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PUSAN NATIONAL UNIVERSITY HOSPITAL

Development of Next generation Medical Devices for the Treatment of Cardiovascular Diseases

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Development of Fenestrated Aortic Arch Stent Graft with Preloaded Catheter for Protecting Branch Arteries : An Experimental Study

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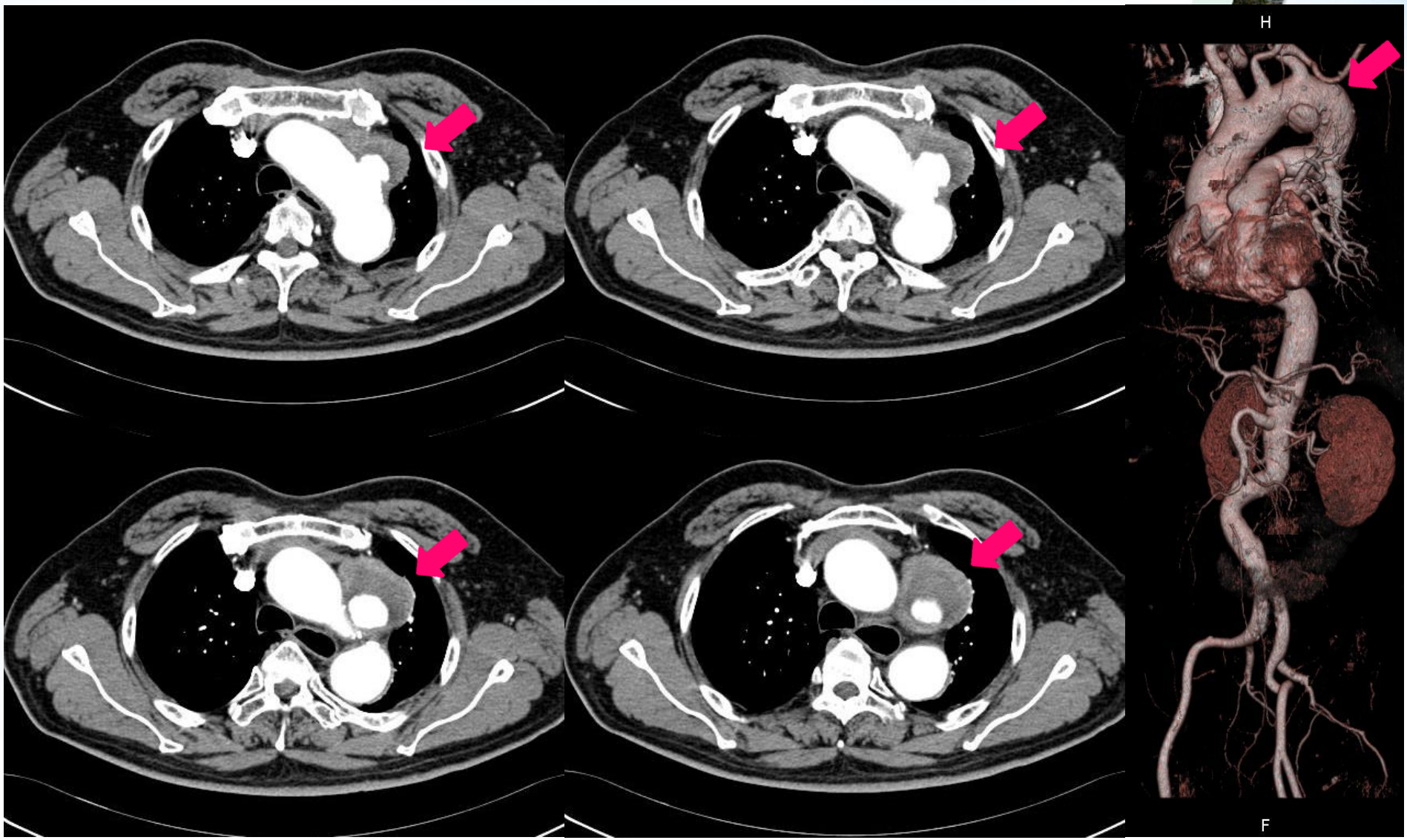
부산대학교병원 순환기내과[1], 흉부외과[2], 병리과[3], 의학연구소[4]

Case

Overcome of Short Landing Zone : Carotid-Lt SCA Bypass

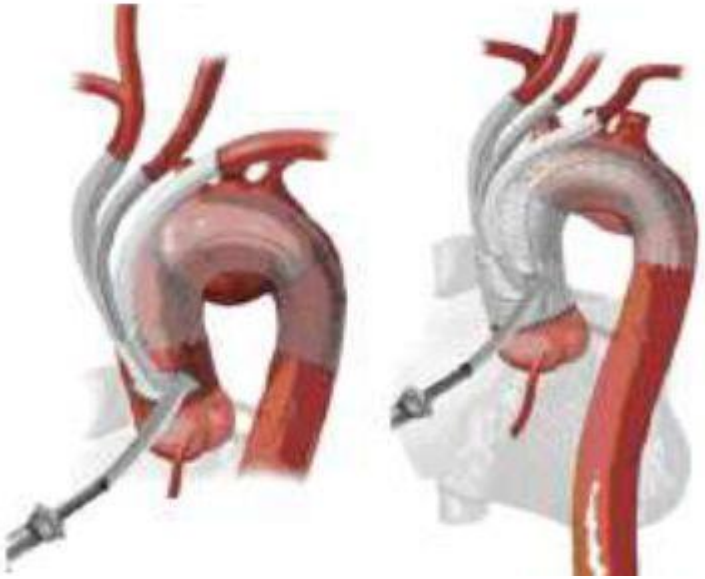
- **79 year old male** patient with chest pain
- PI : transferred because of **suspicious TAA**
- Past History : **recurrent CVA(+), HT(+)**
- Social History : 50 PY, No alcohol
- EKG : Atrial fibrillation

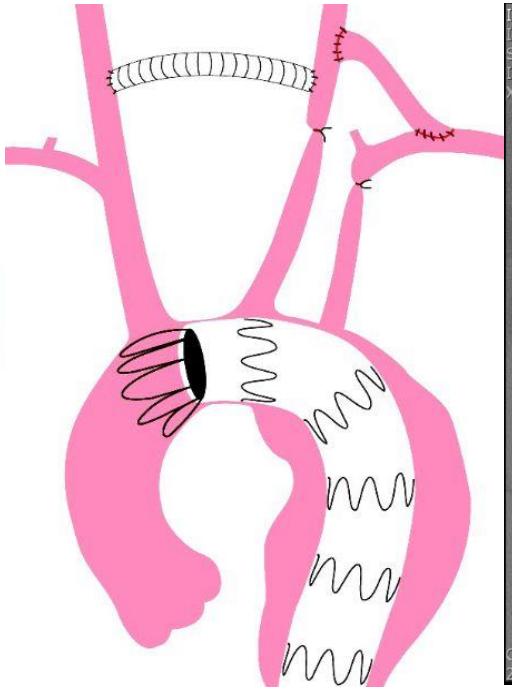
CT aorta



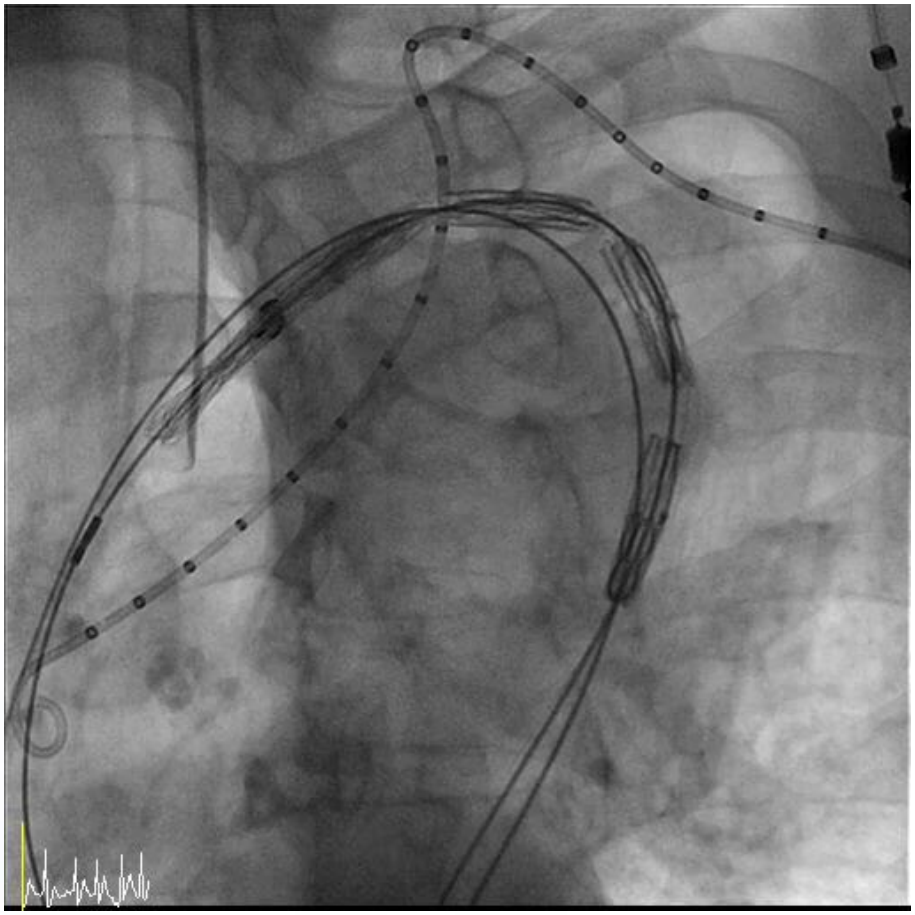
Overcome of Short Landing Zone : Hybrid Operation

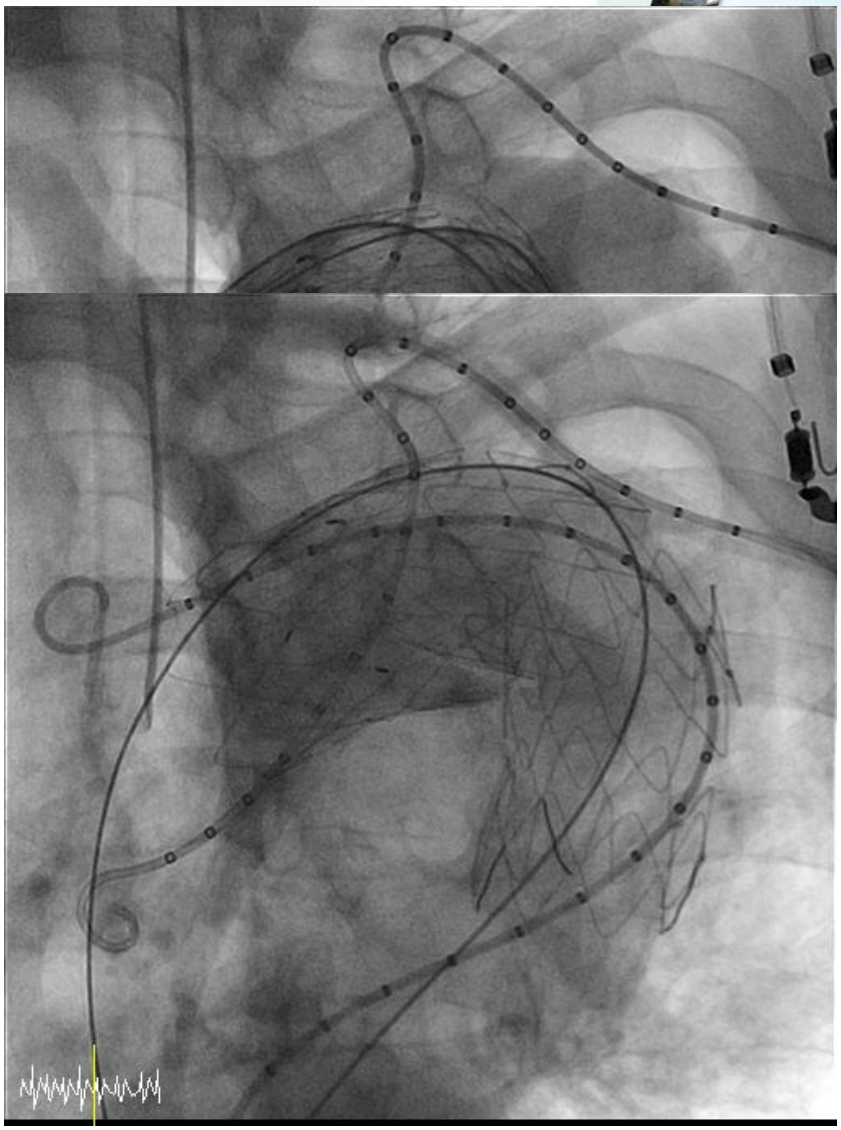
- No long term clinical data
- Risk of bypass graft occlusion(carotid, left SCA)
- Perioperative mortality, morbidity(esp. stroke)



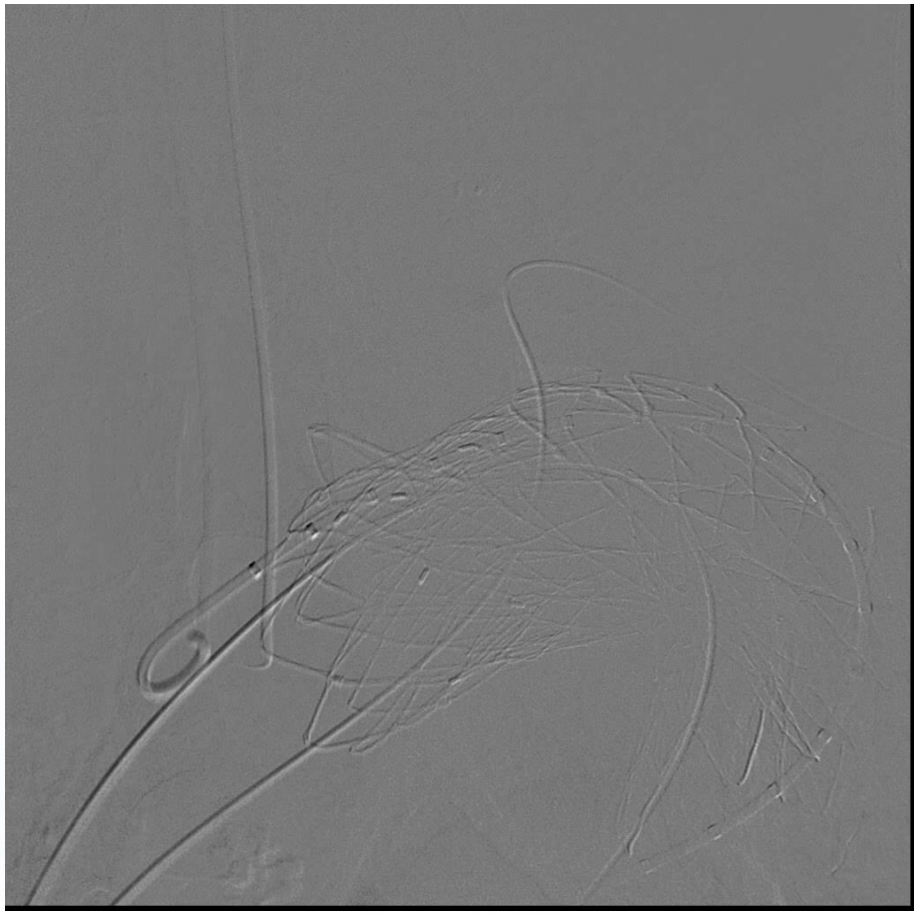


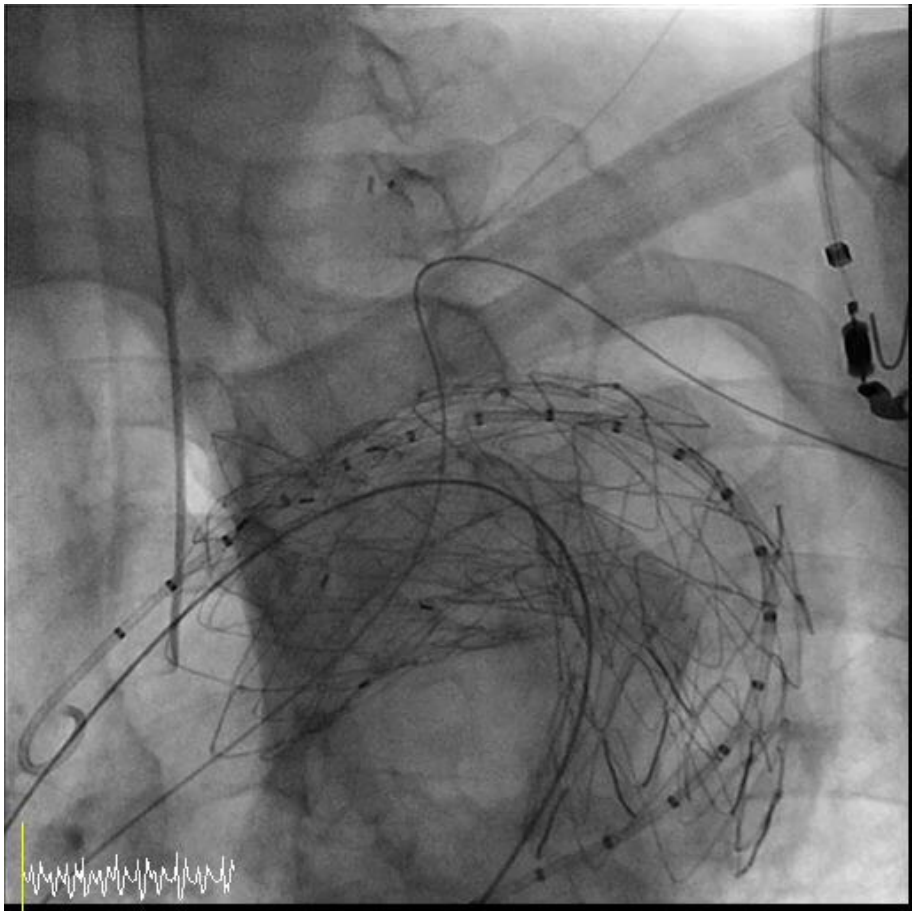
Overcome of Short Landing Zone
: Carotid – Left SCA Bypass



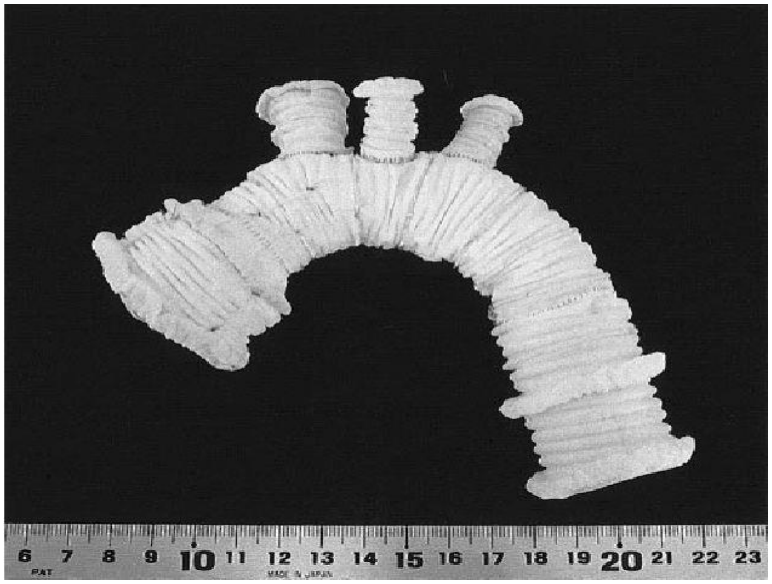


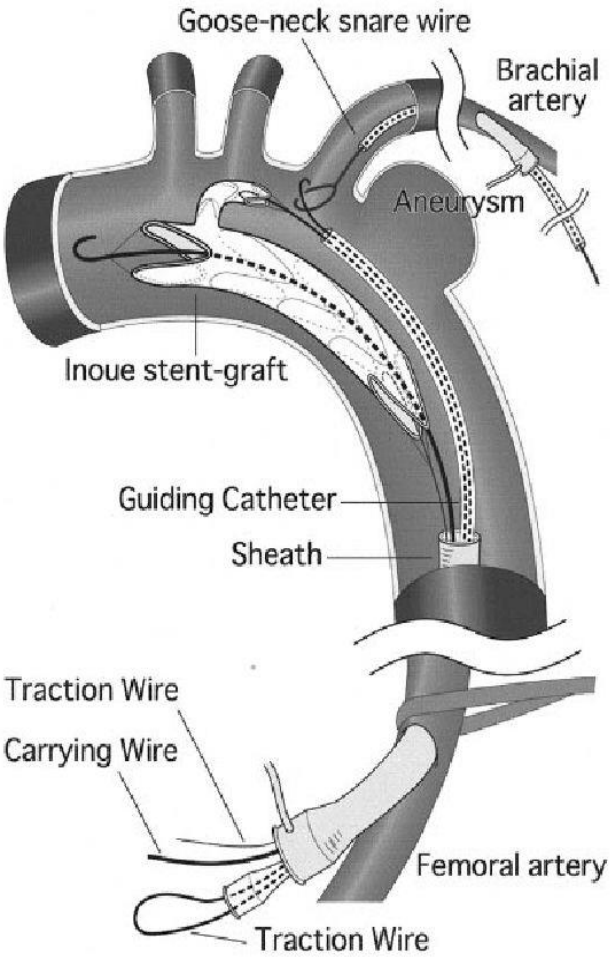
Overcome of Short Landing Zone
: Carotid – Left SCA Bypass





