2017 MID-ATLANTIC
CONFERENCE

*7th ANNUAL* CURRENT CONCEPTS IN
VASCULAR THERAPIES

2017

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Professor of Surgery
Program Director
Vascular Surgery Chief
EVMS

# Arch Pathology:
# The Endovascular Era is here

Arch repair

# Disclosures

Consultant: Cook Medical, Bolton Medical, Medtronic Inc, Volcano, WL Gore

Speakers' Bureau: Bolton Medical, Medtronic Inc., WL Gore

Scientific Advisory Board: Medtronic Inc., Mellon Medical, Volcano

# Objectives

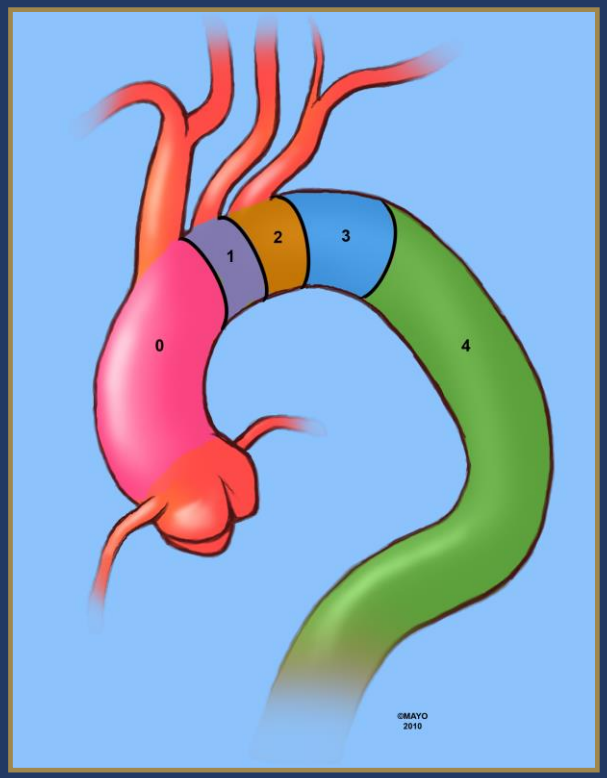
1. describe the technical innovations in endovascular arch repair
2. Explore the 4 methods of endovascular arch repair:
    1. Hybrid procedures
    2. Parallel grafts
    3. In situ fenestrations
    4. Branched or Fenestrated devices

Endovascular arch repair with innominate back table fenestration and LSA in situ fenestration

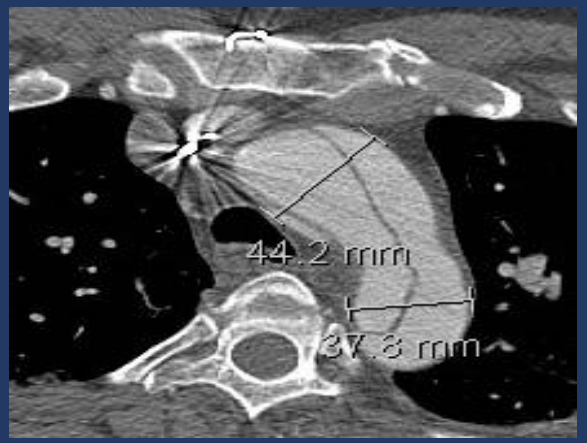
Arch repair

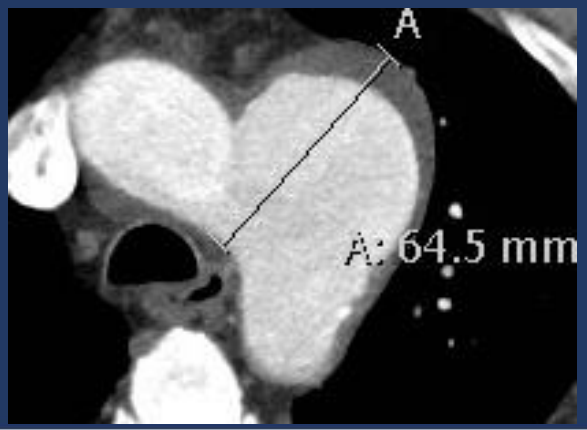
# Background

Up to 50% of TEVAR will require deployment in Zones 0, 1 or 2



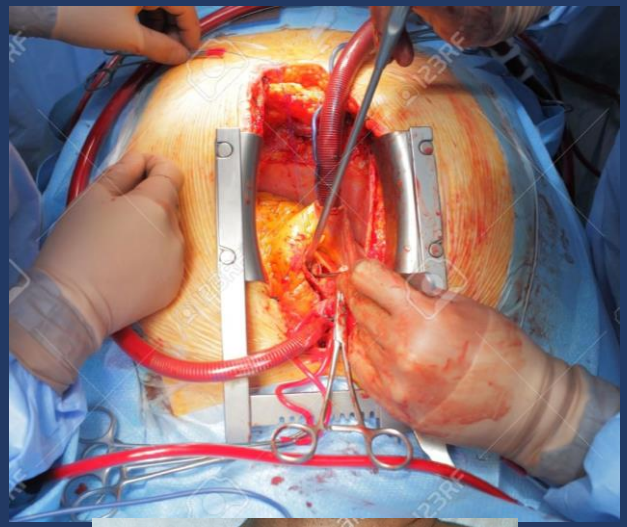

Ishimaru aortic arch zones

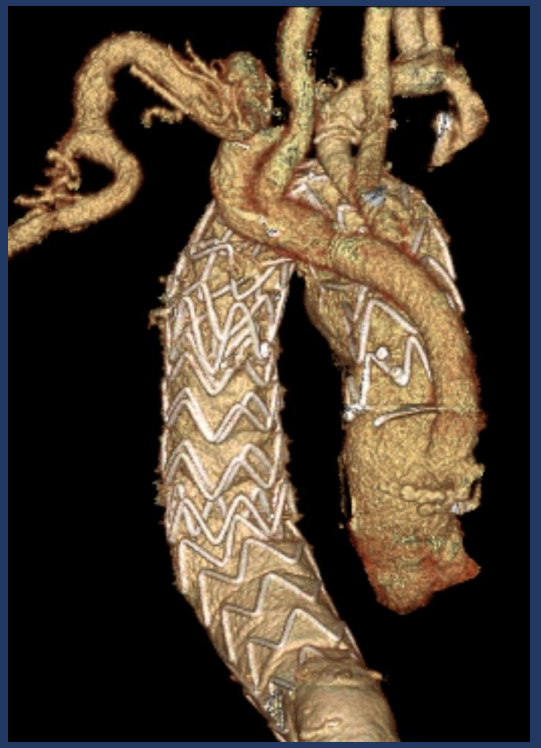




Arch repair

# Background



# Background


Arch repair

# Case study

78 year old male patient
Ruptured 8cm arch aneurysm
Hypotensive, transferred to hybrid room
On table CPR


Arch repair

# Case study

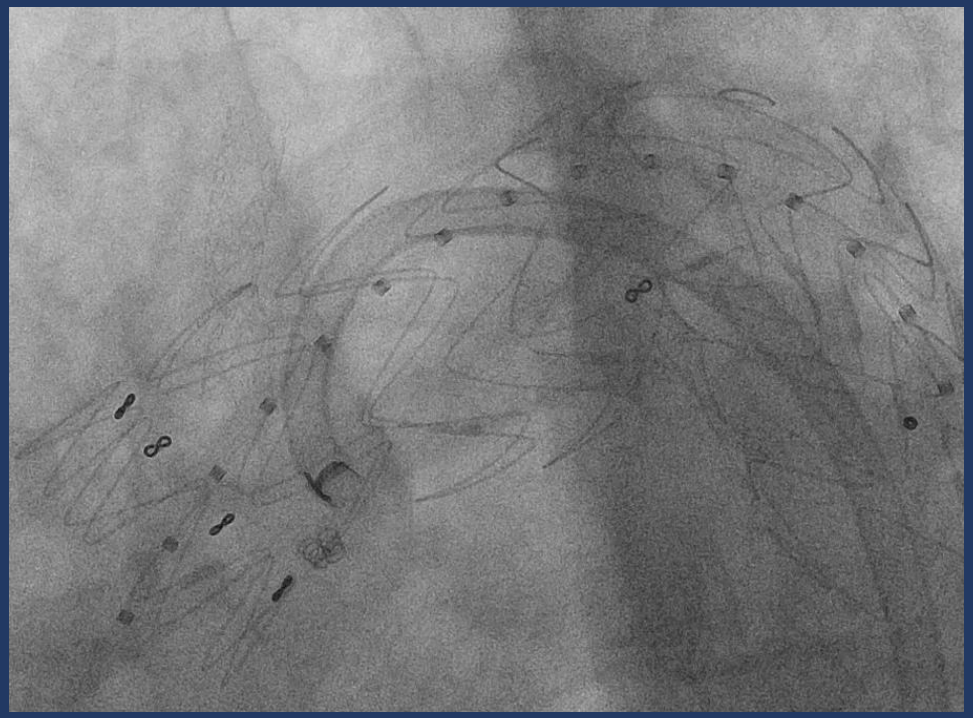
Predeployment arch study with laser in LCA and endograft in the arch


Endograft deployed and retrograde angiogram of the laser fenestrated and stented LCA

