Aortic Arch pathology options: Open, Hybrid, fenestration, Chimney or branched stent-graft?

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Disclosure of Conflicts

None.
Total Volume of Aortic Surgery in Fuwai Hospital (1997-2016)

1143 aortic operations in 2016:
1.9% of mortality.
573 open repair, 93 hybrid procedure, 477 endo-repair
Current Approaches for Arch

- **Open Repair**
  - Total arch replacement

- **Hybrid Techniques**
  - Hybrid arch replacement
  - Debranching + TEVAR
  - Extra-anatomic bypass + TEVAR

- **Total Endo Techniques**
  - Fenestrated stent-graft
  - Branched stent-graft
  - Chimney technique
OPEN REPAIR:
Total arch replacement

- Suitable for arch anatomy, with or without elephant trunk implantation and ascending replacement.
- Standard approach with credible long-term durability.
OPEN REPAIR:
Total arch replacement

- Standard option (2014 ESC, 2010 ACC/AHA/ACCF)
- Circulatory arrest is mandatory
  - Peri-operative complications (cerebral, renal, spinal)
  - Risk arises in aged patient and co-morbidities
- IRAD: Mortality 24.7% (Circulation 2004)
- IRAD: Mortality 17%-26% (2016)
Percentage of aged patients increased every year, age is the first risk factor of mortality and it limits open repair utilization.
Categories of Hybrid Procedure

De-branching:
Arch branch transposition

Hybrid arch replacement

RSA–LCCA
RCCA–LCCA–LSA
RSA–LSA

Extra-anatomic bypass + TEVAR
Debranching Procedure
Ascending - Supra Aortic Branches transposition

◆ Aortic arch pseudoaneurysm
◆ Hybrid technique was adopted.

➢ Ascending aorta – innominate artery – left carotid artery – LSA bypass was achieved first.
➢ Then TEVAR was used.
➢ The patient recovered uneventfully.
Hybrid Arch Replacement

- Avoided DHCA, regular CPB
- Extended landing zone in prosthetic graft, reduce retrograde TAAD
- Antegrade and retrograde delivery could be selected
- Reduced complication compare with total arch replacement
Hybrid procedure

State-of-the-Art of Hybrid Procedures for the Aortic Arch: A Meta-Analysis

George J. Koullias, MD, and Grayson H. Wheatley III, MD

Illinois Cardiac Surgery Associates, Peoria, Illinois; and Department of Cardiovascular Surgery, Arizona Heart Institute, Phoenix, Arizona

Questions have risen with increasing technical complexity, and our aim was to evaluate the outcomes of the hybrid approach. We performed a meta-analysis inclusive of 16 studies with 463 patients reviewed (n = 718), comparing hybrid aortic arch procedures with on-pump or off-pump technique. Overall 30-day mortality was 8.3%. Endoleak and paraplegia was 3.9%, and stroke was 4.4%. There was no difference in mortality or complication rates between on-pump and off-pump procedures, and no affect between on or off-pump.

Mata Analysis Results (2010)

Overall 30-day mortality: 8.3%
EL: 9.2%
Stroke: 4.4%
Paraplegia: 3.9%
No affect between On or off-pump.
A systematic review and meta-analysis of hybrid aortic arch replacement

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Elephant Trunk Arch Debranching:

30-day Mortality: 9.5% 11.9%
Cerebrovascular events 7.6% 3.6%
Spinal cord Injury 6.2% 5.0%
For aortic arch pathology, minimal invasive option is preferred in decision-making.

- Massive Invasive
  - Open repair: Better exposure
- Less Invasive
  - Hybrid: Interim
- Minimal Invasive
  - Total-Endo
- Non-invasive

Adopted from Ivan Casserly MB
Endovascular aortic repair in Fuwai Hospital

101 of 477 patients received total endovascular arch branch revascularization plus TEVAR/EVAR in 2016
Endovascular aortic repair in Fuwai Hospital & Second Xiangya Hospital（Nov2015-Nov2017）

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
</tr>
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<tbody>
<tr>
<td>Total TEVAR</td>
<td>1593</td>
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<tr>
<td>Arch branch revascularization</td>
<td>354</td>
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<tr>
<td>Single Chimney</td>
<td>168</td>
</tr>
<tr>
<td>Double Chimney</td>
<td>16</td>
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<tr>
<td>Triple Chimney</td>
<td>2</td>
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<tr>
<td>Fenestration</td>
<td>92</td>
</tr>
<tr>
<td>Double Fenestration</td>
<td>8</td>
</tr>
<tr>
<td>Triple Fenestration</td>
<td>6</td>
</tr>
<tr>
<td>Snorkel</td>
<td>8</td>
</tr>
</tbody>
</table>
Total Endovascular Repair of Supra-arch Branch

- Fenestrated Technique
- Chimney Technique
- Branched Stent-graft
- Double Chimney Technique
Chimney Stent-graft (CSG)

Nov, 2007
The 1st case of CSG

2008
CSG + PDA occluder

2009
Double CSG

2016
Triple CSG
Double Chimney Technique

During 1.5 years follow up, no complication happened.