New Device to Overcome of Short Landing Zone : Branched, Fenestrated Stent Graft

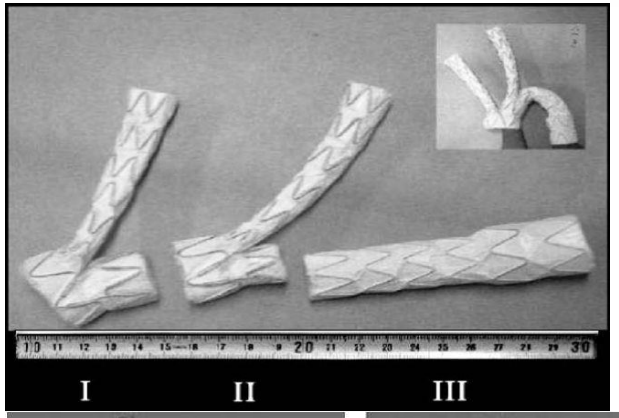


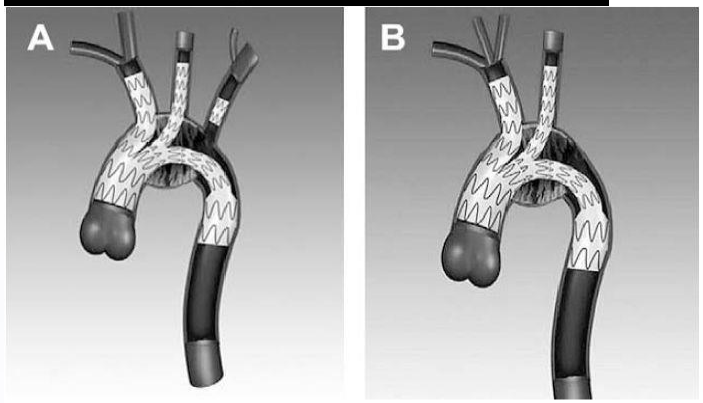


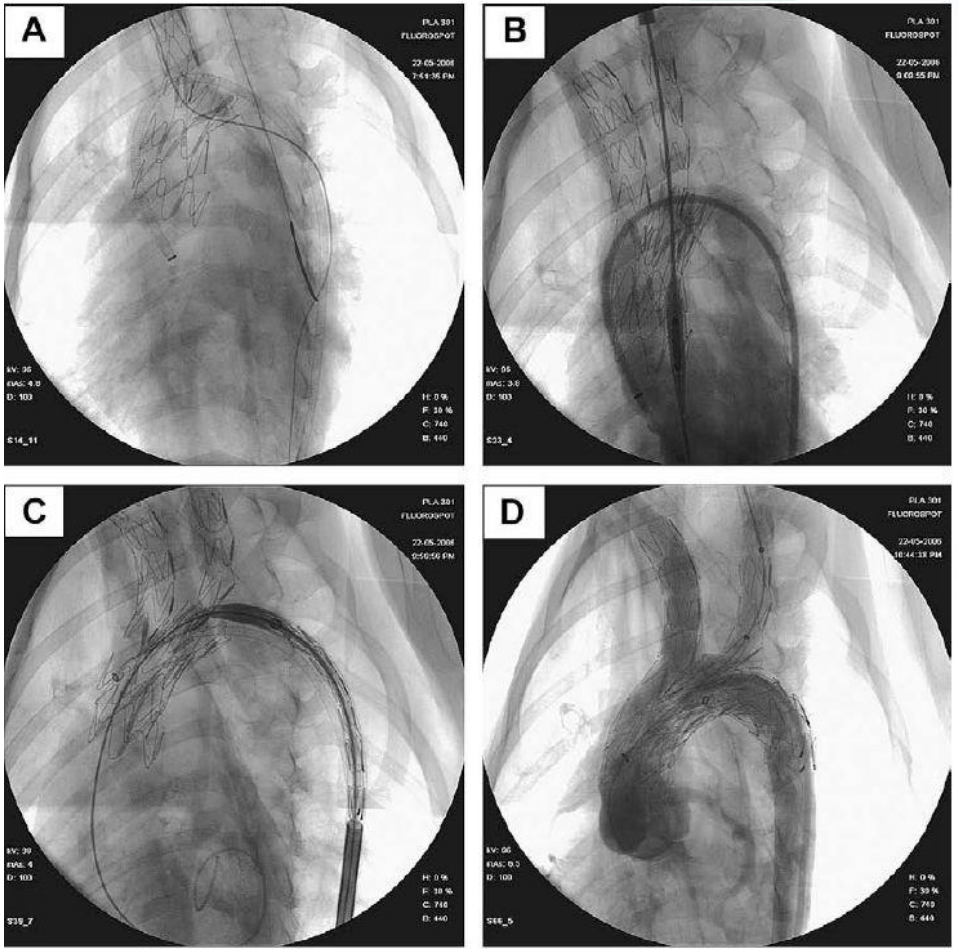
- Large profile 22-24 Fr.
- Need carotid puncture or cutdown
- Complicated procedure
- Long procedure time(3-6 hr)
- Not available until now

*Inoue K et al Circulation.*1999;100[suppl II]:II-316-II-321.

New Device to Overcome of Short Landing Zone : Branched, Fenestrated Stent Graft





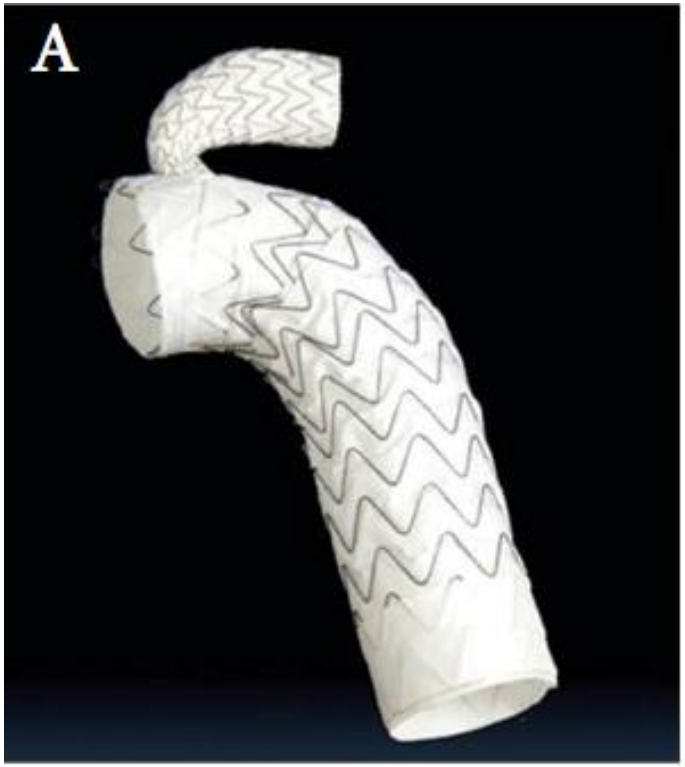


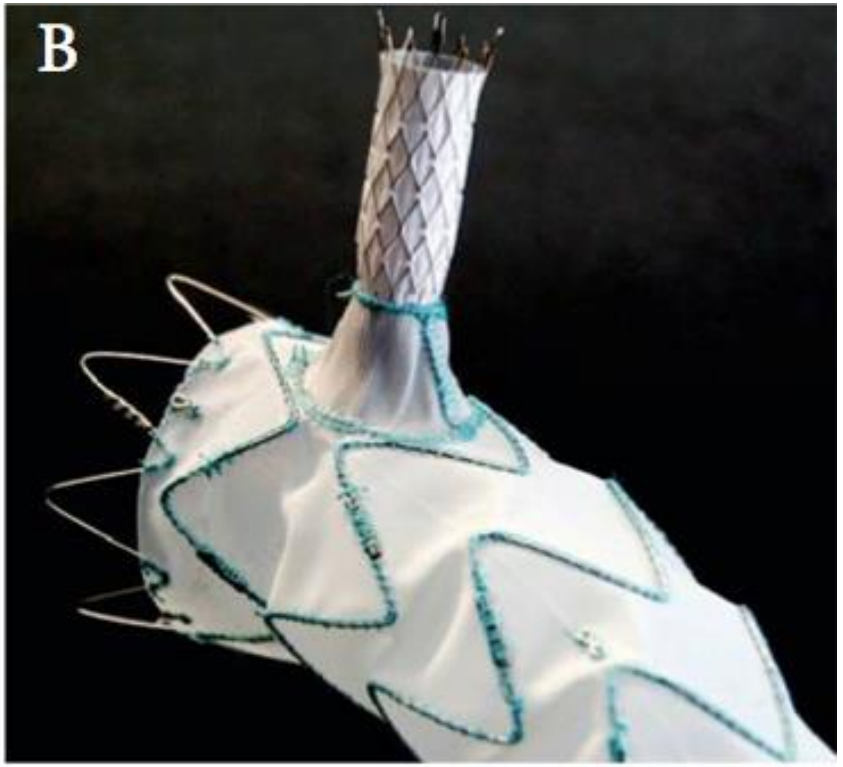
- Large profile
- Need carotid cutdown
- Complicated procedure
- Long procedure time (mean :320 min)
- Animal study only

G. Wei et al. Eur J Vasc Endovasc Surg 2009 May;37(5):560-5.

Fenestrated and branched stent

Gore and Medtronic Company

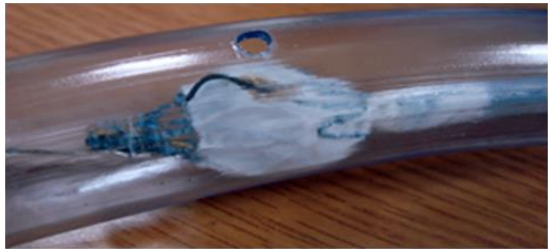


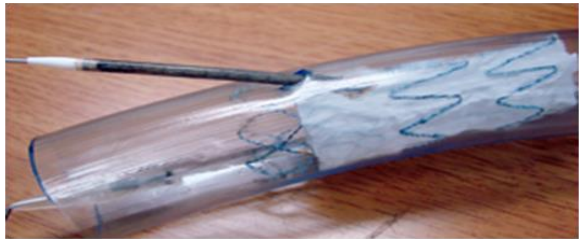


Development of a Novel, Fenestrated Aortic Arch Stent Graft with Preloaded Catheter to Save Branch Arteries : An Experimental Study

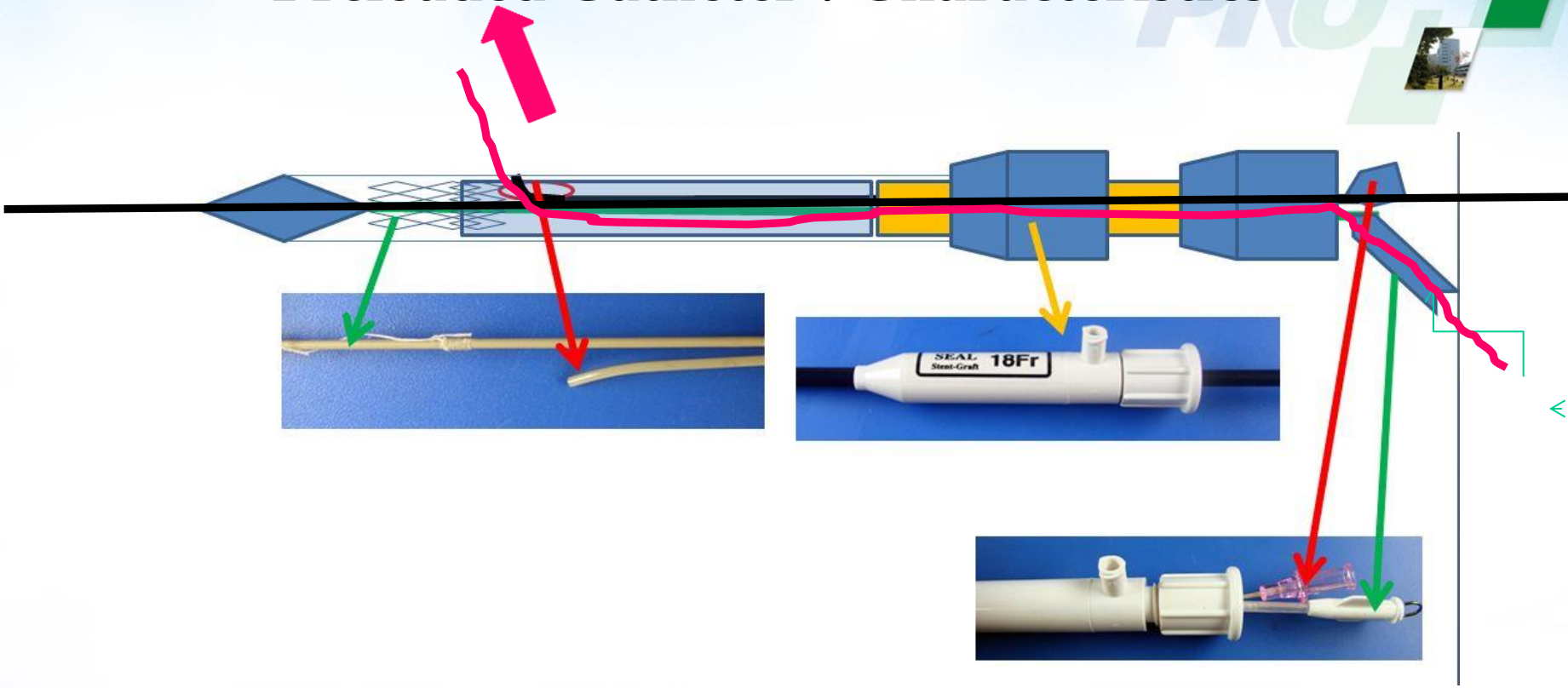
Fenestrated Aortic Arch Stent Graft with Preloaded Catheter : Characteristics

1. **Preloaded catheter** for selection of side branch artery
2. **Easy accessibility of side branch artery** through preloaded catheter
3. **Easy detectable marking of fenestrated site**
4. **Two delay deployment system** at proximal end of stent graft make stent graft movable inside aorta during procedure
5. One step deployment of stent graft for side branch artery
6. **Small profile of stent graft (18 Fr.)**

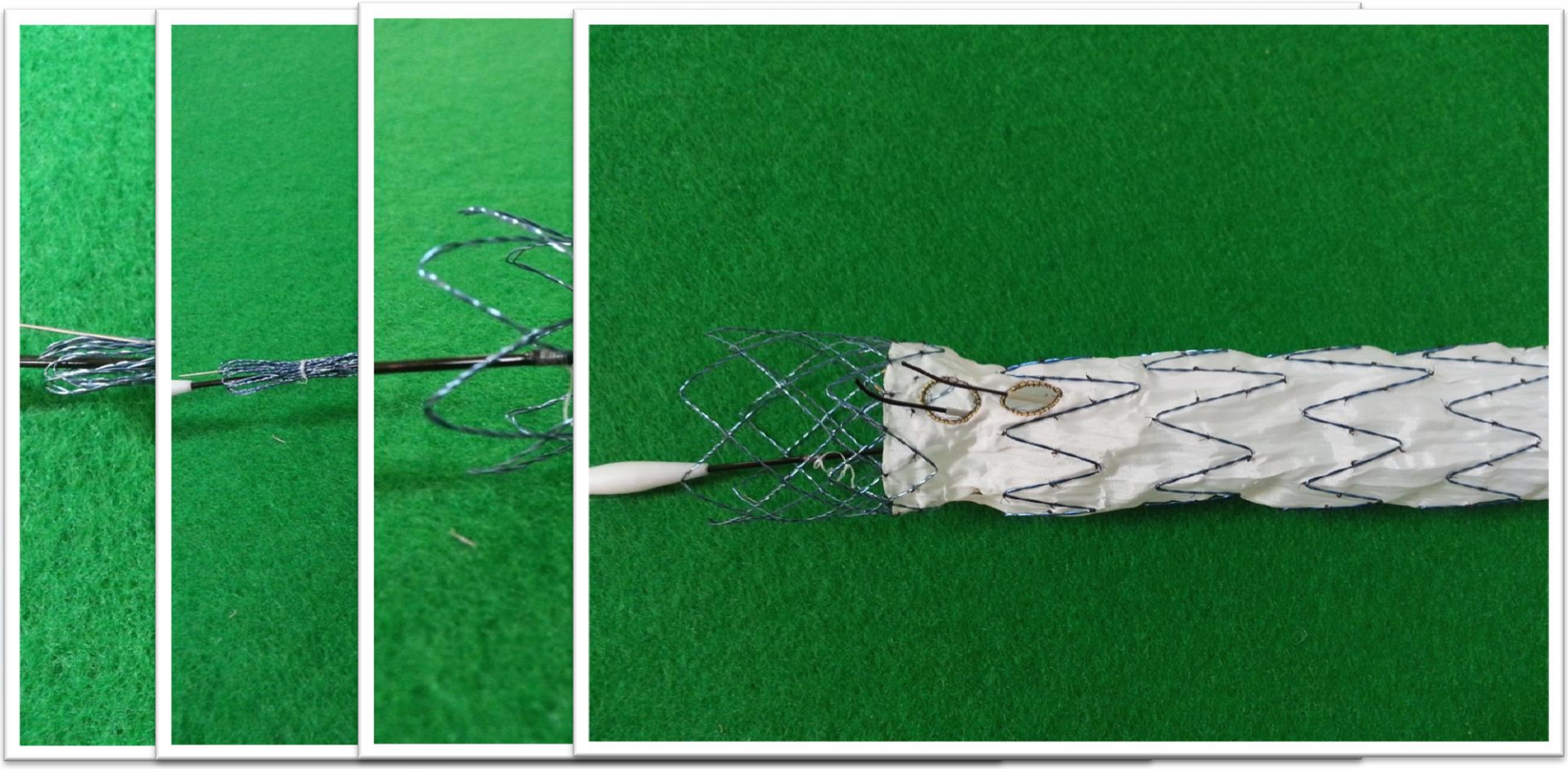




Two Fenestrated Aortic Arch Stent Graft with Preloaded Catheter : Characteristics



Two Fenestrated Aortic Arch Stent Graft with Preloaded Catheter : Characteristics



Method

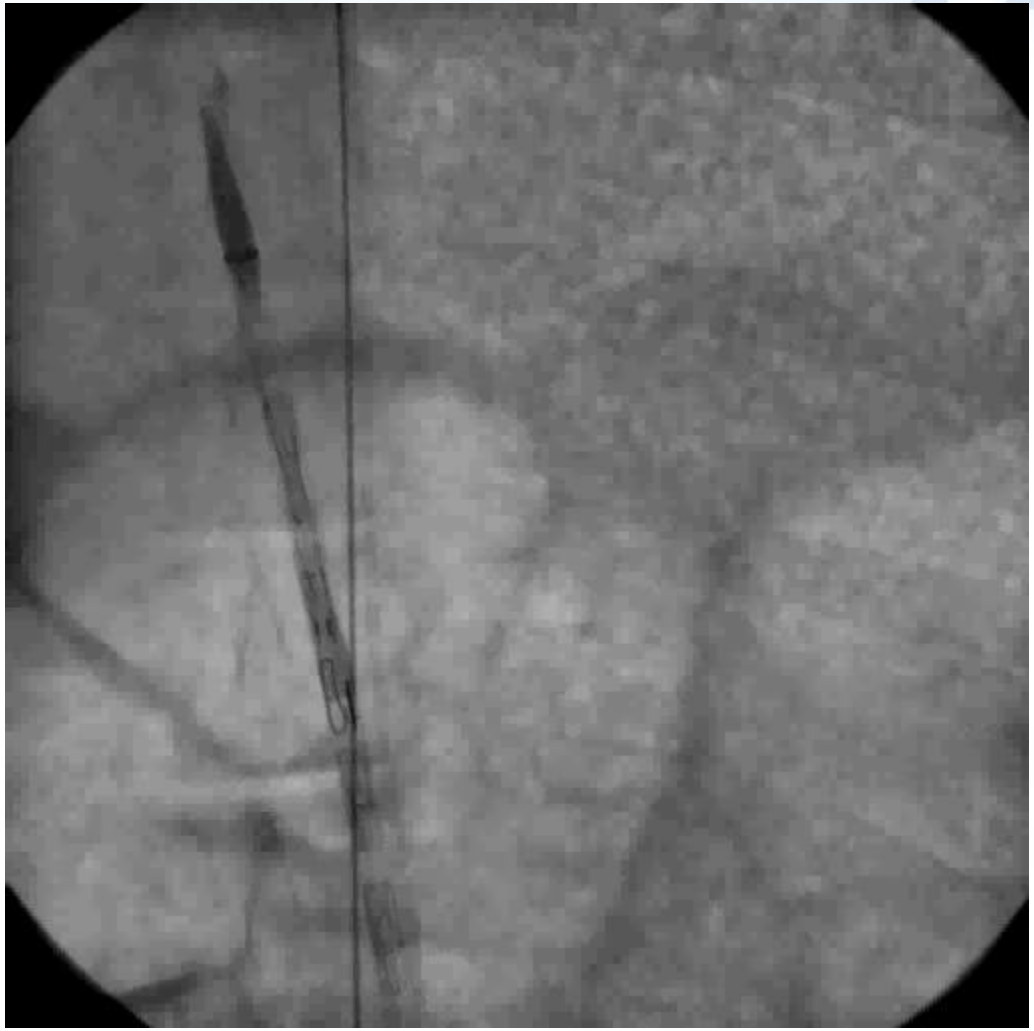
70-80 Kg, 11 swines

0 Day
Procedure of fenestrated aortic arch stent graft
Major Adverse Events Analysis(MAE)

4 weeks
Check Computed Tomography
Major Adverse Events Analysis(MAE)

