YONSEI UNIVERSITY

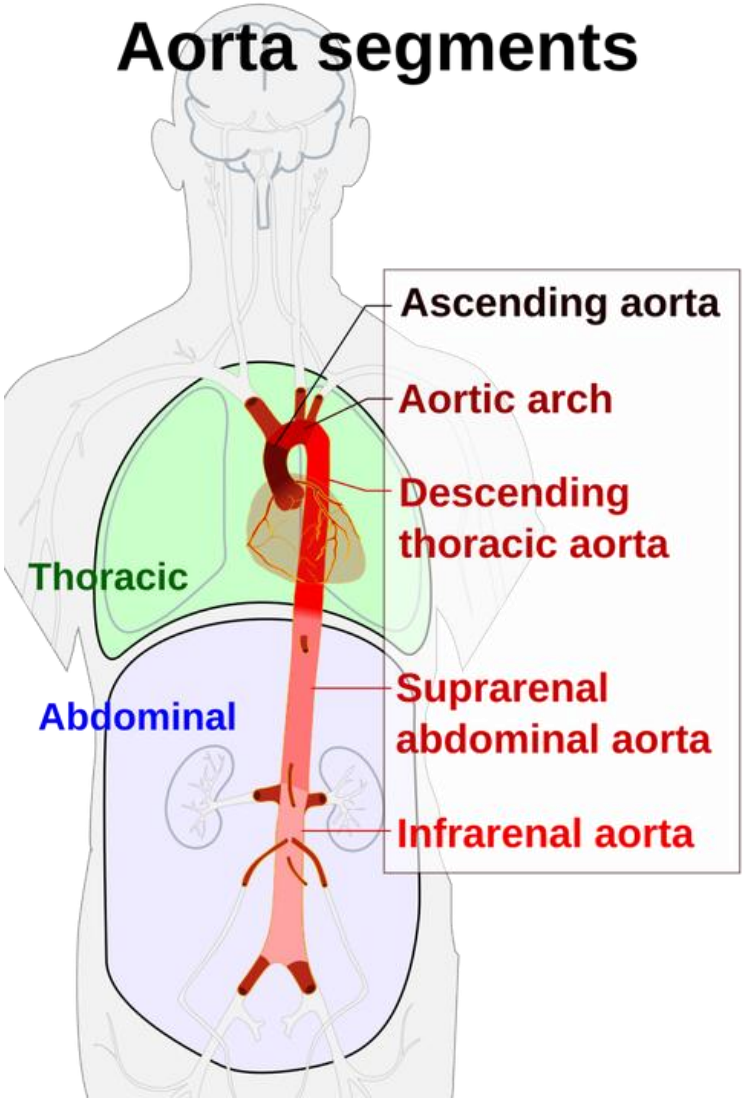
Techniques and complications of aortic surgery

Tae-hoon Kim, M.D.

Aorta & Vascular Center
Gangnam Severance Hospital
Yonsei University College of Medicine