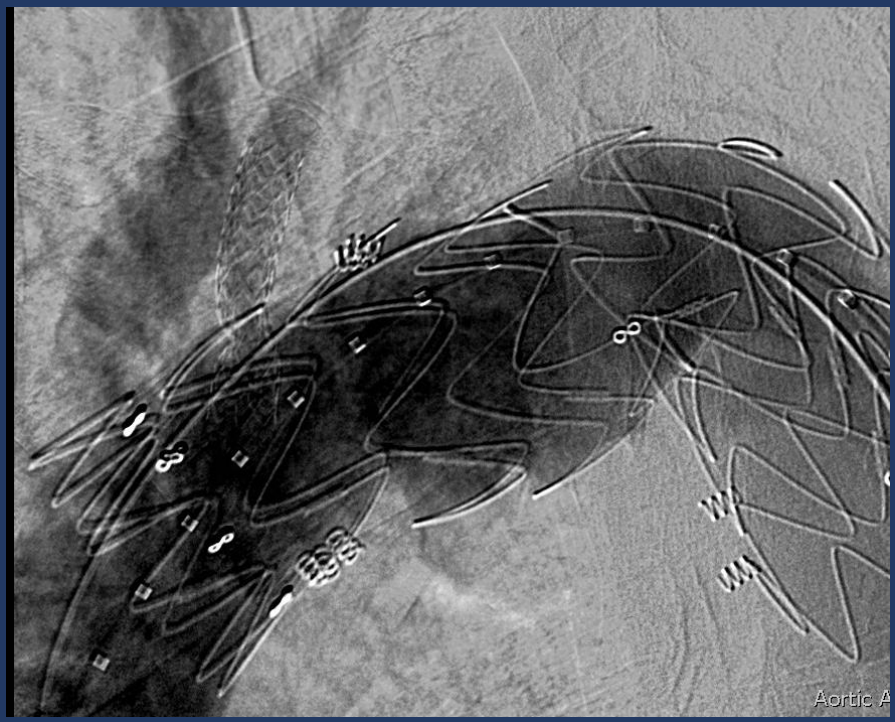
Arch repair

# Case study

Placement of EndoAnchors at the inner curve



Completion arch study with patent LCA fenestration and no endoleaks



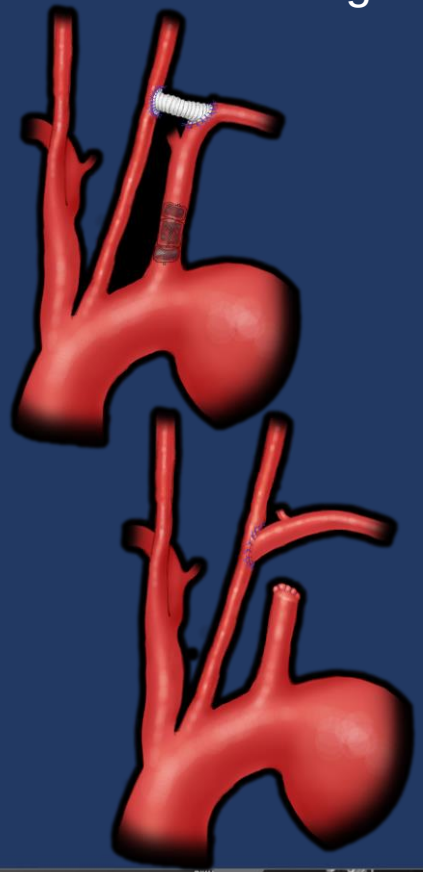
Patient discharged neurologically intact and now at 1 year follow up without reinterventions

Arch repair

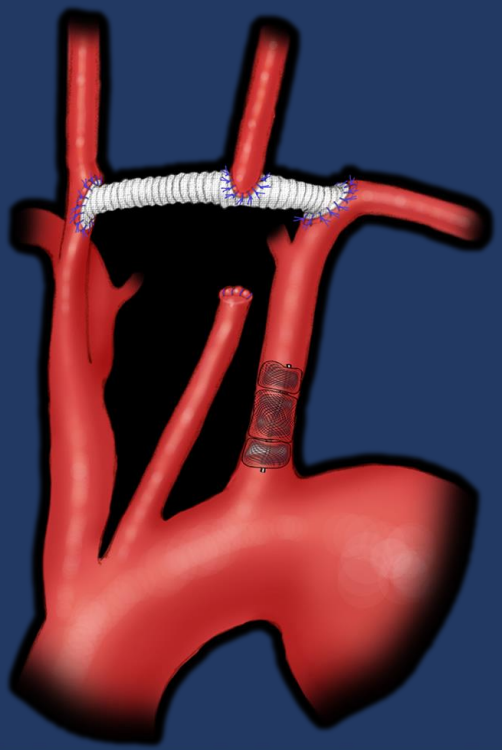
# Hybrid approach

## Arch Debranching with TEVAR

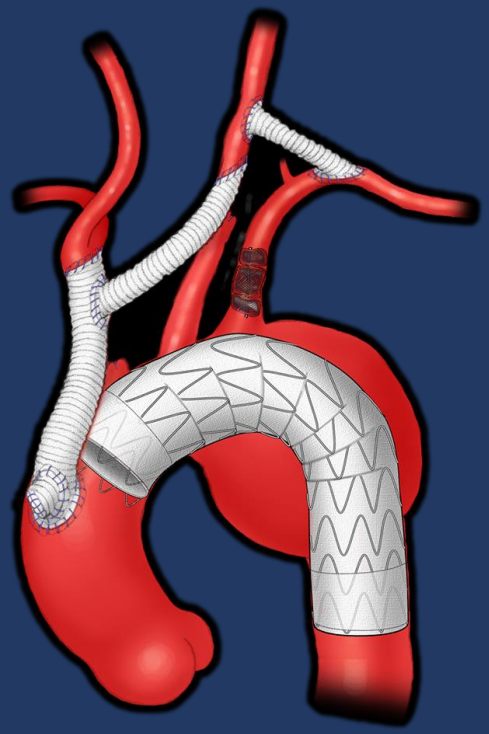
LSA debranching



Hemi arch debranching



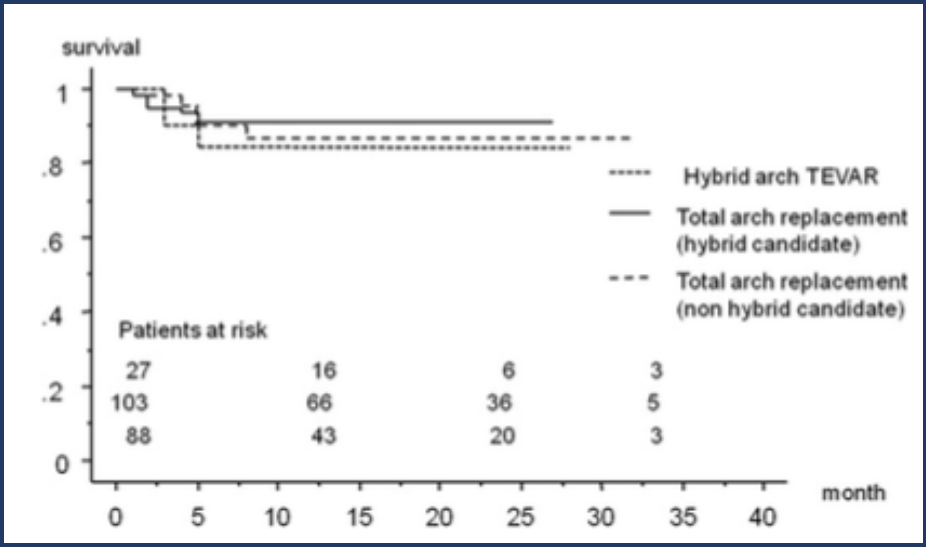
Total arch debranching



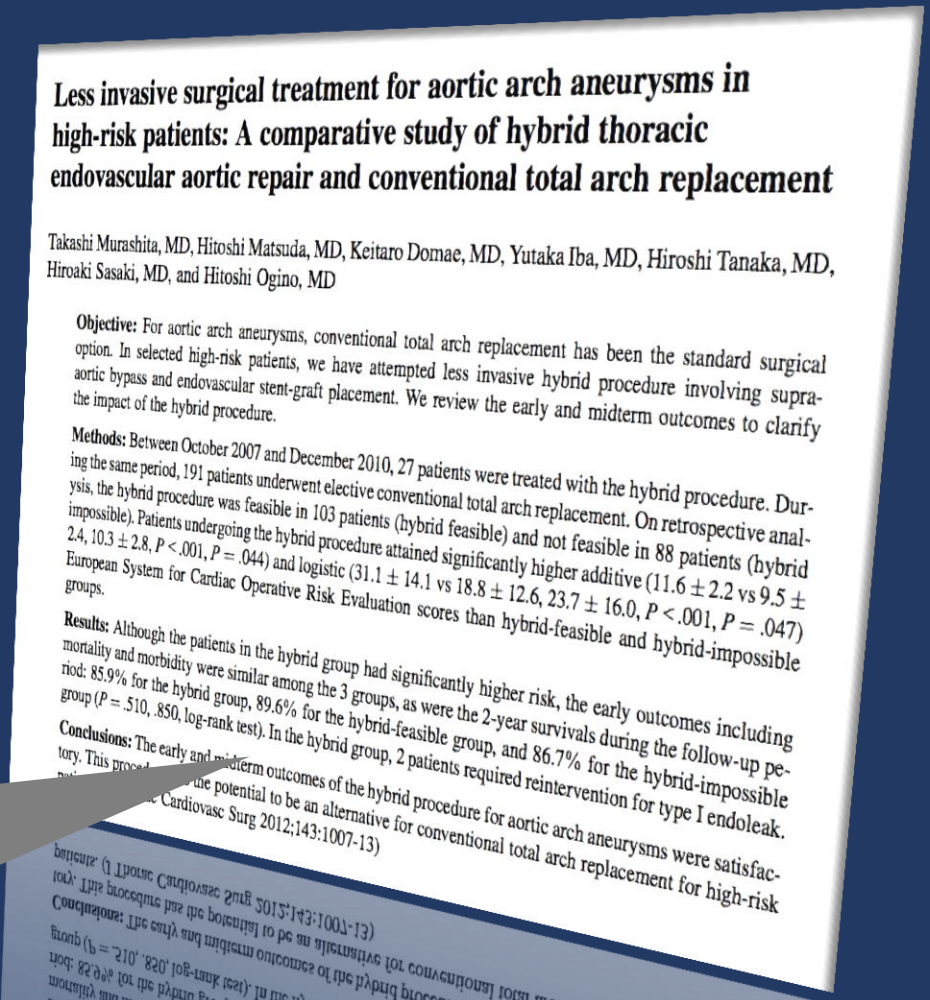
Courtesy of Gustavo Oderich MD

# Outcomes of open total arch vs hybrid repair

27 hybrid arch repairs
vs
103 open arch repairs




"The early and midterm outcomes of hybrid arch TEVAR for aortic arch aneurysm were satisfactory. Hybrid arch TEVAR has the potential to be a less invasive alternative for conventional TAR"



