



*National Center for Cardiovascular Diseases  
Fuwai Hospital , CAMS & PUMC*

# **The challenging Proximal Aortic Neck: Which method will be the 1st option?**

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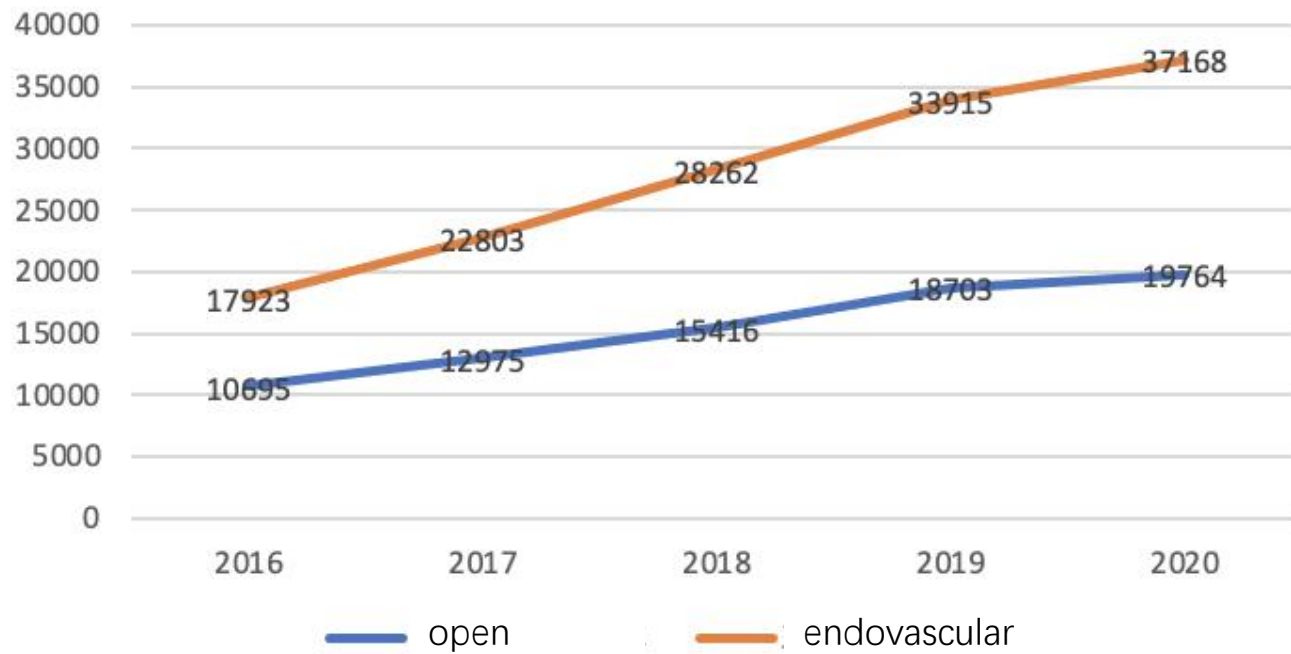
# Disclosure of Conflicts

- I have nothing to disclose

# Volume of Aortic Surgery in China

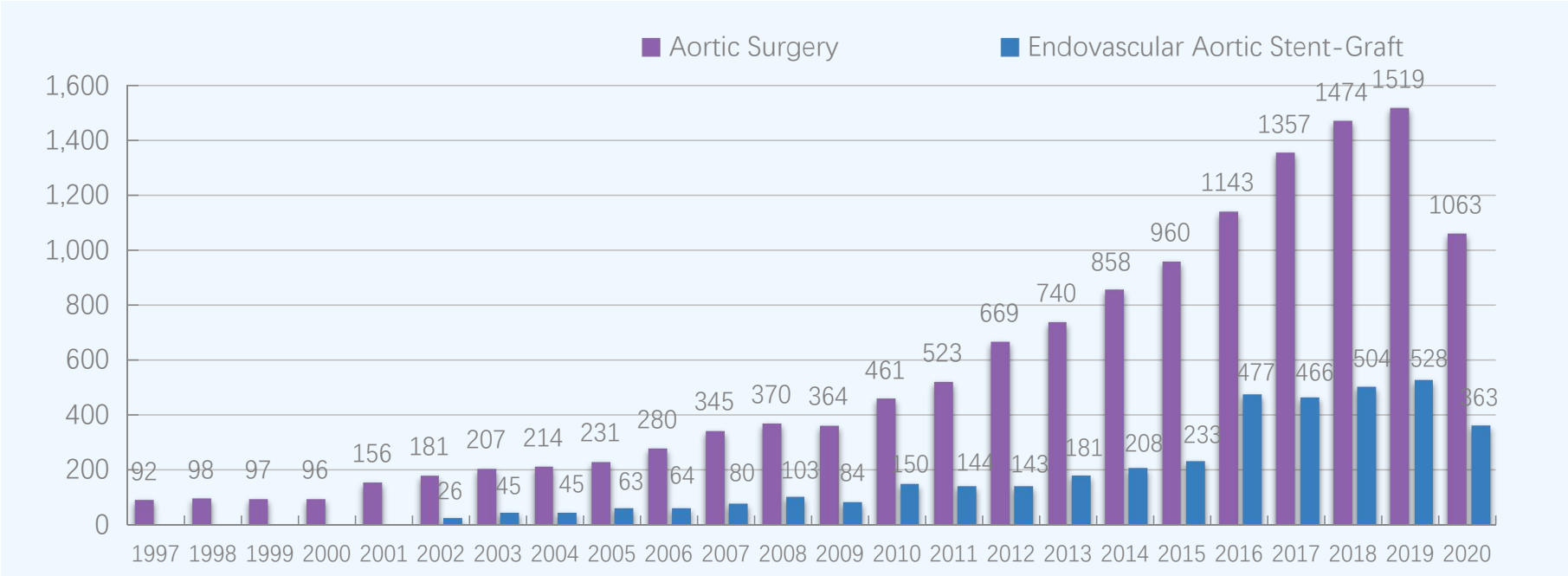
- Data from Hospital Quality Monitoring System, HQMS
- Including 4311 hospital

2016-2020 Volume of Aortic Surgery



# Outcomes of Fuwai Hospital

- 1997–2020 Volume of Aortic Surgery in Fuwai Hospital

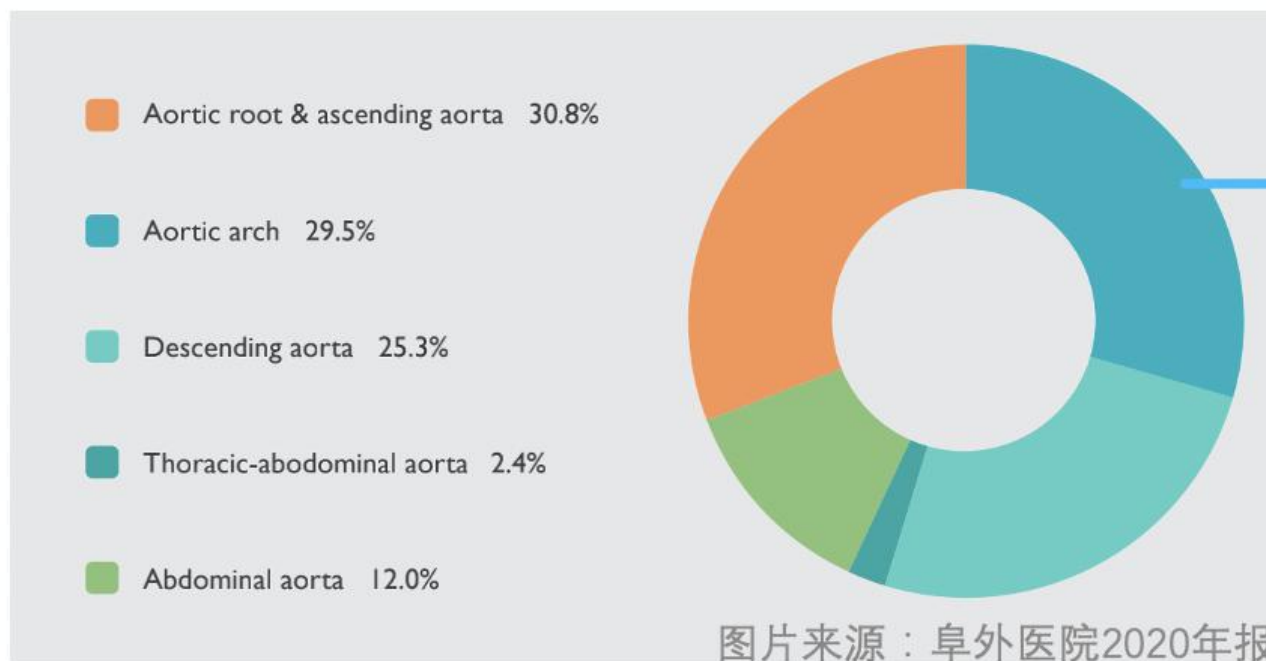




# Composition of Aortic Surgeries at Fuwai Hospital

2019 volume of aortic surgeries :1519      29.6% for Aortic Arch

2020 volume of aortic surgeries :1063      29.5% for Aortic Arch



**open aortic arch operations 327(2019:397)**

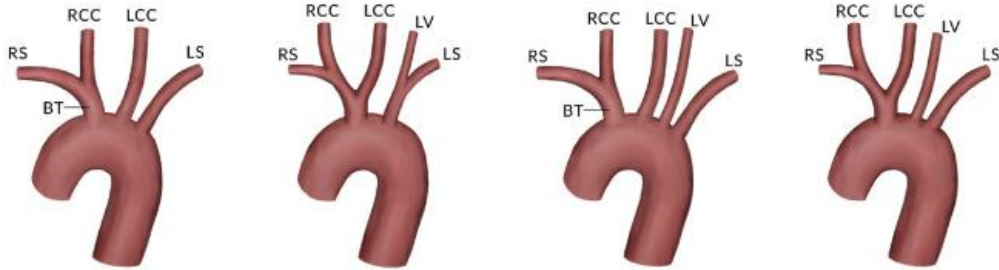
(including simultaneously root or ascending aortic operation)

hybrid operations 50 (2019:82)

**endovascular operation 100 (2019:178)**

composition of aortic procedures at Fuwai Hospital,2020

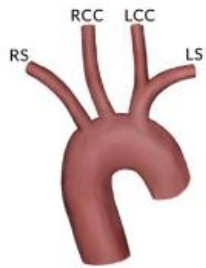
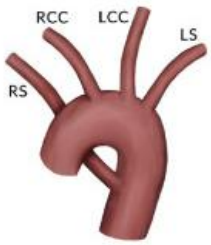
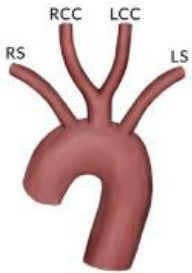
# Complex Arch Conditions



Type 5 – Common Carotid

Type 6 – Aberrant RS

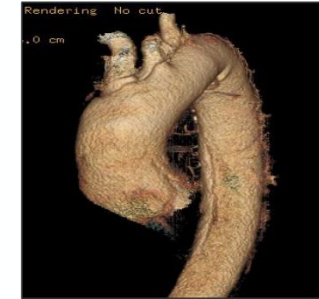
Type 7 – Right Arch



■ *various arch anatomy*

&

■ *different pathophysiology*

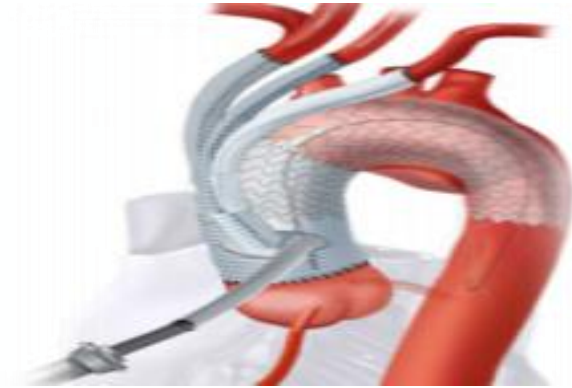
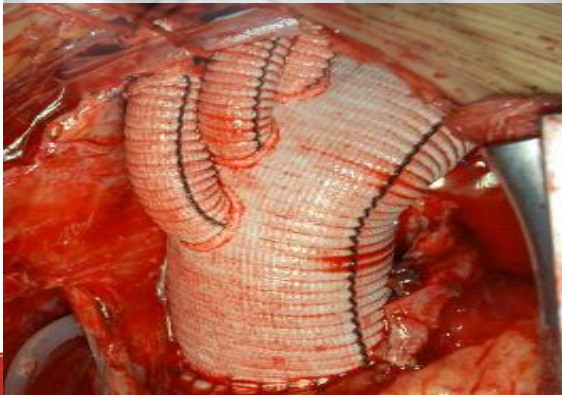


➔ individual strategies are more suitable for arch disease

# HENDO For Arch

Hybrid repair –

- Debranching + TEVAR
- Ascending aorta replacement (CPB) + TEVAR
- Total arch replacement (DHCA) +TEVAR
- Extra-anatomic bypass + TEVAR



**Endovascular repair-**

- Fenestrated stent-graft
- Chimney technique
- Branched stent-graft

...