Aorta Surgery

- **Aortic root surgery**
- **Arch surgery**
- **Thoracoabdominal surgery**



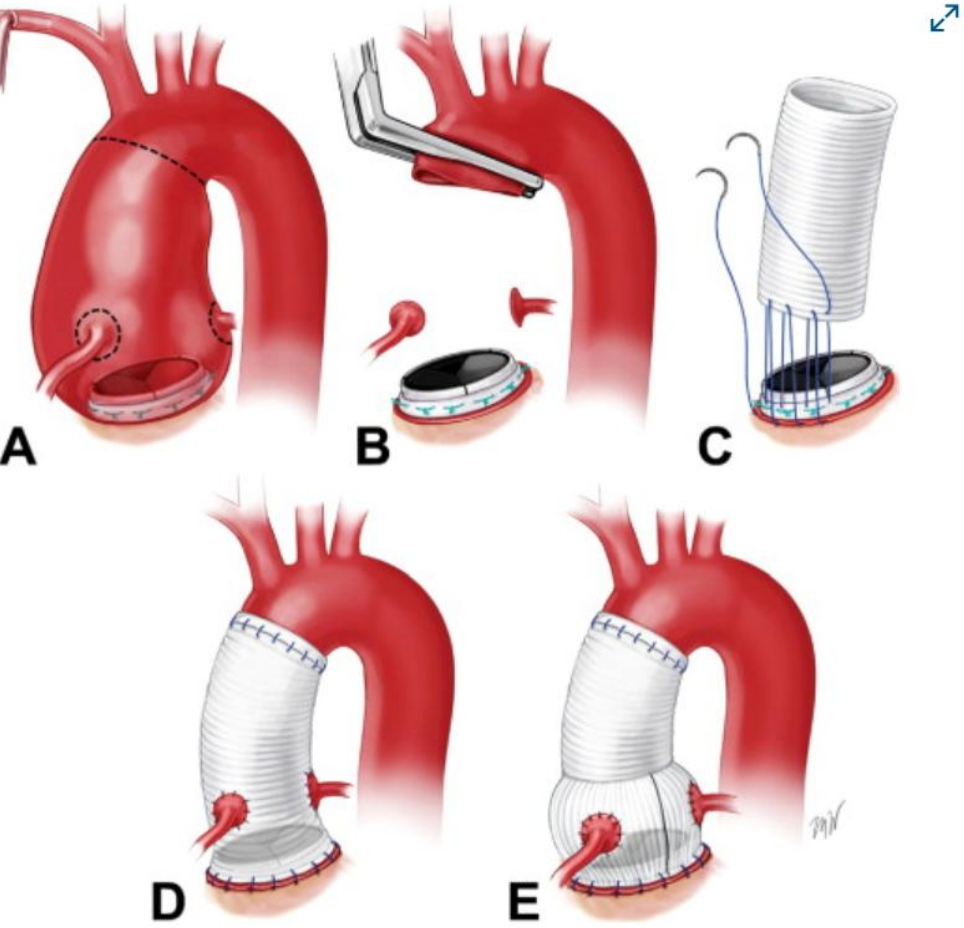
Aorta Surgery

Aortic root surgery

- **Bentall operation**
- **Valve sparing root replacement**

Aorta Surgery

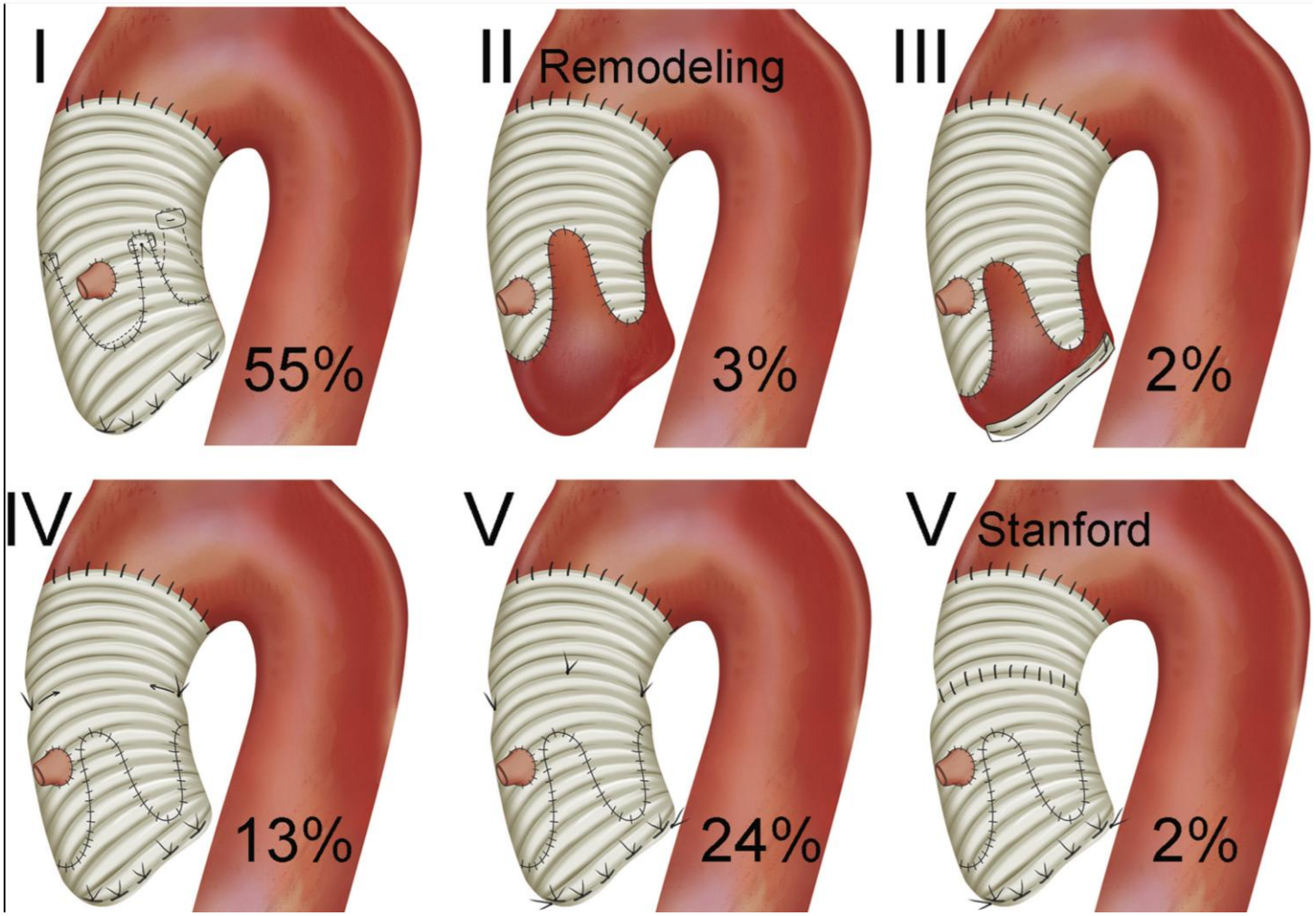
Bentall operation