**Less invasive surgical treatment for aortic arch aneurysms in high-risk patients: A comparative study of hybrid thoracic endovascular aortic repair and conventional total arch replacement**

Takashi Murashita, MD, Hitoshi Matsuda, MD, Keitaro Domae, MD, Yutaka Iba, MD, Hiroshi Tanaka, MD, Hiroaki Sasaki, MD, and Hitoshi Ogino, MD

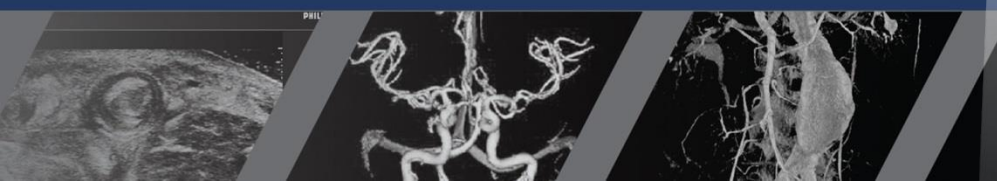
**Objective:** For aortic arch aneurysms, conventional total arch replacement has been the standard surgical option. In selected high-risk patients, we have attempted less invasive hybrid procedure involving supra-aortic bypass and endovascular stent-graft placement. We review the early and midterm outcomes to clarify the impact of the hybrid procedure.

**Methods:** Between October 2007 and December 2010, 27 patients were treated with the hybrid procedure. During the same period, 191 patients underwent elective conventional total arch replacement. On retrospective analysis, the hybrid procedure was feasible in 103 patients (hybrid feasible) and not feasible in 88 patients (hybrid impossible). Patients undergoing the hybrid procedure attained significantly higher additive ($11.6 \pm 2.2$ vs $9.5 \pm 2.4$, $10.3 \pm 2.8$, $P < .001$, $P = .044$) and logistic ($31.1 \pm 14.1$ vs $18.8 \pm 12.6$, $23.7 \pm 16.0$, $P < .001$, $P = .047$) European System for Cardiac Operative Risk Evaluation scores than hybrid-feasible and hybrid-impossible groups.

**Results:** Although the patients in the hybrid group had significantly higher risk, the early outcomes including mortality and morbidity were similar among the 3 groups, as were the 2-year survivals during the follow-up period: 85.9% for the hybrid group, 89.6% for the hybrid-feasible group, and 86.7% for the hybrid-impossible group ($P = .510$, .850, log-rank test). In the hybrid group, 2 patients required reintervention for type I endoleak.

**Conclusions:** The early and midterm outcomes of the hybrid procedure for aortic arch aneurysms were satisfactory. This procedure has the potential to be an alternative for conventional total arch replacement for high-risk

J Thorac Cardiovasc Surg 2012;143:1007-13)



J Thorac Cardiovasc Surg
2012;143:1007-13

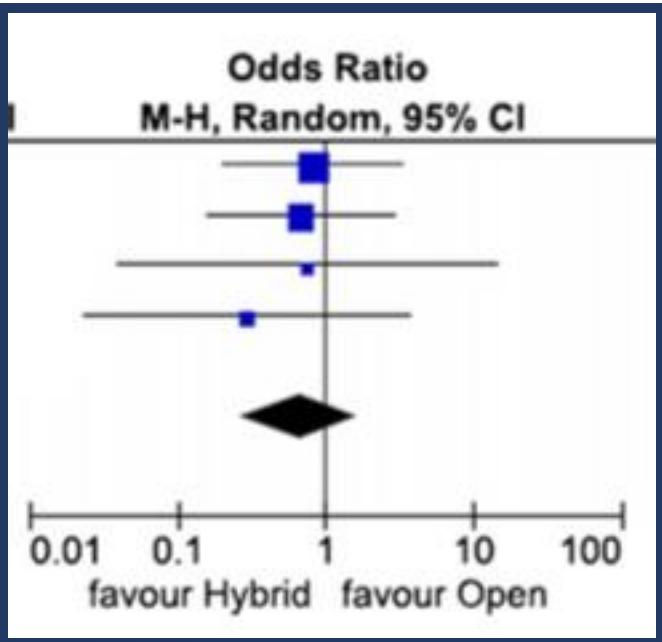
# Outcomes of open total arch vs hybrid repair

**Current results of open total arch replacement versus hybrid thoracic endovascular aortic repair for aortic arch aneurysm: A meta-analysis of comparative studies**

Umberto Benedetto, MD, PhD,[a] Giovanni Melina, MD, PhD,[a] Emiliano Angeloni, MD,[a] Massimiliano Codispoti, MD, FRCS,[b] and Riccardo Sinatra, MD,[a] Rome, Italy, and Cambridge, UK

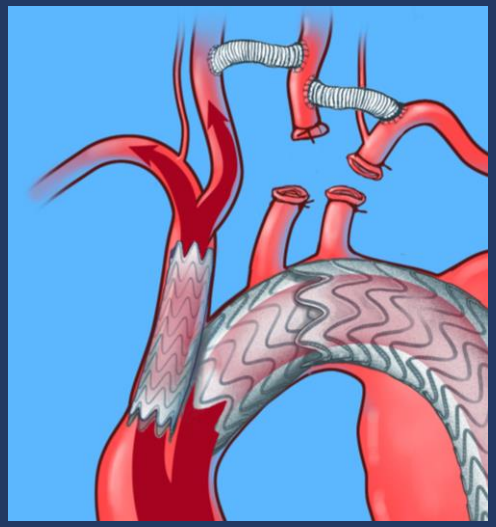
Pooled analysis of operative outcomes showed that Hybrid TEVAR improves operative mortality compared to open total arch repair

Surgical strategy for aortic arch aneurysm should be chosen on the basis of the patient's characteristics




The Journal of Thoracic and Cardiovascular Surgery 2013
Volume 145, Number 1

# Parallel Grafts or Chimneys

TEVAR with parallel grafts technique offers a readily available off the shelf and highly customizable method of endovascular arch repair

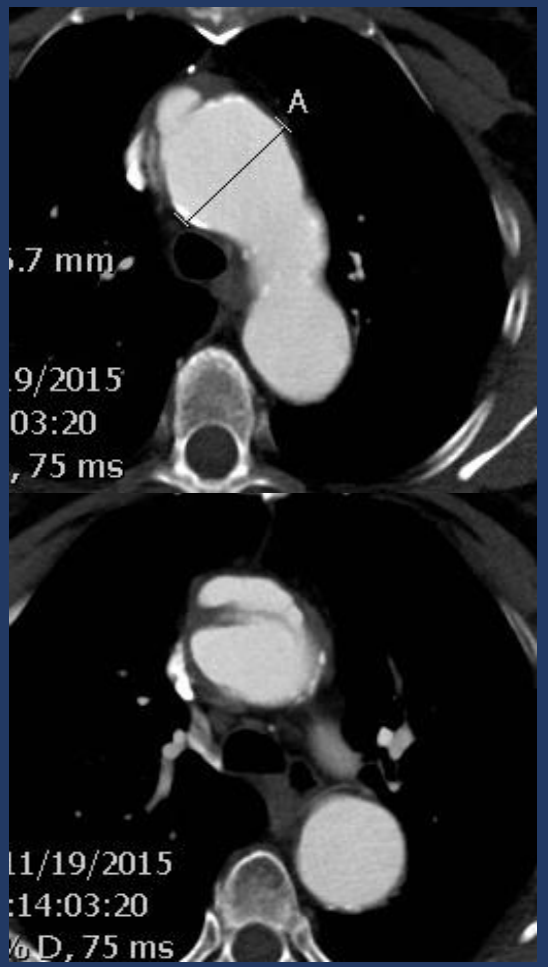
Chimneys can interfere with the sealing goal of endografts at the proximal or distal landing zones and increase the risk of type I endoleaks.