**O**pen arch repair -

- Hemi / Total Arch replacement
- Total Arch Replacement + Frozen Elephant Trunk

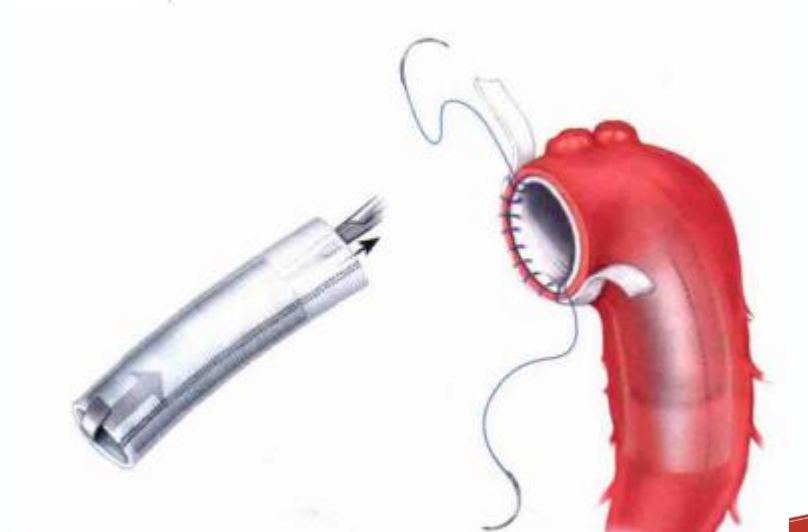
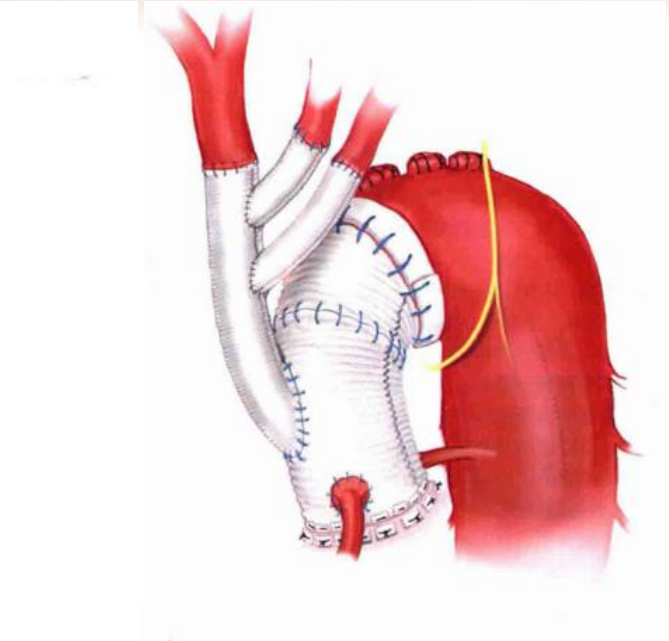
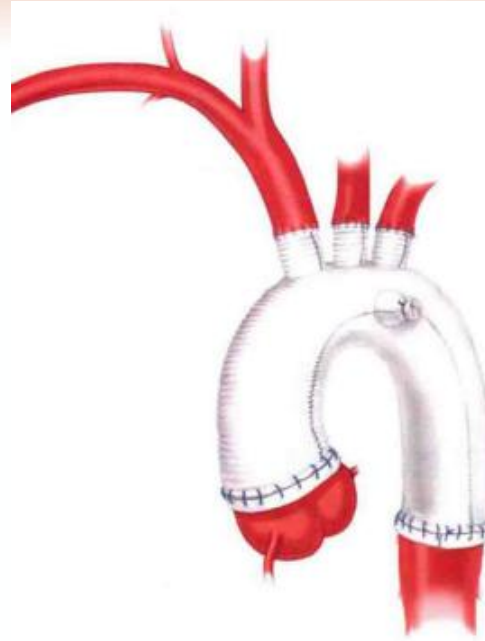


# Open Arch Repair

Hemi arch replacement

Total arch replacement

Total arch replacement + Frozen Elephant Trunk



# Open Arch Repair: Summary of Studies

Source	Open Surgery	No.(Study year)	Age, y( $\pm$ sd)	CPB time	In-hospital mortality
<b>Alessandro Leone et al,2019</b>	Total arch replacement + Frozen Elephant Trunk	<b>437(2007-2017)</b>	<b>61<math>\pm</math>12</b>	<b>234.5<math>\pm</math>68.2</b>	<b>14.9%</b>
<b>Lijing Yang et al,2019</b>	Total arch replacement + Frozen Elephant Trunk	<b>672(2013-2016)</b>	<b>47.4<math>\pm</math>10</b>	<b>191.7<math>\pm</math>63.4</b>	<b>4.3%</b>
<b>Cuntao Yu et al,2019</b>	Total arch replacement + Frozen Elephant Trunk	<b>815(2010-2016)</b>	<b>46.72<math>\pm</math>10.49</b>	<b>196.21<math>\pm</math>63.62</b>	<b>10.7%</b>
<b>Junming Zhu et al, 2021</b>	stented elephant trunk + supra-arch branch recon.	<b>206(2009-2019)</b>	<b>47.5<math>\pm</math>10.3</b>	NA	<b>1.0%</b>
<b>Ming Gong et al,2021</b>	Total arch replacement + Frozen Elephant Trunk	<b>518 (2014-2020)</b>	<b>48.9<math>\pm</math>10.8</b>	<b>206.0 (median)</b>	<b>7.9%</b>

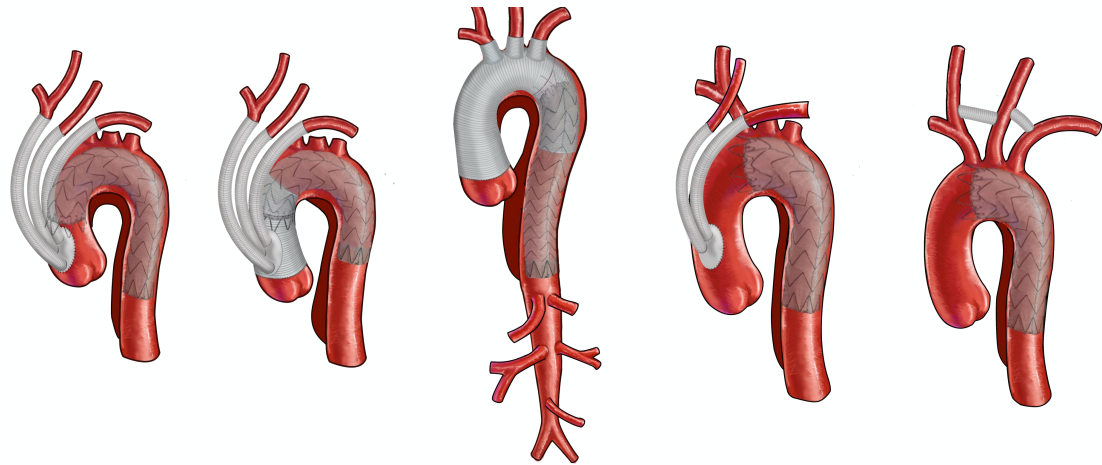
# Hybrid Arch Repair

I: Debranching + TEVAR

II: Ascending aorta replacement (CPB) + TEVAR

III: Total arch replacement (DHCA) + TEVAR

IV: Extra-anatomic bypass for partial arch + TEVAR



I型

II型

III型

IVa型

IVb型

Chang Shu, etc. Chinese Expert Consensus on Hybrid Technique for the Treatment of Aortic Arch Pathology. Chinese Circulation Journal.2020

## 指南与共识

### 杂交技术治疗累及弓部主动脉病变的中国专家共识

国家心血管病专家委员会血管外科专业委员会

#### 摘要

累及弓部的主动脉病变病情复杂, 治疗困难。传统的外科手术与微创腔内修复术均存在不足, 将两种技术相融合的杂交技术 (Hybrid 技术) 则提供了多元化的治疗选择。国家心血管病专家委员会血管外科专业委员会组织专家学者, 参考国内外临床实践, 以国内实践为主, 结合文献报道形成了本专家共识, 旨在阐明 Hybrid 主动脉弓修复术分型、技术优势、所需硬件条件和团队要求, 以及针对各型 Hybrid 手术的适应证、禁忌证、手术基本流程等方面提出规范和建议。

#### Chinese Expert Consensus on Hybrid Technique on Treating Thoracic Aortic Pathologies Involving the Aortic Arch

National Society of Vascular Surgery, China.

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#### Abstract

Aortic lesions involving the aorta arch are complicated and intractable to deal with. Neither conventional surgery nor total endovascular repair alone could satisfactorily treat all patients with aortic lesions involving the aorta arch. Hybrid technique, which combines these two methods, provides a new option for aorta arch reconstruction. This consensus is composed by experts and scholars organized by National Society of Vascular Surgery, primarily based on the practice experience of domestic experts and reference of international clinical practice and literature reports. The purpose of this consensus is to clarify the classification, advantages, facilities and technical team requirements of hybrid aortic arch repairs, and to provide guidance and suggestions on indications, contraindications and operation procedures for different type of hybrid aortic arch repairs.

**Key words** hybrid technique; aortic arch; expert consensus; open surgery; endovascular repair

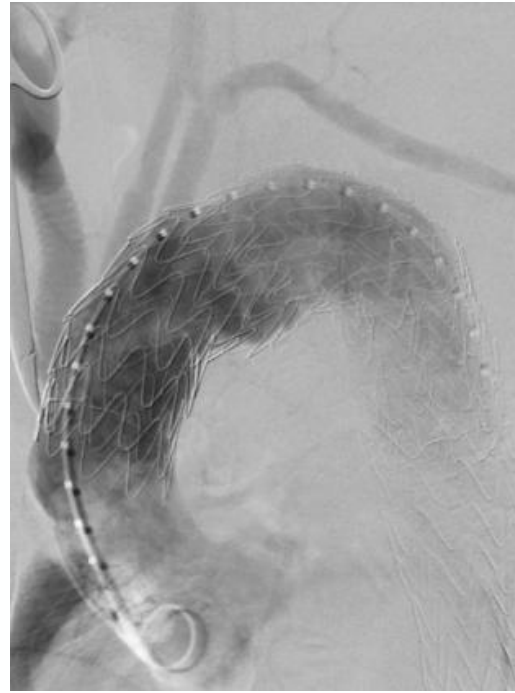
(Chinese Circulation Journal, 2020, 35: 124.)

# Hybrid Arch Repair: Summary of Studies

Source	Hybrid	No.(Study year)	Age, y( $\pm$ sd)	Pathologies	In-hospital mortality
Cuntao Yu et al,2019	Type II	122(2010-2016)	61.34 $\pm$ 7.11	TAAD	9%
Iben Andache et al, 2019	Type IV	12(2015-2018)	66	AD5/TAA7	0
Junming Zhu et al, 2021	Type IV	97(2009-2019)	62.5 $\pm$ 9.0	AD31/TAA31	5.2%
Ming Gong et al,2021	Type I&II	31(2014-2020)	58.8 $\pm$ 10.7	Stanford type A AAS	9.7%

TAAD: Stanford type A aortic Dissection ; TAA: Thoracic Aortic Aneurysm; AAS: Acute Aortic Syndrom

# Hybrid Arch I: Debranching + TEVAR



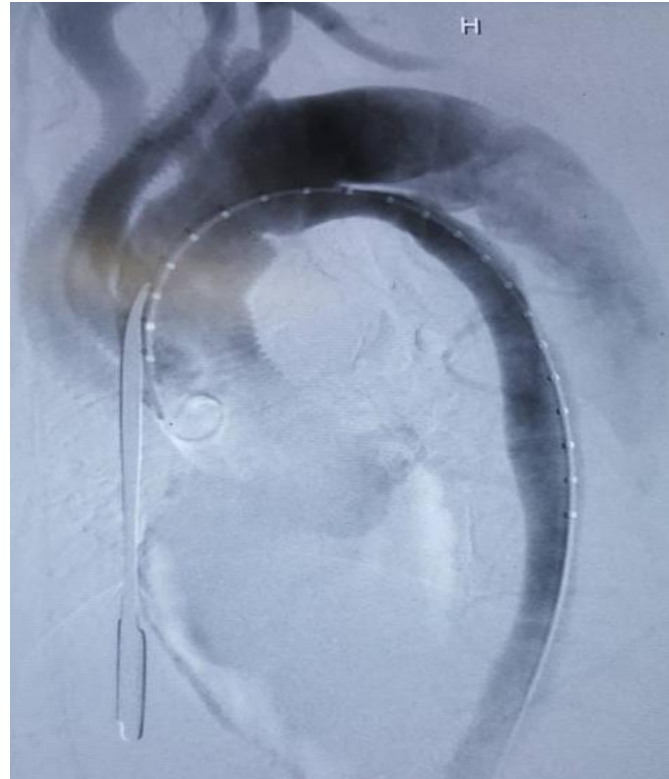
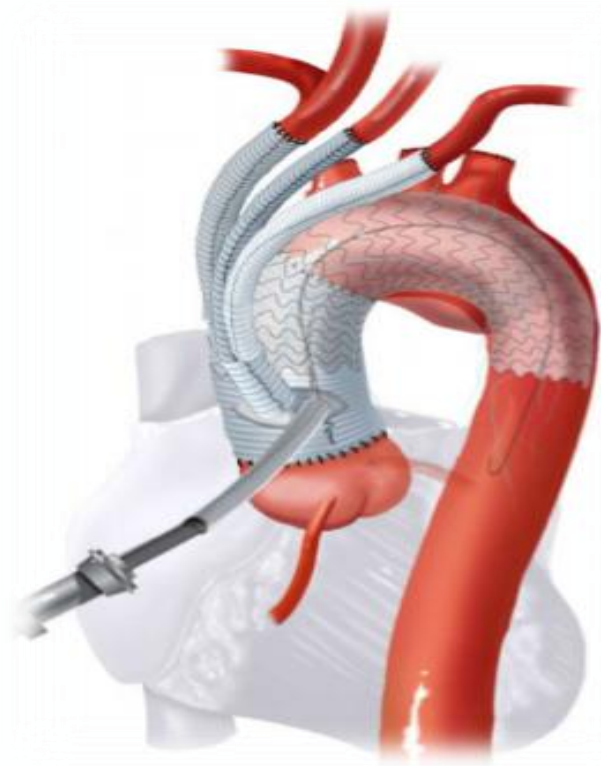
Ascending - Supra Aortic  
Branches Transposition

