Open Aortic Repair After Prior Thoracic Endovascular Aortic Repair

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Background. Thoracic endovascular aortic repair (TEVAR) has been applied to increasingly complex aortic pathology, resulting in an increase in late complications. We characterized patients undergoing open repair after prior TEVAR including indications, operative techniques, and outcomes.

Methods. Chart review and query of a prospectively collected database identified 50 patients who underwent thoracic aortic operation after prior TEVAR. Active follow-up was supplemented by Social Security information for vital status.

Results. From July 2001 to January 2012 open arch (n = 25), descending (n = 6), thoracoabdominal (n = 17), or extra-anatomic bypass (n = 2) operations were performed after previous TEVAR (median interval from TEVAR to open surgical procedure: 13.9 months; interquartile range, 0.5 to 24 months). Indications for open operation included type 1 endoleaks (n = 19), retrograde aortic dissection (n = 9), chronic aortic dissection with persistent growth of the false lumen (n = 16), and graft infection (n = 6). Sixty percent had prior cardiovascular surgical procedures and 18% were done as emergencies. Circulatory support was required in 78% and hypothermic arrest in 48%. Hospital mortality occurred in 3 (6%) patients with no strokes and 1 patient with myocardial infarction; 5 (10%) patients required tracheostomy and 1 required dialysis. Survival was 67% at a median follow-up of 2.9 years.

Conclusions. Conversion to open repair after thoracic stent-grafting may be indicated for type 1 endoleak, retrograde dissection, chronic aortic dissection with persistent false lumen growth, or graft infection. These salvage operations are complex but can be completed safely with good early outcomes and preservation of the stent-graft in most cases. Late outcomes are consistent with the chronic disease state of these patients.

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Thoracic endovascular aortic repair (TEVAR) has become a widely accepted treatment option for patients with thoracic aortic disease and is particularly useful in those patients deemed at high risk for conventional open surgical repair [1]. As experience with these devices has evolved, the application has been expanded to increasingly more complicated anatomy (including proximal deployment within the arch and a tolerance for shorter than recommended landing zones) and pathology (such as aortic dissection) [2–4]. It is estimated that nearly two-thirds of thoracic stent grafts are deployed in situations outside the instructions for use, or "off-label." This more daring use of TEVAR carries the risk of serious complications that may require conversion to open repair [5–8].

The objectives of this study were to (1) characterize patients undergoing open aortic repair after prior TEVAR, (2) describe the indications for conversion and operative techniques used, and (3) assess early and late outcomes.

Patients and Methods

Patients and Indications

From July 2001 to January 2012, 50 consecutive patients underwent open aortic repair after prior TEVAR. TEVAR procedures were performed for various indications at our

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Table 1. Patient Characteristics[a]

Characteristic	n (%)
Demographics	
Age, mean ± SD (years)	60.5 ± 15
Male, n (%)	32 (64)
Comorbidities	
Hypertension	34 (68)
Diabetes mellitus	3 (6)
Smoking	25 (50)
Coronary artery disease	8 (16)
Carotid disease	7 (14)
History of cerebrovascular accident	1 (2)
Peripheral vascular disease	15 (30)
History of congestive heart failure	4 (8)
Renal failure (dialysis dependent)	1 (2)
Chronic obstructive pulmonary disease	9 (18)
Documented vascular disorder[b]	5 (10)
Prior cardiovascular operation	26 (52)
Initial indication for TEVAR	
Degenerative aneurysm	15 (30)
Aortic dissection	31 (62)
Post type A repair	9 (18)
Type B repair	22 (44)
Traumatic transection	3 (6)
Mycotic aneurysm	1 (2)
Type of stent graft used	
Cook Zenith	19 (38)
Gore TAG	26 (52)
Medtronic Talent	2 (4)
Other	3 (6)

[a] N = 50. [b] Marfan's syndrome (n = 3), Loeys-Dietz (n = 1), Takayasu's (n = 1).

TEVAR = thoracic endovascular aortic repair.

and other institutions. During this time period 758 patients underwent TEVAR procedures at our institution. These details and additional patient characteristics of interest including demographics, comorbidities, and morphology of disease are included in Table 1. These conversions to open repair were performed at a median interval of 13.9 months (range 2 days to 91 months) for a variety of reasons including type 1 endoleak (n = 19), acute dissection of the ascending aorta (n = 9), chronic aortic dissection with persistent aneurysmal growth of the false lumen (n = 16), and stent graft infection (n = 6) (Table 2). Of the patients with type 1 endoleak, 26% underwent open repair within the first 30 days since stent grafting. Similarly, 3 of the proximal aortic dissections occurred within the first 30 days after TEVAR, and the other 6 of these were late complications. Additionally, 1 patient who underwent hybrid thoracoabdominal repair for chronic dissection with distal aortic growth of the false lumen (6 months after descending thoracic stent grafting) developed ascending aortic dissection 1 year after the thoracoabdominal conversion. This proximal dissection was due to progression of his disease without a tear at the stent graft level, and that event is described later as an open reintervention during follow-up. Data were obtained from the prospectively maintained Cardiovascular Information Registry (CVIR) at the Cleveland Clinic. Informed consent was waived, and the study was approved by the Institutional Review Board.

Table 2. Indications for Open Conversion[a]

Indication	n (%)
Type 1 endoleak	19 (38)
Proximal (1a)	14 (28)
Distal (1b)	5 (10)
Proximal/retrograde dissection	9 (18)
Chronic dissection with false lumen perfusion and growth	16 (32)
Infected stent graft	6 (12)
Plus rupture (not mutually exclusive)	5 (10)

[a] N = 50.

Operative Techniques

These patients all had extensive thoracic aortic disease and the stent graft therapy failed for a variety of reasons. Consequently, the open operations were performed on various segments of the aorta. Many of these patients required staged aortic repairs and underwent additional operations after the index operation described in this study. For consistency, the index operation referenced in this study is the first open operation involving the thoracic aorta after previous TEVAR. The operations primarily involved the aortic arch in 25 patients, the descending aorta in 6 patients, the thoracoabdominal aorta in 17 patients, or an extra-anatomic bypass in 2 patients. Eighteen percent of these operations were done as emergencies, including 5 ruptures. Circulatory support was required in 78% and deep hypothermic circulatory arrest in 48%. Nineteen patients underwent 23 concomitant procedures during the open aortic procedure. Additional operative details are presented in Table 3.

REVERSE FROZEN ELEPHANT TRUNK PROCEDURE. This procedure has been previously described [5]. In short, this operation is performed with the use of deep hypothermic circulatory arrest with right axillary artery cannulation with or without selective brain perfusion based on the surgeon's choice and the complexity of the reconstruction needed. In all of these patients, the proximal end of the stent graft is directly sutured to the native aorta after opening the proximal aorta during the circulatory arrest period. This operation was performed for type 1a endoleak in 13 patients. For this indication the proximal aorta was replaced with a prosthetic graft in all of our patients, but may also be closed primarily if the tissue is healthy. The other 9 patients treated with this technique were the proximal/retrograde acute aortic dissections.

ARCH DEBRANCHING WITH ANTEGRADE STENT GRAFT DELIVERY. Arch debranching with antegrade stent graft delivery represents another option in patients with arch