Arch repair

# Parallel Grafts or Chimneys

70 years old female patient
Expanding ascending aortic pseudoaneurysm
s/p Ascending and aortic root replacement
CAD with positive NST
COPD with emphysema
Referred by CTS

Reversed Hemi arch debranching
LSA to RCA bypass
LCA transposition

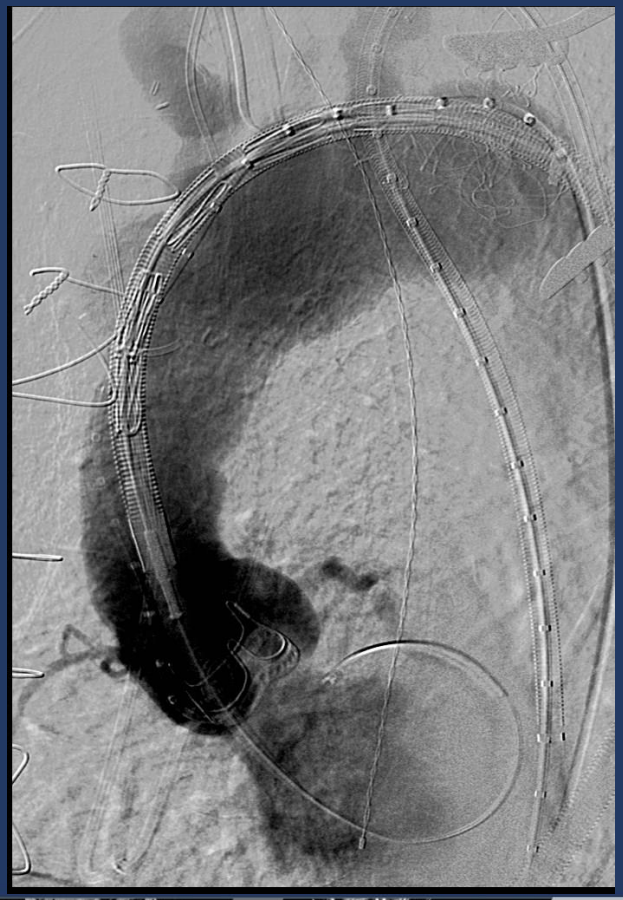



Arch repair

# Parallel Grafts or Chimneys

Arch Study Predeployment

Transient AI from delivery cone and wire in LV



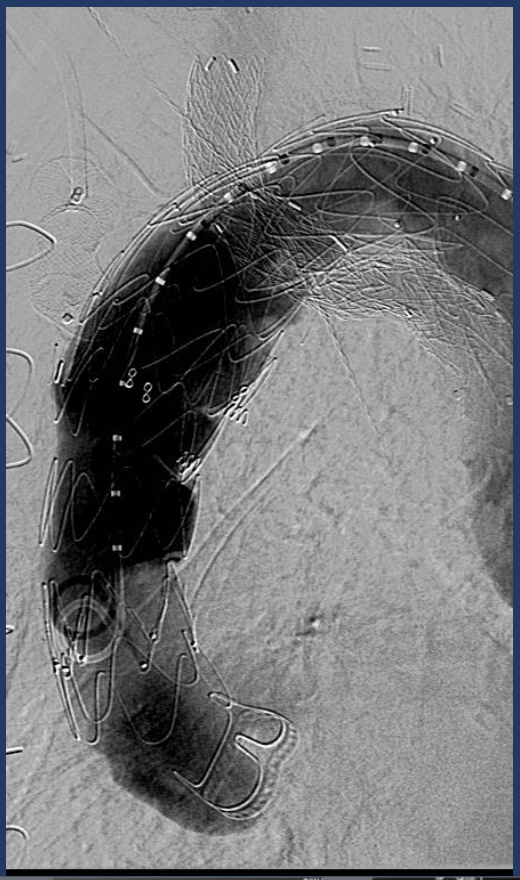
Patent LSA chimney and LVA

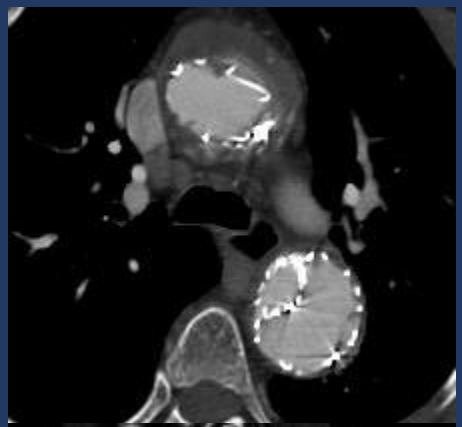
Arch repair

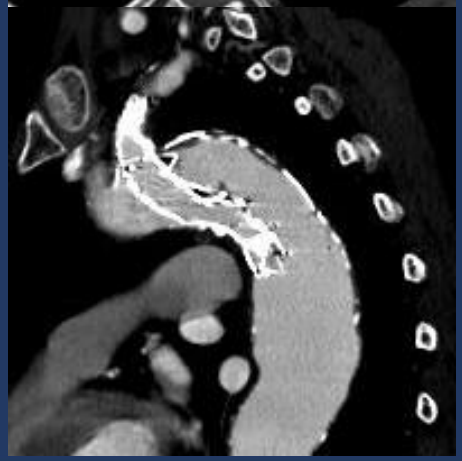
# Parallel Grafts or Chimneys

Completion angiogram after EndoAnchors :
AI resolved, no endoleak, patent SATs

CTA @ 6 months

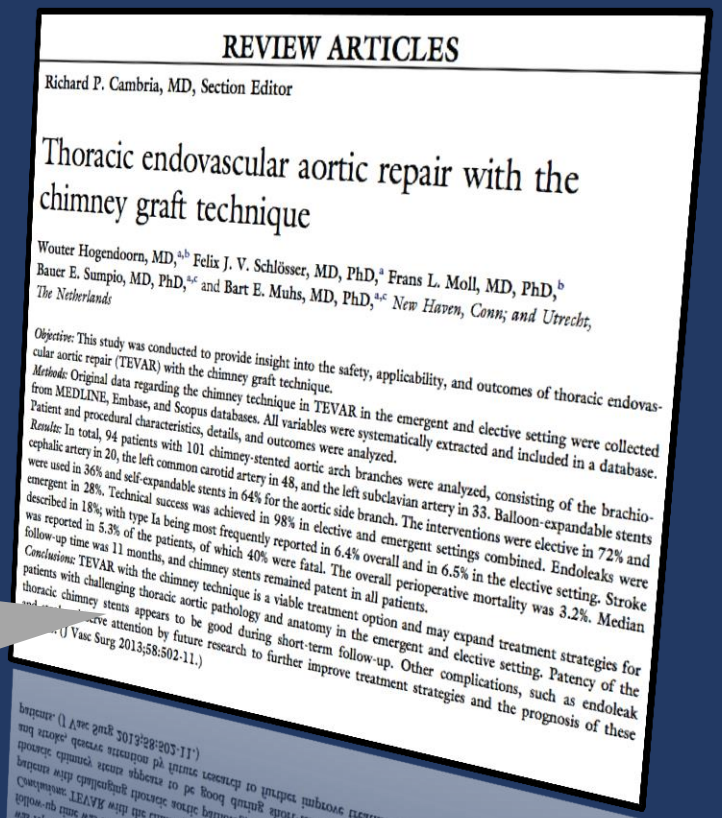






# Parallel Grafts or Chimneys

101 arch branches in
94 patients
Operative mortality 3.2%
Stroke rate 5.3%
Patency 100%



REVIEW ARTICLES

Richard P. Cambria, MD, Section Editor

Thoracic endovascular aortic repair with the chimney graft technique

Wouter Hogendoorn, MD,[a,b] Felix J. V. Schlösser, MD, PhD,[a] Frans L. Moll, MD, PhD,[b] Bauer E. Sumpio, MD, PhD,[a,c] and Bart E. Muhs, MD, PhD,[a,c] *New Haven, Conn; and Utrecht, The Netherlands*

*Objective:* This study was conducted to provide insight into the safety, applicability, and outcomes of thoracic endovascular aortic repair (TEVAR) with the chimney graft technique.

*Methods:* Original data regarding the chimney technique in TEVAR in the emergent and elective setting were collected from MEDLINE, Embase, and Scopus databases. All variables were systematically extracted and included in a database. Patient and procedural characteristics, details, and outcomes were analyzed.

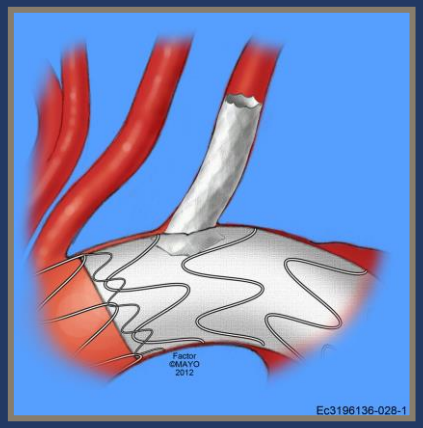
*Results:* In total, 94 patients with 101 chimney-stented aortic arch branches were analyzed, consisting of the brachiocephalic artery in 20, the left common carotid artery in 48, and the left subclavian artery in 33. Balloon-expandable stents were used in 36% and self-expandable stents in 64% for the aortic side branch. The interventions were elective in 72% and emergent in 28%. Technical success was achieved in 98% in elective and emergent settings combined. Endoleaks were described in 18%; with type Ia being most frequently reported in 6.4% overall and in 6.5% in the elective setting. Stroke was reported in 5.3% of the patients, of which 40% were fatal. The overall perioperative mortality was 3.2%. Median follow-up time was 11 months, and chimney stents remained patent in all patients.

*Conclusions:* TEVAR with the chimney technique is a viable treatment option and may expand treatment strategies for patients with challenging thoracic aortic pathology and anatomy in the emergent and elective setting. Patency of the thoracic chimney stents appears to be good during short-term follow-up. Other complications, such as endoleak [illegible] serve attention by future research to further improve treatment strategies and the prognosis of these [illegible]. (J Vasc Surg 2013;58:502-11.)