## Advantages

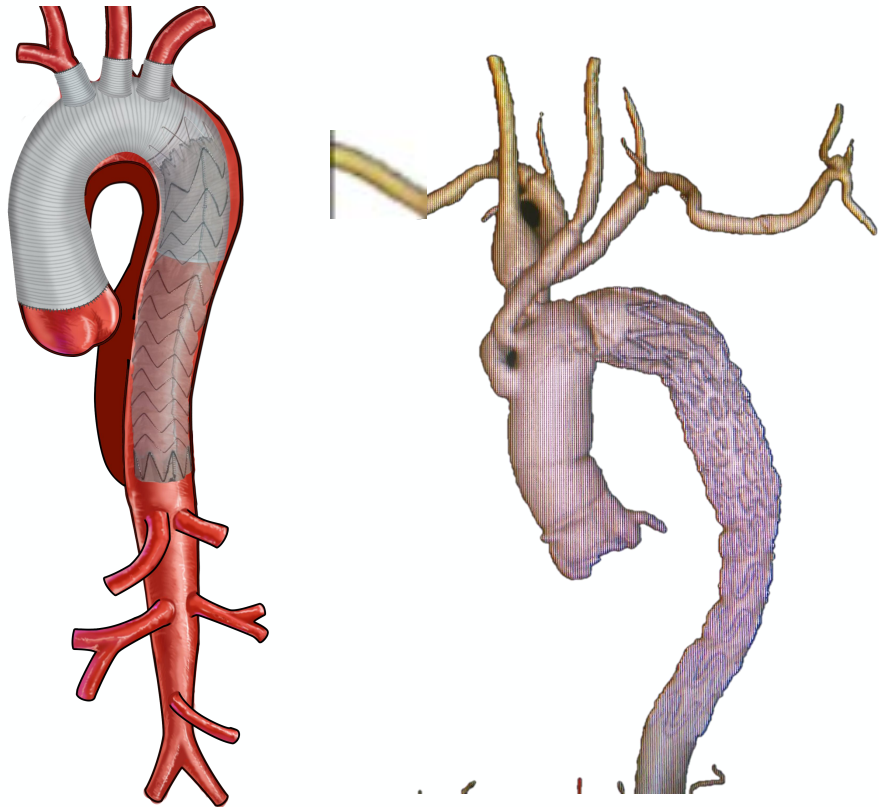
1. Extension of landing zone for healthy aorta
2. One-stage repair supra-aortic branches pathologies



# Hybrid Arch II: Ascending aorta replacement (CPB) + TEVAR



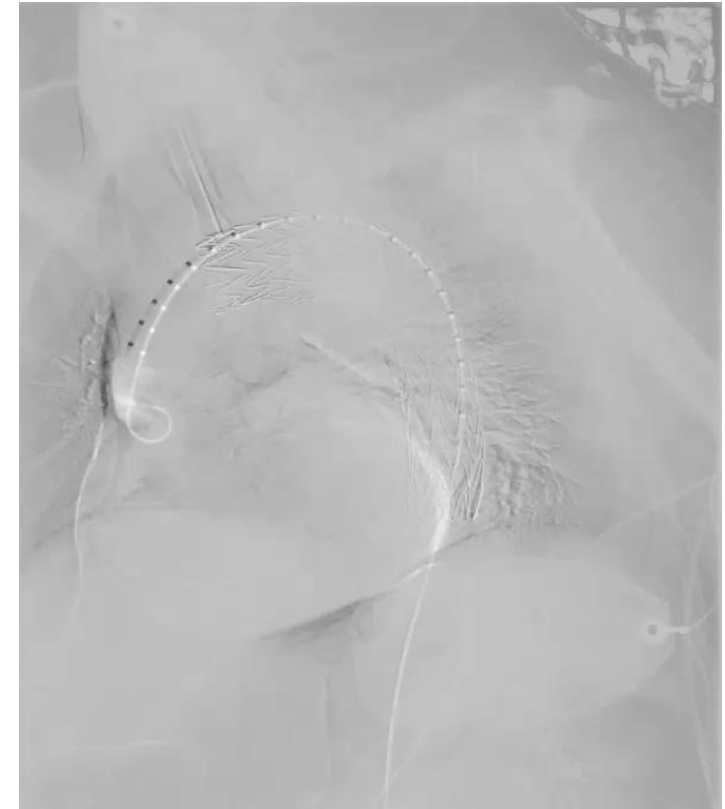
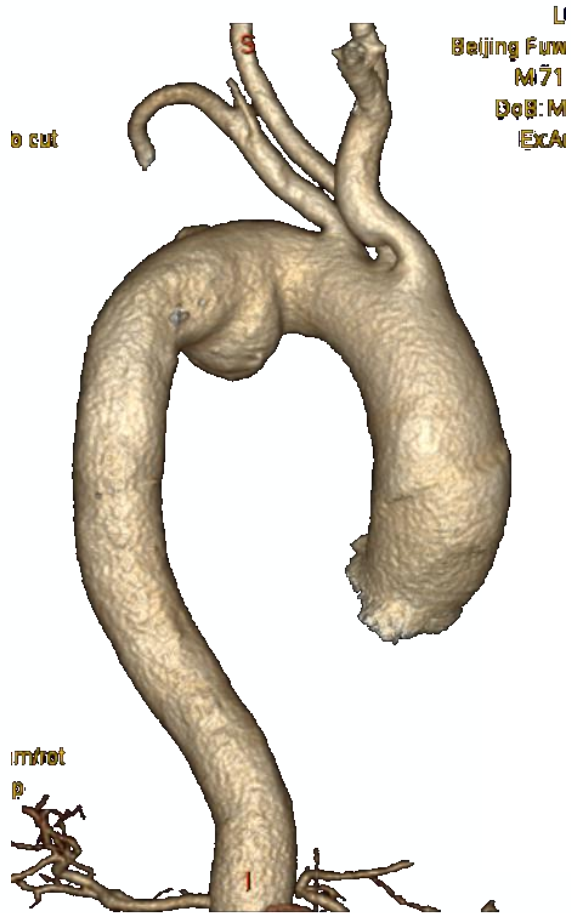
# Hybrid Arch III: arch replacement + TEVAR



## *Advantages*

- 1. One-stage repair aortic arch and descending aortic pathologies*
2. Avoid acute ischemia of distal organs and limbs

# Hybrid Arch IV : Extra-anatomic bypass + TEVAR



TEVAR+LCCA-LSA bypass grafting

# Endo techniques for aortic arch



Chimney Technique



Fenestrated  
Technique



Branched Stent

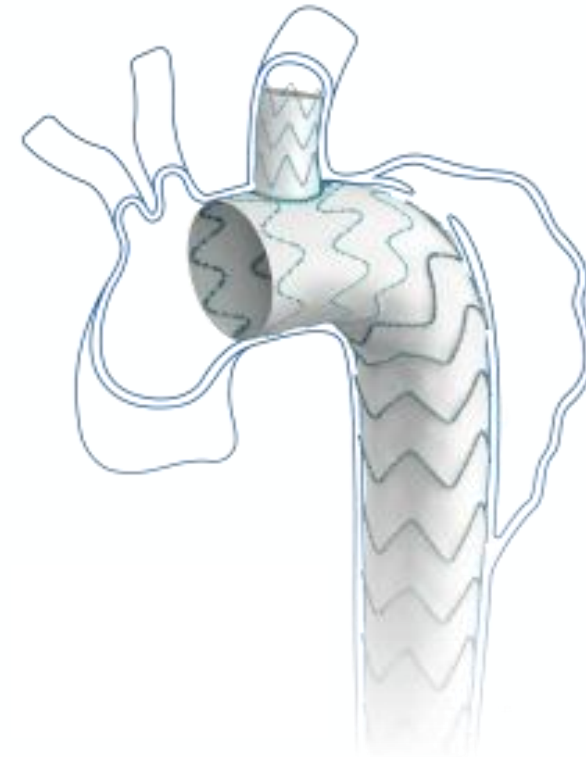
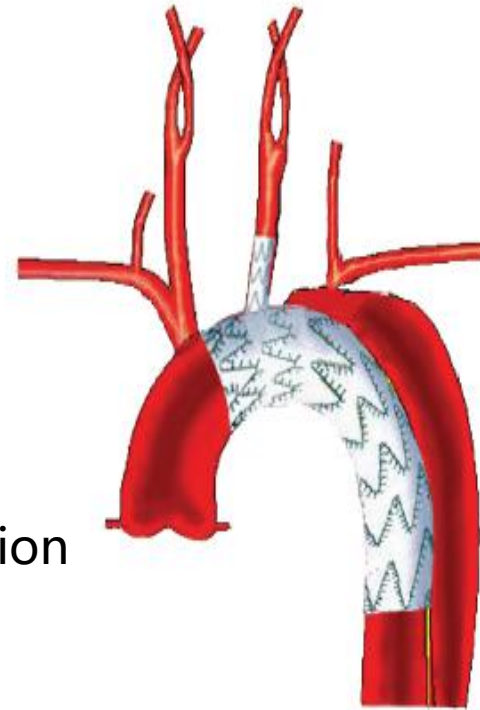


# Endo for Arch: Branched Stent-grafts

- **Branched Arch Endograft**

Strength:

- Conforming to the vessel anatomy
- Standardized operation procedure
- Avoiding 'gutter' endoleaks and migration



# Branched Stent-grafts :Summary of studies from China

Source	No. (Study period)	Age, y( $\pm$ sd)	Pathologies	immediate Type I endoleak	30-day mortality
Zhou Min et al,2018	21 (2013-2016)	64.3 $\pm$ 12.2	TBAD(A6/SA13/C2)	4.8%	0
Wei Minxin et al,2020	12(2017-2019)	55 $\pm$ 14.9	Acute TBAD	0	0

