CAD,* coronary artery disease; *DM,* diabetes mellitus; *EF,* cardiac ejection fraction; *HTN,* hypertension; *PAD,* peripheral arterial disease; *TAAA,* thoracoabdominal aortic aneurysm. Continuous variables are presented as mean ± standard deviation, and categorical variables are presented as number (%).

reference value for judgment of the efficacy of total endovascular and hybrid repairs.

METHODS

The prospectively maintained computerized database of the Division of Vascular Surgery was screened for patients who received an open operation for TAAAs, and all imaging series of preoperative, postoperative, and follow-up computed tomography angiography (CTA) or magnetic resonance angiography (MRA) scans were evaluated. For the patients retrieved, the respective perioperative and follow-up information was recorded from the University Medical Center inpatient and outpatient database and retrospectively analyzed. Additional follow-up information was collected by contacting either the patients or their general practitioner (in case of deceased patients) by telephone interview.

In total, we analyzed a consecutive series of 62 patients (40 men) who had been operated on between 1998 and 2012. The patient demographics and aortic characteristics are given in Table I. Patient risk factors were defined as follows: hypertension (controlled with one or more drugs), diabetes (oral antidiabetic medication or insulin therapy), nicotine abuse (active smoking of one pack or more per day), hyperlipidemia (controlled with one or more drugs), coronary artery disease (history of disease of one vessel or more), and renal insufficiency (serum creatinine concentration ≥2 mg/dL).

Table II. A, Operative details, morbidity, and mortality

Operative details	
Neuromonitoring	34 (55)
CSF drainage	35 (57)
Maximum CSF pressure, mm Hg	10 ± 1.3
pCPB/LHBP	51 (82)/11 (18)
pCPB/LHBP duration, minutes	172 ± 66
OR time, hours	6.4 ± 1.9
Morbidity and mortality	
In-hospital mortality	14 (23)
Paraplegia	5 (8)
Recurrent laryngeal nerve injury	4 (11)
Bleeding or hematoma, operative site	16 (26), 3 splenic lacerations
Intracranial hemorrhage	1 (2)
Small bowel perforation	1 (2)
Pulmonary complications (ARDS or pneumonia)	20 (32)
Renal complications (temporary dialysis)	9 (15)
Median ICU days	4 (range, 2-76)
Median ventilator days	2 (range, 1-76)
Median days until discharge	21 (range, 13-90)

ARDS, Acute respiratory distress syndrome; *CSF,* cerebrospinal fluid; *ICU,* intensive care unit; *LHBP,* left-sided heart bypass; *OR,* operative; *pCPB,* partial cardiopulmonary bypass.
Continuous variables are presented as mean ± standard deviation or median (range), and categorical variables are presented as number (%).

Preoperative imaging consisted of either high-resolution contrast-enhanced CTA with 1-mm or 3-mm sections or contrast-enhanced MRA in selected cases (elevated serum creatinine concentration). All patients gave informed consent to the operation; institutional ethics board approval was obtained, and consent of individual patients was waived as this was a retrospective analysis. The operations were performed under general anesthesia using a double-lumen tube, and the patients were positioned in the Crawford position. A cerebrospinal fluid drain was inserted; it was kept below a maximum pressure of 10 mm Hg for the time of the operation, and it was continued for 72 hours postoperatively. Intraoperative neuromonitoring was performed with somatosensory and motor evoked potentials (ISIS IOM Neuromonitoring System; Inomed Medizintechnik GmbH, Emmendingen, Germany). In our division, we use distal aortic perfusion complemented by selective renovisceral perfusion in TAAA surgery either by means of the heart-lung machine and partial cardiopulmonary bypass (pCPB) or by left-sided heart bypass (LHBP). The dosage of unfractionated heparin applied before initiation of perfusion was 300 IU/kg (activated clotting time >450 seconds) for pCPB and 5000 IU (activated clotting time >150 seconds) for LHBP. The operative details are listed in Table II, *A*. Revascularization of the renovisceral vessels was performed in most cases by the island patch technique described by Crawford, which usually encompasses the celiac trunk, the superior mesenteric artery (SMA), and the right renal artery, or a selective revascularization by transposition in the main graft body or by a separate bypass graft (7- or 8-mm polyester) was achieved. Selective visceral perfusion