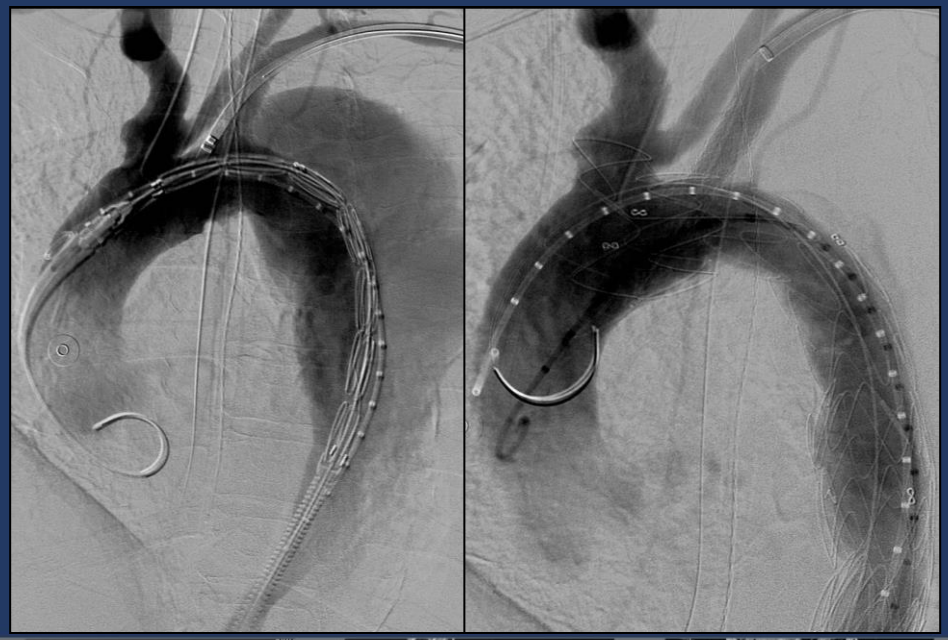
J Vasc Surg 2013;58:502-11

Arch repair

# In Situ Fenestration




TEVAR with in situ fenestration technique offers a readily available off the shelf and highly customizable method of endovascular arch repair

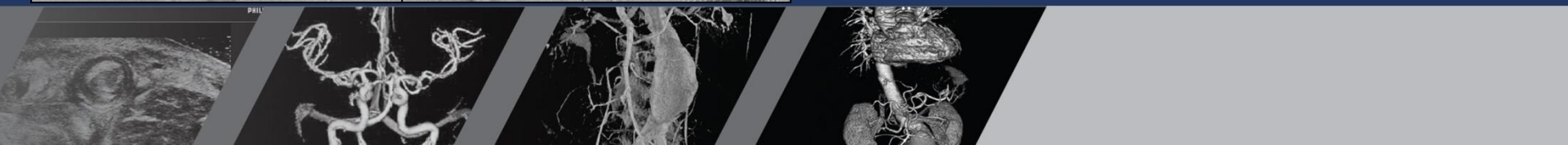


Quick and simple

Eliminates the need for rotational alignment

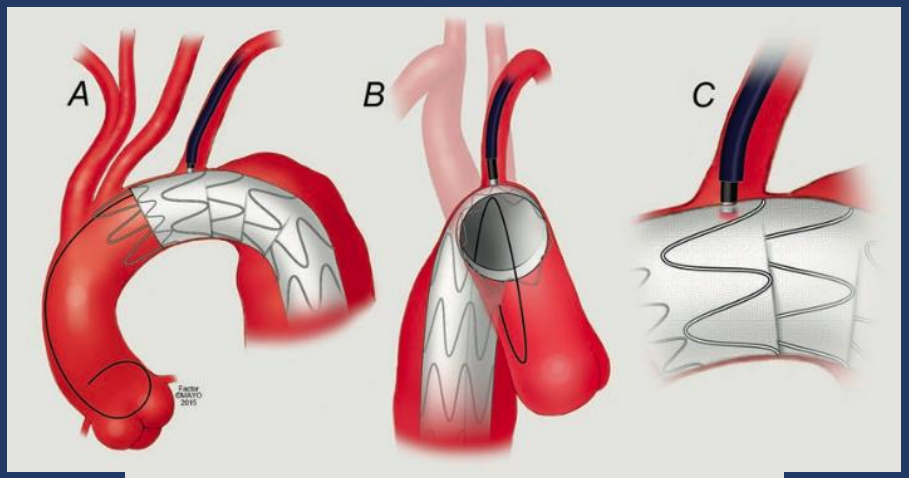
Less catheter manipulations

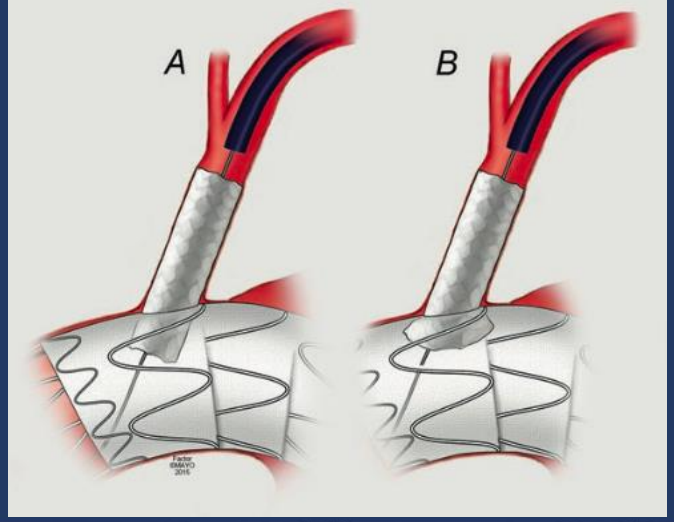
Can be a bail out

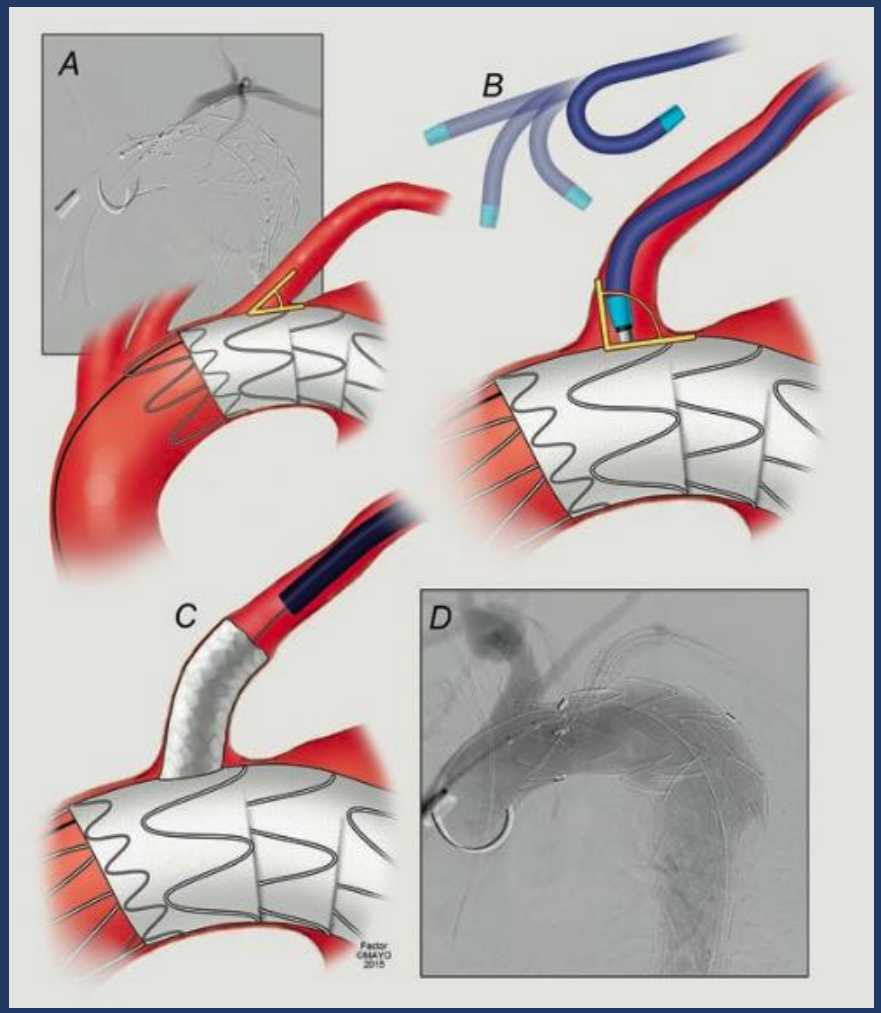


Arch repair

# In Situ Fenestration




Arch repair

# In Situ Fenestration

CLINICAL RESEARCH STUDIES

From the Southern Association for Vascular Surgery

## In situ laser fenestration during emergent thoracic endovascular aortic repair is an effective method for left subclavian artery revascularization

Richard E. Redlinger Jr, MD, Sadaf S. Ahanchi, MD, and Jean M. Panneton, MD, *Norfolk, Va*

*Background:* Retrograde laser fenestration of the left subclavian artery (LSA) during emergent thoracic endovascular aortic repair (TEVAR) uses a relatively simple intraoperative method of endograft modification to revascularize aortic branches for a variety of acute thoracic aortic pathologies. This study presents our expanded experience and midterm outcomes of TEVAR with laser fenestration to revascularize the LSA as an alternative to debranching.

*Methods:* Patients who underwent TEVAR with LSA revascularization by laser graft fenestration from September 2009 through August 2012 were retrospectively reviewed. TEVAR was performed with deployment of a Dacron (DuPont, Wilmington, Del) endograft over the LSA orifice. Laser catheter fenestration of the graft was performed through retrograde brachial access, followed by balloon-expandable covered stent deployment through the fenestration to traverse the endograft and LSA. Routine postoperative follow-up imaging with computed tomography angiography was performed to assess TEVAR and LSA fenestration patency, endoleak, and aneurysm/dissection exclusion.