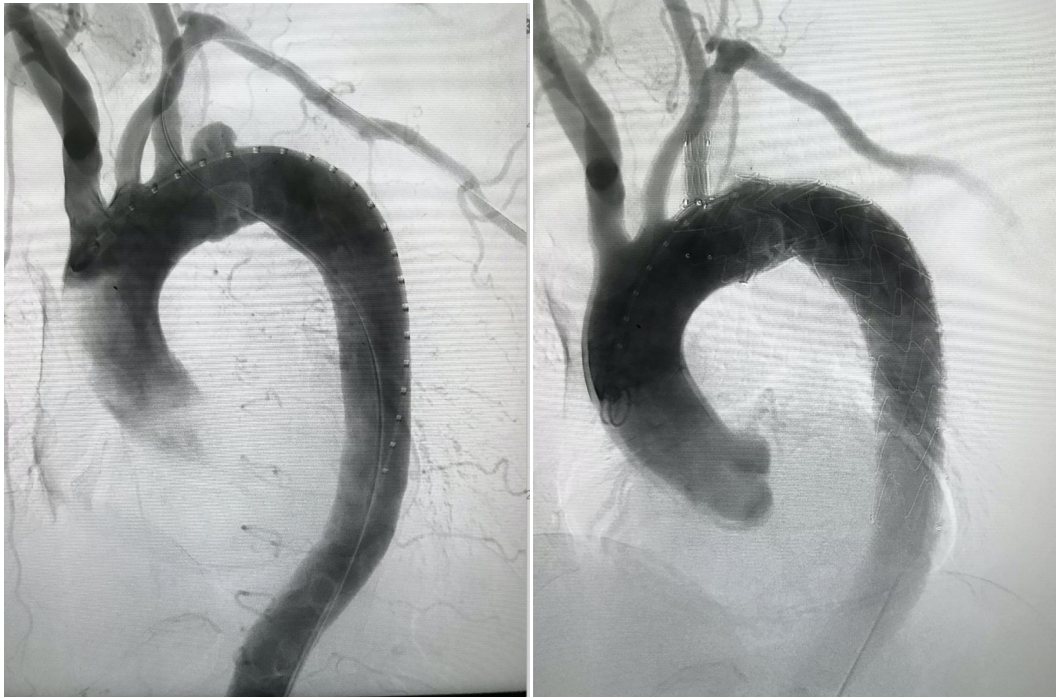
A: acute; SA: subacute; C: chronic

# Branched Stent-grafts Case 1

➤ Male, 57yr

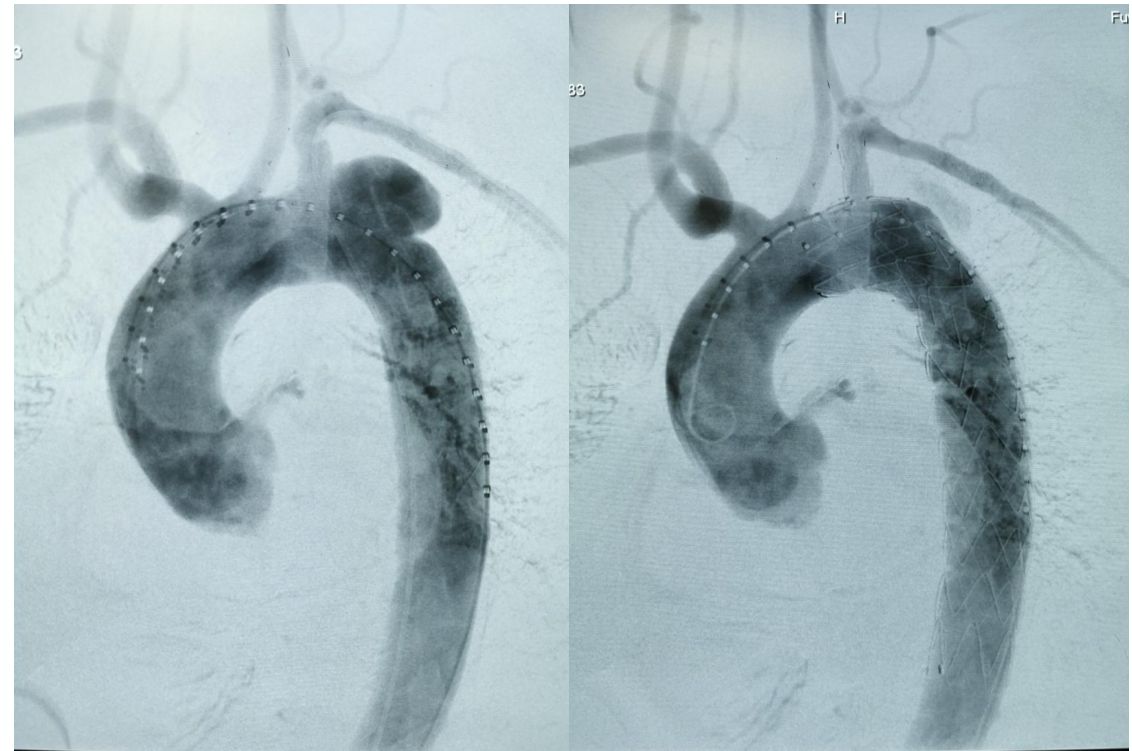


# Branched Stent-grafts



**Case 2**

**Case 3**



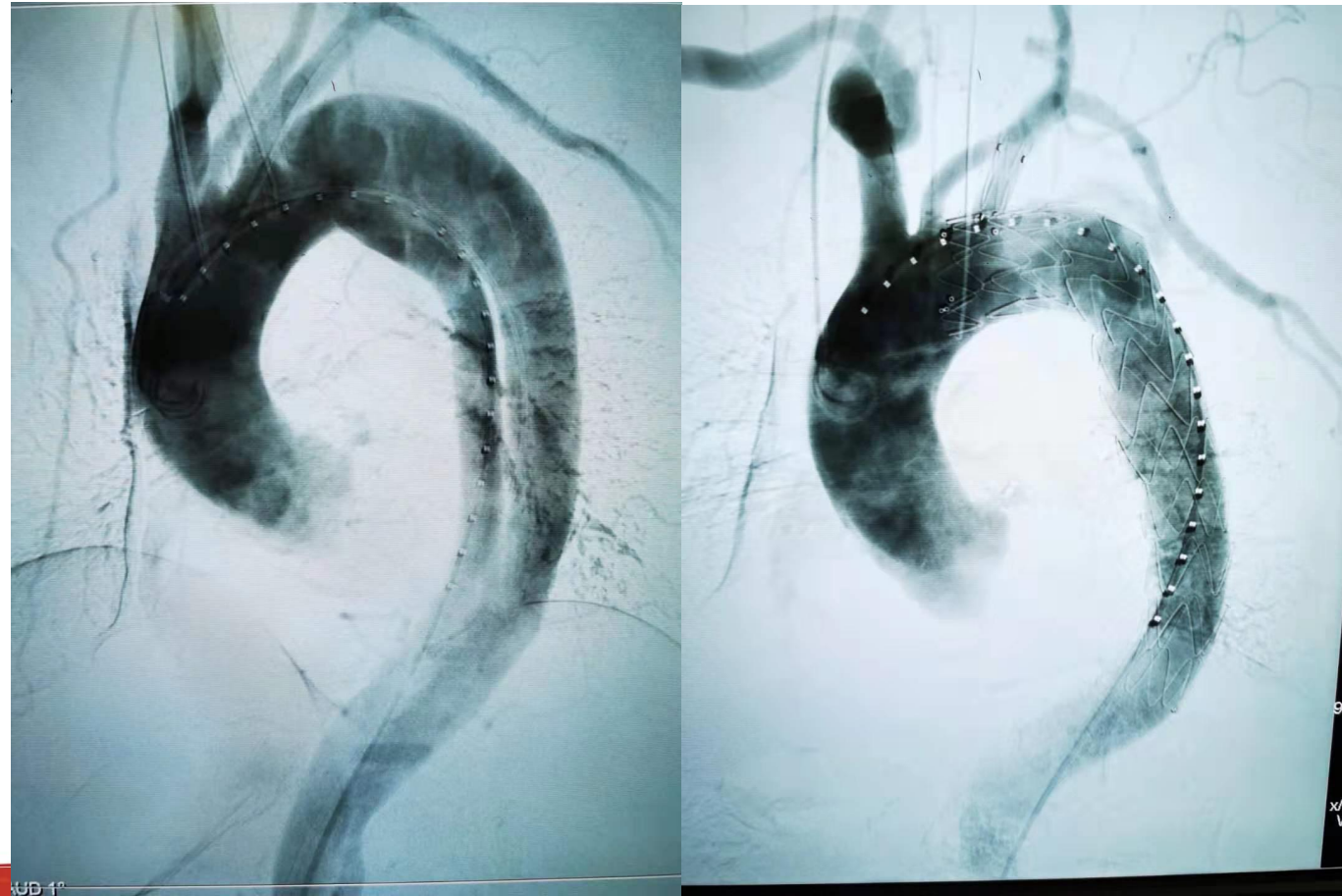


# Branched Stent-grafts



**Case 4**

**Case 5**



WD 1"

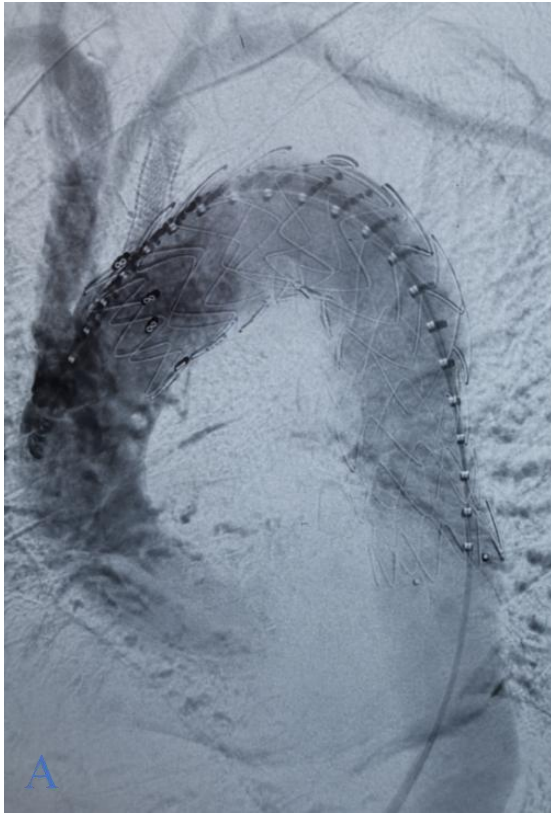
96

x/y

W

# Endo for Arch : Chimney technique

Single-chimney



2021-7-13

Double-chimney



2021-7-1

Triple-chimney



2020-6-18

Triple-chimney



2020-10-29



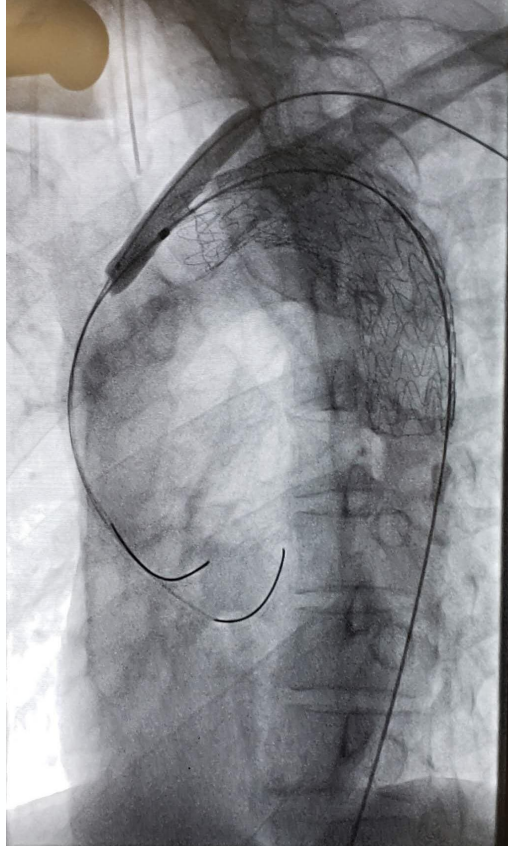
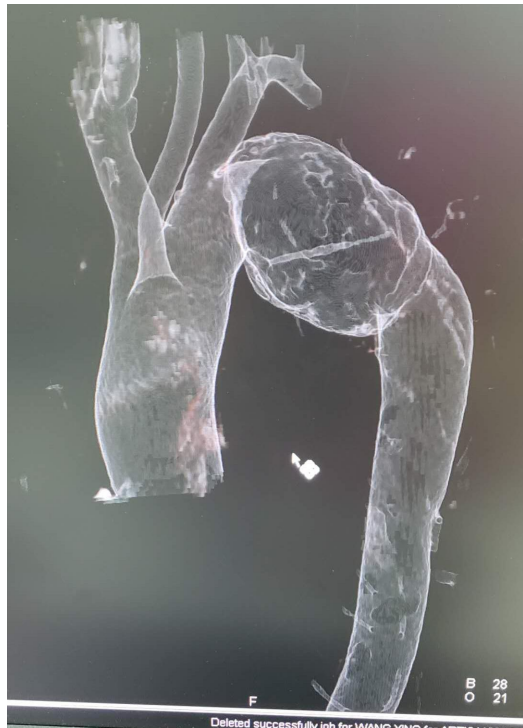
# Chimney technique: Summary of studies from China

Source	Patients No. (Study period)	Age, y( $\pm$ sd)	Pathologies	immediate Type I endoleak	30-day mortality
GUO WEI et al 2018	67 (2006-2015)	53 $\pm$ 6.5	AD	4.55%	1.52%
Luo Jianfang et al,2019	159 (2012-2017)	54 $\pm$ 11	TBAD	19%	2%
Jing Zaiping et al,2020	364(2008-2016)	61.9 $\pm$ 10.9	TAD271/TAA93	17.9%	0.8%
Shu Chang et al,2020	126 (2016-2017)	58 $\pm$ 13.5	AD59/TAA21/PAU/30	11.1%	2.4%

Fuwai & Second Xiangya hospital up to 2020-6: total number of 345; immediate Type I endoleak 7.6%(26) ; mortality in 30 days 1.7%(6)

# Chimney technique Case 1

fit for this aortic arch anatomy angle



## Chimney technique Case 2

- Male, 64-years-old
- Stanford B AD
- accepted TEVAR in other hospital
- New intimal tear distal from stent

- For this case chimney technique was used to revascularize LSA which was covered by stent graft