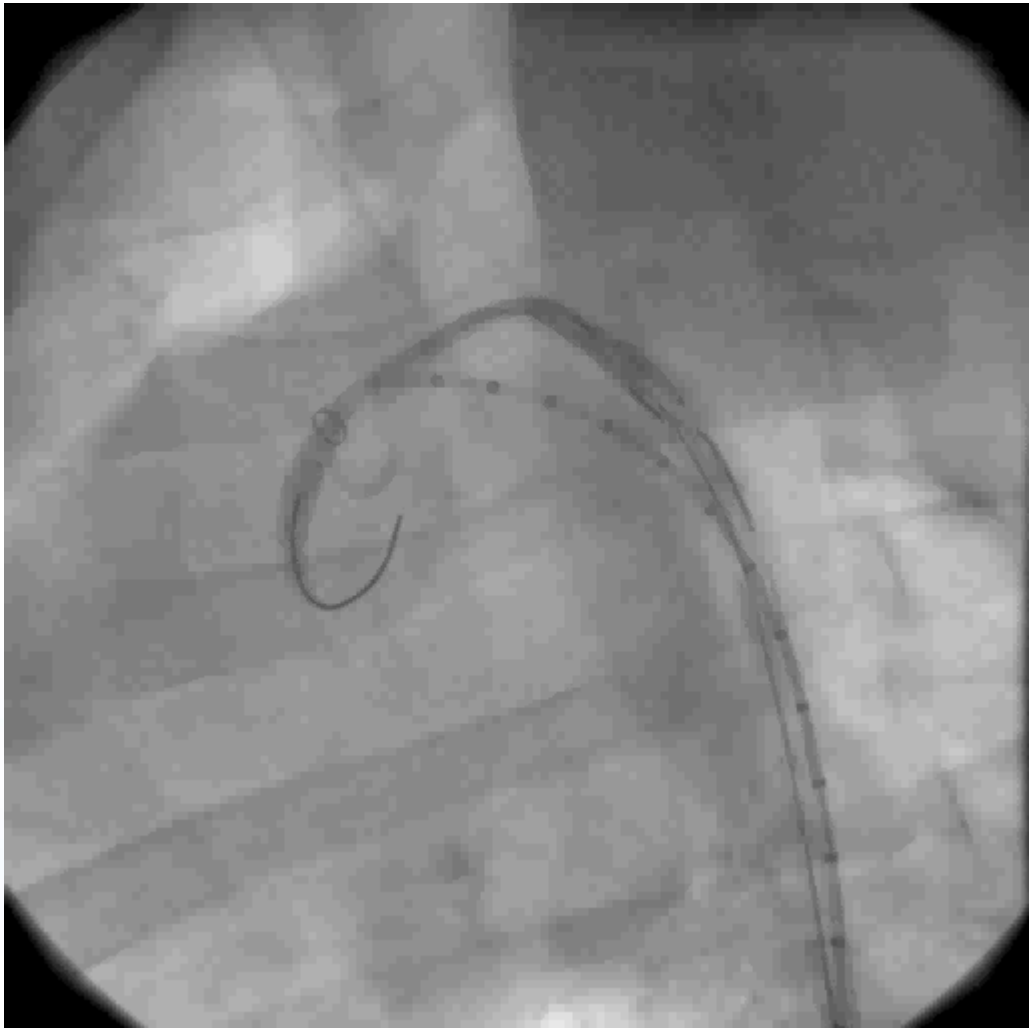
8 weeks
Sacrifice and Postmortem examination : gross pathology
Major Adverse Events Analysis(MAE)

Step of Procedure
: Confirmation of fenestrated site marking



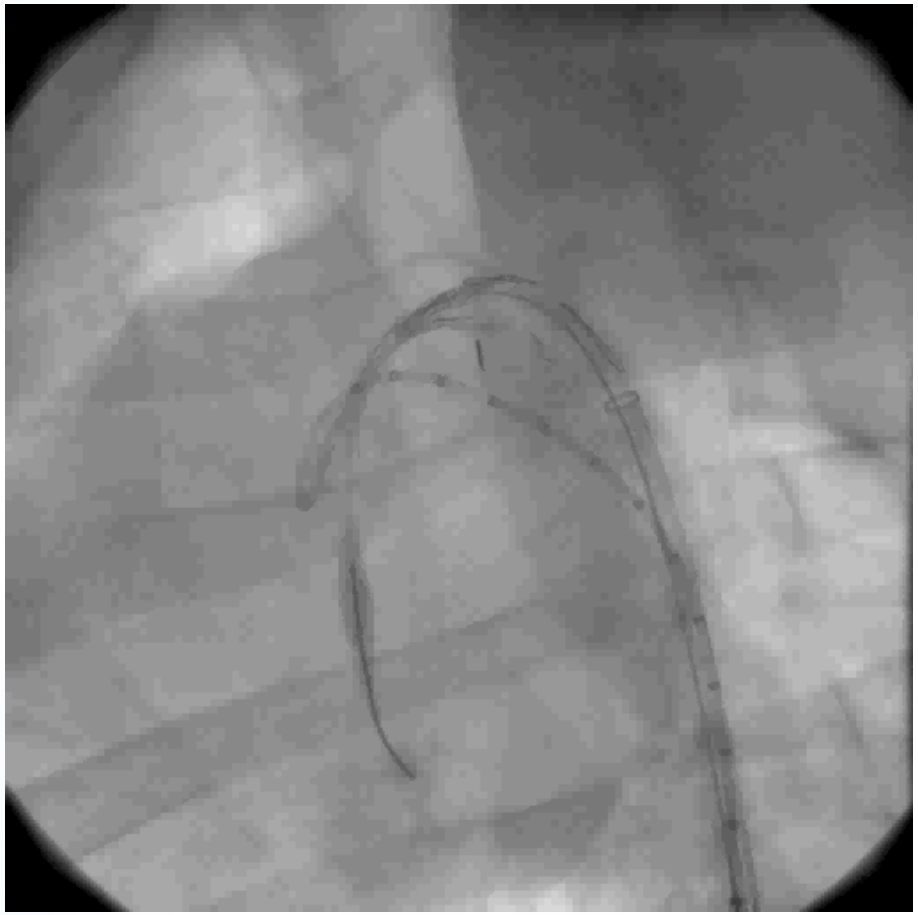
3. Easy detectable marker of fenestrated side hole

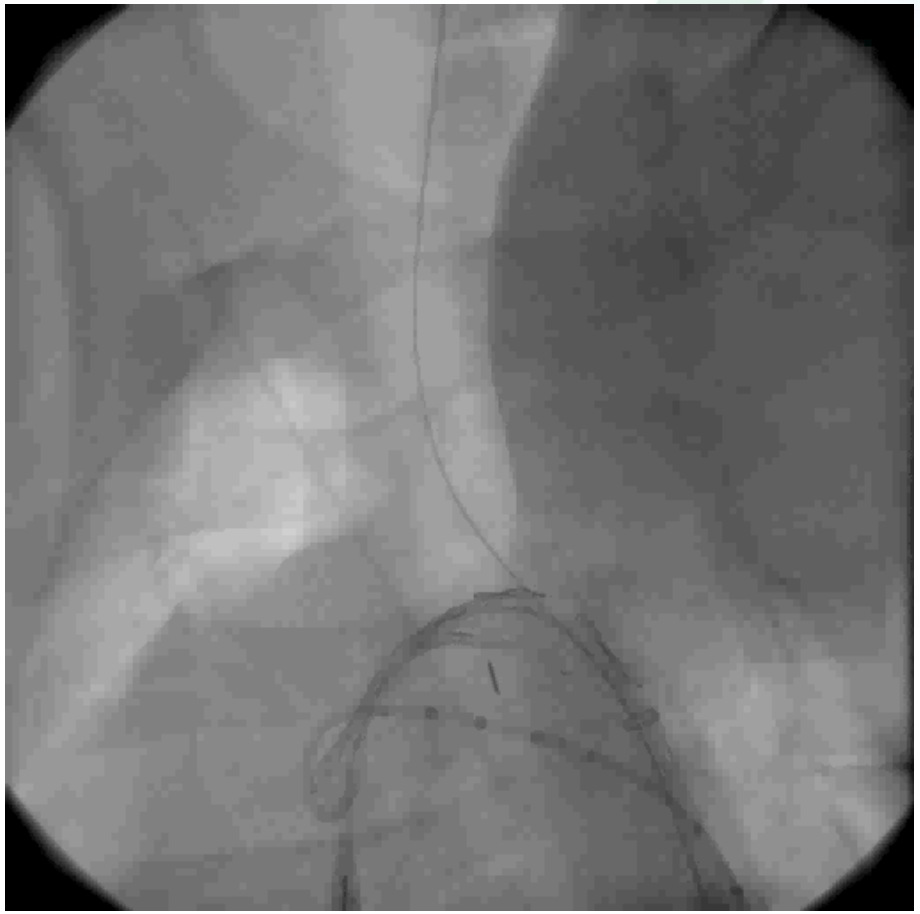
2 Fenestrated Type Stent Graft
: Partial deployment of stent graft to fenestrated site



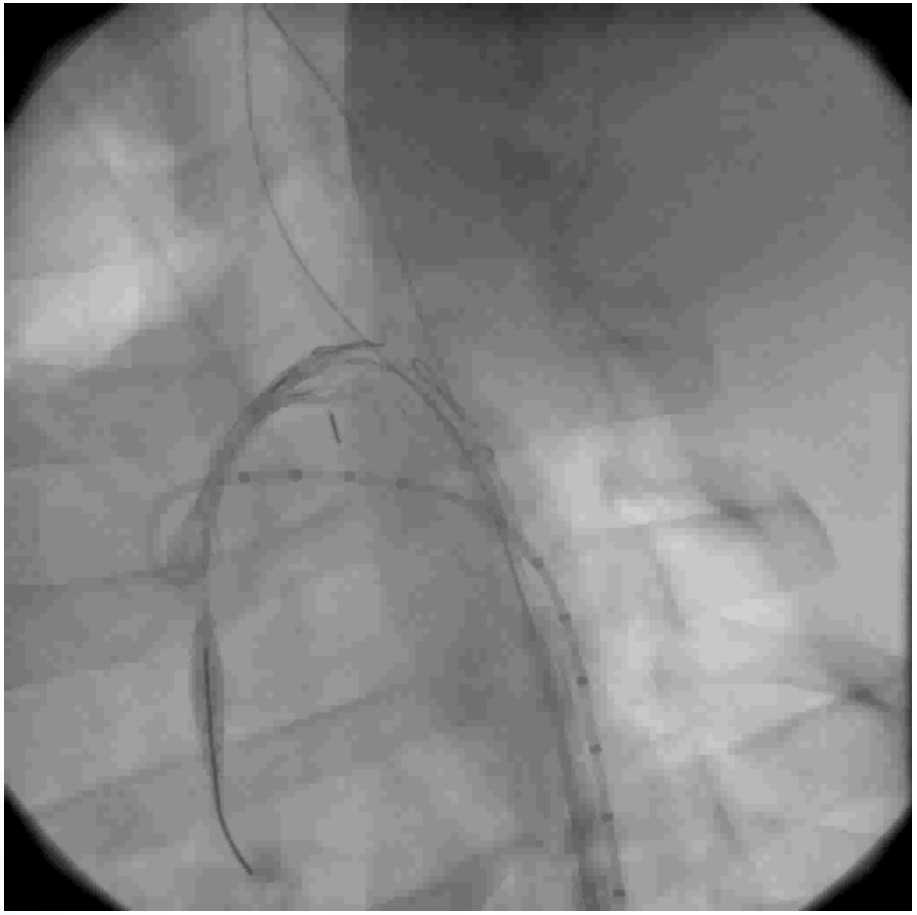
2 Fenestrated Type Stent Graft

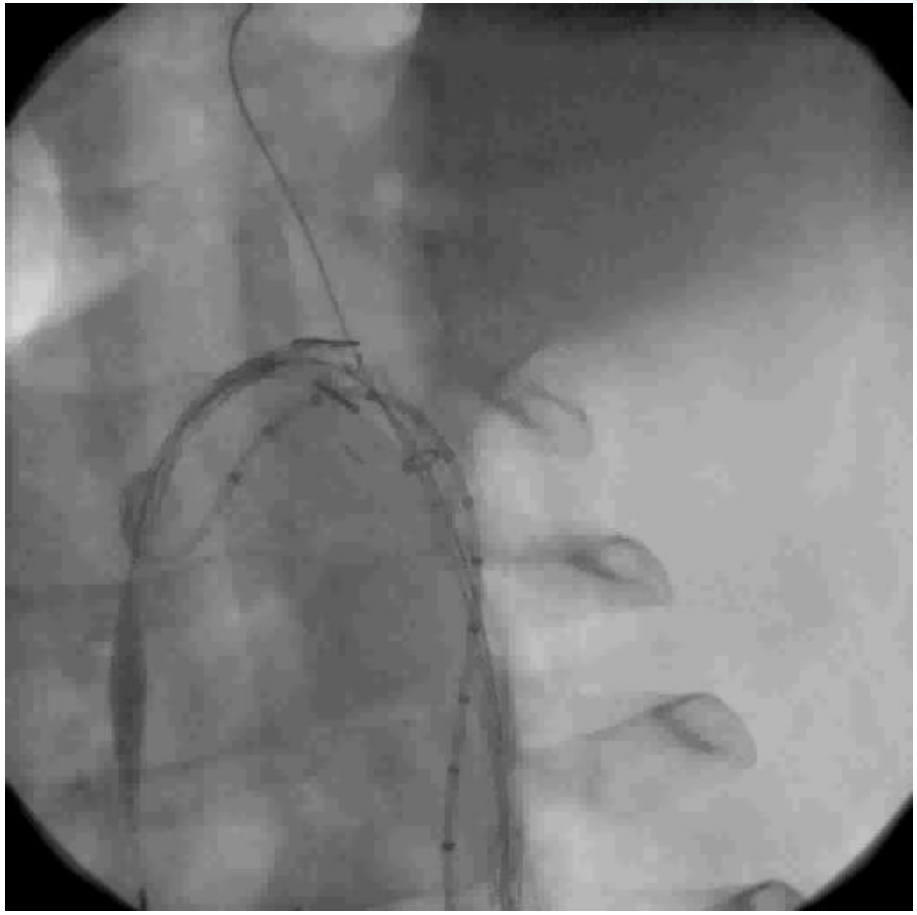
: Selection of carotid arteries via preloaded catheter





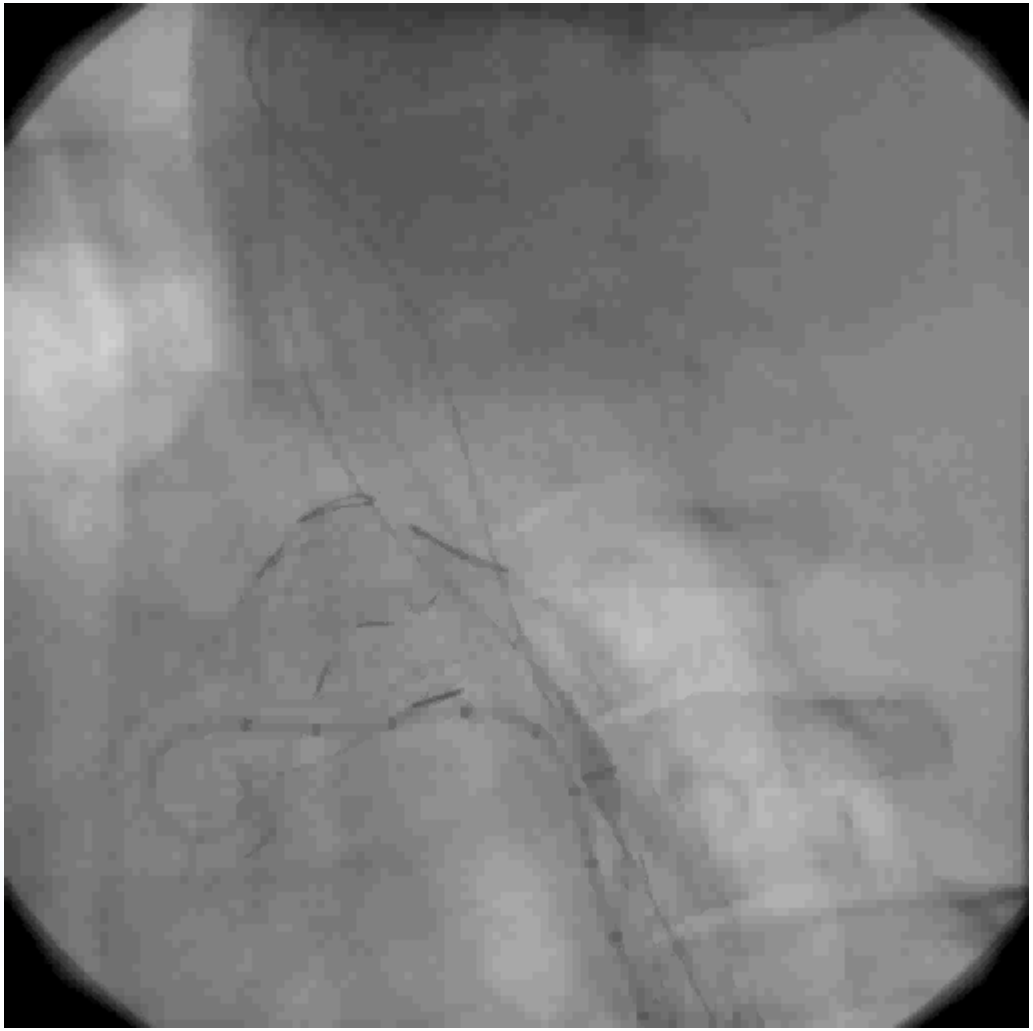
Step of Procedure
: Fitting and Main SG Deployment

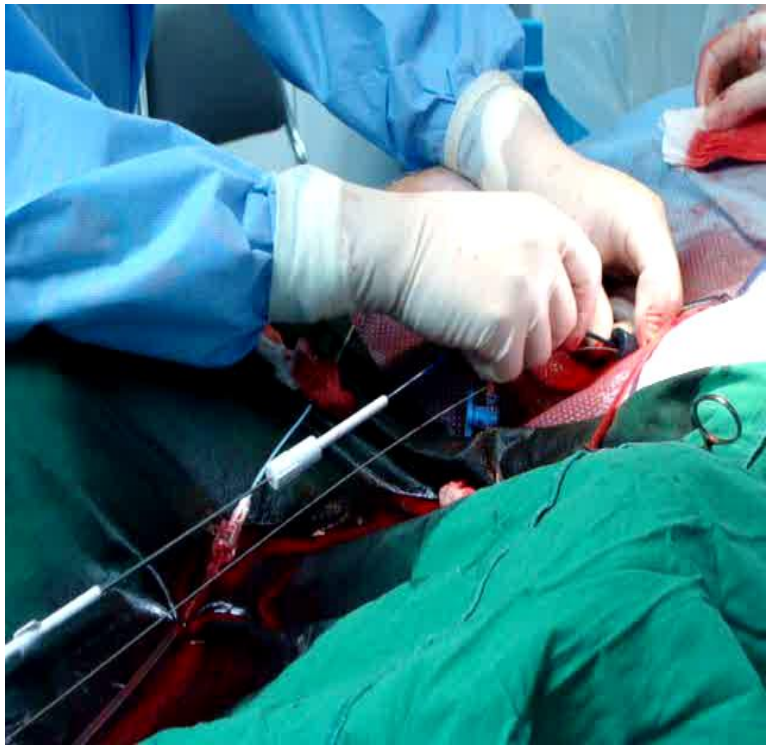




4. Two delay deployment system : **stent graft movable** inside aorta

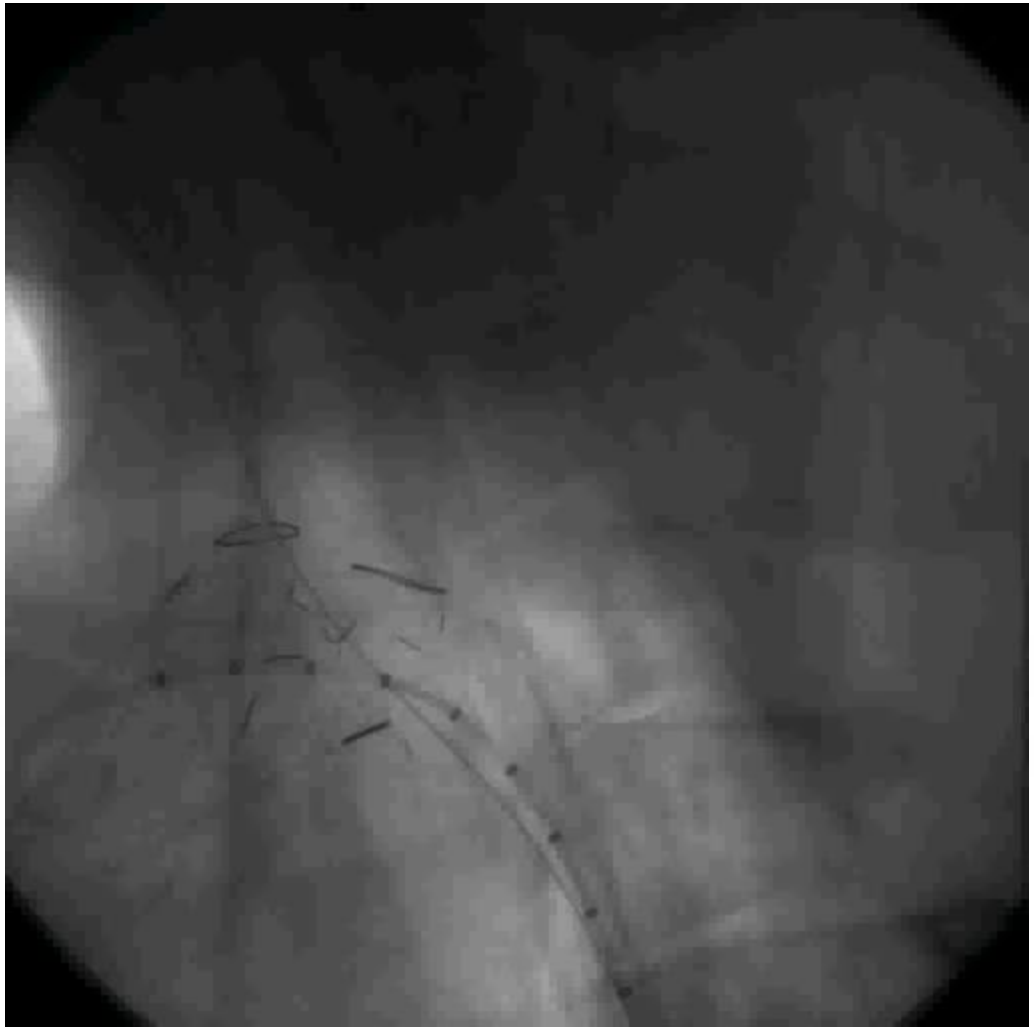
2 Fenestrated Type Stent Graft
: Advance of stent graft for caortid artery