As a result, double chimney technique can be used for retrograde type A aortic dissection with caution.
The patient, 84 years old, male, received TEVAR for aortic aneurysm in 2005, and suffered from chest pain for 1 month.

With the development of popularization of endovascular technique and increasing of average life span, more and more post-TEVAR complications will happen and need secondary intervention in the future.

Double chimney technique is an efficient and safe technique to extend the proximal landing zone of aortic arch, especially for aged patient.
Triple Chimney Technique

- 3 months after TEVAR plus triple chimney procedure
- Double chimney with LSA snorkel stent
Institutional outcomes in Fuwai Team Chimney Cohort

Clinical Investigation

Thoracic Endovascular Aortic Repair With Single/Double Chimney Technique for Aortic Arch Pathologies

Tun Wang, MD, PhD1,2,*, Chang Shu, MD, PhD1,2,*, Ming Li, MD, PhD1,2, Quan-ming Li, MD, PhD1,2, Xin Li, MD, PhD1,2, Jian Qiu, MD, PhD1,2, Kun Fang, MD, PhD3, Alan Dardik, MD, PhD4, and Chen-zi Yang, MD, PhD1,2,*

Abstract

Purpose: To summarize a single-center experience using the single/double chimney technique for thoracic endovascular aortic repair (TEVAR) for aortic arch pathologies. Methods: From November 2009 to October 2012, a total of 122 patients (mean age 50.4±1.3 years, range 20–80; 92 men) with aortic arch pathologies underwent TEVAR or double chimney grafts to reconstruct the aortic arch and subclavian arteries. Pathologies included thoracic aortic dissection (n=39), thoracic aortic aneurysm (n=3), penetrating aortic ulcer (n=6), and chronic dissection (n=6). Follow-up examinations included computed tomography (CT) scans. Results: The aortic stent-grafts were deployed in 55 patients (86%), and 57 patients (93%) had a survival rate of 93% at 3 months. The technical success rate was 98.6%, and the 30-day survival rate was 98.6%. The adverse event rate was 8.2%. The Kaplan-Meier estimates of freedom from all adverse events (A) and of freedom from all endoleaks (B) at 22 months were 73.8% and 87.9%, respectively. Conclusion: The double chimney technique should be used judiciously owing to its potential complications.
Institutional outcomes in Fuwai Team

First experience with the double chimney technique in the treatment of aortic arch diseases

Tun Wang, MD, PhD,1,a,b Chang Shu, MD, PhD,1,a,b Quan-ming Li, MD, PhD,1,a,b Ming Li, MD, PhD,1,a,b Xin Li, MD, PhD,1,a,b Hao He, MD, PhD,1,a,b Alan Dardik, MD, PhD,2 and Jian Qiu, MD, PhD,1,a,b changsha and Beijing, China; and New Haven, Conn

ABSTRACT

Objective: The objective of this study was to summarize our initial experience using the double chimney technique to treat aortic arch diseases.

Methods: From December 2009 to October 2016, 23 patients with aortic arch diseases, including 20 acute aortic dissections, 2 aortic aneurysms, and 1 type I endoleak after thoracic endovascular aortic repair (TEVAR) were treated using a double chimney technique. An emergent operation was performed in only one patient with an acute aortic dissection for severe left lower extremity ischemia. All patients were observed after TEVAR with computed tomography scans at 2 weeks, at 3 and 6 months, and annually thereafter.