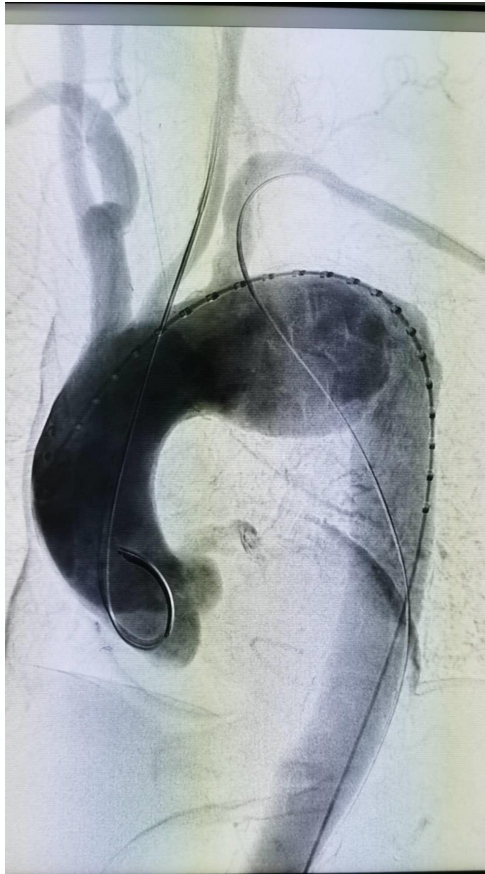
Pre-operation



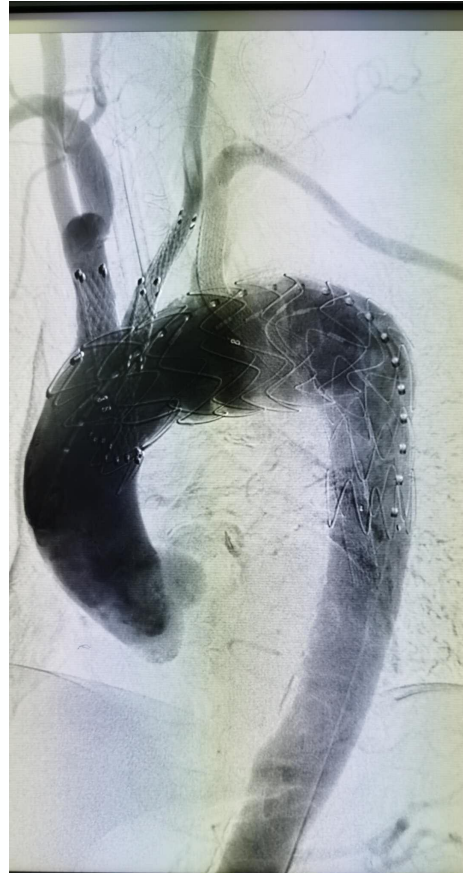
Post-operation



# Chimney technique Case 3



*male, 58-year-old*



*operation time: 2020-6*



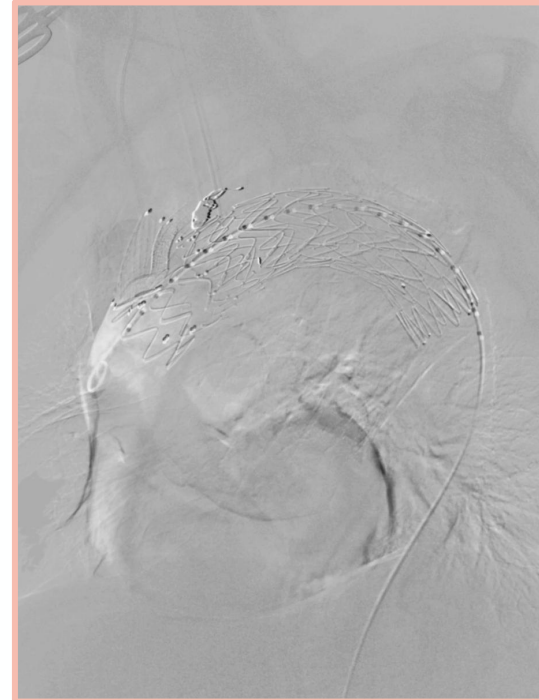
*2020-8 CTA*

- Male, 58-years-old
- Chimney for IA, LCCA; snorkel for LSA

# Chimney technique Case 4



Before operation



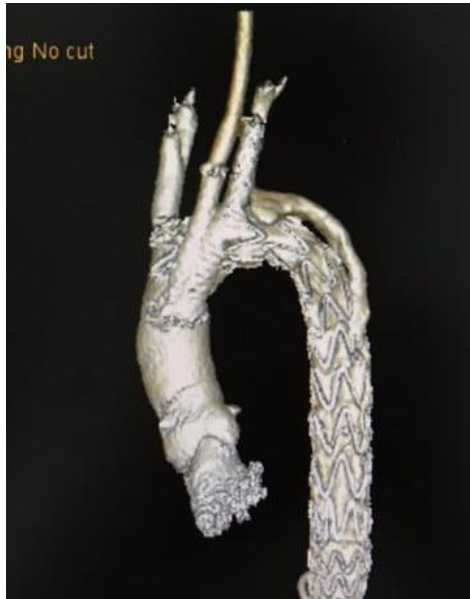
After operation

- Male, 88-years-old
- Accepted TEVAR+ Chimney for LCCA+LSA embolization in other hospital, but the primary stent migrated

# Chimney technique

## ----How to treat the endoleak?

Acute TBAD case treated by Ch-TEVAR using Valiant 32-200, Endurant 28-80, Fluency 8-60, 8-80



6 months postoperation



18 months postoperation



Endoleak can be observed for a few months  
Just **control the BP and wait** most of the time!  
Additional surgery or reintervention are seldom needed

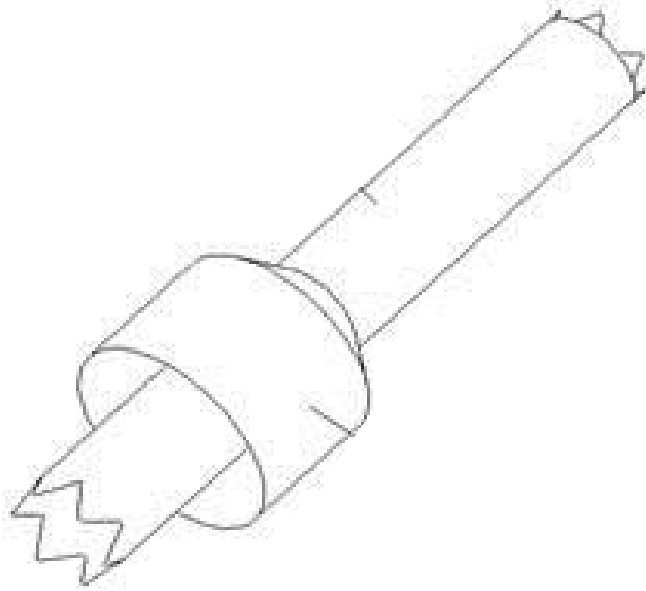


# **Chimney technique**

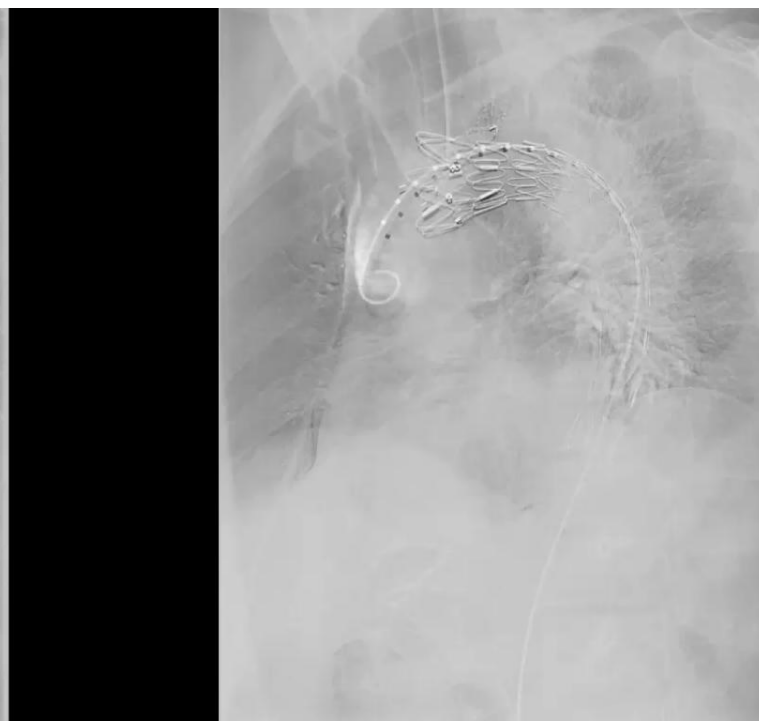
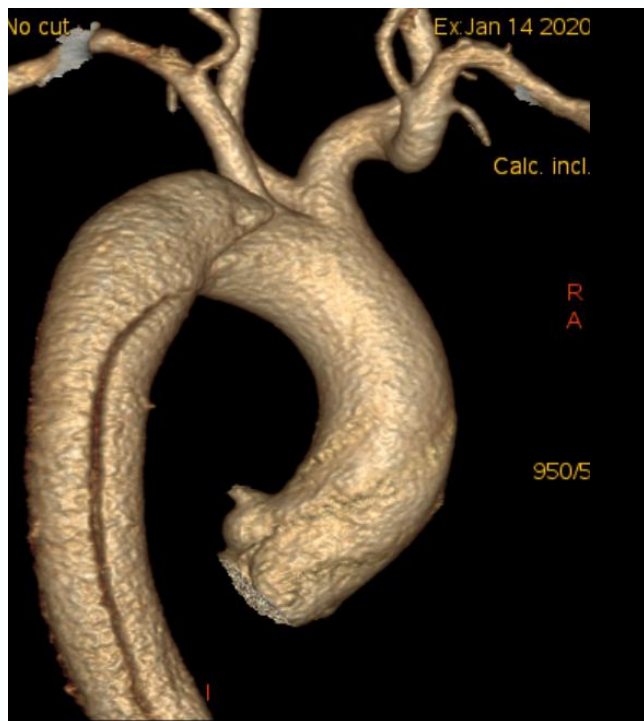
**----How to treat the endoleak?**

## **The Skirt Stent-graft**

**Newly designed chimney graft for prevention of endoleak**



# The Skirt Stent-graft case presentation



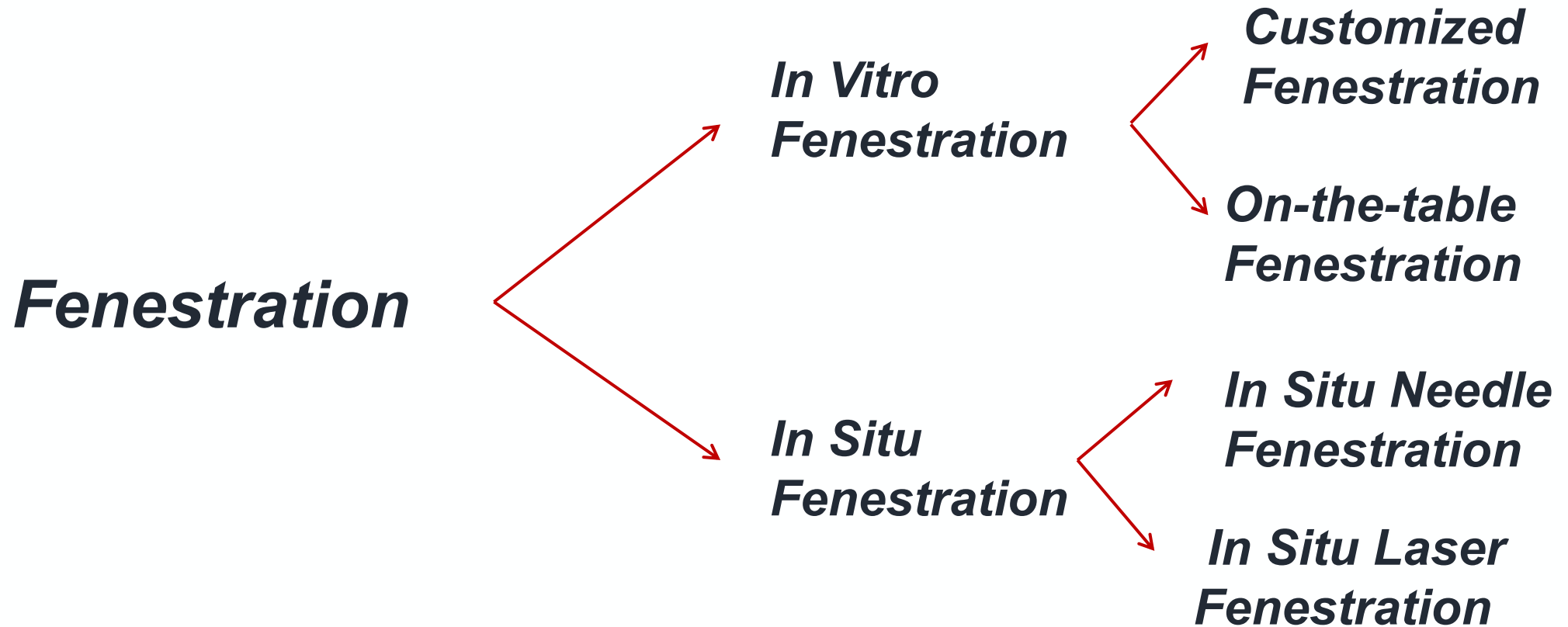
# Midterm outcome of skirt-stent multicenter clinical trial

Enrolled case	CT before discharge	follow-up in 6 months	follow-up in 12 months	SAE
150	150	143	102	37

Effectiveness evaluation index	before discharge	30 days	6 months	12 months
<b>type I or type III endoleak</b>	6% (9/150)	NA	3% (5/143)	2.9% (3/102)
aortic stent graft displacement	0% (0/150)	0% (0/148)	0% (0/143)	0% (0/102)
Postoperative branch vessel patency rate	100%(150/150)	100%(148/148)	100%(143/143)	100%(102/102)
remodeling of aortic dissection	100%(150/150)	100%(148/148)	100%(143/143)	100%(102/102)

