Staged Hybrid Repair of Extensive TAAA

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Disclosure of Interest

Gilbert R Upchurch Jr: I have the following potential conflicts of interest to report:

- Part owner in Antyllus Inc., a company aimed at developing a medical therapy for aortic aneurysms

- I do not have any potential conflict of interest
Disclosures

• No disclosures or conflicts of interest

Staged hybrid approach using proximal thoracic endovascular aneurysm repair and distal open repair for the treatment of extensive thoracoabdominal aortic aneurysms

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Objective: Repair of patients with extent I and II thoracoabdominal aortic aneurysms (TAAAs) is associated with significant morbidity and mortality, whereas repair of more distal extent III and IV TAAAs has a lower risk of paraplegia and death. Therefore, we describe an approach using thoracic endovascular aneurysm repair (TEVAR) as the index operation to convert extent I and II TAAAs to extent III and IV TAAAs amenable to subsequent open aortic repair to minimize patient risk.

Methods: Between July 2007 and March 2012, 10 staged hybrid operations were performed to treat one extent I and nine extent II TAAAs. Aortic aneurysm pathology included five chronic type B dissections, three acute type B dissections, and two penetrating aortic ulcers. Initially, the proximal descending thoracic aorta was repaired with TEVAR for coverage of the most proximal fenestration or penetrating ulcer, with seven elective and three emergent repairs. Interval open distal aortic replacement was performed in a short-term planned setting or for progressive dilatation of the distal aortic segment. In the open repair, the proximal end of the graft was sewn directly to the distal end of the TEVAR and outer wall of the aorta.

Results: Average patient age was 48 years, and 66% were men. Risk factors included hypertension (80%), current tobacco use (50%), and Marfan syndrome (30%). Complications after TEVAR included type IA (n = 1) and type II (n = 3) endoleaks, pleural effusions (n = 3), and acute kidney injury (n = 1). Three patients required endovascular reinterventions. In patients with dissection, persistent filling of the false lumen was common and associated with distal thoracic aortic dilation. Complications of open repair included acute kidney injury in two patients, but no cardiac, pulmonary, or neurologic morbidity. Median time between TEVAR and open repair was 14 weeks. Most importantly, no deaths or neurologic deficits occurred after either procedure during a median follow-up of 35 weeks.

Conclusions: A staged hybrid approach to extensive TAAAs combining proximal TEVAR, followed by interval open distal TAAA repair, is safe and appears to be an effective alternative to traditional open repair. This approach may decrease the significant morbidity associated with single-stage open extent I and II TAAA repairs and may be applicable to multiple TAAA etiologies. (J Vasc Surg 2012;56:1495-1502.)

Staged hybrid repair of extensive thoracoabdominal aortic aneurysms secondary to chronic aortic dissection

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Objective: Many patients with aortic dissection develop Crawford extent I or II thoracoabdominal aortic aneurysms (TAAAs). Because open repair is associated with a high morbidity and mortality, hybrid approaches to TAAA repair are emerging. In this study, we evaluated the midterm outcomes and aortic remodeling of a hybrid technique that combines proximal thoracic endovascular aneurysm repair (TEVAR), followed by staged distal open thoracoabdominal repair for patients with Crawford extent I or II TAAAs secondary to chronic aortic dissection.

Methods: We identified 19 patients with Crawford extent I (n = 1) or extent II (n = 18) TAAAs secondary to chronic aortic dissection who underwent a staged hybrid repair from 2007 to 2014 at our institution. Nine patients had previous open ascending aortic surgery for type I aortic dissection. Stage 1 TEVAR was performed via percutaneous (n = 8), femoral cutdown (n = 8), or iliac exposure (n = 3). The left subclavian artery was covered in nine patients and revascularized in eight patients using carotid-subclavian bypass (n = 7) or laser fenestration (n = 1). Stage 2 open repair was performed a median of 18 weeks later with partial cardiopulmonary bypass via left femoral arterial and venous cannulation for visceral and lower body perfusion. The open thoracoabdominal graft was anastomosed proximally in an end to end fashion with the endograft. We then assessed surgical morbidity and mortality, midterm survival, and freedom from reintervention. Aortic remodeling was measured and change in maximum aortic and false lumen diameter at last follow-up (median, 5 years) from baseline was assessed.

Results: There were no deaths, strokes, or chronic renal failure in this cohort. After stage 1 TEVAR, three patients required repeat intervention for endoleak (type IA, n = 1; type IB, n = 1; type II, n = 1) before open repair. After stage 2 open repair, there was a single delayed permanent paralysis 2 weeks after discharge. At a median 3-year follow-up (range, 6 months-6.2 years), there were no deaths, neurologic events, endoleaks, or TAAA reinterventions. Complete false lumen thrombosis occurred in 100% of the patients, with maximum false lumen diameter decreasing from 34.3 ± 15.3 mm to 13.2 ± 12.0 mm (P < .01) and total aortic diameter decreasing from 60.2 ± 9.0 mm to 49.3 ± 7.6 mm (P < .01).