Step of Procedure

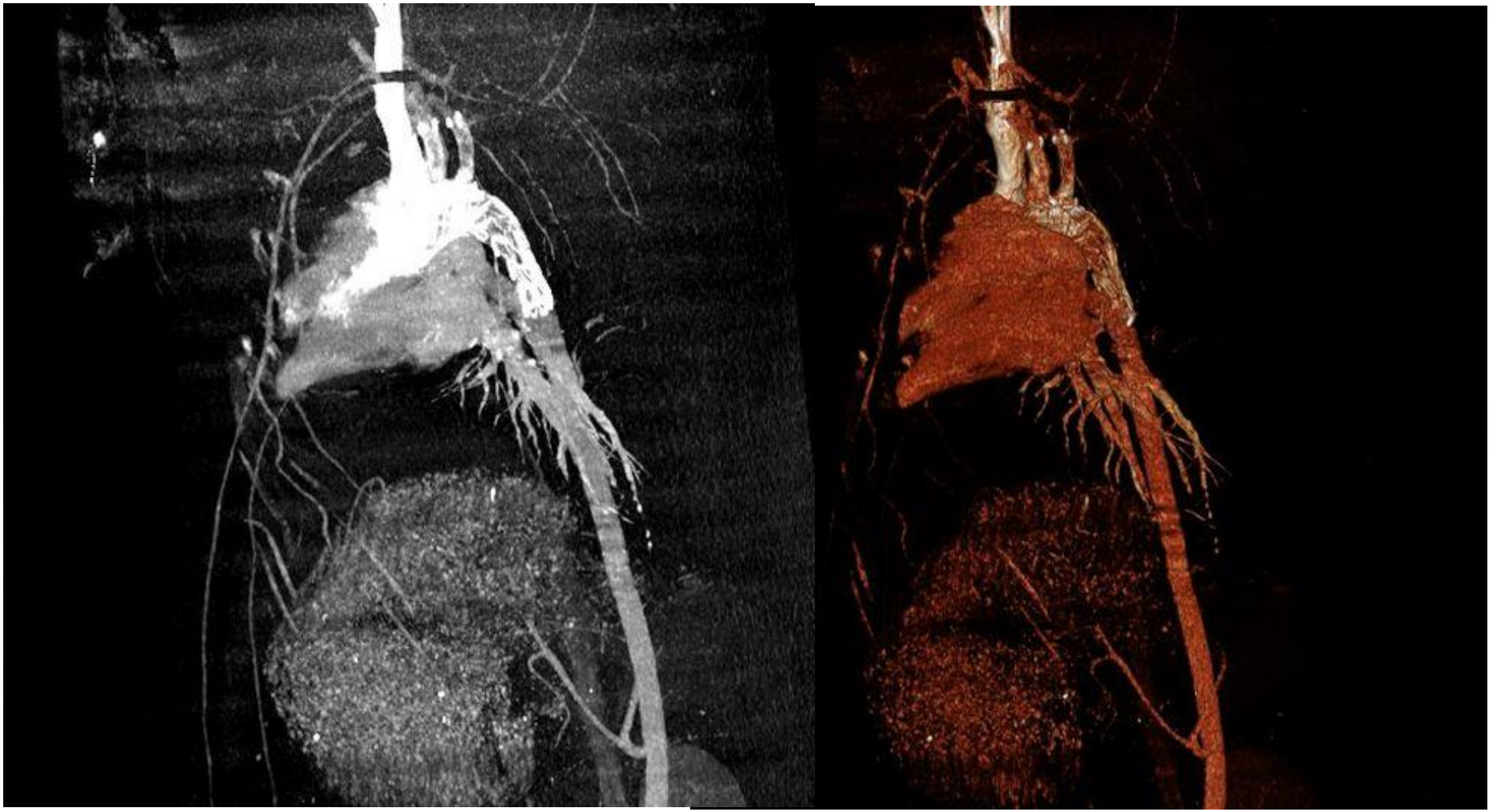
: Aortography after fenestrated aortic arch stent graft



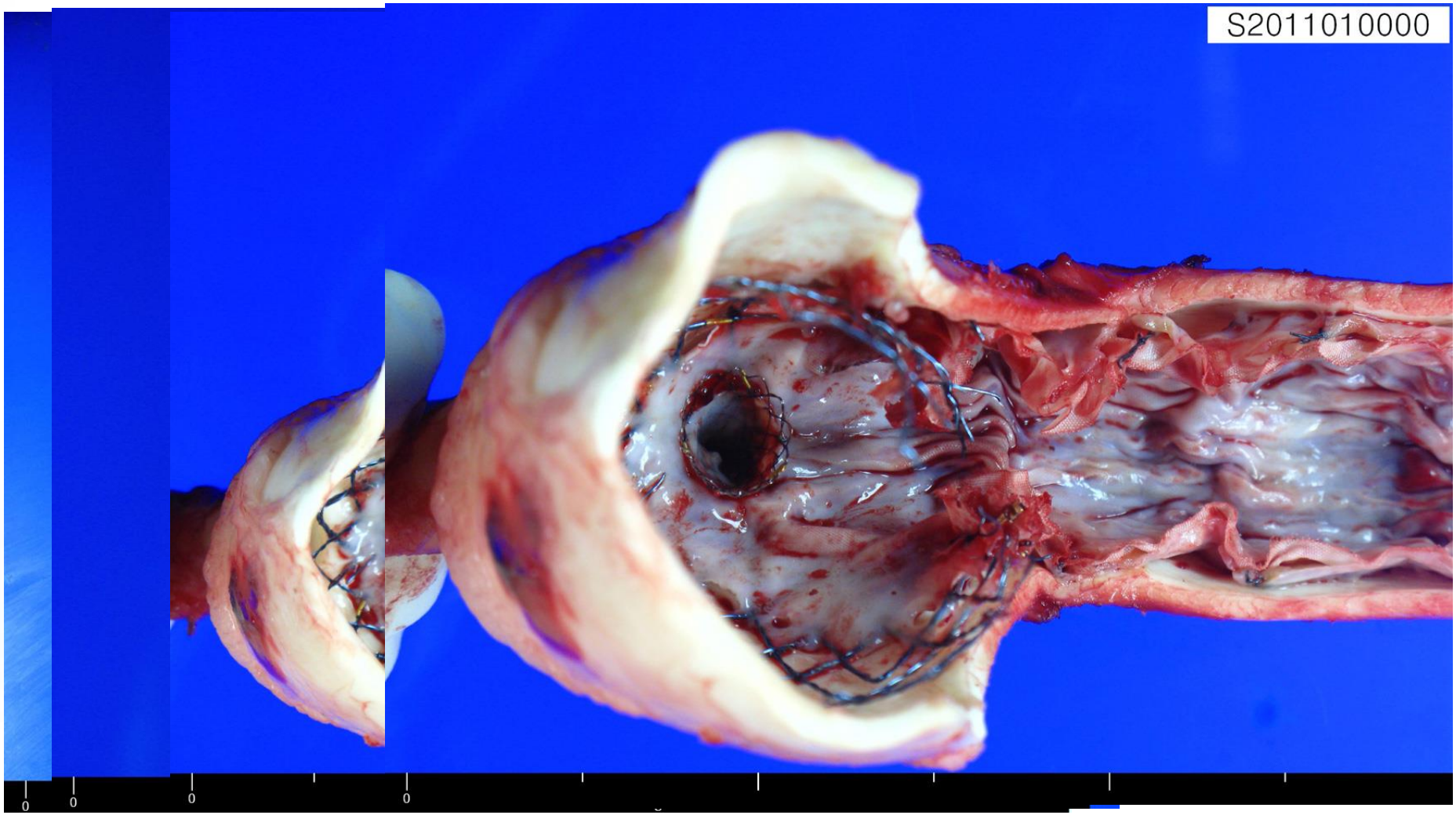
Results

	1-FASG	2-FASG
Total procedure time	31.02±5.02 min	45.78±9.62 min
Selection time of carotid artery	4.82±0.73 min	6.82±2.54 min
Success of procedure	6 (100%)	5 (100%)
CT finding	6	5
Endoleak	0% (0/6)	0% (0/5)
Disconnection of stent grafts	0% (0/6)	0% (0/5)
Occlusion of stent graft for carotid artery	0% (0/6)	0% (0/5)
Postmortem gross finding	6	5
Disconnection of stent grafts	0% (0/6)	0% (0/5)
Fracture of stent grafts	0% (0/6)	0% (0/5)
Tear of stent grafts	0% (0/6)	0% (0/5)
Occlusion of stent graft for carotid artery	0% (0/6)	0% (0/5)
4 weeks MAE	16.7% (1/6)	0% (0/5)
8 weeks MAE	16.7% (1/6)	0% (0/5)

CT Finding after 4 weeks
: 2 Fenestrated Type Stent Graft



Postmortem Exam : Gross Pathology



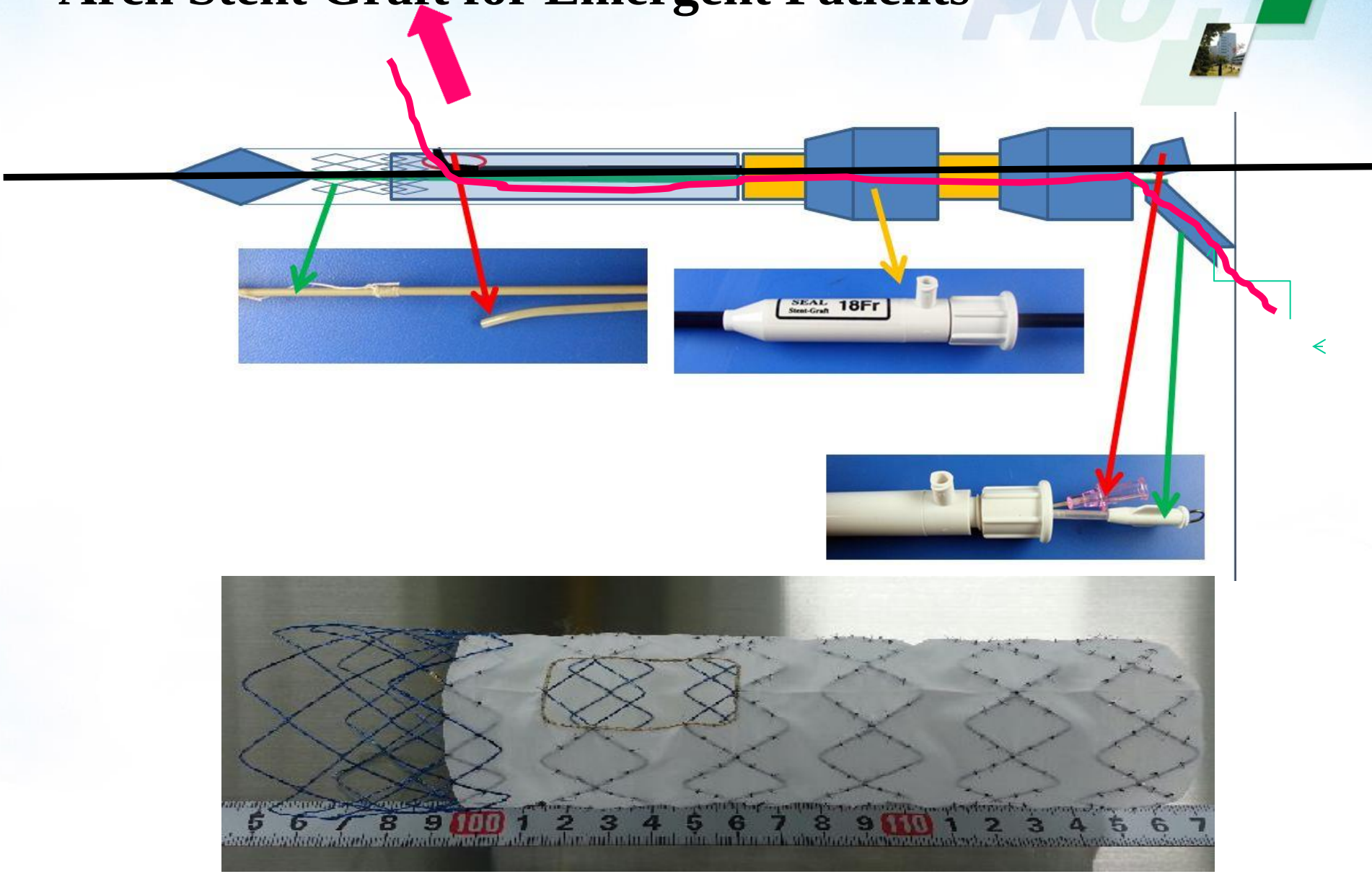
For Emergent Patients

- **3 days** need for Fenestrated aortic arch stent graft
- **Different size and length** of thoracic aorta, innominate a., carotid a., and SCA in patients thoracic aortic disease

- Aortic pathologies usually occurred at **lesser curvature, lateral side** of thoracic aortic arch.
- Development of **ready-made fenestrated** aortic arch stent graft for emergent patients

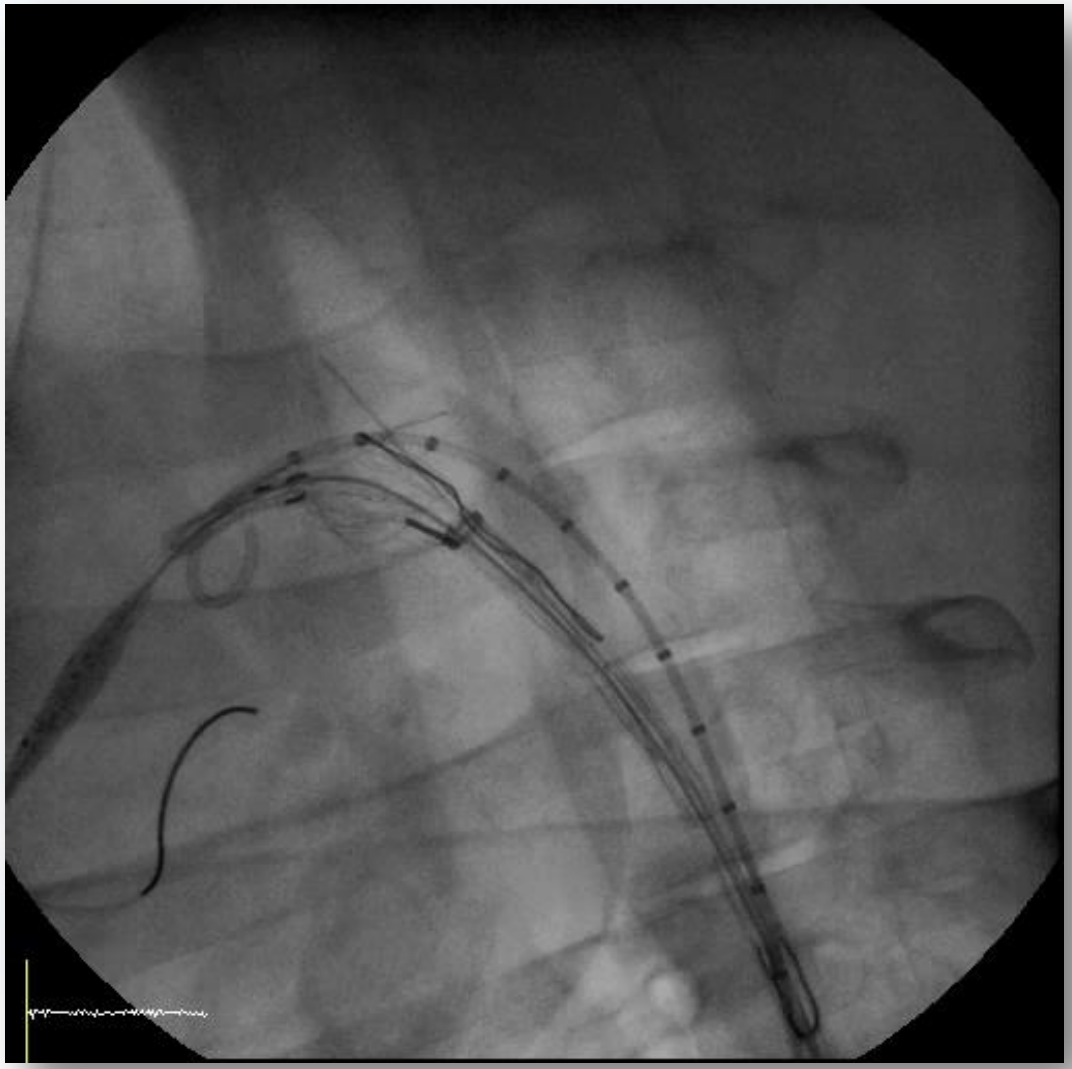
Development of Window Type Fenestrated Aortic Arch Stent Graft with Preloaded Catheter for Protecting Branch Arteries : An Experimental Study

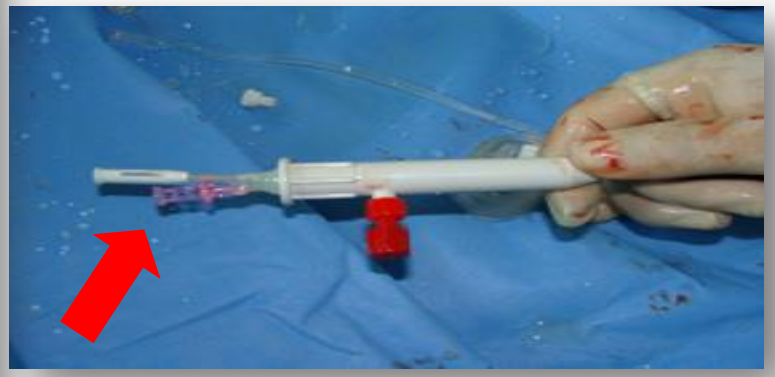
Development of Ready-Made Fenestrated Aortic Arch Stent Graft for Emergent Patients

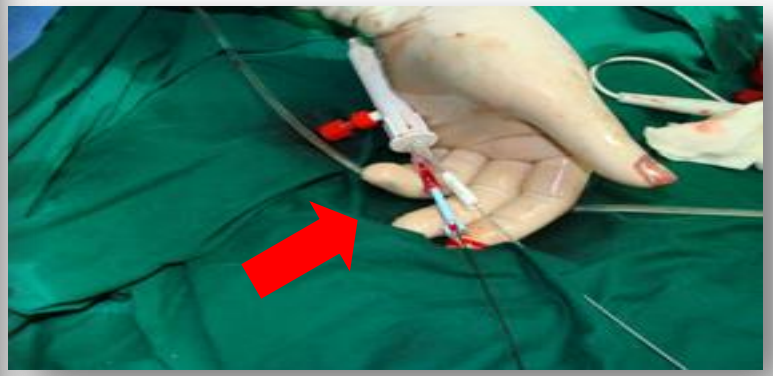


Window Type Stent Graft:

Selection of carotid artery via preloading catheter





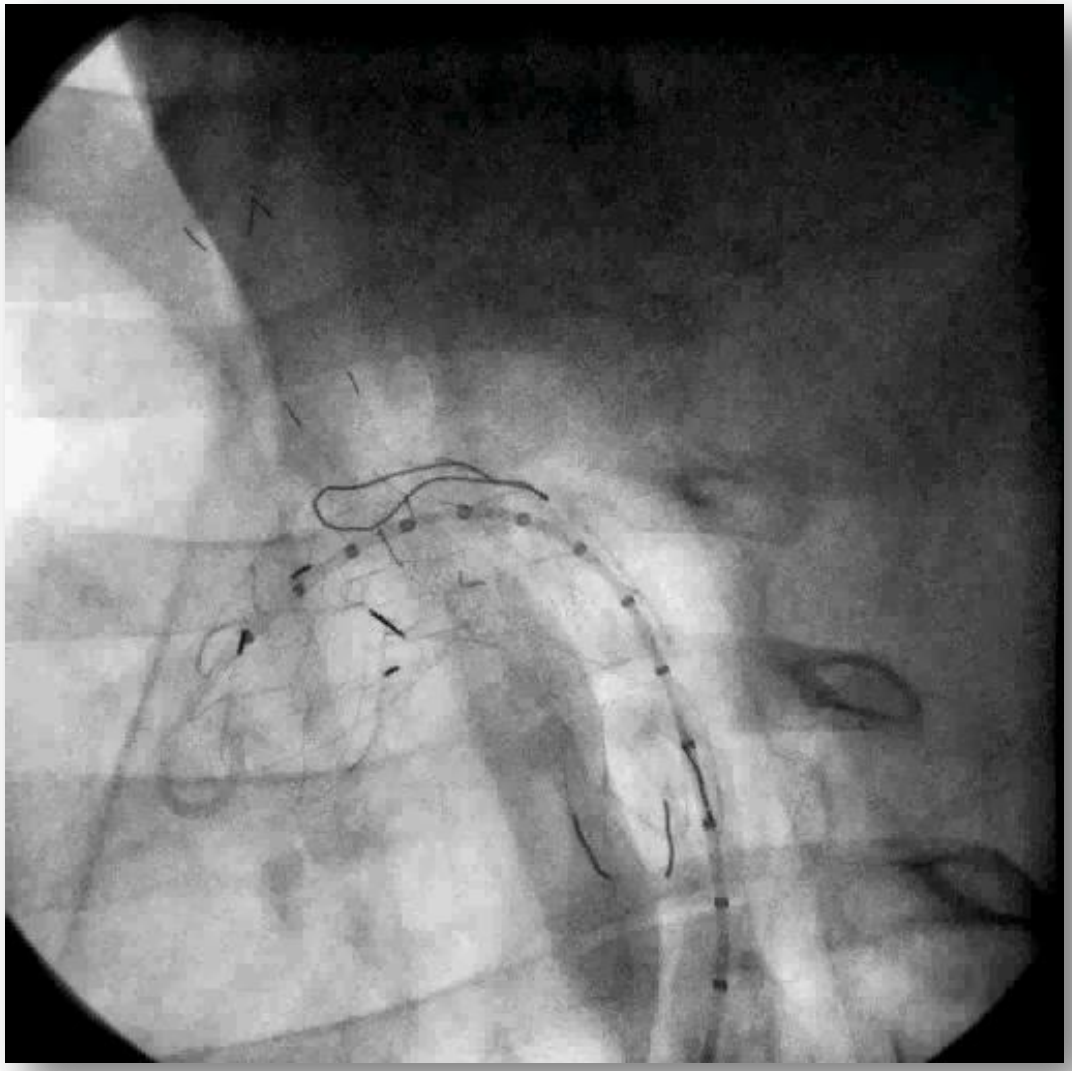


Window Type Stent Graft:

Advance of stent graft for carotid artery

Step of Procedure:

Aortography after Window Type aortic arch stent graft

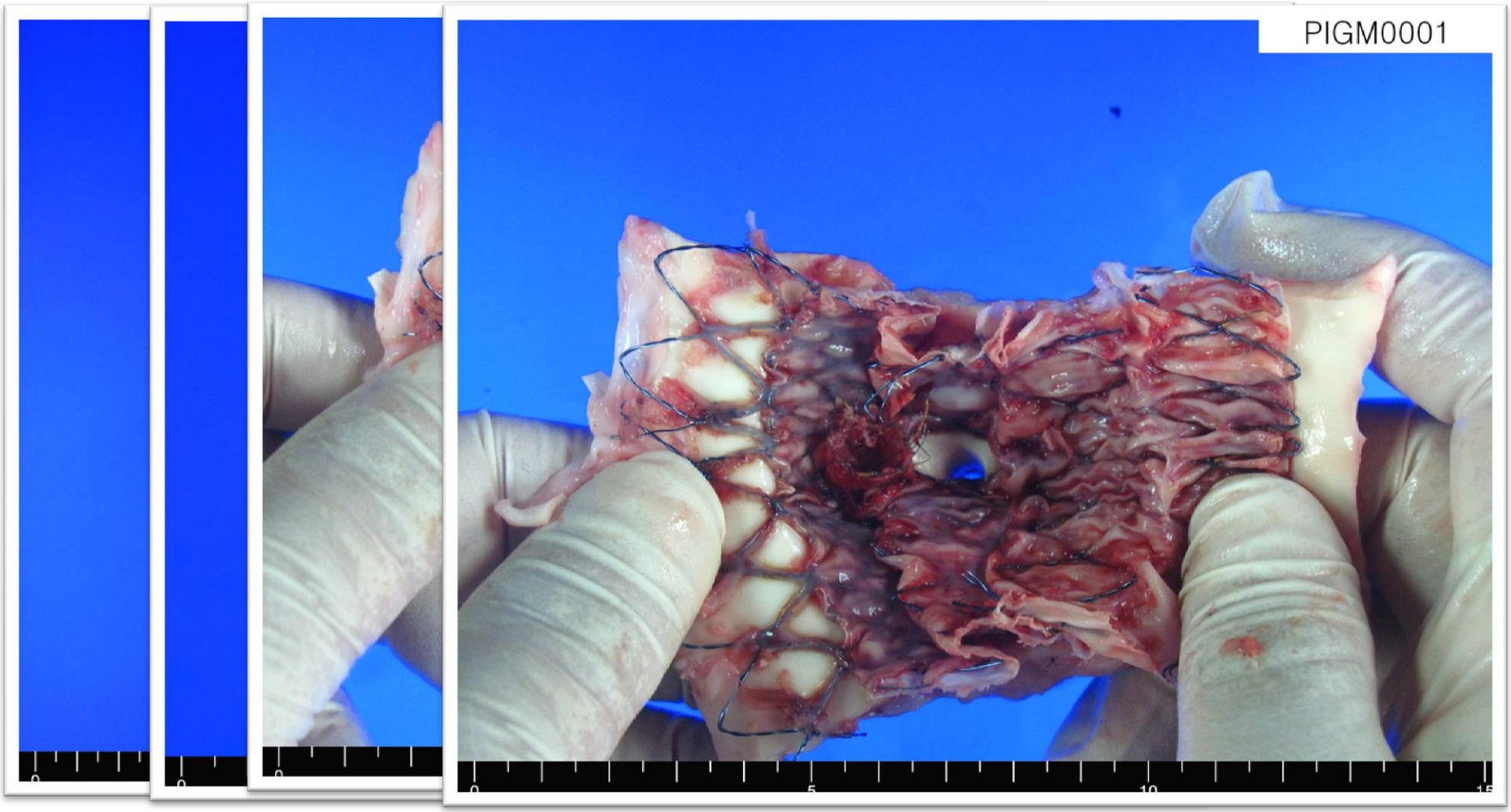


Results:

Window Type Fenestrated Aortic Arch Stent Graft

Total procedure time	**27.15±4.02 min**
Selection time of carotid artery	**5.72±0.62 min**
Success of procedure	**6 (100%)**
CT finding or Aortography	6
Endoleak	0% (0/6)
Disconnection of stent grafts	0% (0/6)
Occlusion of stent graft for carotid artery	0% (0/6)
Postmortem gross finding	6
Disconnection of stent grafts	0% (0/6)
Fracture of stent grafts	0% (0/6)
Tear of stent grafts	0% (0/6)
Occlusion of stent graft for carotid artery	0% (0/6)
4 weeks MAE	**0% (0/6)**
8 weeks MAE	**0% (0/6)**

Postmortem Exam : Gross Pathology



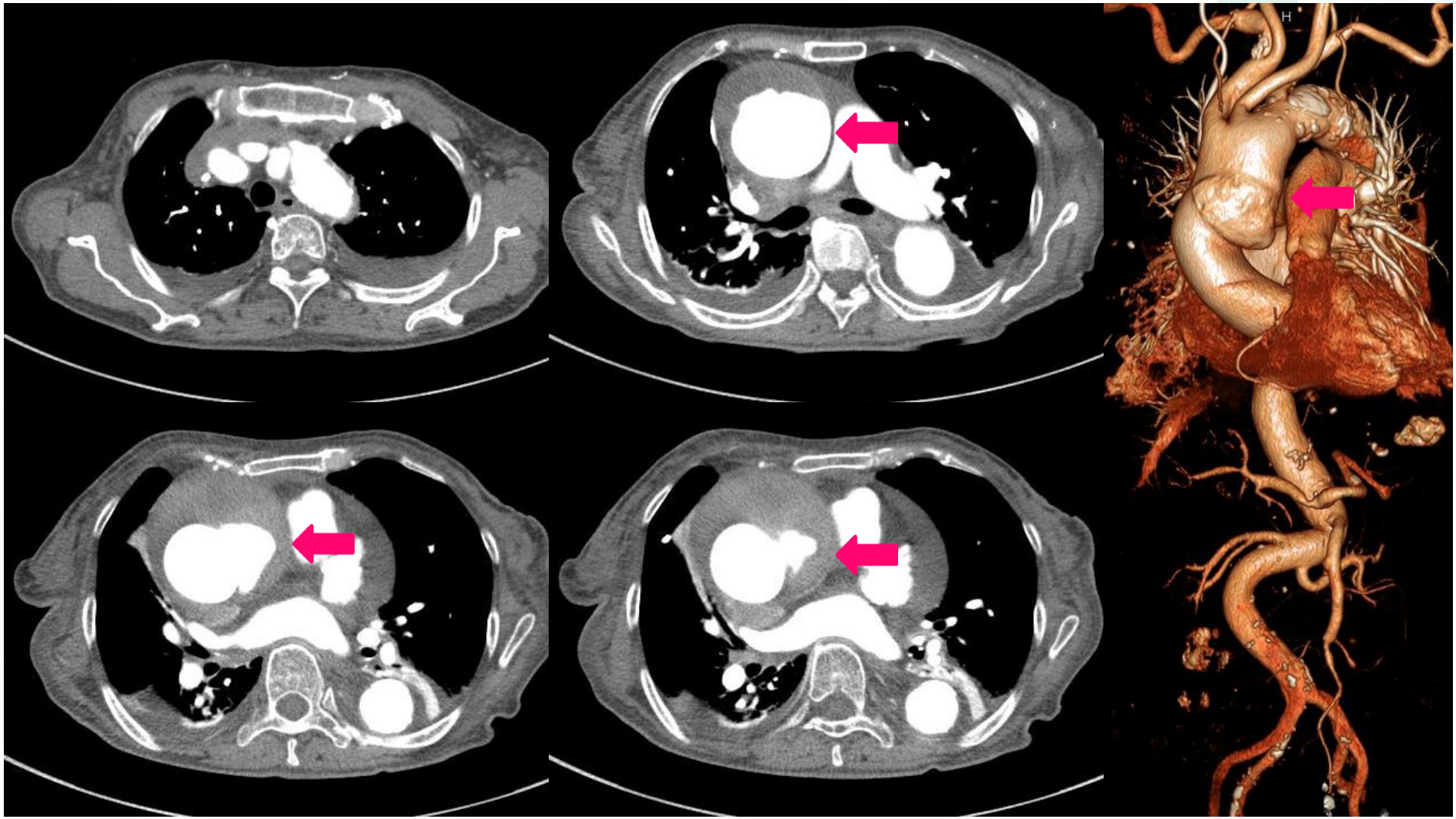
Case

:Window Type Fenestrated Aortic Arch Stent Graft

History

- A hypertensive **79 year-old female**
- **CC** : chest discomfort radiating to the back
- **V/S**: **90/60-92**
- **Past Hx**: old CVA (+)
- **Social Hx**: no smoking, no alcohol drinking
- **CT aorta**:
  - **Ascending penetrating aortic ulcer with intramural hematoma**
  - Pericardial effusion

CT aorta on ED



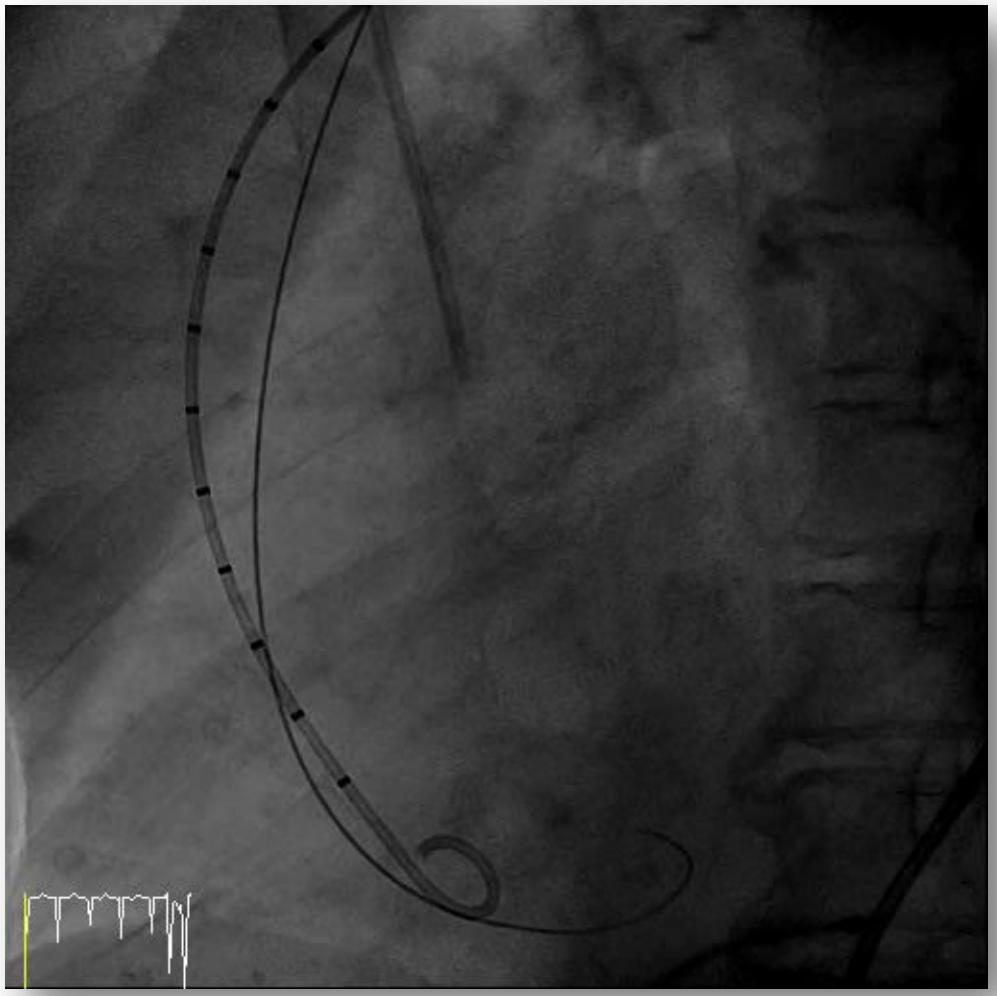
Progress

- **Clinical diagnosis**:
  - **Rupture ascending PAU with IMH**

- **Plan**
  - Surgical repair was Recommended
  - Surgical repair was **Refused** by patient
  - **Informed consent** about fenestrated stent graft
  - Window type fenestrated stent graft was considered

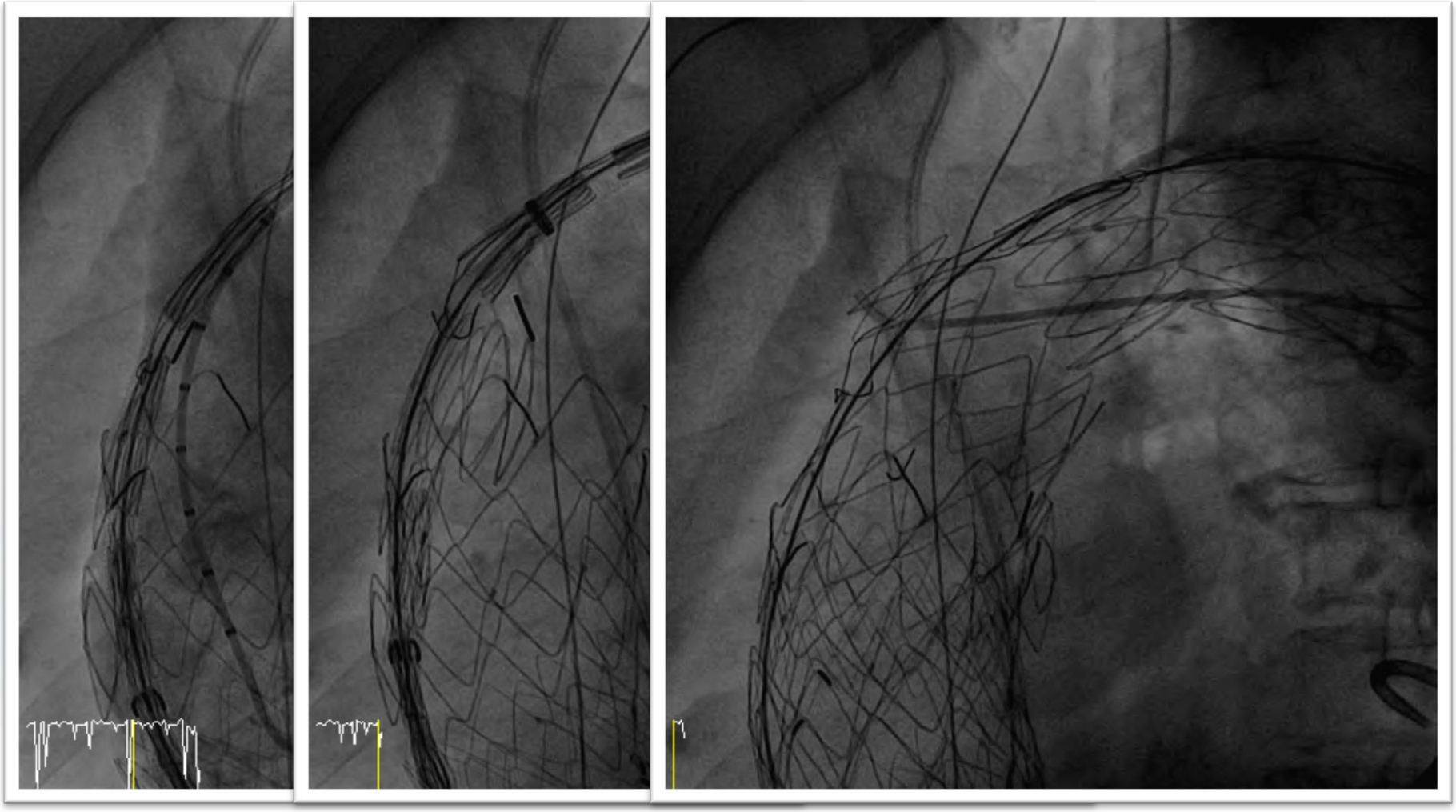
Ascending and Aortic Arch Stent Graft

：Aortography



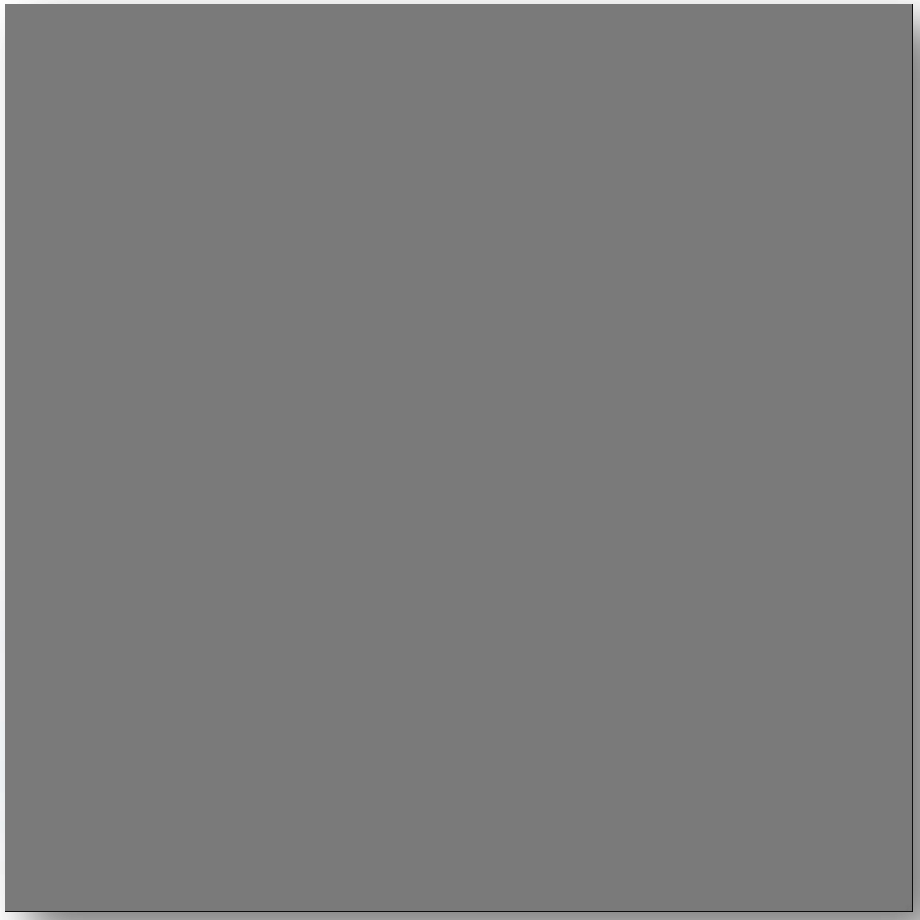
Ascending and Aortic Arch Stent Graft

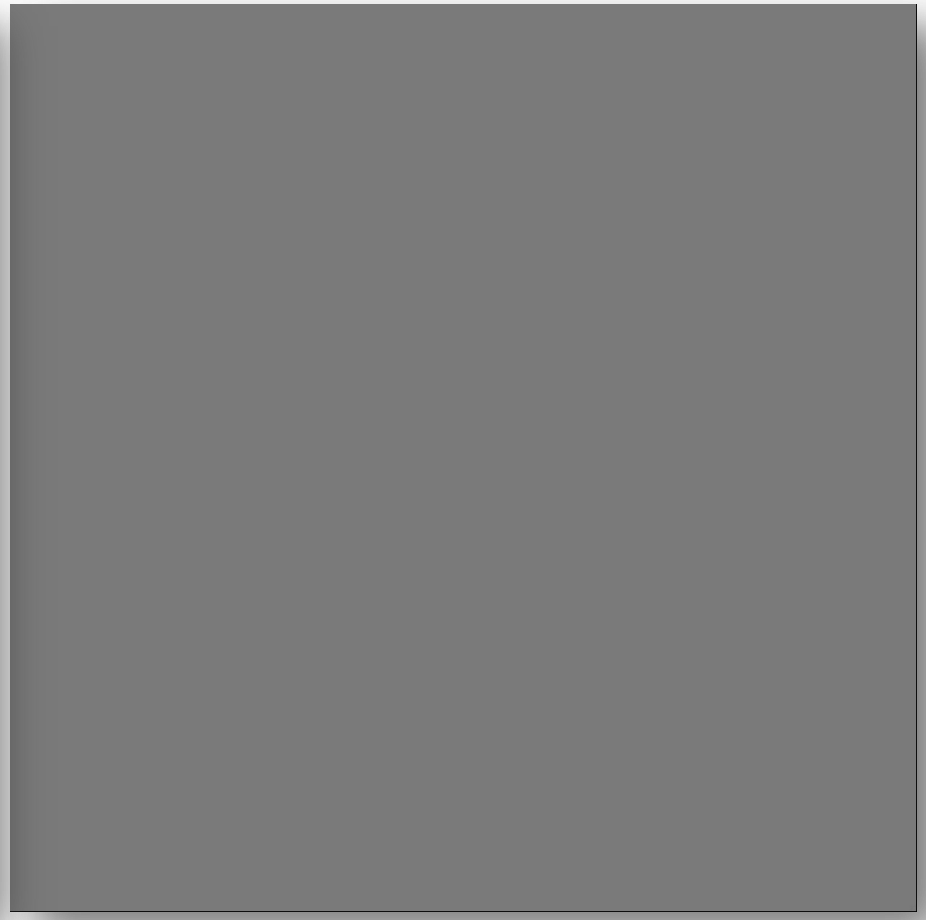
: Overapping insertion of window type stent graft