- Aortic root and AscAo replacement
- AVR
  - Tissue
  - Mechanical
- Coronary reimplantation

Aorta Surgery

Valve sparing aortic root replacement



Aorta Surgery

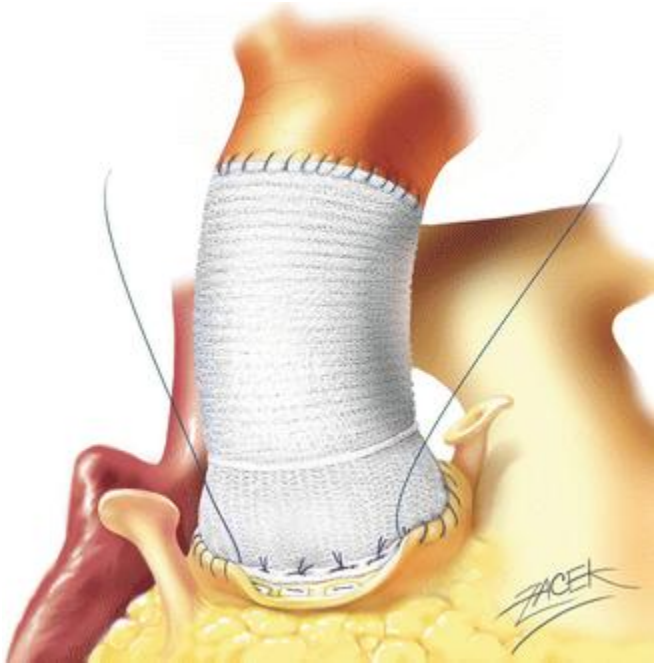
Complications

- **Bleeding**
- **Conduction**
- **Valvular dysfunction**
- **Coronary problem**