Update to sep-2021

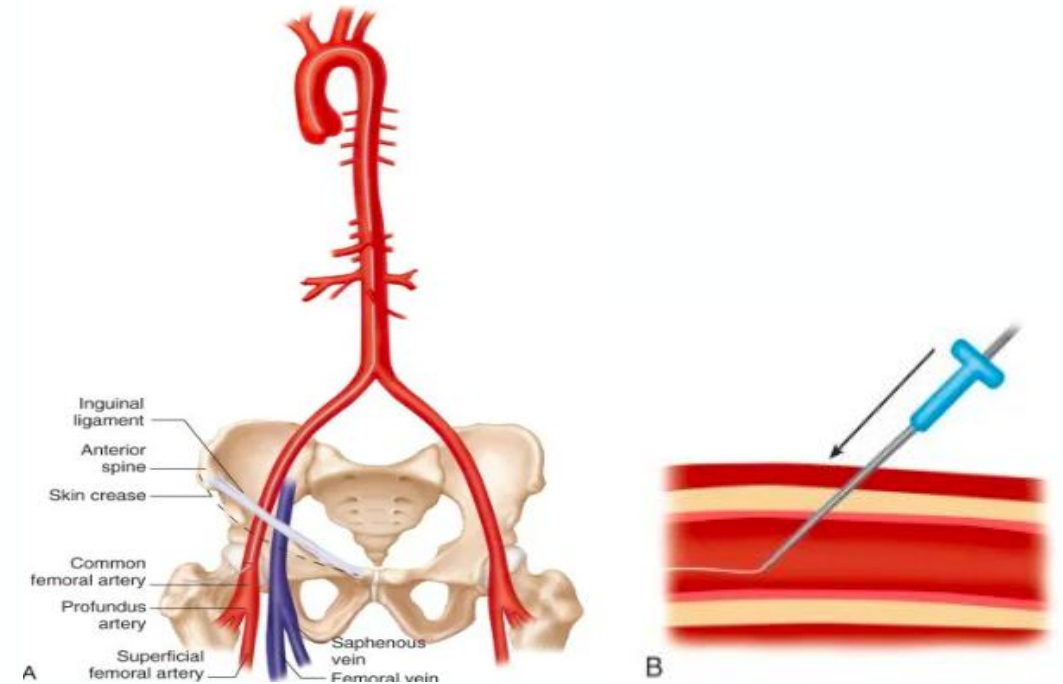
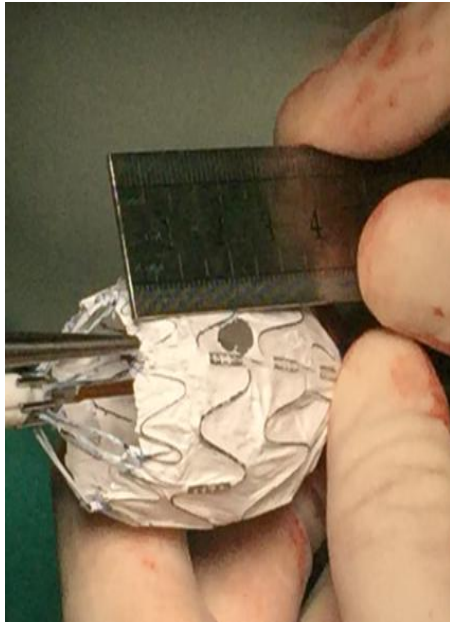
# Endo for Arch : Fenestration technique





# *In Vitro Fenestration*

## *Advantage:*



✓ Mostly < 45 minutes from the first to the last angio-  
(The least radiation exposure time is **5min** for fenestration TEVAR and LSA stenting!)

✓ More fit to the anatomy of the aortic arch than chimney

✓ only one Puncture point / incision  
at femoral artery

## In Vitro Fenestration Technique: Summary of studies from China

Source	No. (Study period)	Age, y( $\pm$ sd)	Operative time,min	immediate Type I endoleak	30-day mortality
Zaiping, Jing et al,2020	110(2008-2016)	63.6 $\pm$ 11.0	89.0 $\pm$ 14.7	3.6%	0.9%
Xiangchen, Dai et al 2021	51 (2015-2019)	57.6 $\pm$ 12.5	119.4 $\pm$ 37.1	2.0%	0
Chang Shu et al 2021	125 (2015-2020)	57.6 $\pm$ 12.5	64.6 $\pm$ 19.3	- 5.6% at 30 days, 0 late endoleak	0.8%

**Fuwai & Second Xiangya hospital up to 2020-6: total number of 349;  
immediate Type I endoleak 1.2%(4) ;  
mortality in 30 days 1.7%(6)**



# Self-Radiopaque Markers Guiding Physician-Modified Fenestration

## S-Fenestration

- Operation time:  $64.6 \pm 19.3$ min
- Time from first DSA to the last:  $25.6 \pm 14.3$ min
- Success rate of PMF alignment: 98.4%. (PMF: Physician-Modified Fenestration)



- 2021 Chang Shu et al.
- Single Center of Second Xiangya Hospital

## Self-Radiopaque Markers Guiding Physician-Modified Fenestration (S-Fenestration) in Aortic Arch Endovascular Repair

Xin Li<sup>1,2</sup>, Chang Shu<sup>1,2,3\*</sup>, Quanming Li<sup>1,2</sup>, Hao He<sup>1,2</sup>, Ming Li<sup>1,2</sup>, Lunchang Wang<sup>1,2</sup>, Jiehua Li<sup>1,2</sup>, Dingxiao Liu<sup>1,2</sup> and Mingyuan Du<sup>1,2</sup>

<sup>1</sup> Department of Vascular Surgery, The Second Xiangya Hospital, Central South University, Changsha, China, <sup>2</sup> The Institute of Vascular Diseases, Central South University, Changsha, China, <sup>3</sup> Center of Vascular Surgery, State Key Laboratory of Cardiovascular Diseases, Fuwai Hospital, National Center for Cardiovascular Diseases, Chinese Academy of Medical Science and Peking Union Medical College, Beijing, China

**Backgrounds and Objectives:** Thoracic endovascular aortic repair (TEVAR) has currently become the “first-line choice” for descending aortic pathologies. For pathologies located at the aortic arch, TEVAR with physician-modified fenestration (PMF) has been gained popularity as an alternative choice. However, stent fenestration is an experience-dependent technique and comes with possible adverse events such as misalignment. This study aims to introduce the self-radiopaque PMF (SF), which uses the radiopaque marker as a guiding indicator.

**Methods:** This is a single-center retrospective study of 125 patients who underwent the SF-TEVAR in Second Xiangya Hospital from December 2015 to December 2020. Data include basic clinical information and technique records of SF-TEVAR with follow-up results.

**Results:** According to the SF-TEVAR protocol, we have performed the procedures on 125 patients and obtained an instant success rate of 98.4%. A total of 140 aortic stent-grafts and 44 bridging stents have been implanted in this study. The operation time is  $64.6 \pm 19.3$  min, X-ray exposure time (from first digital subtraction angiography (DSA) to last DSA) is  $25.6 \pm 14.3$  min, and contrast volume is  $82.2 \pm 22.6$  ml. The success rate of PMF alignment is 98.4%. One bailout stent-graft was implanted into the left subclavian artery (LSA) by the chimney technique (0.8%). One fenestration was successfully and immediately corrected after misalignment (0.8%). Large simultaneous fenestration was performed in six patients (4.8%) for the left common carotid artery (LCCA) and LSA and in two patients (1.6%) for LA, LCCA, and LSA. One hundred twenty-two out of 125 patients' LSAs have been kept patent by the technique during the follow-up. The bridging stent group consists of 44 patients who received LSA stents, while the non-bridging stent group includes the other 81 patients. Type I endoleak has occurred in seven patients (5.6%) 1 week after the procedure. During follow-up (23  $\pm$  18 months), survival rate is 95.7% and branch artery patent rate is 97.4%.

**Conclusions:** The SF-TEVAR technique, which utilizes the radiopaque marker in stent-graft as an indication for PMF in TEVAR, seems a likely safe, effective, and efficient

### OPEN ACCESS

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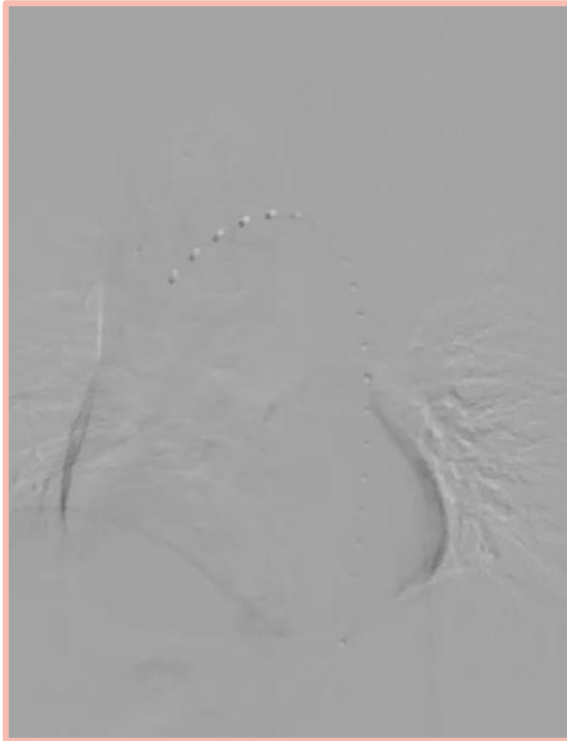
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Endovascular Repair.  
Front. Cardiovasc. Med. 8:713301.  
doi: 10.3389/fcvm.2021.713301

# S-Fenestration

## Case1 fenestration and stenting for LSA

Male 62 years old



Chronic aortic dissection



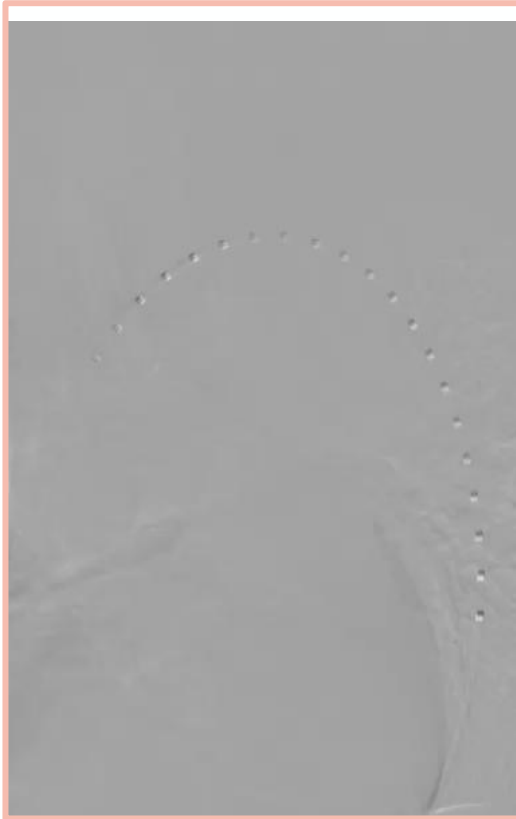
Operation time 2021-2-25



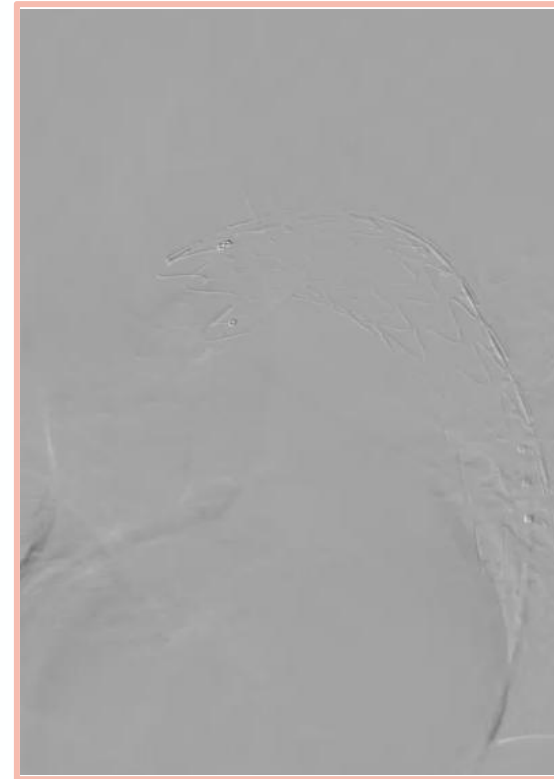


# S-Fenestration

Case2 fenestration and stenting for LSA, fenestration for left vertebral artery

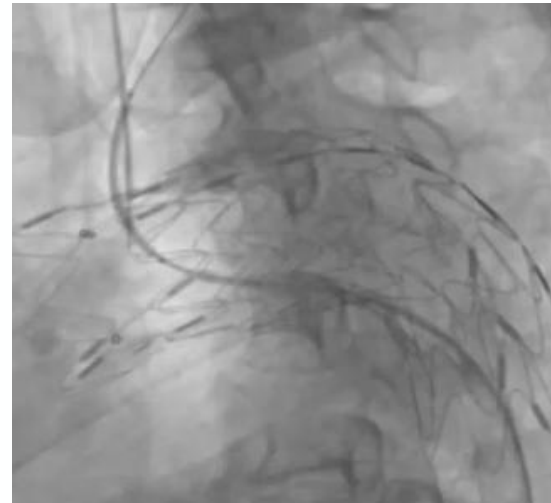
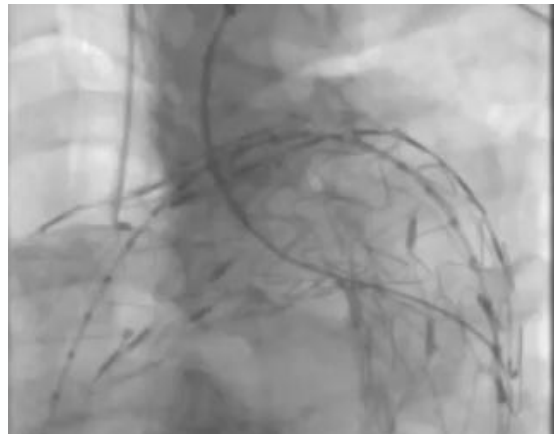
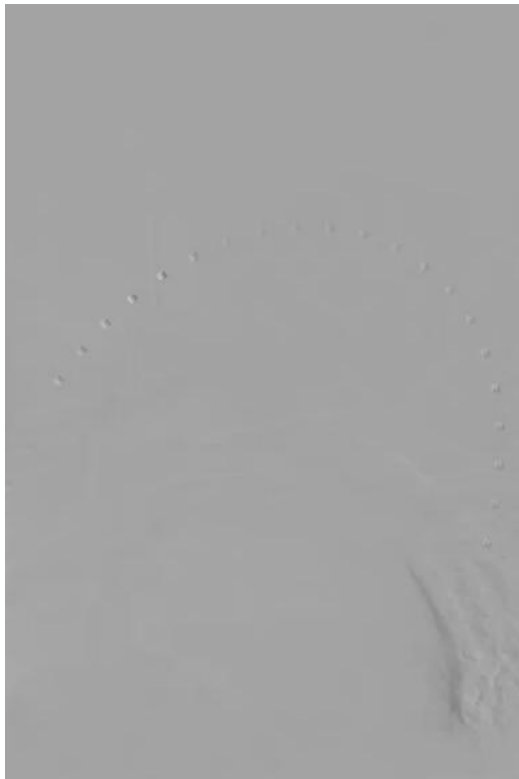