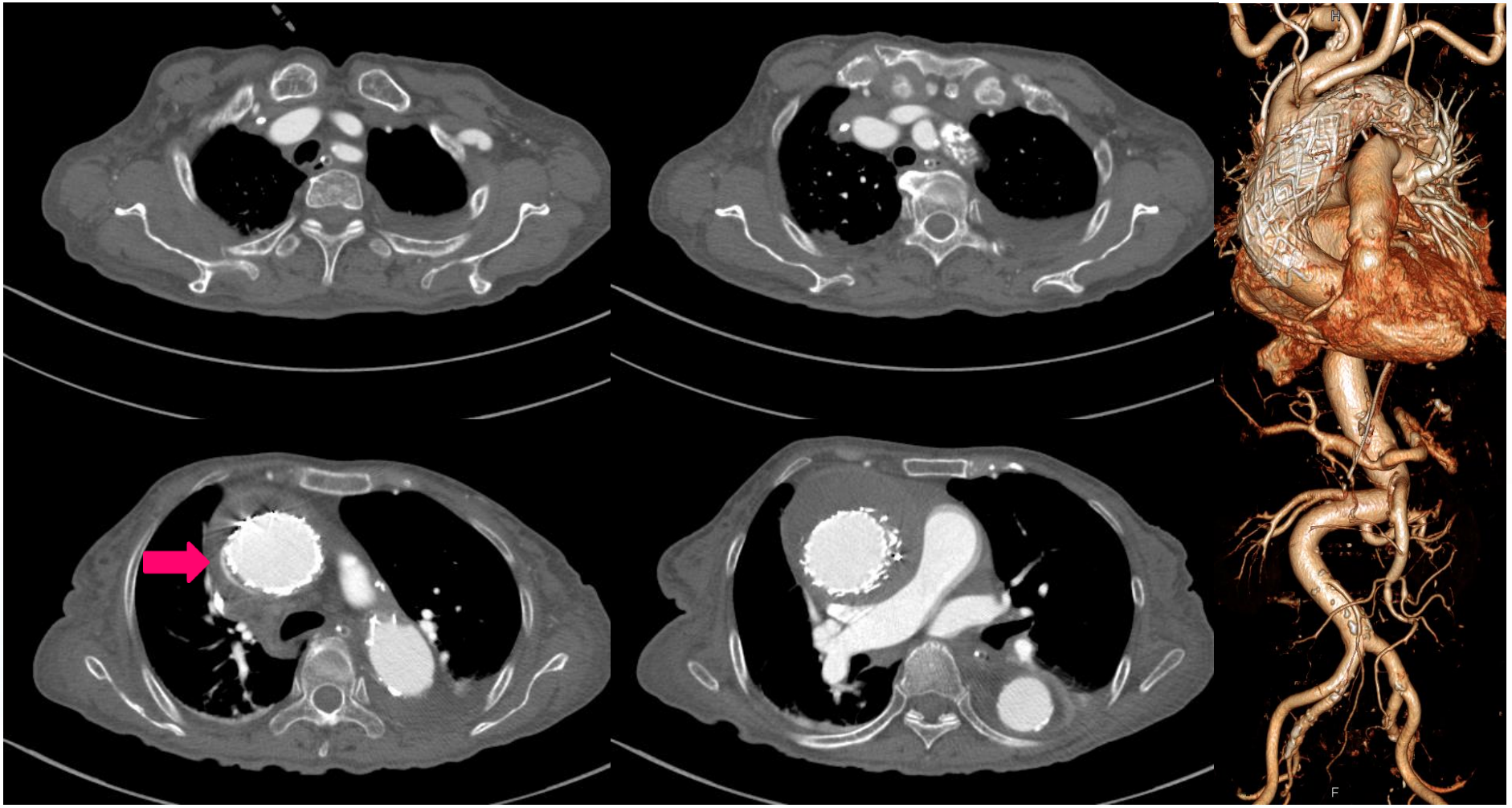
Ascending and Aortic Arch Stent Graft

: Final Angiography





CT aorta at 1month



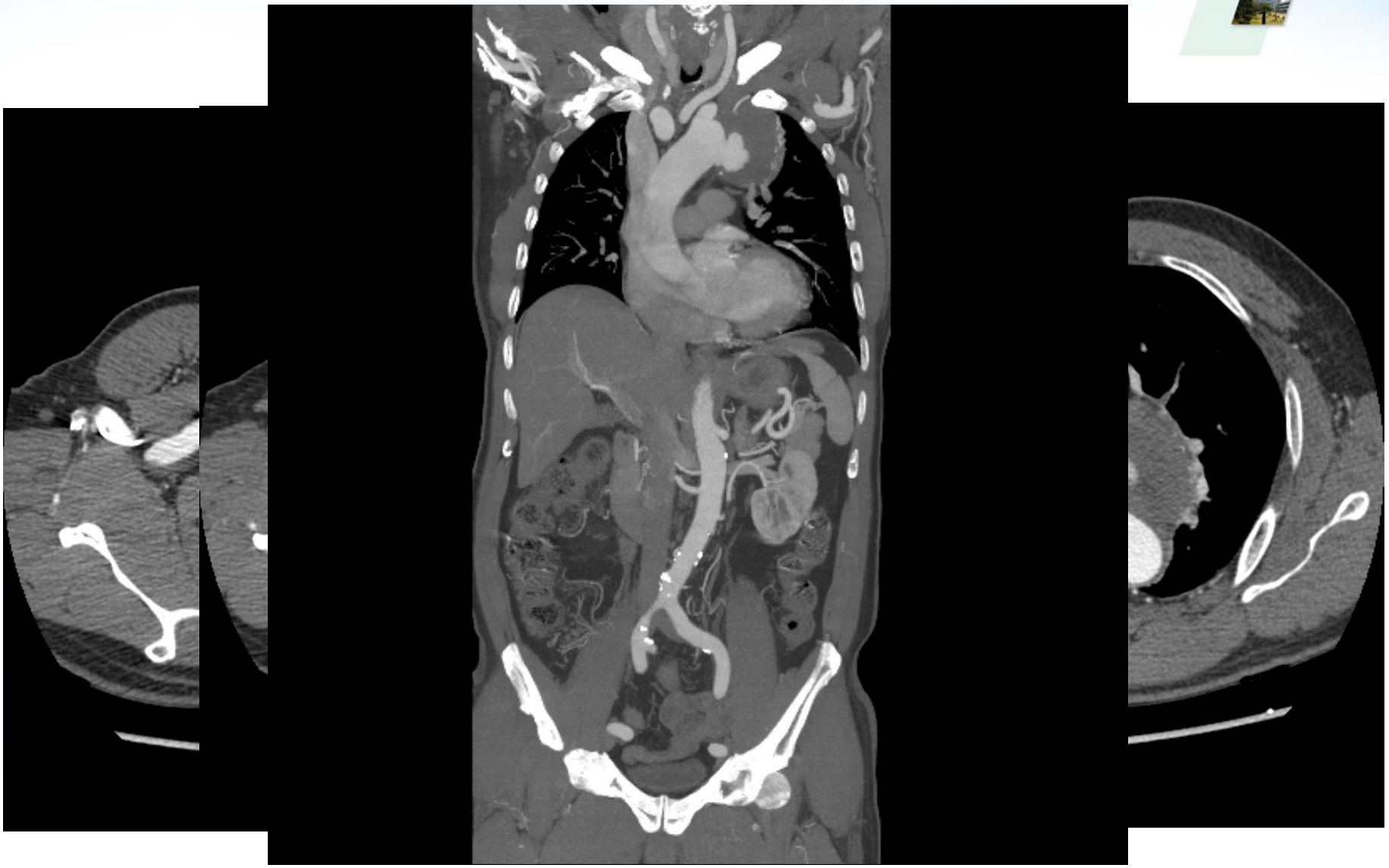
Indonesian Case

One Branch Type
Fenestrated Aortic Stent Graft

History

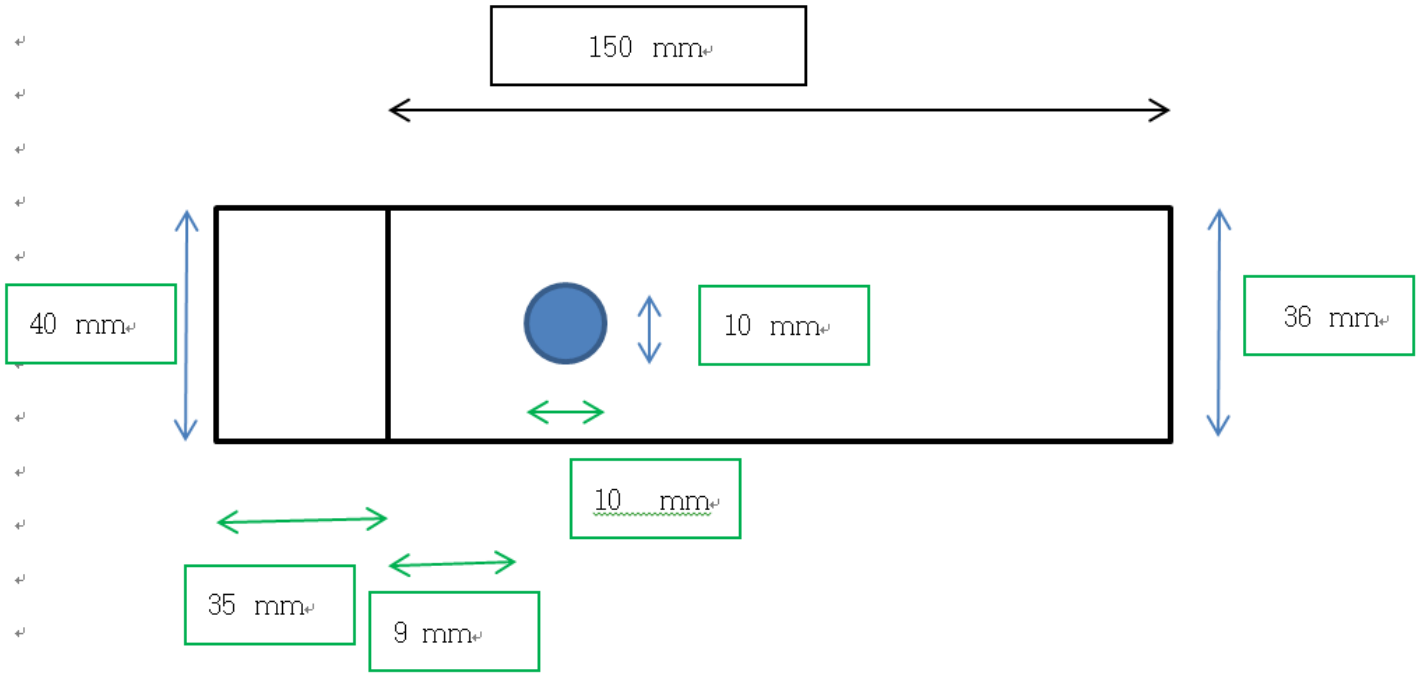
- A 65-year-old woman
- Saccular type aortic aneurysm in the aortic arch
- Proximal neck from left SCA to aneurysm : 6 mm

C T



One Branch Fenestrated Aortic Stent Graft

1. Main Fenestrated Stent Graft：



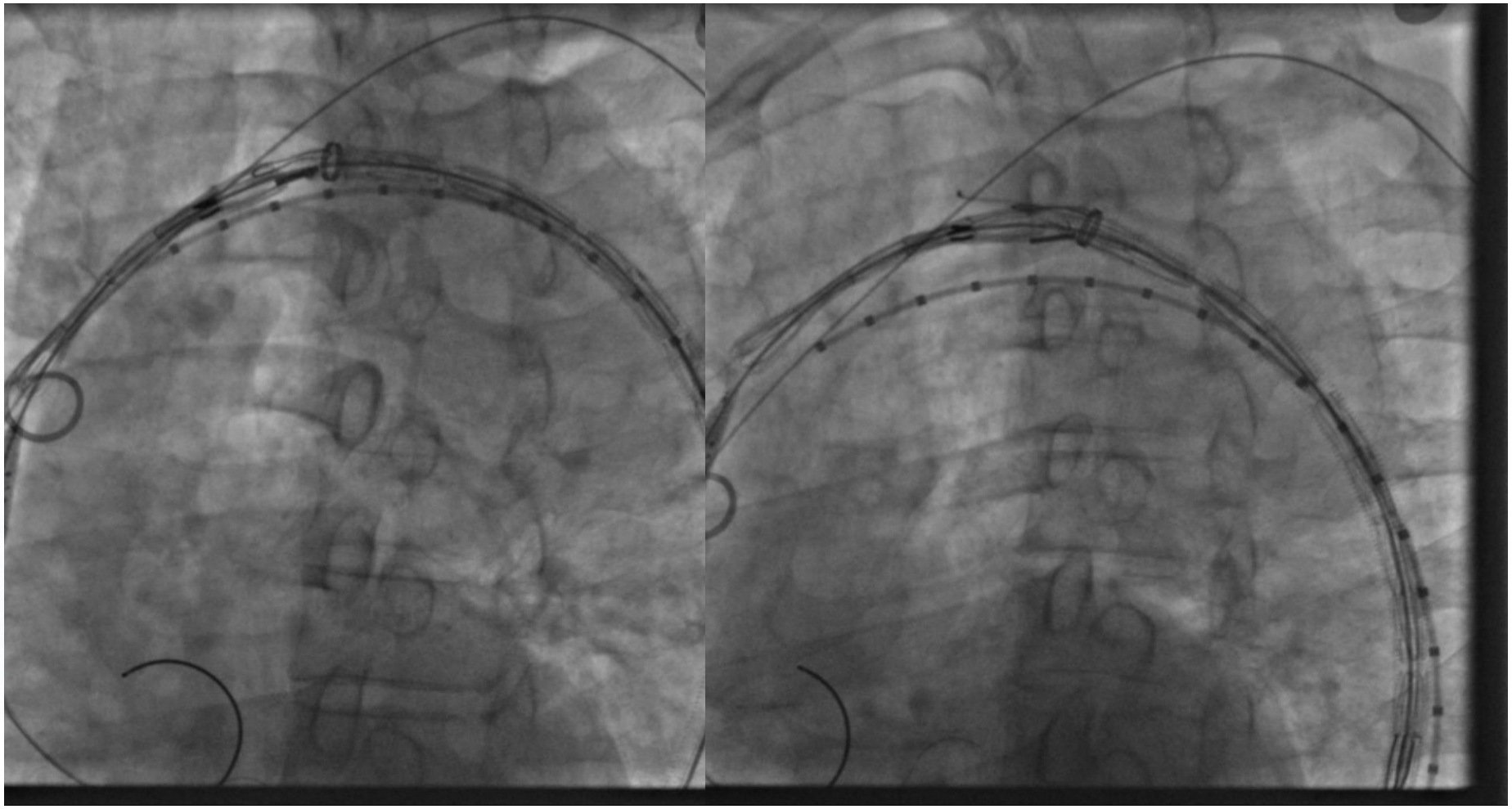
2. Side Branch Flare Stent Graft

12X30 flare graft stent

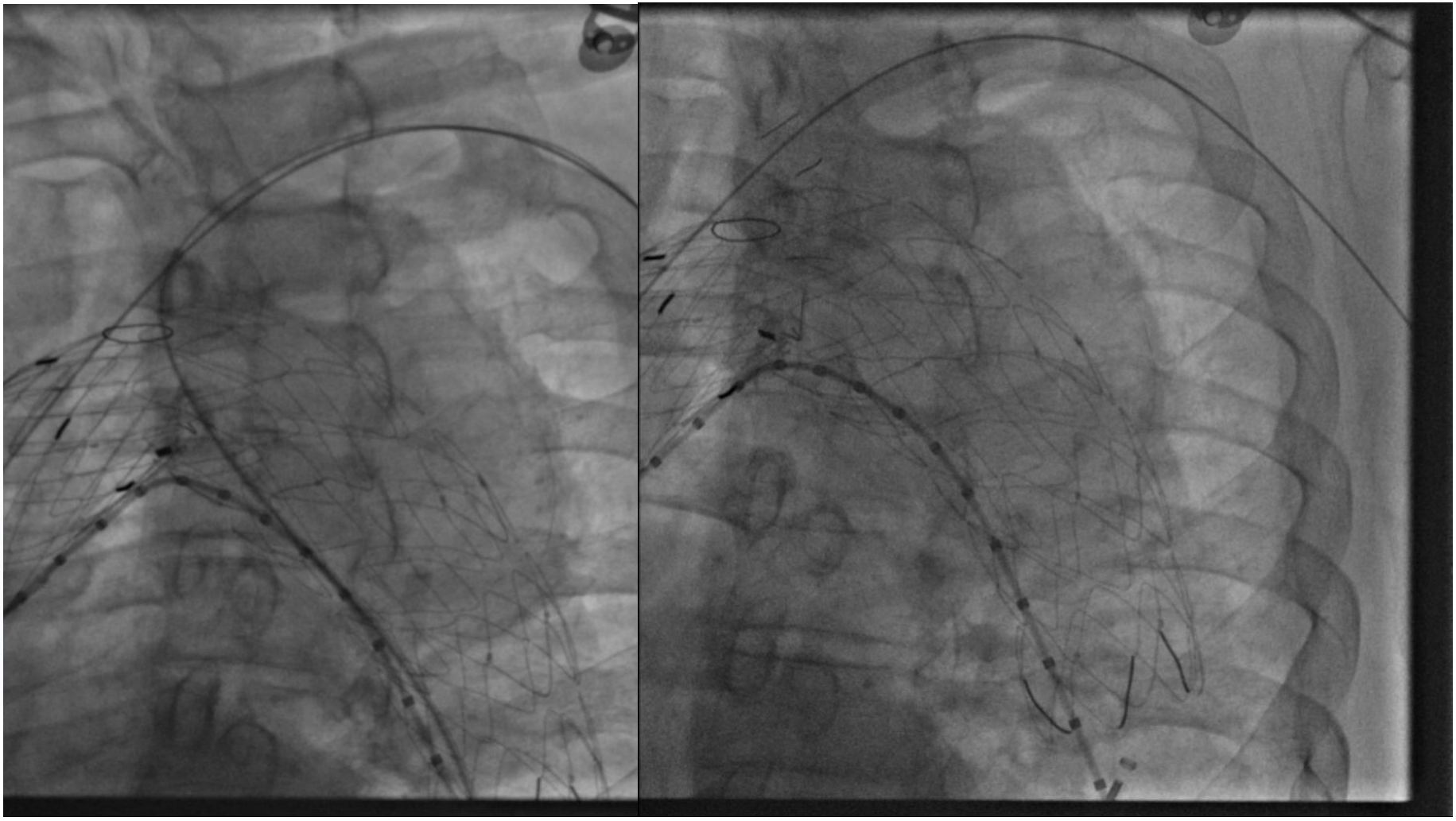
12X40 flare graft stent

One Branch Fenestrated Aortic Stent Graft

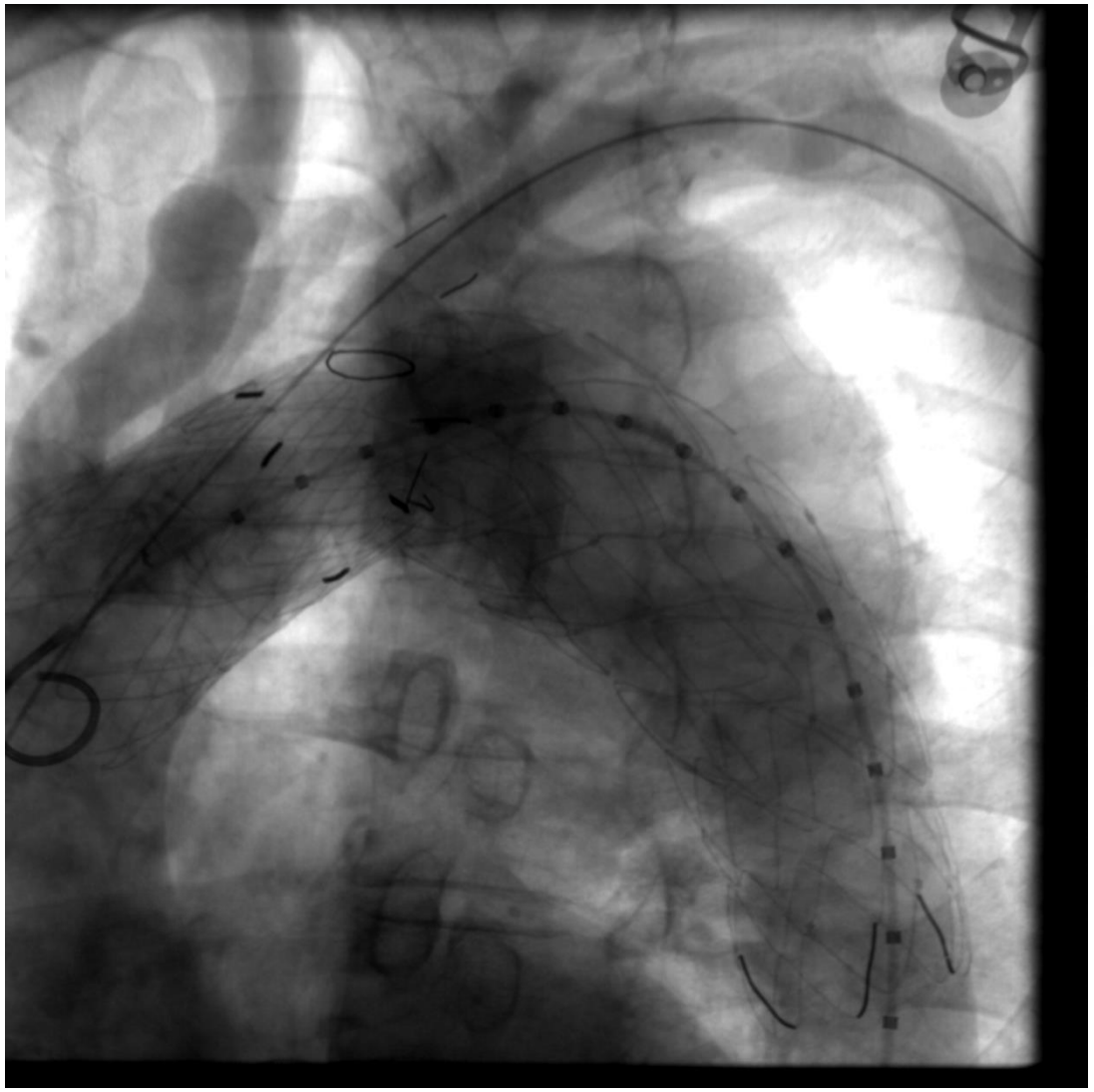
One Branch Fenestrated Aortic Stent Graft



One Branch Fenestrated Aortic Stent Graft



One Branch Fenestrated Aortic Stent Graft



Fatigue and MRI Test

Exponent

MRI Compatibility of S&G Biotech's Vascular Stents

Final Report

Prepared for
S&G Biotech, Inc.
Jungang Induspia, #304
449 Duncho-daero, Jungwon-gu
Seongnam-si, Gyeonggi-do
462-713, South Korea

Prepared by

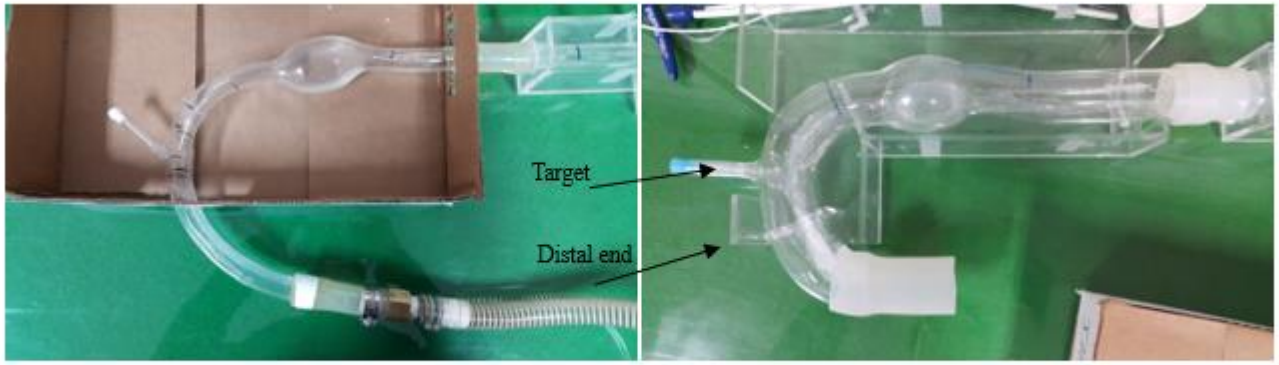
Exponent
3440 Market Street
Suite 600
Philadelphia, PA 19104

Summary of MRI compatibility test results.