Results: In all patients, aortic arch lesions were covered, and supra-aortic branches were patent without morbidity. In 22 patients, the innominate artery (IA) and left common carotid artery were reconstructed with the proximal landing zone in zone 0. In 1 patient, the left common carotid artery and left subclavian artery were reconstructed. During the procedure, there were three (13%) type I endoleaks. Chimney stent graft migration occurred in one (4%) patient perioperatively, compression of a chimney stent graft occurred in one (4%) patient 4 days after TEVAR. There were no type II endoleaks or perioperative mortality. Median follow-up was 260 ± 198 (range, 3-94) months, with no TEVAR-related deaths. Partial

Fig 1. Patient 22 required reconstruction of all supra-aortic branches and an emergent secondary operation. A-C, Computed tomography (CT) angiography on admission. D, Digital subtraction angiography (DSA) at the end of the operation. E, Emergent CT 4 days later. F and G, DSA at the beginning and end of the secondary operation. H and I, CT angiography during follow-up. J Orifice of the left common carotid artery (LCCA) was dissected. 2 the right vertebral artery with severe stenosis. 3, patent chimney stent graft in the innominate artery (IA), 4, compressed chimney stent graft in the IA; 5, patent chimney stent graft in the LCCA; 6, patent snorkeI stent graft; 7, compressed chimney stent graft in the IA with little blood flow; 8, reopened chimney stent graft in the IA; 9, patent chimney stent graft in the IA.

Report of our center shows well results using double chimney. 87.0% free from any Endoleaks. 73.8% free from any adverse evenets
A current systematic evaluation and meta-analysis of chimney graft technology in aortic arch diseases.

Ahmad W, Mylonas S, Maid P, Brunkwall JS.

Author information

Abstract

OBJECTIVE: The aim of this study was to provide a review of the literature on the use of chimney graft (CG) technique in treating arterial diseases of the aortic arch and to extrapolate conclusions by summarizing the reported outcomes in a meta-analysis.

METHODS: An extensive electronic search of the Medline, Cochrane Library, Embase, and Current Contents for relevant studies from January 2000 to November 2017 was performed. Inclusion criteria were: type of procedure (chimney graft technique) and outcomes: early and late type A dissection.

RESULTS: Of the 478 reports identified, 85 fulfilled the inclusion criteria and were included in the meta-analysis: 78 (98.8%) were prospective and 7 (9.4%) were retrospective. The overall technical success was 91.3% (95% confidence interval [CI], 87.4%-94.0%). The overall mortality was 7.9% (95% CI, 5.1%-10.8%) in patients with chimney aortic arch grafts (CAGs) with a 30-day mortality of 6.6% (95% CI, 2.8%-12.5%). There was no significant difference in overall outcomes: early and late type A dissection.

CONCLUSIONS: Chimney graft technique is an established procedure for treating aortic arch diseases. The overall technical success is 91.3% with a 30-day mortality of 7.9%. Early and late type A dissection rates are low.}

2017 Meta-analysis report

373 patients and 387 CGs

Overall technical success: 91.3%
Pooled 30-day mortality: 7.9%
Overall early type Ia EL: 9.4%
Early patency: 97.9%
Late patency: 92.9%
Retrograde type A dissection: 1.8%
Stroke: 2.6%
Fenestration Technique

Fenestration

In Vitro Fenestration

Off-the-shelf Fenestration

Physician-modified Fenestration

In Situ Needle Fenestration

In Situ Laser Fenestration
In Vitro Fenestration: *Physician-modified* fenestration
Fenestration:
Branch stent insertion
Pre-dilation and modelling of fenestration

Antegrade fashion:
Via femoral access

Retrograde fashion:
Via branchial access
On-the-table manner of *In vitro* fenestration plus LSA branch stenting
Double Fenestration plus chimney

LCCA + LSA: in vitro fenestration with Viabahn insertion
Inominate artery: Chimney with Fluency insertion
Fenestrated Graft: In situ fenestration

Ballooned fenestration needle in facilitating *in situ* Fenestration
In situ fenestration
In situ fenestration
In situ fenestration: from single to multiple branch

Endovascular Total Arch Repair Using In Situ Fenestration for Arch Aneurysm and Chronic Type A Dissection

Yoshiaki Katada, MD, PhD, Shunichi Kondo, MD, PhD, Eitoshi Tsuboi, MD, PhD, Kyu Rokkaku, MD, PhD, Yoshihito Irie, MD,
Department of Cardiovascular Surgery, Iwaki Kyoritsu General Hospital, Tokyo Medical and Dental University, Tokyo, and Department of Cardiovascular Surgery, Fukushima, Japan

Background. Total arch replacement and ascending aorta and arch replacement are the gold standard treatments for aortic arch aneurysm and are possible treatment strategies for chronic type A dissection, with good reported outcomes. However, because total arch replacement is extremely invasive, it can be difficult to perform in some patients. We designed an endovascular total arch repair procedure with the use of in situ fenestration and commercially available devices, and we present our initial experience.