Conclusions: Staged hybrid TAAA repair, using a combination of proximal TEVAR with open distal repair, can be performed using established endovascular skills and technology coupled with traditional open aortic surgical techniques, with low surgical morbidity and mortality. In the midterm, staged hybrid TAAA repair was associated favorable survival, aortic remodeling, and freedom from reintervention. (J Vasc Surg 2015;61:148.)
Treatment Options for TAAA with Associated Dissection

• TAAA in setting of dissection even more complicated
• Open repair
  – Large incision, pulmonary complications, visceral/renal hypoperfusion
• Hybrid repair with visceral de-branching followed by thoracic endograft
  – Combined procedure with nearly 60% post operative renal dysfunction
  – Staged procedure with risk of interval rupture
# Treatment Strategy

<table>
<thead>
<tr>
<th></th>
<th>Extent II</th>
<th>Extent III/IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>13-42%</td>
<td>4-24%</td>
</tr>
<tr>
<td>Paraplegia</td>
<td>7.5-32%</td>
<td>1 – 6.5%</td>
</tr>
</tbody>
</table>

1. Repair proximal TAAA with dissection first with TEVAR
2. Followed by interval open distal TAAA
   - Eliminates complex high proximal anastomosis
   - Distributes spinal cord ischemia over time
Our Protocol

TEVAR with left subclavian artery revascularization (n=8)

Staged interval (13 days – 5.5 yrs)

Open distal TAAA repair with partial cardio pulmonary bypass (fem-fem bypass)
### Study Cohort – 19 patients (July 2007-June 2014)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean</th>
<th>SD or No. (%)</th>
</tr>
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<tbody>
<tr>
<td>Age, years</td>
<td>54 ± 18</td>
<td></td>
</tr>
<tr>
<td>Male sex</td>
<td>14 (79%)</td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>17 (89%)</td>
<td></td>
</tr>
<tr>
<td>Current tobacco use</td>
<td>8 (42%)</td>
<td></td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>11 (58%)</td>
<td></td>
</tr>
<tr>
<td>COPD</td>
<td>2 (11%)</td>
<td></td>
</tr>
<tr>
<td>Chronic renal insufficiency (GFR &lt; 60 ml/min)</td>
<td>3 (16%)</td>
<td></td>
</tr>
<tr>
<td>ESRD on HD</td>
<td>1 (5%)</td>
<td></td>
</tr>
<tr>
<td>Baseline renal function -</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serum creatinine, mg/dL</td>
<td>1.1 ± 0.3</td>
<td></td>
</tr>
<tr>
<td>Estimated GFR, mL/min</td>
<td>79 ± 23</td>
<td></td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>3 (16%)</td>
<td></td>
</tr>
<tr>
<td>Marfan syndrome</td>
<td>4 (21%)</td>
<td></td>
</tr>
<tr>
<td>Body mass index</td>
<td>29 ± 7</td>
<td></td>
</tr>
<tr>
<td>Crawford extent, %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extent II</td>
<td>18 (95%)</td>
<td></td>
</tr>
<tr>
<td>Extent I</td>
<td>1 (5%)</td>
<td></td>
</tr>
<tr>
<td>Maximum TAAA diameter, cm</td>
<td>6.0 ± 0.9</td>
<td></td>
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</tbody>
</table>
TEVAR

- Left subclavian artery revascularization, if planned coverage
- Endograft from left subclavian to celiac artery level
  - Initially limited coverage
- Distal type 1 B endoleak expected
- Lumbar drain for 24-48 hours standard
Staged Distal Open Repair

- Aorta and endograft are transected
- Dissection septum is divided to allow endograft expansion
- Tapered aortic wall + endograft sewn directly to graft
- Partial cardiopulmonary bypass, perfusion of mesenterics and renals used
Staged Open Repair

- Proximal aortic control
- Celiac artery
- Superior mesenteric artery
- Left renal artery
- Distal aortic control
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Fig 3. Staged hybrid approach. A, Distal thoracic aorta is represented with endograft in the true lumen and thrombus/debris in the false lumen. B, The thrombus/debris is removed from the false lumen, dissection septum is divided, and the aortic wall is cut along the red dashed line to taper the aortic wall. C, The anastomosis is made with an end-to-end attachment of the endograft, tapered aortic wall, and felt reinforcement to the prosthetic graft.
Distal thoracic aorta and endograft anastomosed to multi-branch graft
• Left fem-femoral A-V lower body aortic bypass
• Perfusion cannulas in all the visceral branches – No visceral ischemia.
• 6mm graft to a large intercostal artery
• Multi-branch graft
Visceral anastomosis – Rt Renal → Celiac → SMA → Lt Renal
Anastamosis to stent graft and aorta
## Combined Mid-Term Outcomes – Stages 1 and 2

<table>
<thead>
<tr>
<th>TEVAR</th>
<th>(N = 19), No. (%)</th>
<th>Open TAAA repair</th>
<th>(N = 19), No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death</td>
<td>0 (0)</td>
<td>Death</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Stroke/paraplegia</td>
<td>0 (0)</td>
<td>Stroke/paraplegia</td>
<td>1 (5.2)</td>
</tr>
<tr>
<td>Acute kidney injury</td>
<td>1 (5.2)</td>
<td>Acute kidney injury</td>
<td>5 (26.3)</td>
</tr>
<tr>
<td>(Serum creatinine &gt;2 mg/dL)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type I endoleak</td>
<td>2 (10.5)</td>
<td>Chronic renal failure</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Type II endoleak</td>
<td>1 (5.2)</td>
<td></td>
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</tbody>
</table>

3 patients with baseline renal insufficiency with pre op GFR < 60 returned to their pre op renal functions. All with S Cr < 2mg/dl
A) TEVAR

B) Open distal aortic repair

C) Distal aortic repair

7.1 cm

5.5 cm
Conclusions

• Staged approach for extensive TAAA repair with proximal TEVAR followed by interval open repair of aortic dissections is safe and effective

• May decrease overall morbidity and mortality compared to traditional open repair
  – Interval time to allow collateralization to spine (do not cover L subclavian artery)
  – Cause of TAAA is repaired at initial operation, unlike hybrid approach with visceral de-branching performed first
  – First procedure is minimally invasive and may increase likelihood of patient return for second operation
Treatment Goal

7.1 cm extent II TAAA from dissection

s/p TEVAR with distal open repair
Thomas Jefferson’s Home Monticello