*Results:* TEVAR with laser fenestration was successfully performed in 22 patients (12 men; mean age, 57 years) in an urgent or emergent setting secondary to unremitting symptoms or rupture. Twelve patients had large symptomatic thoracic aortic aneurysms (eight secondary to chronic dissection); four patients had acute symptomatic type B aortic dissection, and six patients had an intramural hematoma or penetrating aortic ulcer, or both. An average of two endografts (range, 1-4) were deployed. LSA-covered stents were 8 to 10 mm in diameter. Mean operative time was 154 ± 65 minutes. Average hospital length of stay was 12 ± 7 days. No major fenestration-related complications occurred. One patient developed postoperative paraplegia. One patient died in the postoperative period, for an in-hospital mortality rate of 4.5%. Two patients died of non-TEVAR-related causes at a mean follow-up of 10 months (range, 1-40 months). Follow-up computed tomography angiography imaging demonstrated a 100% primary patency for the LSA stents. One patient had an asymptomatic LSA stent stenosis. Type II endoleaks from the LSA in two patients required endovascular coil embolization. No fenestration-related type I or III endoleaks were noted.

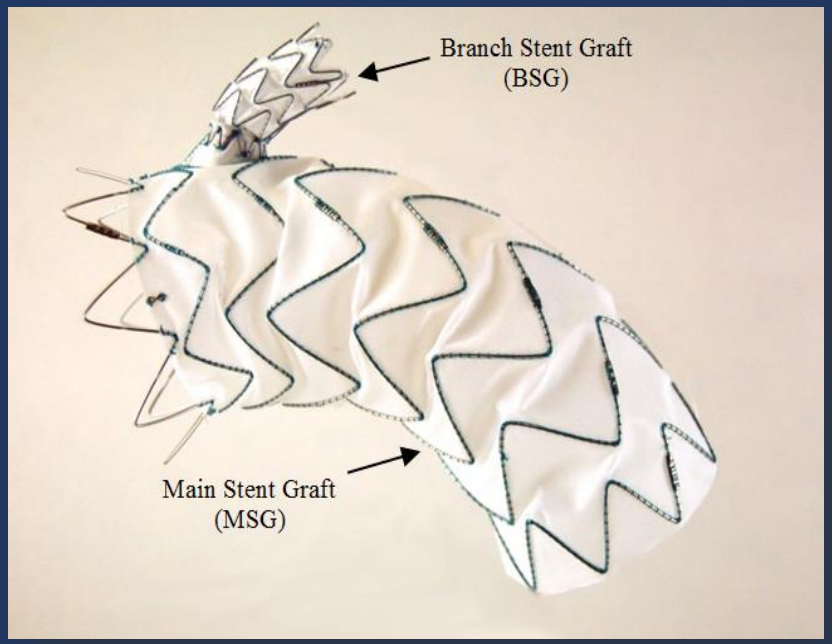
*Conclusions:* In situ retrograde laser fenestration is a feasible and effective option for LSA revascularization during TEVAR involving a spectrum of acute thoracic aortic pathology. Laser fenestration provides a rapid, reproducible method of fenestrating the endograft material. The high technical success, low fenestration-related morbidity, and excellent midterm patency support this technique of intraoperative endograft modification. (J Vasc Surg 2013;58:1171-7.)

J Vasc Surg 2013;58:1171-7

# Single branch device

## 2 current ongoing IDE trials

Medtronic Valiant Mona LSA branch stent-graft

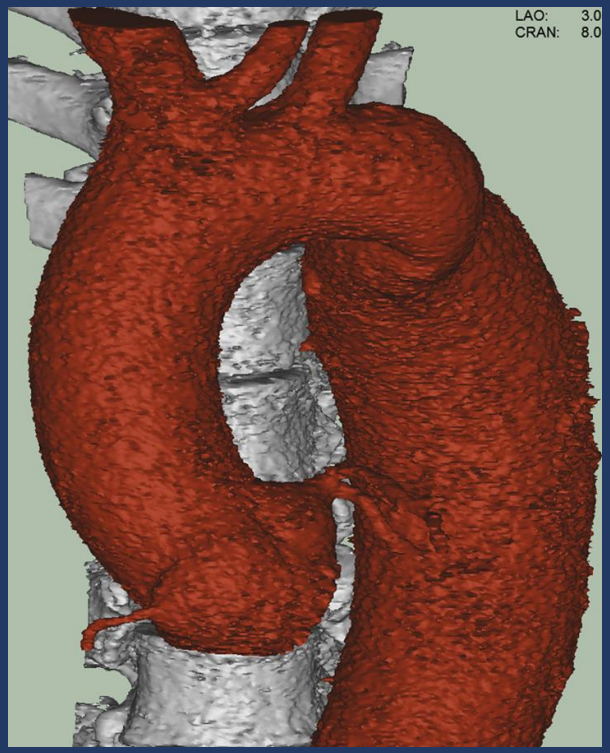



Gore thoracic branch endoprosthesis

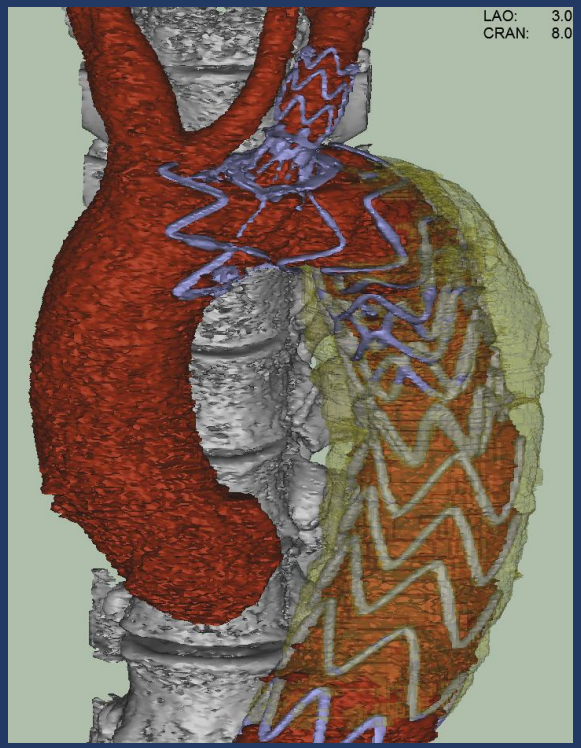
# Single branch device

## Medtronic Valiant Mona LSA branch stent-graft

Early Feasibility Study
11 patients
100% Technical success




Phase 1 Mona LSA Trial
18 patients
Stroke rate = 0%




Arch repair

# Single branch device

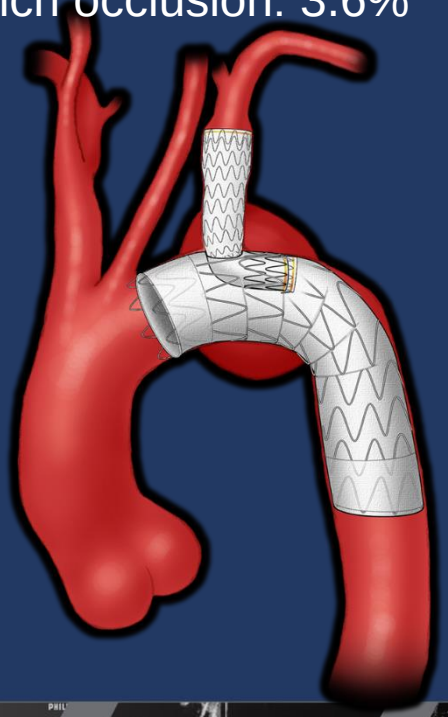
## Gore thoracic branch endoprosthesis Trial

### Zone 2: 28 patients

100% Technical success

Stroke rate: 3.6%

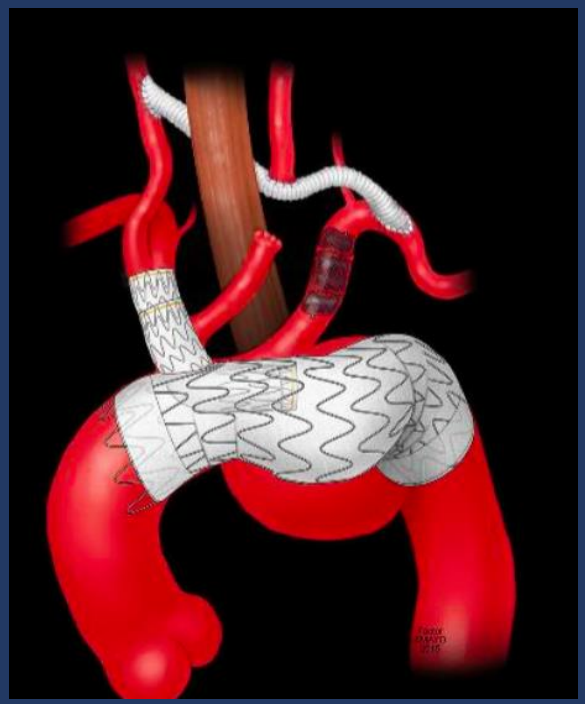
Branch occlusion: 3.6%



### Zone 0-1: 8 patients

100% Technical success

Stroke rate: 25%



Arch repair

# Single branch device

## CASTOR Branched Aortic Stent-Graft System


MicroPort Endovascular

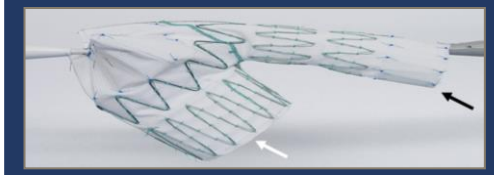
- 11 centers in China
- 73 patients with aortic dissection
- 98.6% Technical success
- Unibody design with main body and LSA branch