Aorta Surgery

Complications

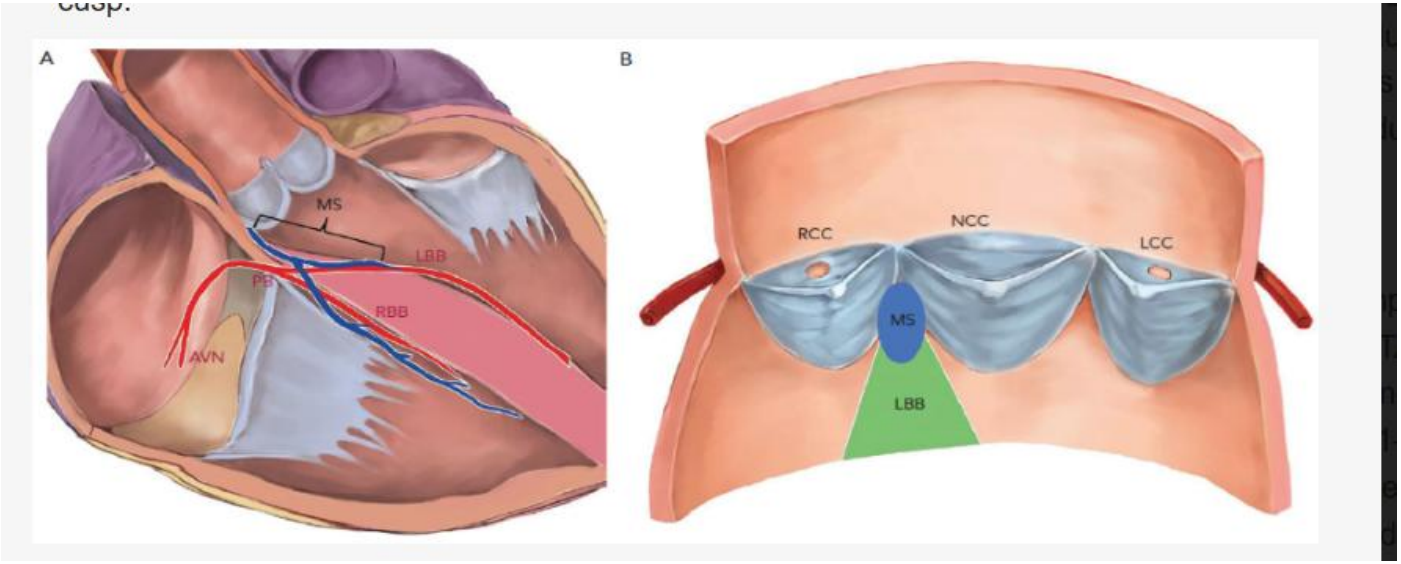
- **Bleeding**
  - **Why ?**
    - **Root anastomosis**
      - **Not visible after ACC off**
    - **Coronary re-implantation**
      - **Not visible after ACC off (LCA)**
  - **How to overcome ?**



Aorta Surgery

Complications

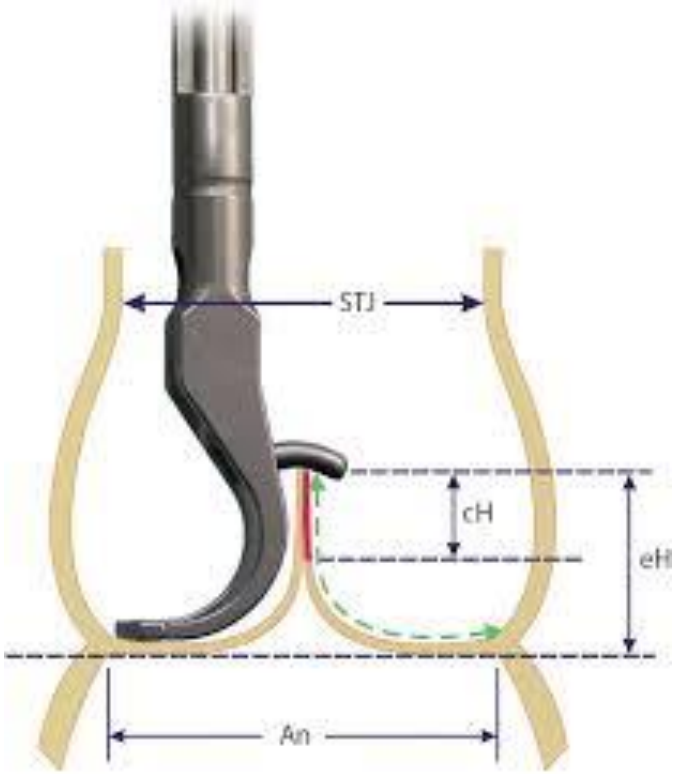
- **Bleeding**
- **Conduction**
- **Valvular dysfunction**