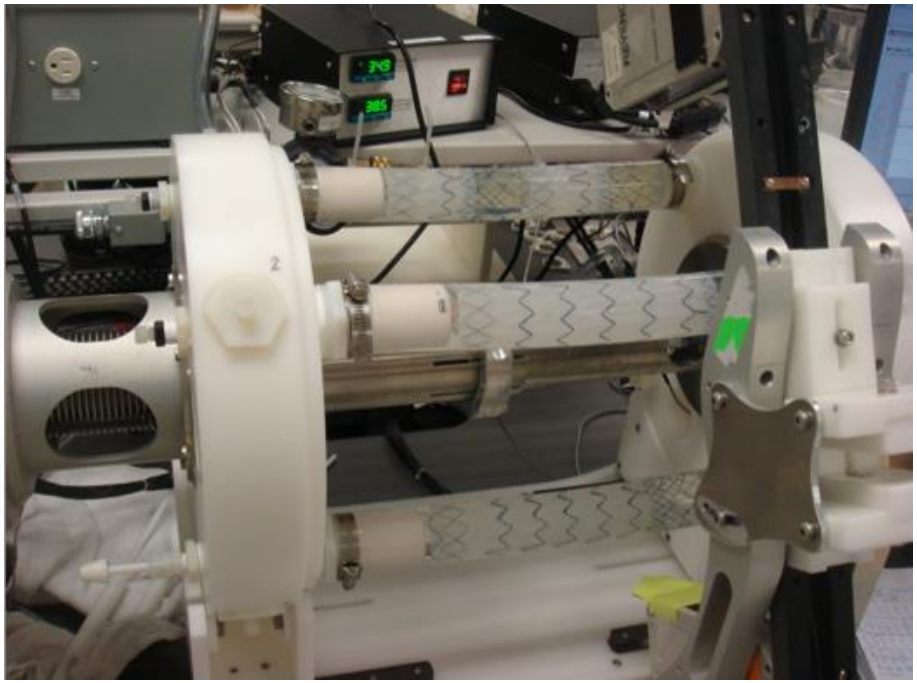
Evaluation	Field Strength	Results
Displacement Force (ASTM criteria)	3 T	PASS
Torque (Qualitative assessment)	3 T	PASS
Artifact (maximum ASTM)	1.5 T	0.5 cm
	3 T	0.9 cm
Heating† (maximum)	1.5 T	2.3°C
	3 T	2.7°C

† Maximum whole-body SAR of 4.0 W/kg

Fatigue and MRI Test



Phantom



ilac-MRA A2LA

Accredited Laboratory

A2LA has accredited

MEDICAL DEVICE TESTING SERVICES

Minnetonka, MN

for technical competence in the field of

Mechanical Testing

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 *General requirements for the competence of testing and calibration laboratories*. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009*).

Presented this 11th day of June 2015.

President & CEO
For the Accreditation Council
Certificate Number 2783.01
Valid to May 31, 2017

For the types of tests to which this accreditation applies, please refer to the laboratory's Mechanical Scope of Accreditation.

Clinical Study for Fenestrated Aortic Stent Graft : One Branch Type

프로토콜 요약

임상시험 명칭	분지혈관을 보호하는 개창형 대동맥 스텐트 그라프트 임상 연구 계획서 : 1 개의 분지 Type
임상시험 단계	제 ___상 임상시험 (식약청에서 선택하기로함)
목적	새로 개발된 분지혈관을 보호하는 개창형 대동맥 스텐트 그라프트의 안정성과 효과를 평가하기 위한 희귀의료기기 임상연구를 실시하기 위하여 이 서류를 제출합니다.
연구 방법	전향적, 다기관, 등록관찰연구
시험책임자	이한철 교수 부산대학교병원 순환기내과 602-739 부산시 서구 아미 1 동 Telephone: +82-51-240-7794, Fax: +82-51-240-7796 E-mail: glaraone@hanmail.net
임상시험 의뢰자	에스앤지 바이오텍

In Progress

- Waiting for approvel of KFDA (2015.11)

- Got for a medical patent in Korea, Apply in Europe

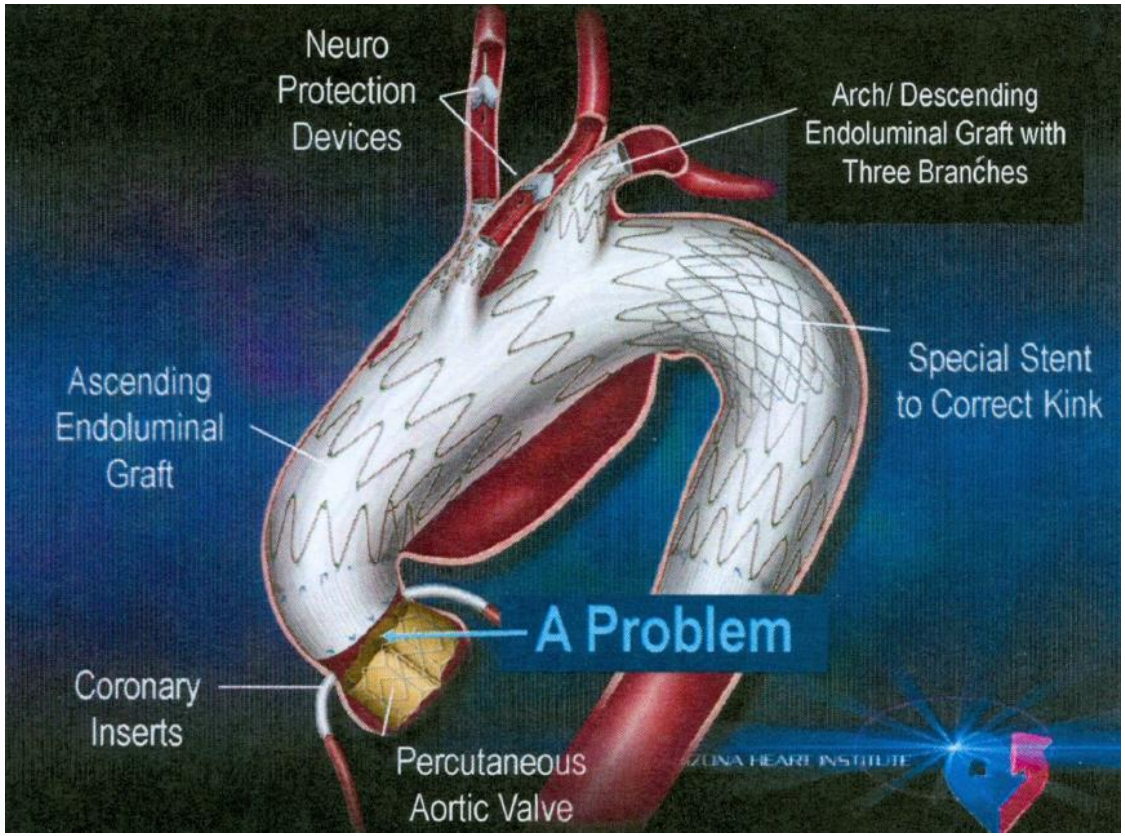
- Begin Fenestrated Aortic Stent Graft Registry
  1. Korean Registry
  2. Indonesia and East Asia Registry

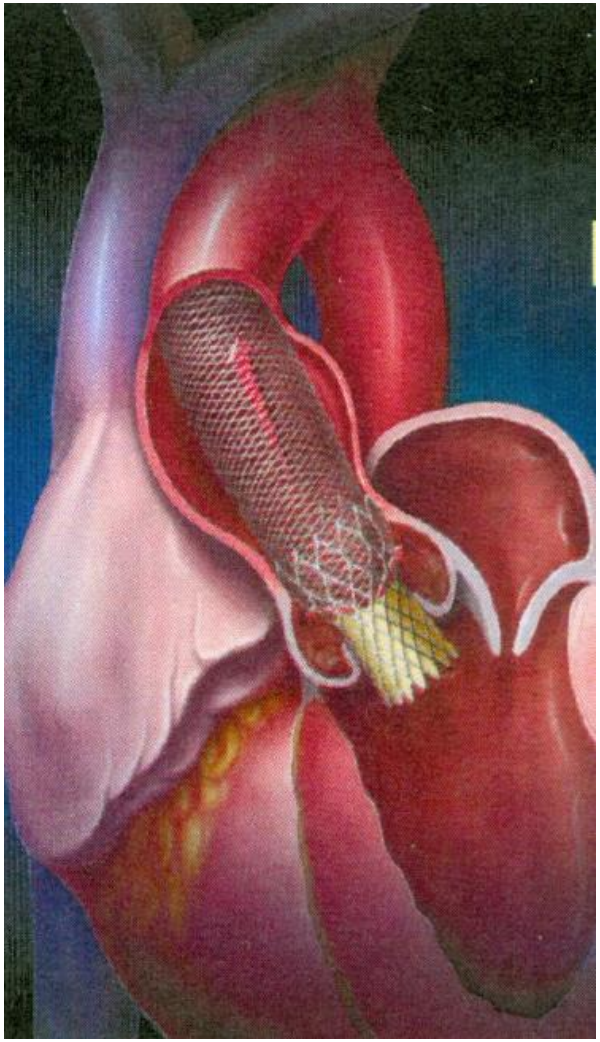
- Emergent Use of ready-made fenestrated aortic arch stent graft for emergent patients

Unsolved Problem

- Curvature of aortic arch
- Various anatomy of aorta, carotid, innominate artery
- Dynamic motion of aorta
- Endothelialization of stent graft
- Long term durability of stent graft ?

New Future ?


Neuro
Protection
Devices
Arch/ Descending
Endoluminal Graft with
Three Branches
Special Stent
to Correct Kink
Ascending
Endoluminal
Graft
A Problem
Coronary
Inserts
Percutaneous
Aortic Valve



부산대학교병원
PUSAN NATIONAL UNIVERSITY HOSPITAL

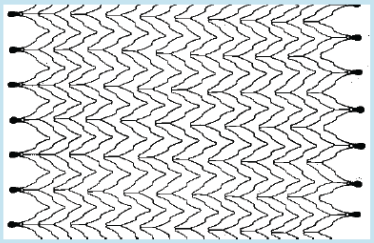
Development of Bioabsorbable Vascular Stent

Han Cheol Lee, MD, PhD.

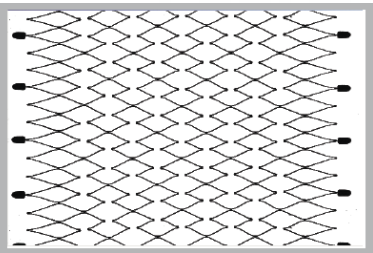
Divisionof Cardiology, Department of Internal Medicine, Pusan National University Hospital, Pusan, South Korea

Vascular Stent

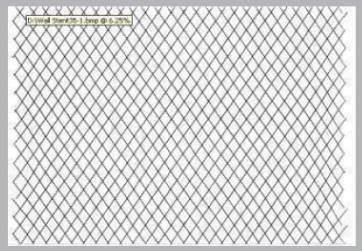
Vascular Stent



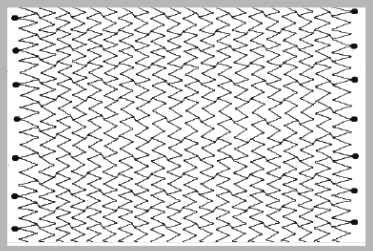
ABSOLUTE™ .035



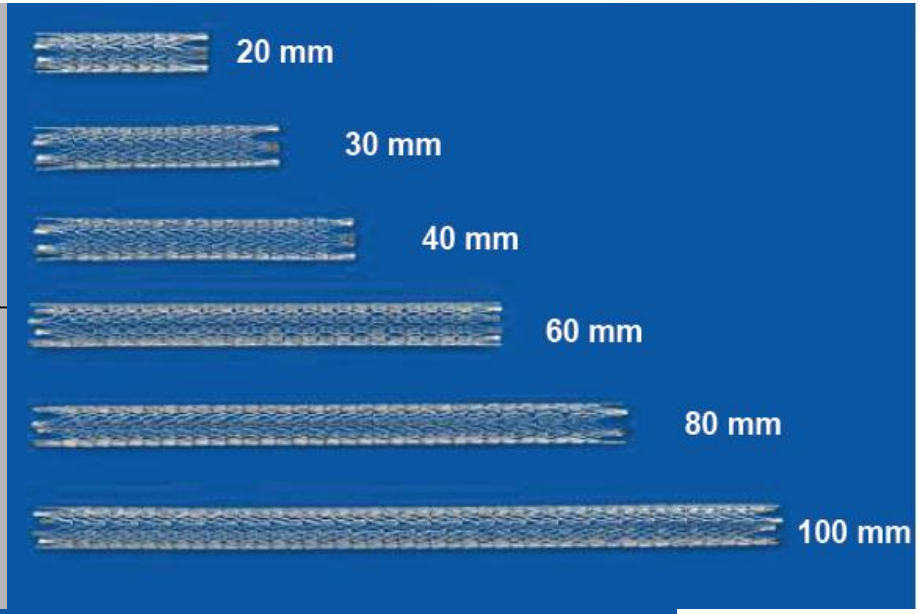
Stent A

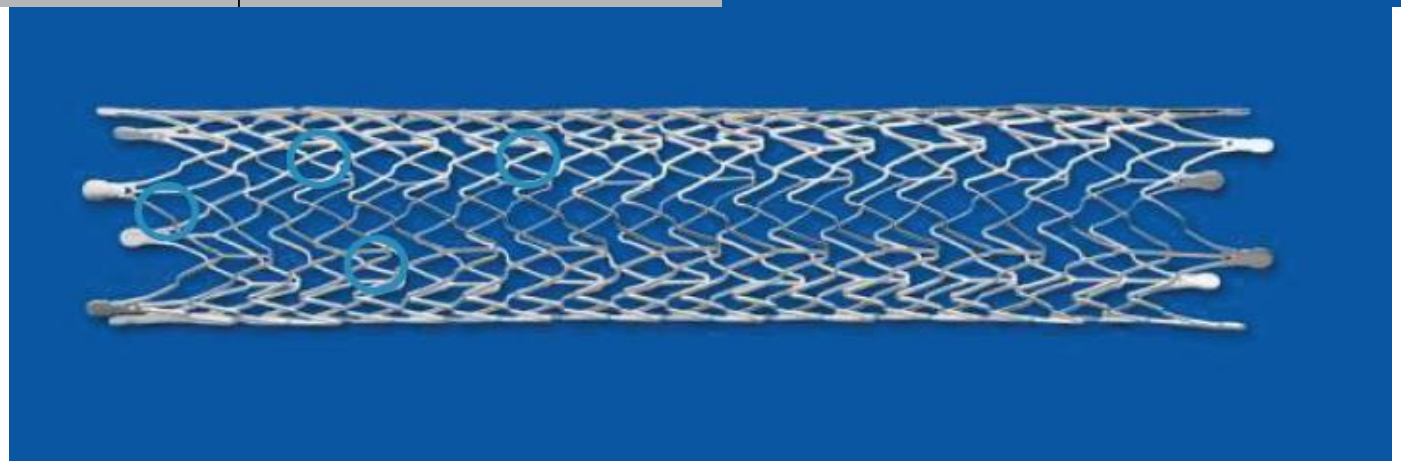


Stent B



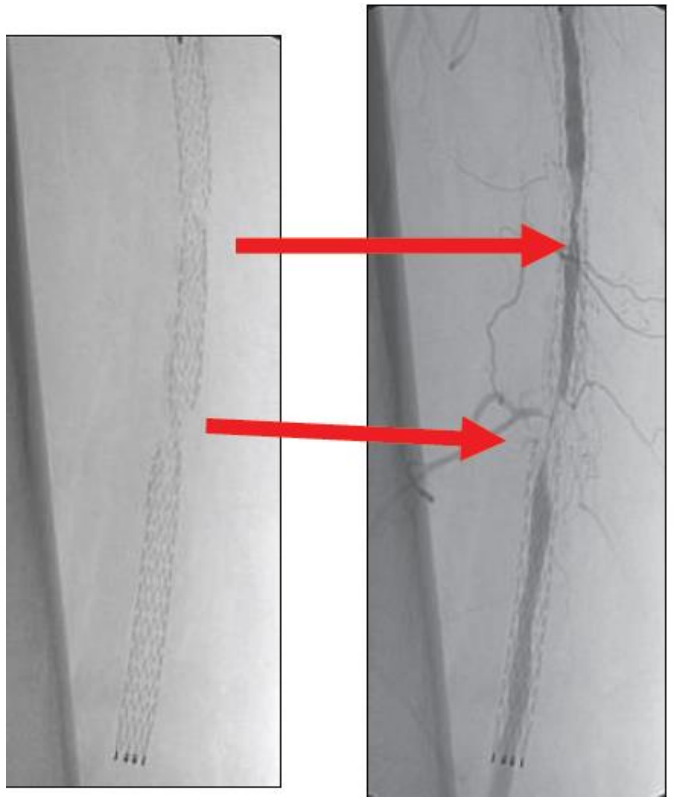
Stent C



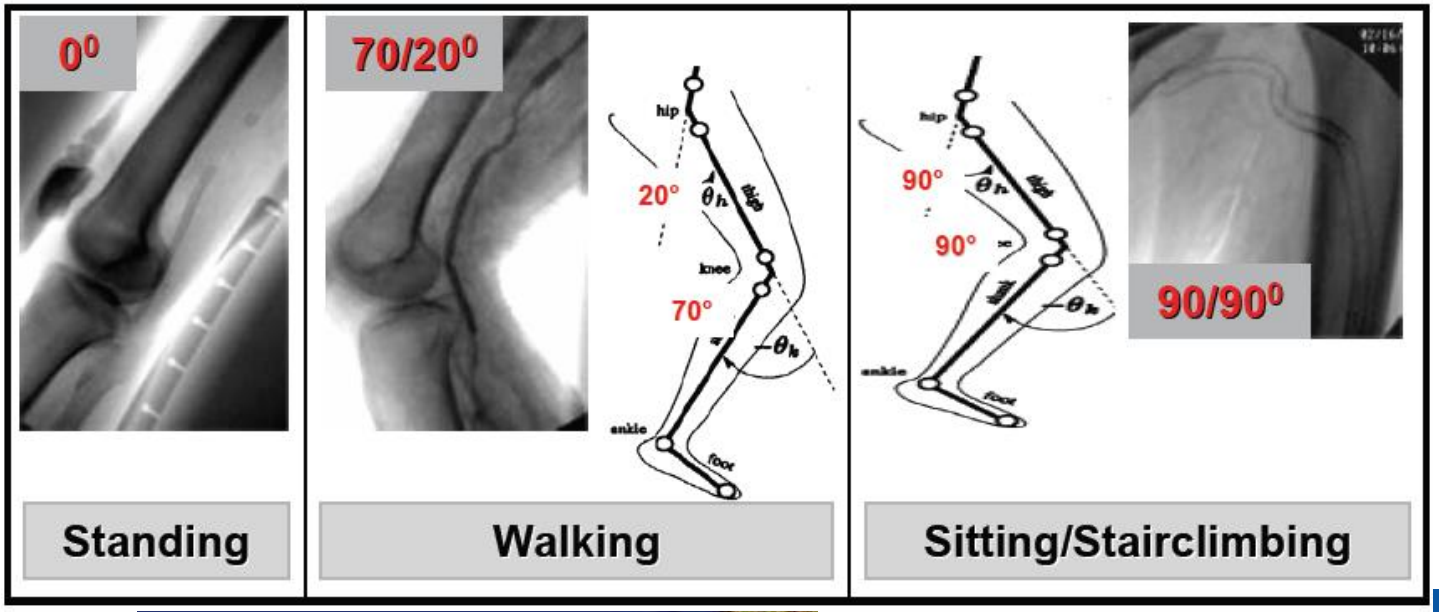


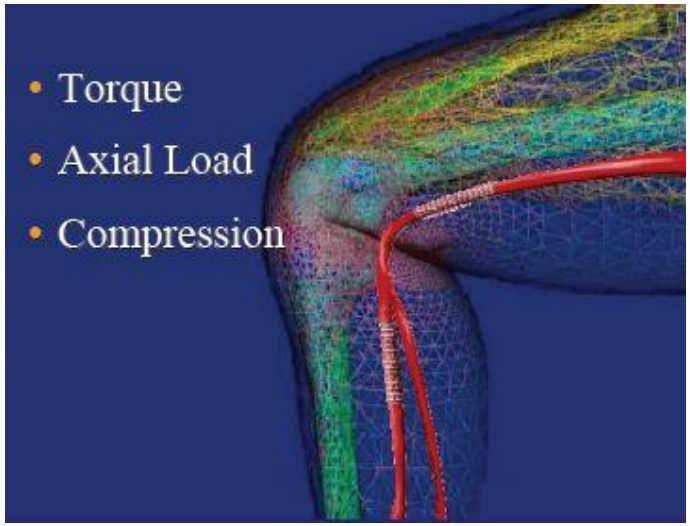
Limitations of Vascular Stent

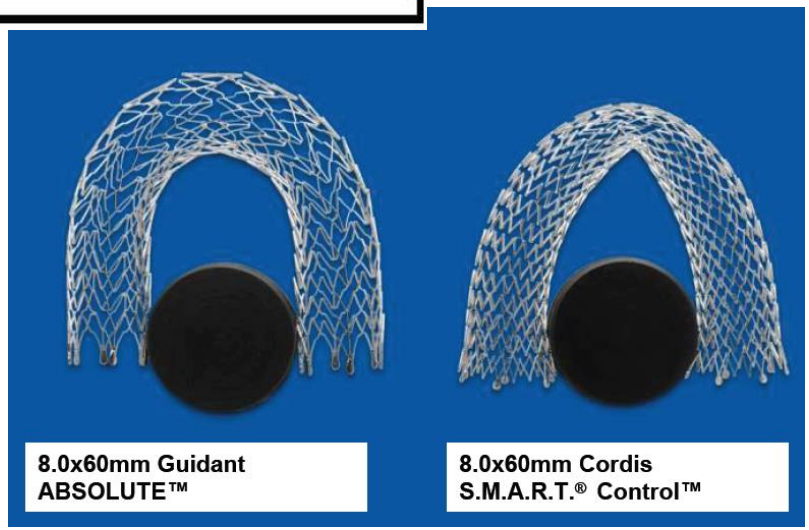
- Material: Nitinol
- **Restenosis (SFA : 50-60%)**
- **Articulation (Hip, Knee joint)**
- Poor clinical result of DES
- Problem : trauma



Vascular Stent

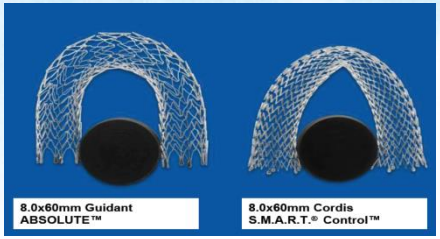






Bioabsorbable Vascular Stent

- Available at the Hip, Knee joint
- Low restenosis rate
- Low trauma



Bioabsorbable Vascular Stent

- Polymer based bioabsorbable stent
- Metal based bioabsorbable stent
- Strong radial force
- Absorption rate > 3-6 months.
- Flexibilty at the Hip and Knee joint.