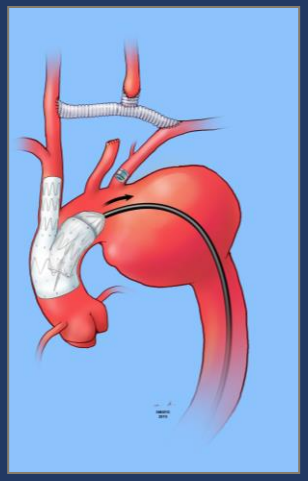
Arch repair

# Multi branch device

**2001-2003**

**Chuter T et al,**
**J Vasc Surg 2003**





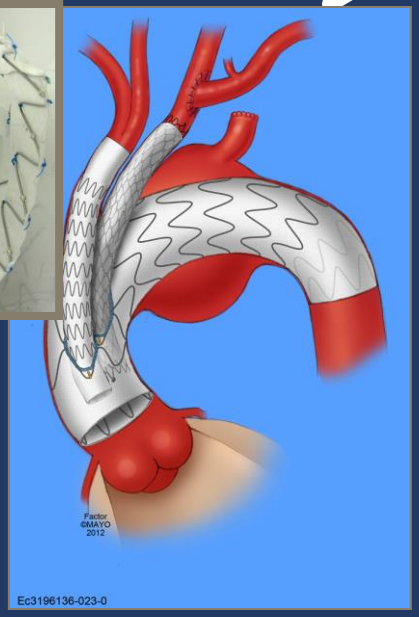
- **Lt. Carotid access**
- **Large diameter sheath (24-26Fr)**

**2007-2008**

**Chuter, Greenberg, Ivancev**
**Abraham, Haulon**

- **External branches**
- **Limited space for catheterization**

**2009-2013**




- **Internal branches**
- **Double reducing ties**
- **Self-oriented to outer curvature**
- **More space for catheterization**

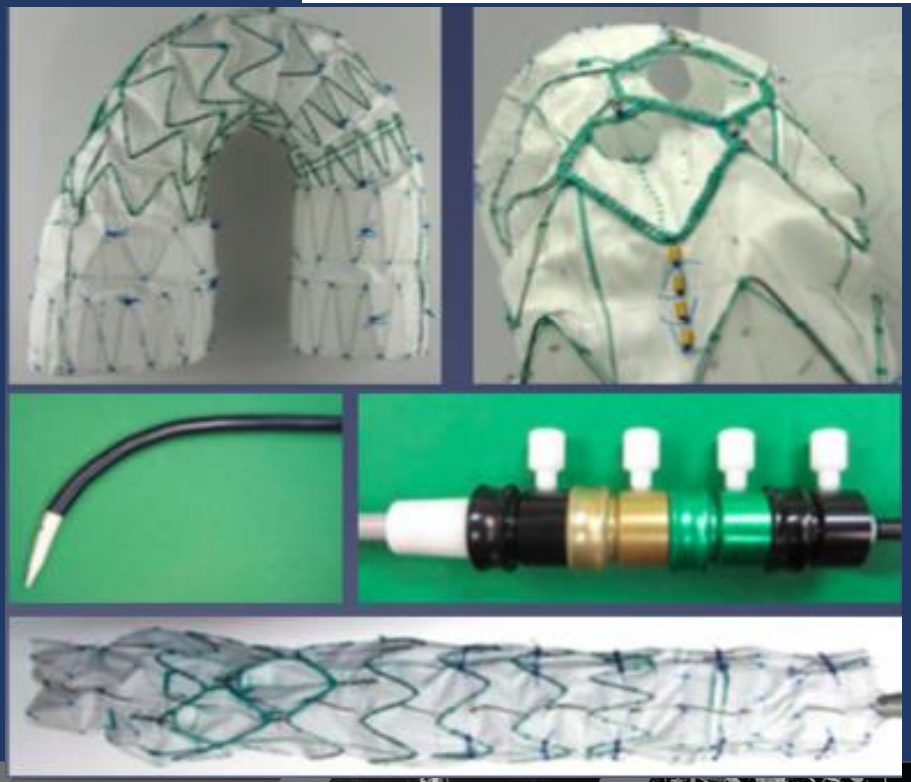
Arch repair

# Multi Branch device



## Global experience with an inner branched arch endograft

Stéphan Haulon, MD, PhD,[a] Roy K. Greenberg, MD,[b] Rafaëlle Spear, MD,[a] Matt Eagleton, MD,[b] Cherrie Abraham, MD,[c] Christos Lioupis, MD,[c] Eric Verhoeven, MD, PhD,[d] Krassi Ivancev, MD,[e] Tilo Kölbel, MD, PhD,[f] Brendan Stanley, MD,[g] Timothy Resch, MD,[h] Pascal Desgranges, MD, PhD,[i] Blandine Maurel, MD,[a] Blayne Roeder, PhD,[j] Timothy Chuter, MD,[k] and Tara Mastracci, MD[b]



- Double inner branch
- Multicenter Study, 2009-3013
- 38 patients
- Technical success = 32/38
- Mortality = 13%
- Neuro events = 16%

J Thorac Cardiovasc Surg 2014

Arch repair

# Multi Branch device

Total endovascular arch repair with dual branch device

J Thorac Cardiovasc Surg 2014

# Multi branch device

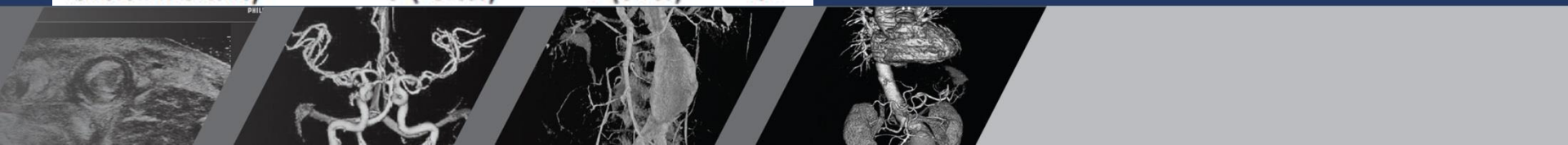
**Editor's Choice — Subsequent Results for Arch Aneurysm Repair with Inner Branched Endografts,** ☆

R. Spear [a], S. Haulon [a,*], T. Ohki [b], N. Tsilimparis [c], Y. Kanaoka [b], C.P.E. Milne [a], S. Debus [c], R. Takizawa [b], T. Kölbel [c]

Eur J Vasc Endovasc Surg 2016

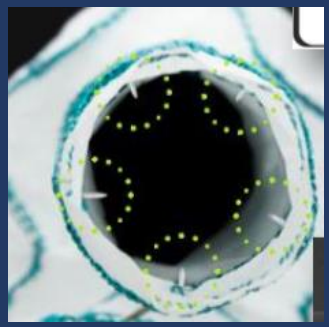
| | Group 1 ($n = 38$) | Group 2 ($n = 27$) | $p$ |
|---|---|---|---|
| Procedure | | | |
| Length (min) | 250 (210–330) | 295 (232–360) | .35 |
| X-ray time (min) | 46 (32–84) | 39.3 (34–61) | .07 |
| Volume of contrast (mL) | 150 (95–207) | 183 (120–290) | .03 |
| Early post-operative | | | |
| Endoleaks | 11 (28.9%) | 3 (11.1%) | .08 |
| Secondary procedures | 4 (10.5%) | 4 (14.8%) | .61 |
| Cerebrovascular events | 6 (15.8%) | 3 (11.1%) | .60 |
| Systemic complications | 17 (44.7%) | 13 (43.3%) | .79 |
| Mortality | 5 (13.2%) | 0 (0%) | .05 |
| Follow up ($n = 33$) | | | |
| Endoleaks | 3 (9.1%) | 2 (7.4%) | .82 |
| Secondary procedures | 3 (9.1%) | 2 (7.4%) | .82 |
| Mortality | 4 (12.1%) | 1 (3.7%) | .24 |
| Overall mortality | 9 (23.6%) | 1 (3.7%) | .02 |

Three-center experience demonstrated an improvement in patient outcome when compared with the early global experience of the technique published in 2014



# Multi branch device

- Based on the Relay Plus NBS platform
- Off the shelf with variable MSG diameter
- Large single aperture with 1 or 2 internal tunnel(s)
  - Single: innominate
  - Double : innominate & LCA
- Engaging lock mechanism for the branch stent graft



Arch repair

# Multi branch device

## Worldwide experience with double branch

| Center | Investigator | City | Country |
|---|---|---|---|
| Ospedale San Camillo Forlanini | Prof. Cao | Roma | Italy |
| Ospedale G. Brotzu | Dr. Camparini | Cagliari | Italy |
| Hopital Rangueil | Prof. H. Rousseau | Toulouse | France |
| Osaka University Hospital | Dr. Kuratani | Osaka | Japan |
| UMC Utrecht | Prof. F. Moll – dr. Van Herwaarden | Utrecht | Netherlands |
| Hopital George Pompidou | Dr. J. M. Alsac | Paris | France |
| Hospital UCA de Oviedo | Dr. M. Alonso | Oviedo | Spain |
| St. Mary's Hospital - London | Dr. M. Hamady | London | United Kingdom |
| Linköping University Hospital | dr. C. Forssell | Linköping | Sweden |

| | Total |
|---|---|
| **N** | **26** |
| Male | 69,2% |
| Mean Age | 72y |
| TAA | 80,8% |
| PAU | 3,8% |
| Type B Dissection | 15,4% |
| Procedure completed | 100% |
| Freedom from endoleak | 92,3% |
| Perioperative overall death | 11,5% |
| Perioperative procedure related death | 3.8% |

# Fenestrated device



**Advantage of a precurved fenestrated endograft for aortic arch disease: Simplified arch aneurysm treatment in Japan 2010 and 2011**