Methods. Seven patients (chronic type A aortic dissection, n = 3; thoracic arch aneurysm, n = 4) who underwent endovascular total arch repair with the use of in situ fenestration thoracic endovascular aortic repair from zone 0 landing were retrospectively analyzed. All the procedures were performed under general anesthesia and center.
### Overall clinical treatment success:
- Physician-modified fenestration: 91.4%
- Off-the-shelf fenestration: 95.0%


<table>
<thead>
<tr>
<th>Outcome</th>
<th>PMSG Group, %a</th>
<th>OSFG Group, %a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intraoperative results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of fenestrations/branches</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simple fenestration</td>
<td>93.2 (90.4 to 95.3)</td>
<td>3.7 (32.5 to 41.3)</td>
</tr>
<tr>
<td>Scallop fenestration</td>
<td>5.2 (1.5 to 7.8)</td>
<td>20.5 (17.0 to 24.5)</td>
</tr>
<tr>
<td>Endoleaks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type I</td>
<td>4.3 (2.0 to 8.6)</td>
<td>3.3 (1.1 to 8.8)</td>
</tr>
<tr>
<td>Type III</td>
<td>1.1 (0.2 to 4.2)</td>
<td>13.2 (8.0 to 20.9)</td>
</tr>
<tr>
<td>Reinterventions for endoleak and TV event</td>
<td>4.5 (2.1 to 9.0)</td>
<td>5.8 (2.6 to 12)</td>
</tr>
<tr>
<td>Procedure success</td>
<td>82.9 (76.6 to 87.8)</td>
<td>86.8 (79.1 to 92)</td>
</tr>
<tr>
<td>MAE</td>
<td>12.8 (8.6 to 18.7)</td>
<td>7.4 (3.7 to 14)</td>
</tr>
<tr>
<td>Short and midterm results</td>
<td></td>
<td></td>
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<tr>
<td>Aneurysm-related mortality</td>
<td>1.1 (0.2 to 4.3)</td>
<td>0</td>
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<tr>
<td>All-cause mortality</td>
<td>10.7 (6.8 to 16.3)</td>
<td>4.1 (1.5 to 9.9)</td>
</tr>
<tr>
<td>Permanent dialysis</td>
<td>2.7 (1.0 to 6.5)</td>
<td>0.8 (0.0 to 5.0)</td>
</tr>
<tr>
<td>Permanent paraplegia</td>
<td>0.5 (0.0 to 3.4)</td>
<td>1.7 (0.3 to 6.4)</td>
</tr>
<tr>
<td>Persistent or new endoleaks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type I</td>
<td>1.1 (0.2 to 4.3)</td>
<td>0</td>
</tr>
<tr>
<td>Type III</td>
<td>1.6 (0.4 to 7.0)</td>
<td>1.7 (0.3 to 6.4)</td>
</tr>
<tr>
<td>Overall clinical treatment success</td>
<td>91.4 (86.2 to 94.9)</td>
<td>95.0 (89.1 to 98.0)</td>
</tr>
</tbody>
</table>
Branched stent-graft
Branched Stent-graft under Trials

**Cook arch-branch**
- Available in the EU, Canada, and South America
- Over 100 patients have been treated with this system
- Ascending aortic diameters must be ≤ 38 mm to ensure good proximal fixation and seal

**The Valiant Mona LSA stent-graft system**
- “Volcano” type cuff
- Allowing for 20° to 30° of mal-alignment between the cuff and the SCA

**Relay NBS Plus**
- 7 patients have been treated with these custom devices in Europe

**Gore TAG thoracic branch endoprosthesis**
- Currently being studied in the United States for a zone 0-2 deployment

**Castor Micro-port**
First single-arm branched stent-graft available in China

*Adapted from Endovascular Today*
Open portion procedure remains standard approach for aortic arch pathology with long-term durability yet higher mortalities.

Hybrid and total endovascular procedure may substitute open repair for patients with significant comorbidities.

Endo-techniques and devices, including fenestrated stent-graft/branched stent-graft/chimney technique are expected and should be done individually according to the aortic arch pathology.

For total endo-technique (Fenestration and chimney approach, etc.), long-term durability, efficacy and safety remains to be investigated in larger patient cohorts before being widely adopted.
2018 China Vascular Congress (CVC) & Annual Meeting of National Society of Vascular Surgery, China (NSVS)

Welcome You!

August 2018, Beijing, China