Acute aortic dissection



# S-Fenestration

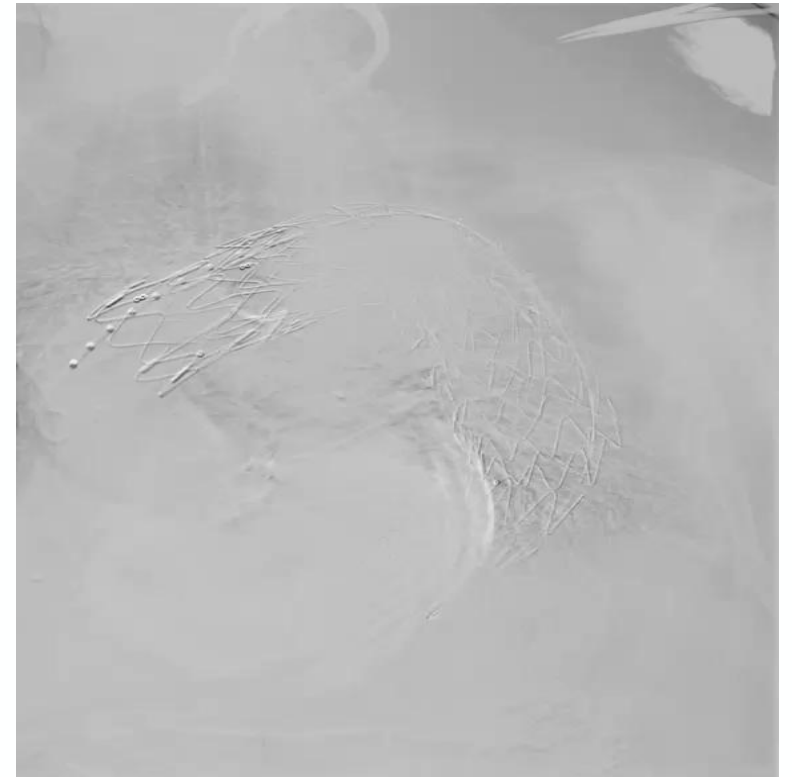
## Case3 fenestration and stenting for LCCA and LSA



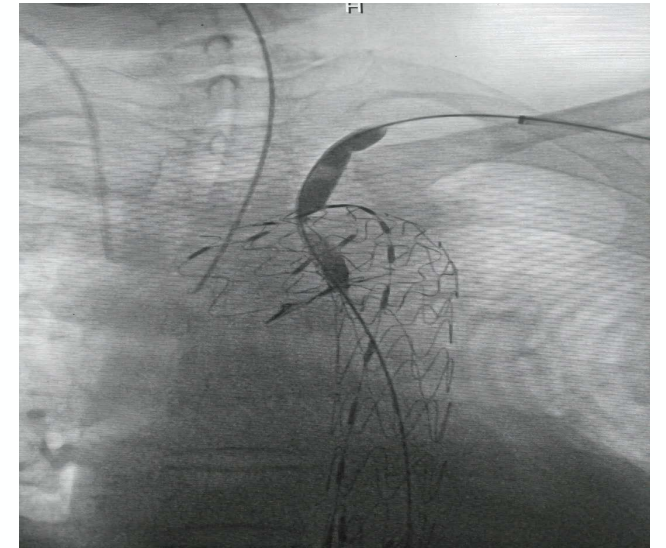
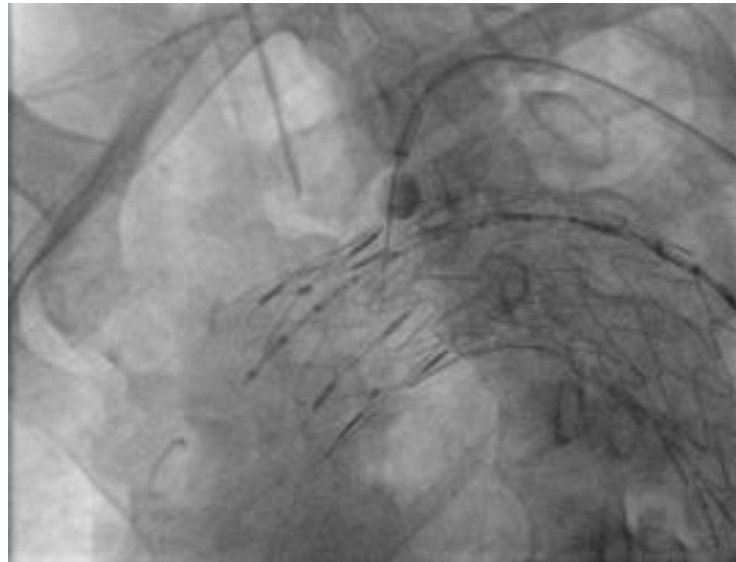
# S-Fenestration

## Case4 fenestration for IA,LCCA and LSA

- Male, 72 years old
- 10 years ago , the patients had been given TEVAR because of aortic dissection



# *In Situ Fenestration*



*Balloon expandable puncture needle for in-situ fenestration*



## In Situ Fenestration Technique: Summary of studies from China

Source	No. (Study period)	Age, y( $\pm$ sd)	Device for fenestration	immediate Type I endoleak	30-day mortality
Wei Guo et al,2018	18(2006-2015)	53.0 $\pm$ 6.5	0.014 BMW wire.	0	0
Hongkun Zhang et al ,2019	37(2016-2017)	55.1	aspiration biopsy needle	0	NA
Xinwu Lu et al,2019	58(2014-2018)	58	laser catheter	5.2%	3.5%
Chang Shu et al 2021	50(2015-2020)	57.6 $\pm$ 12.5	The balloon expandable puncture needle	0	0

# CSkirt™ Aortic Arch Stent Graft—CASE



Female, 54 years

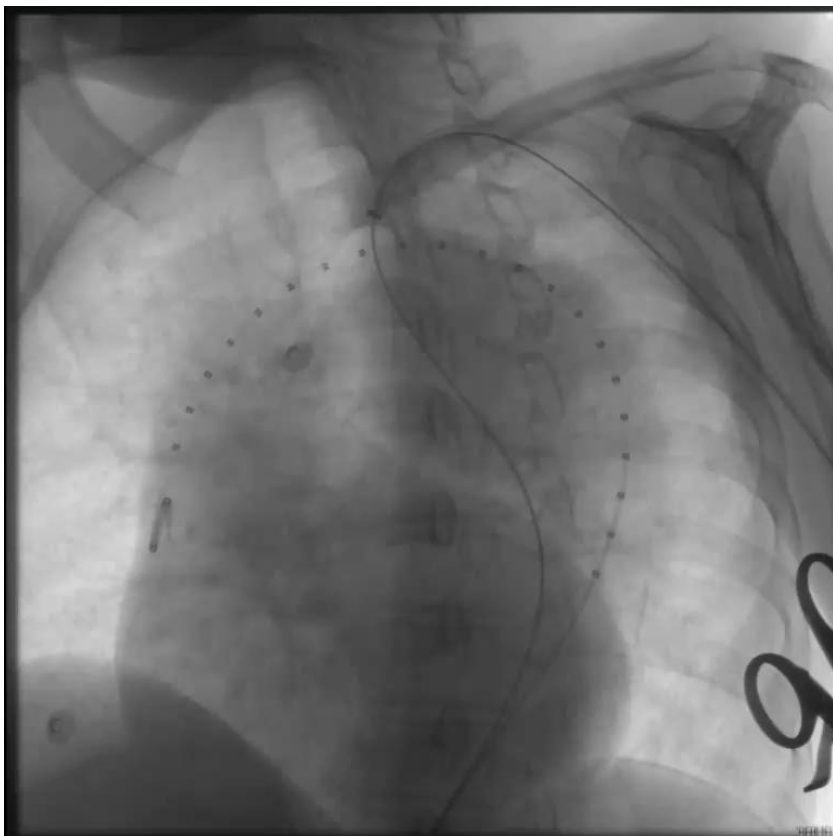
Abrupt chest and back pain for 5 days,

Diagnosis:

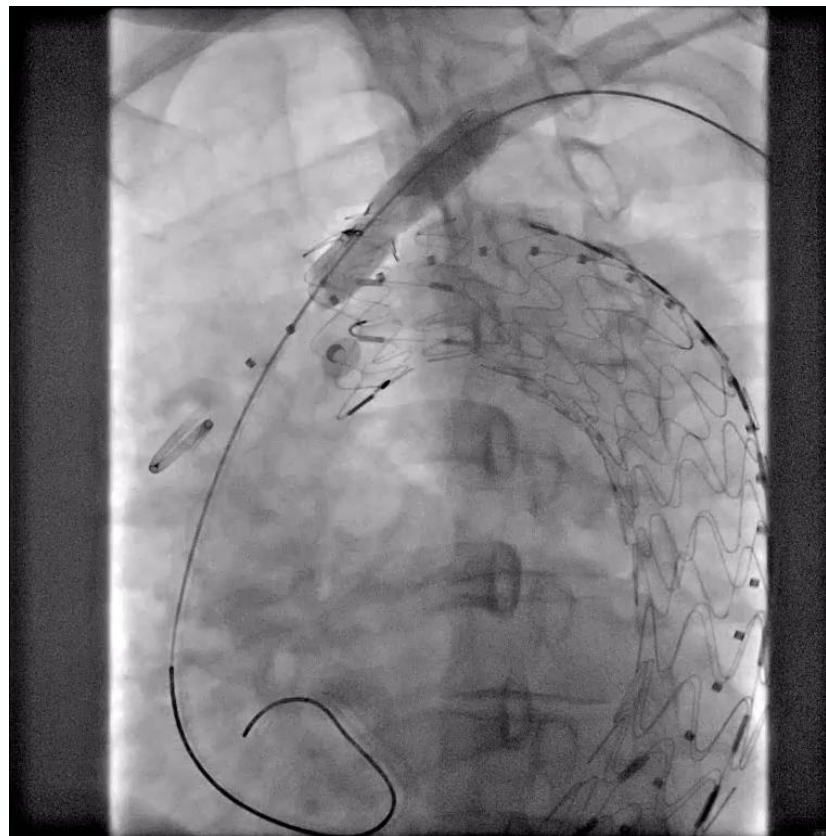
1. TBAD, distance between intimal tear and LSA <0.5cm
2. Hypertension