Yoshihiko Yokoi, MD, Takashi Azuma, MD, and Kenji Yamazaki, MD, PhD

383 patients in 35 centers

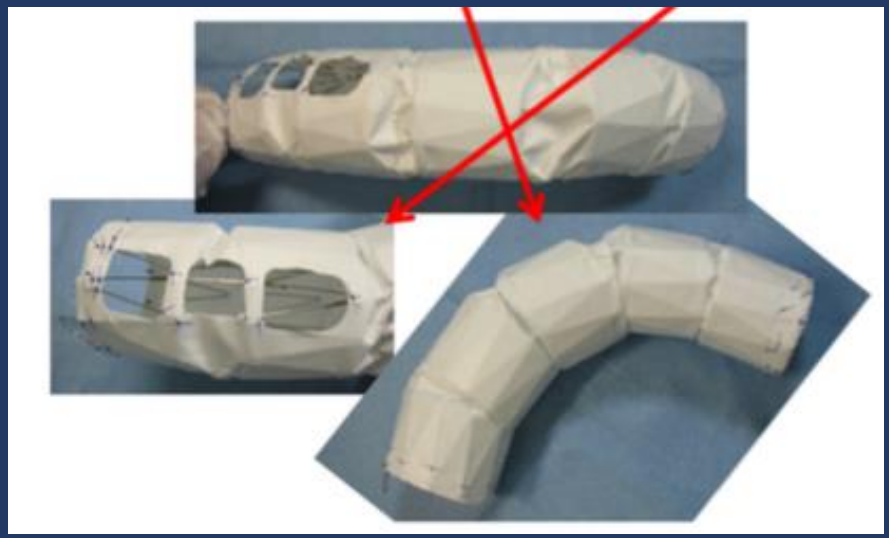
Zone 0 in 94.7%

Mean operative time = 161 min

Initial success = 95.8%

30 day mortality = 1.6%

Stroke rate = 1.8%



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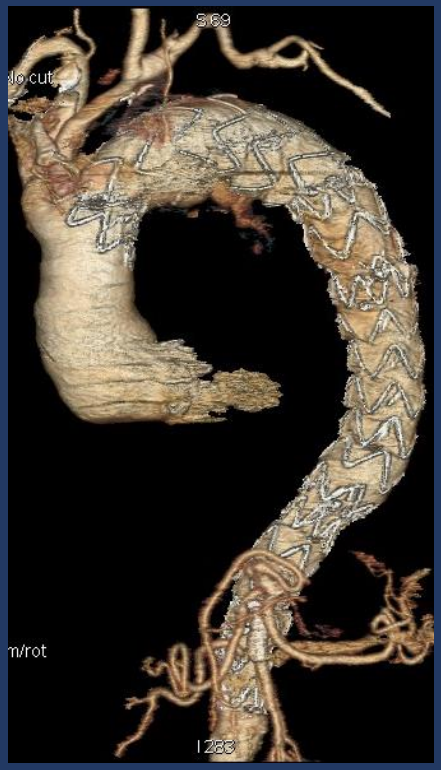
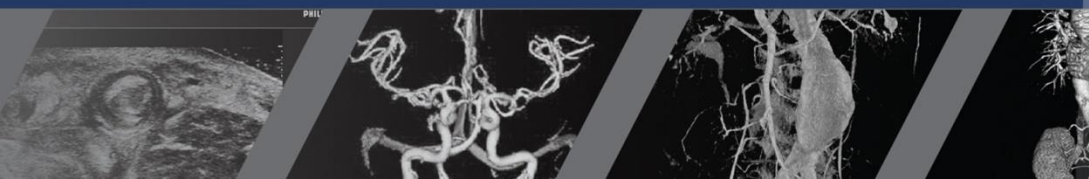
Arch repair

# Ancillary device

Therapeutic use of EndoAnchors for proximal type I endoleak 1 yr after TEVAR & 4 vessels FEVAR for Type I TAAA







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ORIGINAL ARTICLE

TOWARDS AN ENTIRELY ENDOVASCULAR AORTIC WORLD

## The use of EndoAnchors to rescue complicated TEVAR procedures

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ABSTRACT

BACKGROUND: The aim of this study was to assess the applicability and outcomes of EndoAnchor use in the endovascular repair of thoracic and thoracoabdominal aortic aneurysms.

METHODS: A retrospective review was performed of all thoracic endovascular aortic repairs (TEVARs) performed with the use of EndoAnchors between December 2012 and January 2016. Primary study endpoints included freedom from migration, freedom from aortic- related intervention, and freedom from post-operative type I or type III endoleak.

RESULTS: During this study period, a total of 54 patients underwent TEVAR for thoracic or thoracoabdominal aneurysm with the use of EndoAnchors at our institution. Twenty-seven cases were performed as the index operation. Twenty-seven cases were considered redo operations. EndoAnchors were deployed for therapeutic and prophylactic indications. Mean follow-up was 9.6±8.8 months. EndoAnchors were used for therapeutic indications in 31.5% of patients and for prophylactic indications in 68.5%. The technical success of EndoAnchor deployment was 99.8%. The overall initial technical success of the operation was 98.1%. There were no instances of graft migration. The overall endoleak rate was 5.4% with prophylactic EndoAnchor use and 11.8% with therapeutic use. Aortic-related reintervention was required in 13.5% of patients who received prophylactic EndoAnchor failure. A p value of <0.05 was considered significant.

CONCLUSIONS: EndoAnchors can be safely utilized in TEVAR with high rates of technical success. These results demonstrate the potential to enhance thoracic endograft efficacy and durability with the use of therapeutic and prophylactic EndoAnchors. Long-term data is needed to further define the use of this technology in the thoracic aorta.

(Cite this article as: Ongstad SB, Miller DF, Panneton JM. The use of EndoAnchors to rescue complicated TEVAR procedures. J Cardiovasc Surg 2016;57:716-29)

**Key words:** Thoracic aortic aneurysm - Endoleak - Endovascular procedures.

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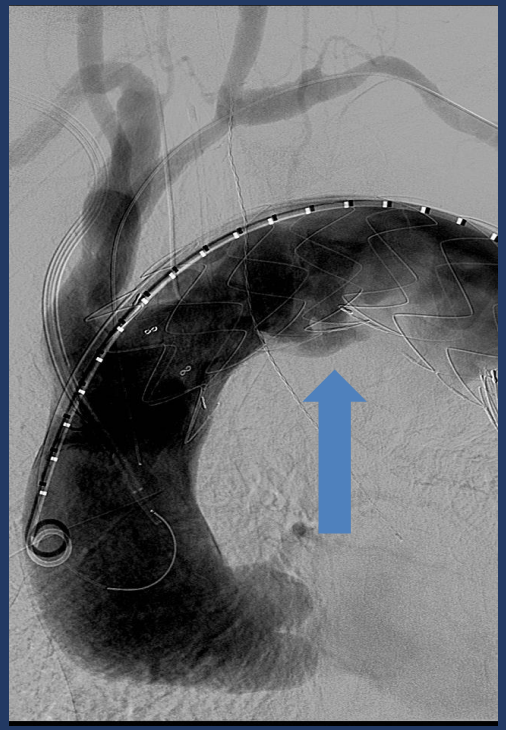
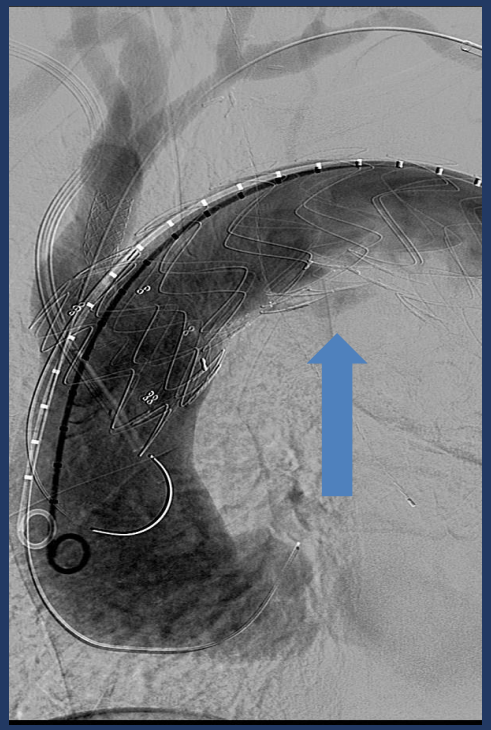
Arch repair

# Ancillary device

## Placement of Endo Anchors at inner curvature for type I endoleak

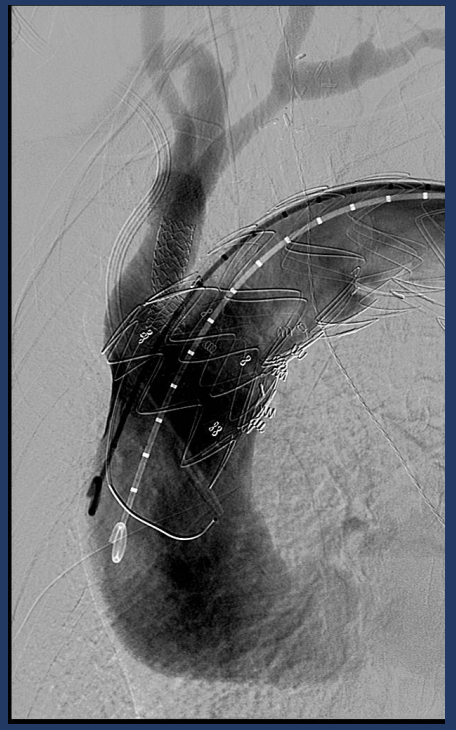


Type Ia endoleak



Persistent endoleak after redo TEVAR & LCA fenestration

EndoAnchors deployed at inner curve



Type Ia endoleak resolved

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# Summary

Open arch repair is associated with significant operative morbidity and should be reserved for young and good risk patients

Creative approaches for endovascular arch repair, such as parallel grafts or in situ fenestrations can be used safely with satisfactory early technical success

Single or dual branch devices will offer a total endovascular solution to arch pathologies

# Summary

The endovascular era is here