Bioabsorbable Vascular Stent

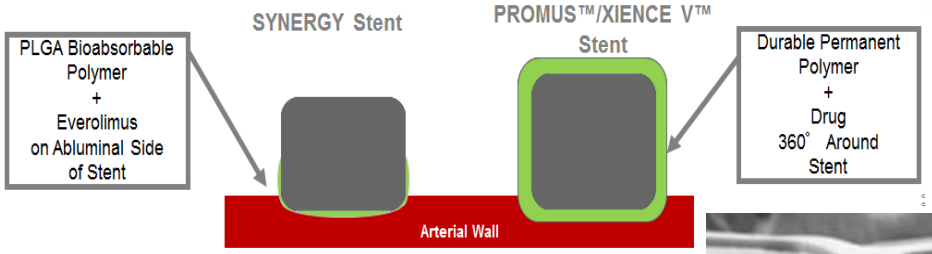
- **Metal based**

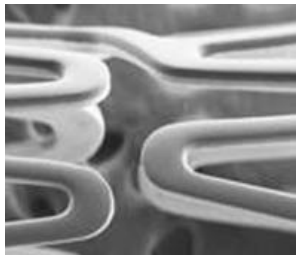
- **Polymer based**

Manufactoring of Stent

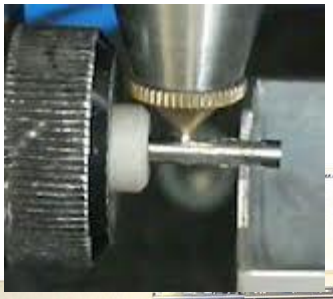
4. Drug Eluting

1. 7mm X 30mm bioabsorbable Tube



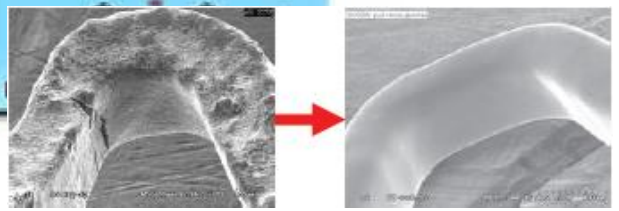


2. Stent Design and Laser Cutting



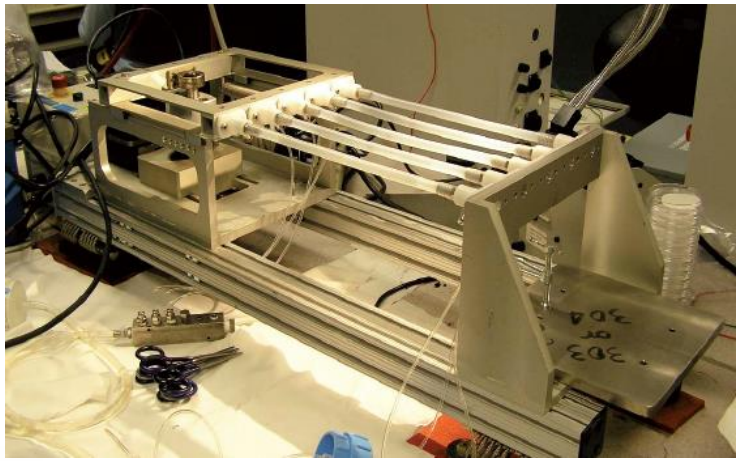
3. Polishing

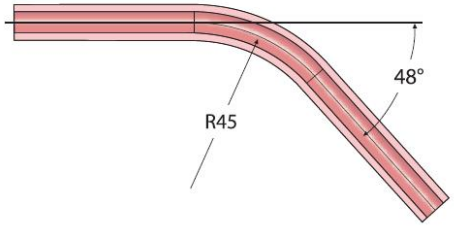
WonderShine



Manufactoring of Stent

5. Fatigue Testing

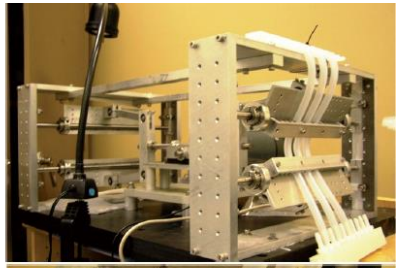


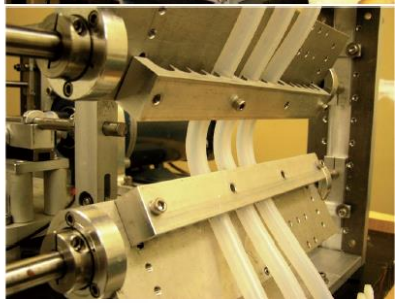


Bend Angle, Radius: 48°, 45mm

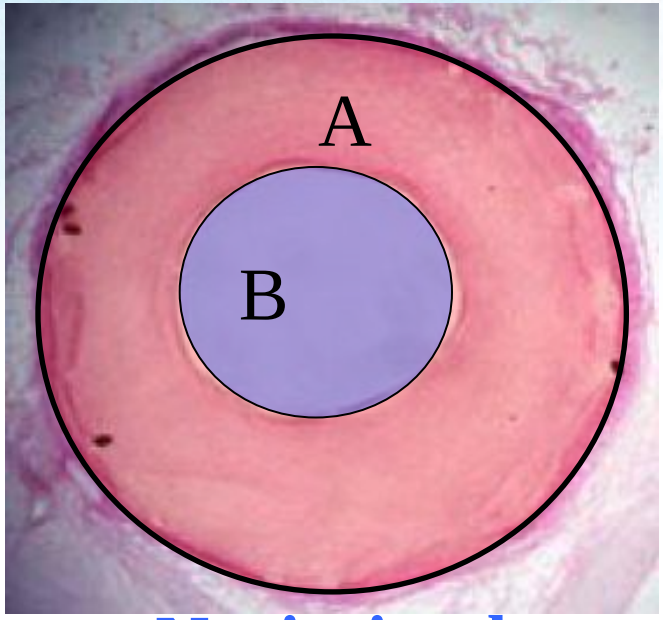
Total Cycles: 10 million cycles (assuming worst case of 1 million cycles per year)

Frequency: 7 Hz



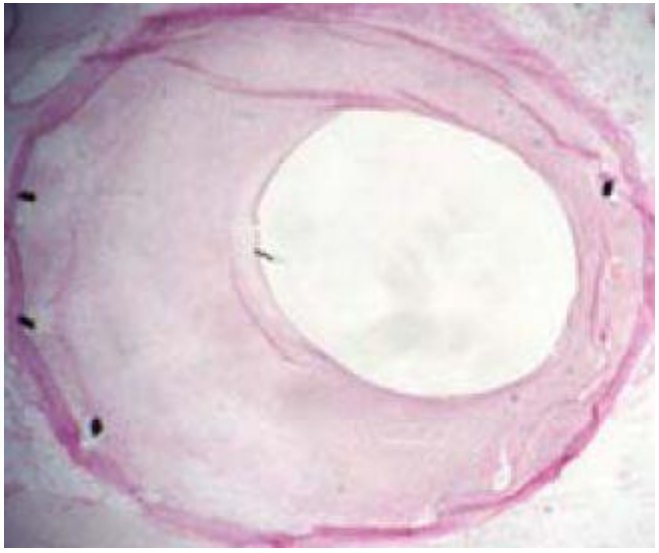


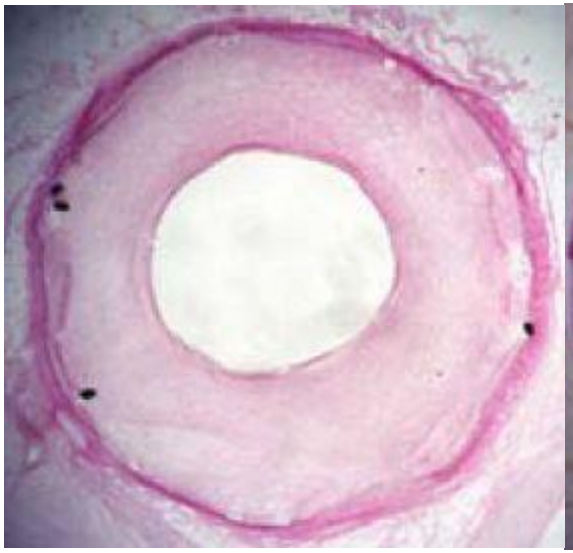
Animal Examination

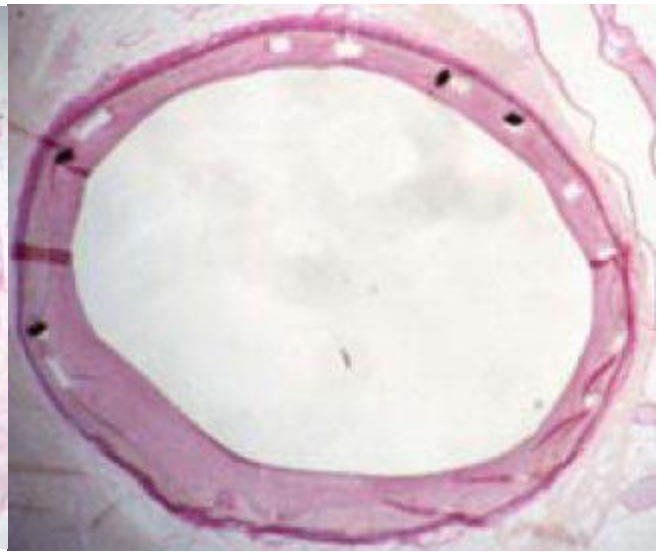


Neointimal space

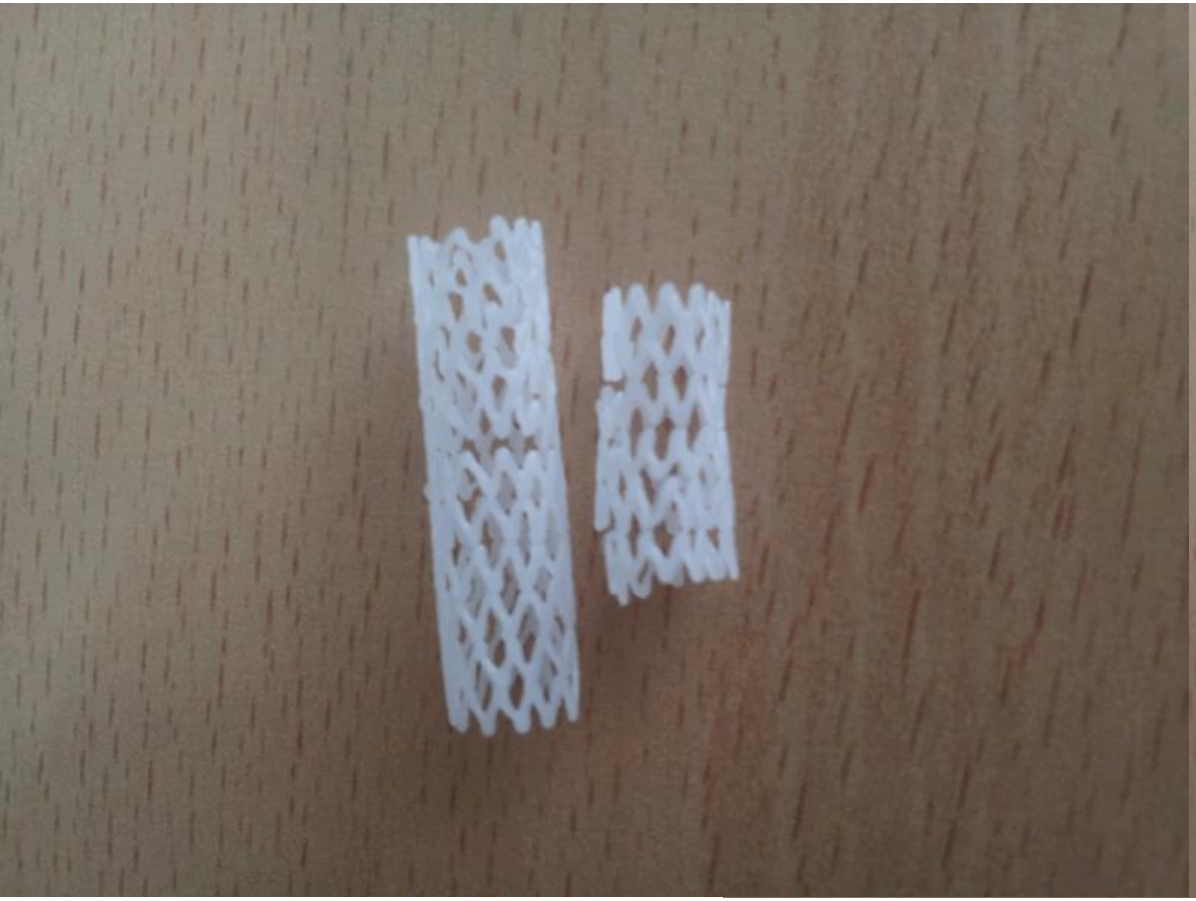
= A-B







Proto Type of Bioabsorbale Vascular Stent : Polymer developed by PNUH and Postech

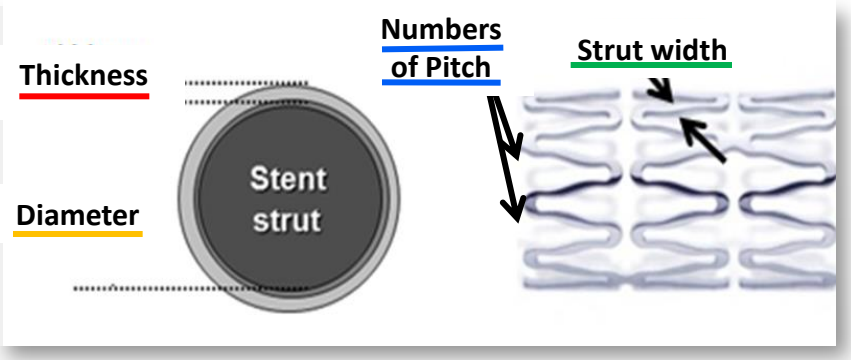


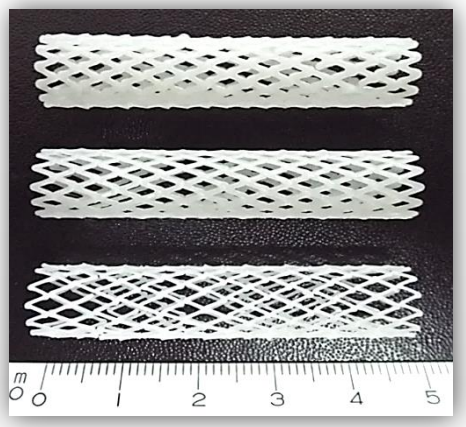
Radial force : 기존 vascular stent 1.0 N, PNUH stent 1.1N

Bioabsorable Peripheral Polymer Stent : PNUH and Postech

- **Fabrication of mesh type stent**

Terms of stent structure



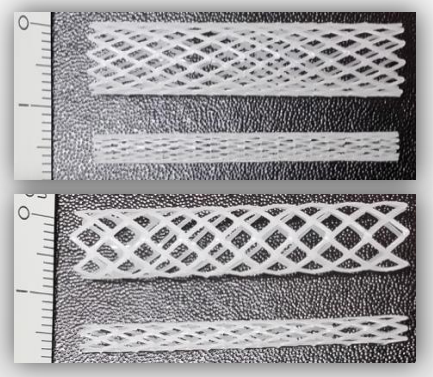


800 μm

660 μm

330 μm

Strut width



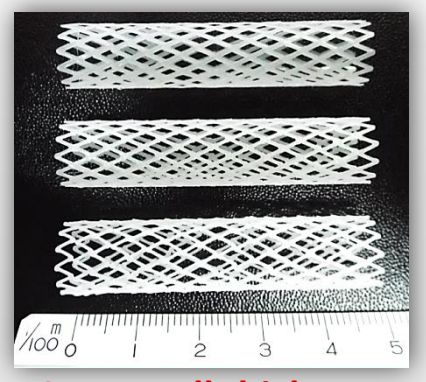
8mm

3mm

8mm

3mm

Stent diameter

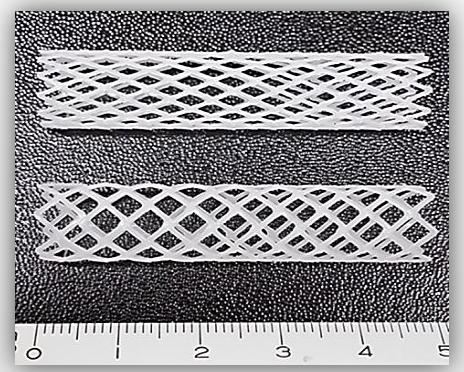


200μm

400μm

600μm

Stent wall thickness

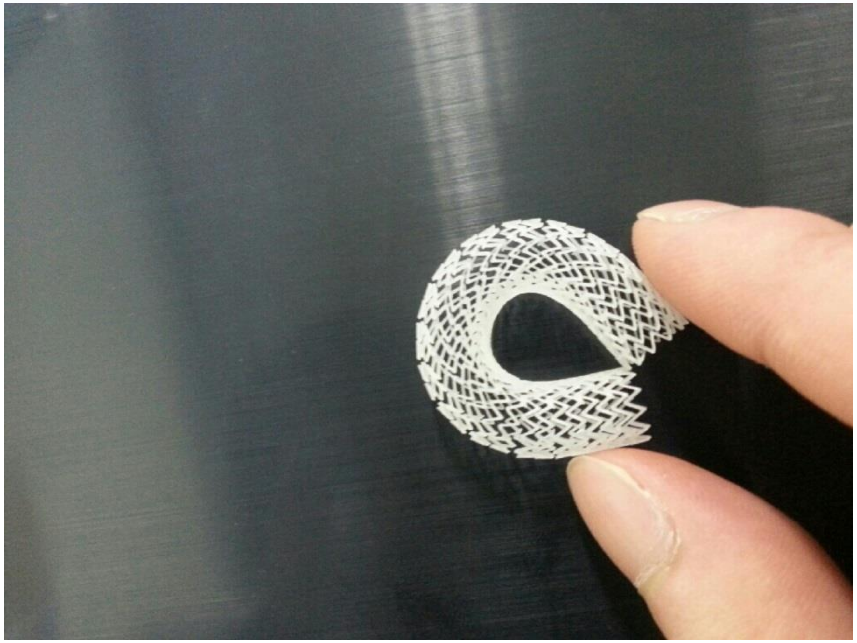


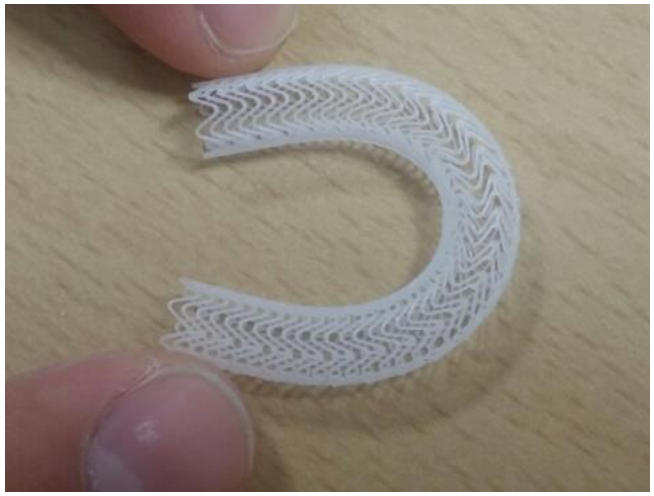
12 pitch

6 pitch

Pitch

Bioabsorable Peripheral Polymer Stent : PNUH and Postech





Patency

1	특허명	스텐트, 스텐트 삽입장치 및 이를 이용한 시술방법		
등록인		*이한철 · 강성권*	국/내외 구분(국가)	*국내(대한민국)*
등록번호		출원번호 10-2012-0054741	등록년월일	출원날짜 2012-05-23

2	특허명	심장판막 고정장치		
등록인		이한철 · 강성권 · 제갈승환 · 장의수	국/내외 구분(국가)	*국내(대한민국)*
등록번호		출원번호 10-2013-0050795	등록년월일	출원날짜 2013-05-06

3	특허명	스텐트, 스텐트 삽입장치 및 이를 이용한 시술방법		
등록인		이한철 · 강성권 · 정소희	국/내외 구분(국가)	PCT출원
등록번호		출원번호 PCT/KR2013/003624	등록년월일	출원날짜 2013-04-26

4	특허명	스텐트, 스텐트 삽입장치 및 이를 이용한 시술방법		
등록인		이한철/조동우/심진형/하동헌/윤원수	국/내외 구분(국가)	*국내(대한민국)*
등록번호		출원번호 10-2013-0095812	등록년월일	출원날짜 2013.08.13

Thanks for Our Team

순환기내과

: 김진희, 안진희, 이혜원, 이한철, 차광수, 홍택종

흉부외과 : 송승환, 김상필,

병리과 : 김지연

의학연구소 수의사 : 박종하

부산대학교병원
PUSAN NATIONAL UNIVERSITY HOSPITAL

Thank you for your attention