The first enrolled case in Cskirt Multicenter clinical trial,China

# CSkirt™ Aortic Arch Stent Graft—CASE

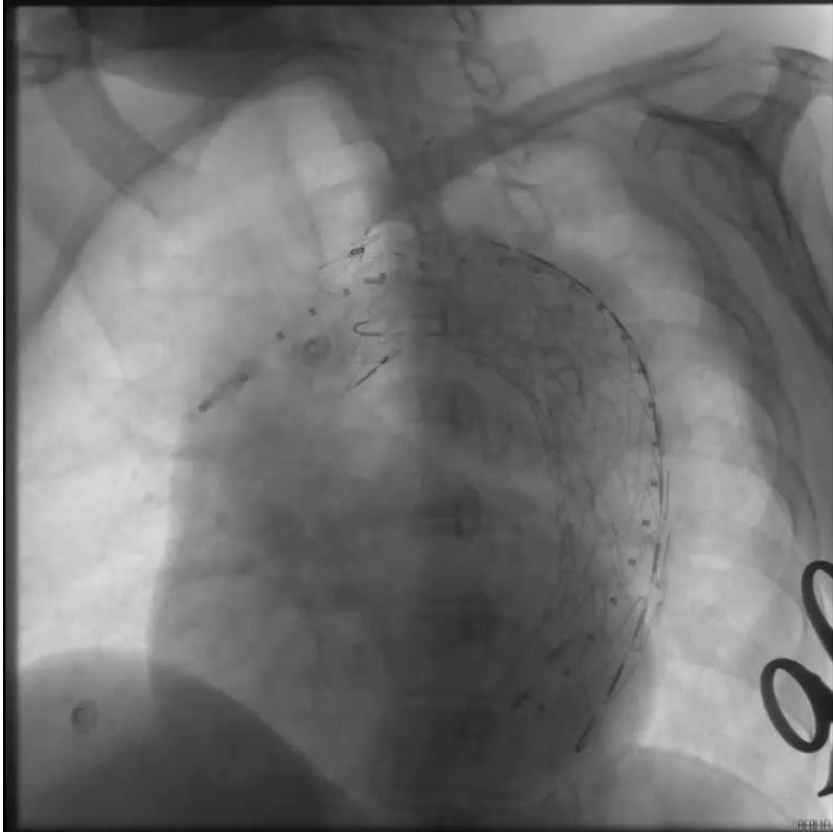


Left brachial artery & femoral artery access,  
angiography



In-situ fenestration, 6mm balloon expansion

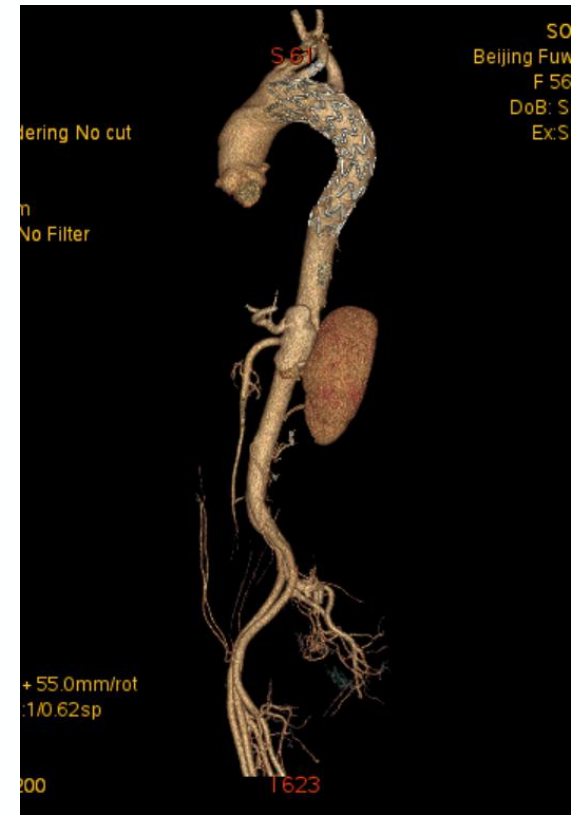
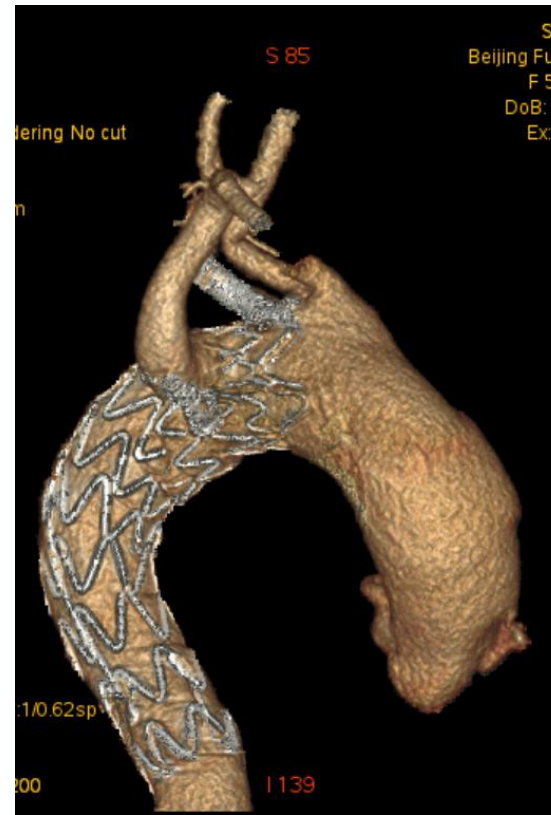
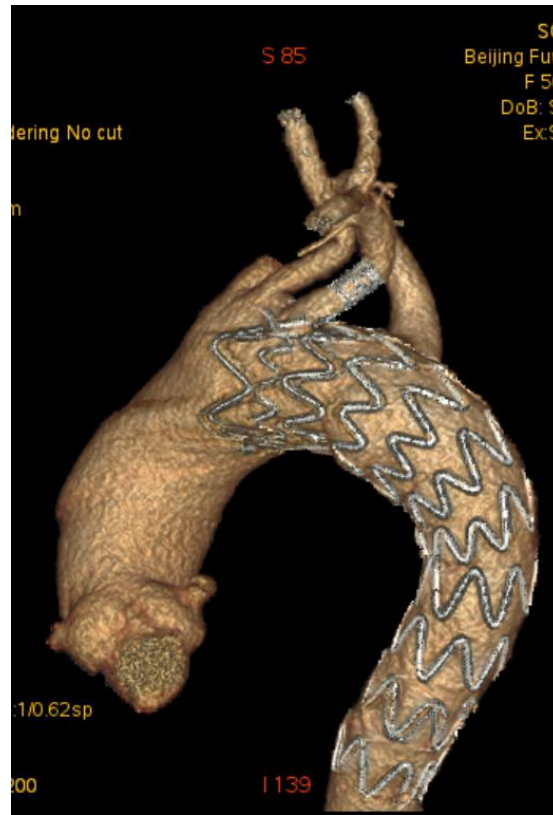
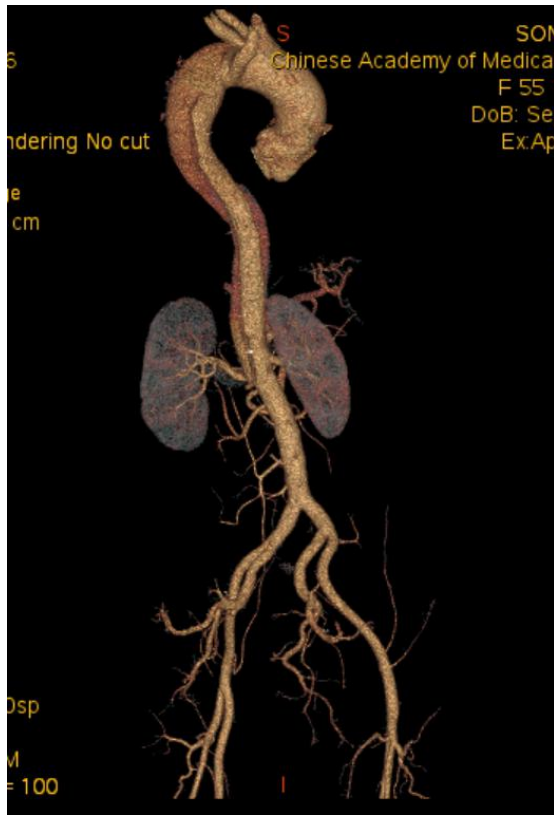
# Cskirt™ Aortic Arch Stent Graft—CASE



Release Cskirt stent graft, exclude lesion totally

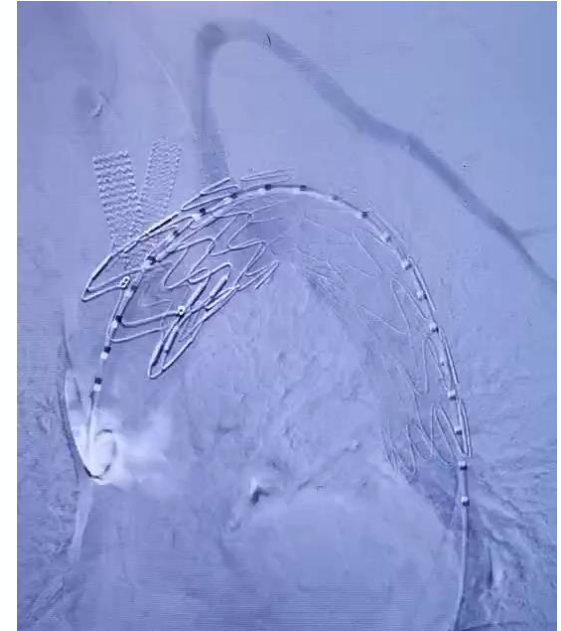


# Combination of In Vitro Fenestration and Chimney



CTA in 18 months follow-up

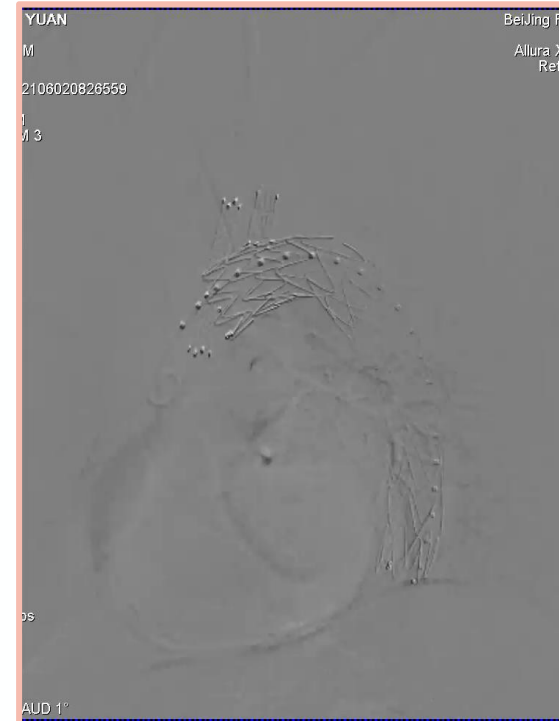
# ***Combination of In Vitro Fenestration and snorkel***



# Combination of Branched stent-graft and Chimney



Male, 79y



2021-6-2





# Combination of Branched stent-graft and Fenestration

## Long-Term Outcomes of Thoracic Endovascular Repair for Aortic Arch Dissection Using Customized Single-Branched Fenestrated Stent-Graft

Xiaoye Li, MD<sup>1,2</sup> , Lei Zhang, MD<sup>1</sup>, Chao Song, MD<sup>1</sup>, Hao Zhang, MM<sup>1</sup>, Shibo Xia, MM<sup>1</sup>, Haiyan Li, BSc<sup>1</sup>, Zaiping Jing, MD, PhD<sup>1</sup>, and Qingsheng Lu, MD<sup>1</sup>

From 2009-2011, 16 patients with aortic arch dissection received this procedure,  
30-day outcomes: mortality 1(6.25%), type I endoleak 1 (6.25%)

Vascular and Endovascular Surgery

1-9

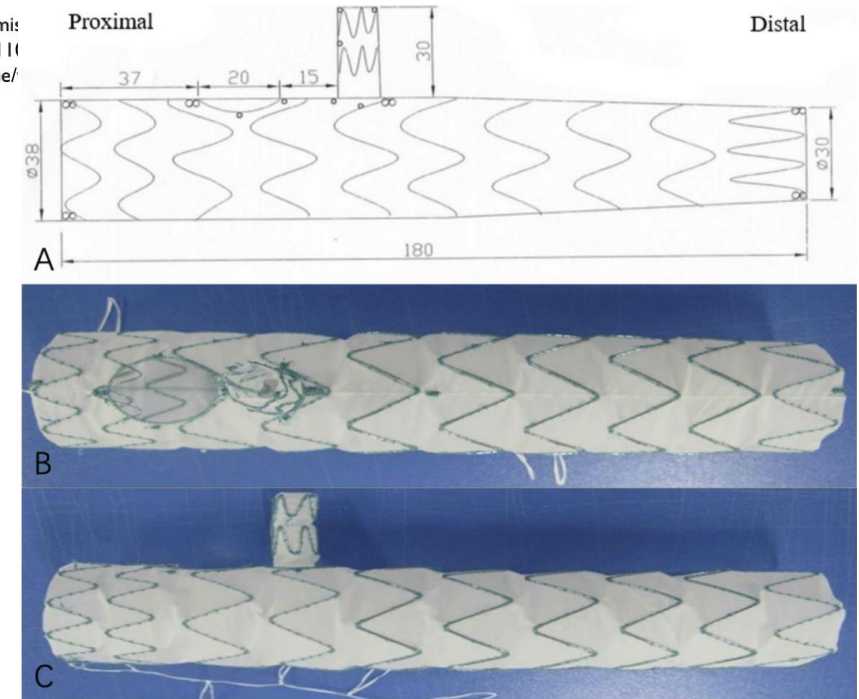
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DOI: 10.1177/1538574421111

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# “HENDO” for Arch

## Hybrid repair –

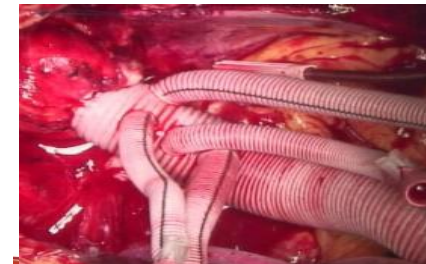
- effective for arch pathology involving ascending aorta
- less morbidities

## Endovascular repair-

- promising future
- landing zone and endoleak
- special designed *Longuette™* Aortic Branch Stent Graft System and *C-skirt™* Aortic Arch Branch Stent Graft

## Open arch repair -

- fundamental solution for complex anatomy
- morbidity of deep hypothermic circulatory arrest
- **Hybrid-Endovascular-Open Arch Repair**
- ***For the best interest of PATIENTS***



**Thanks for your attention!**