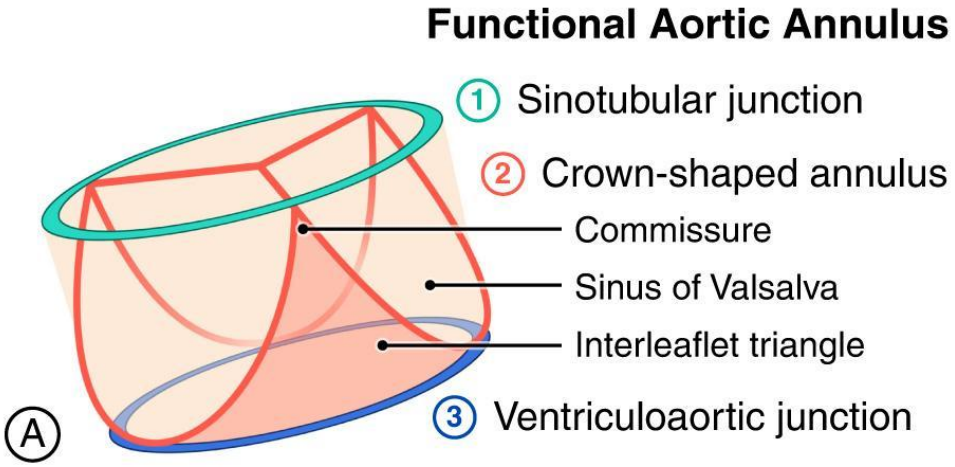


Aorta Surgery

Complications

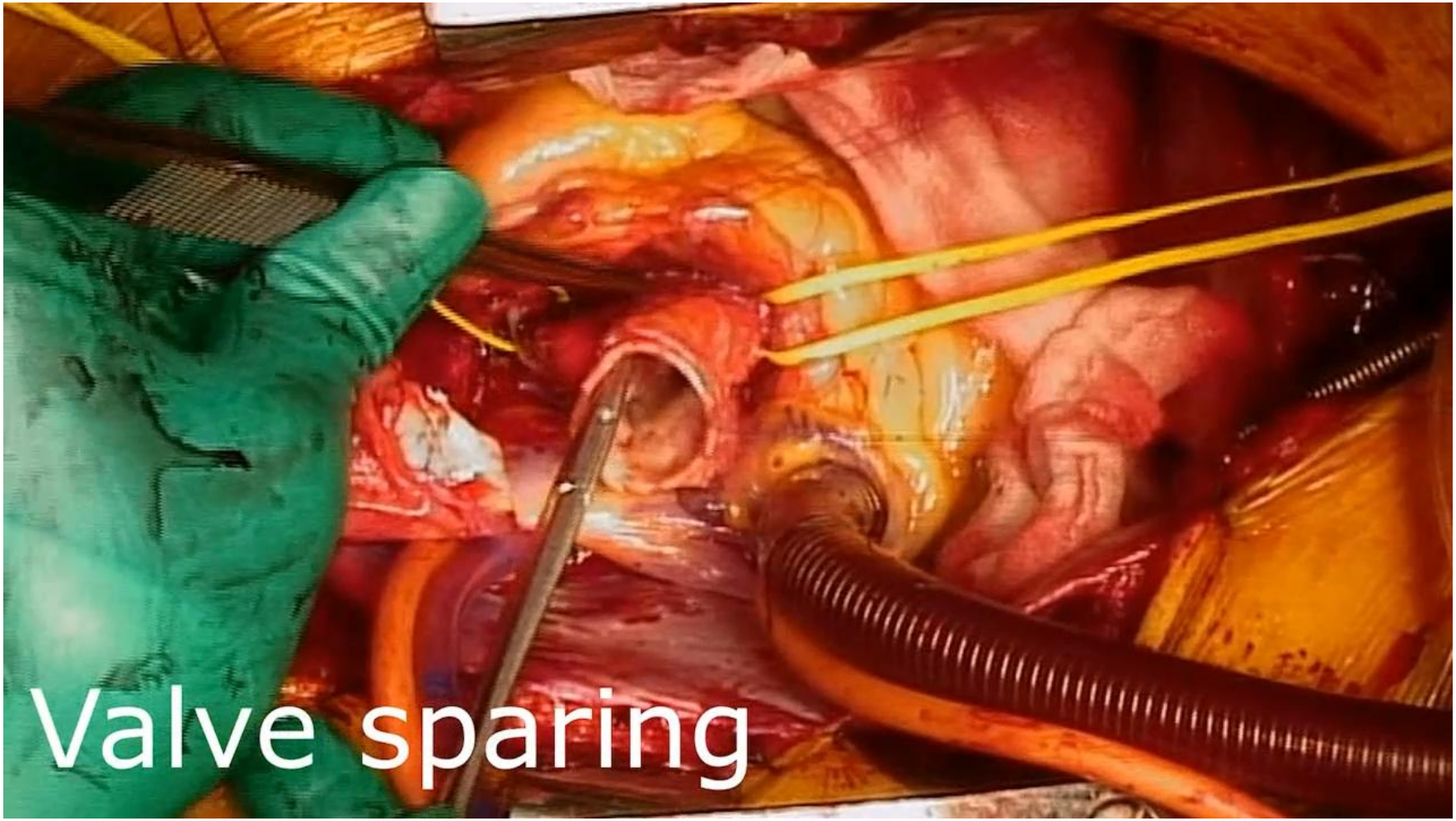
- **Bleeding**
- **Conduction**
- **Valvular dysfunction**



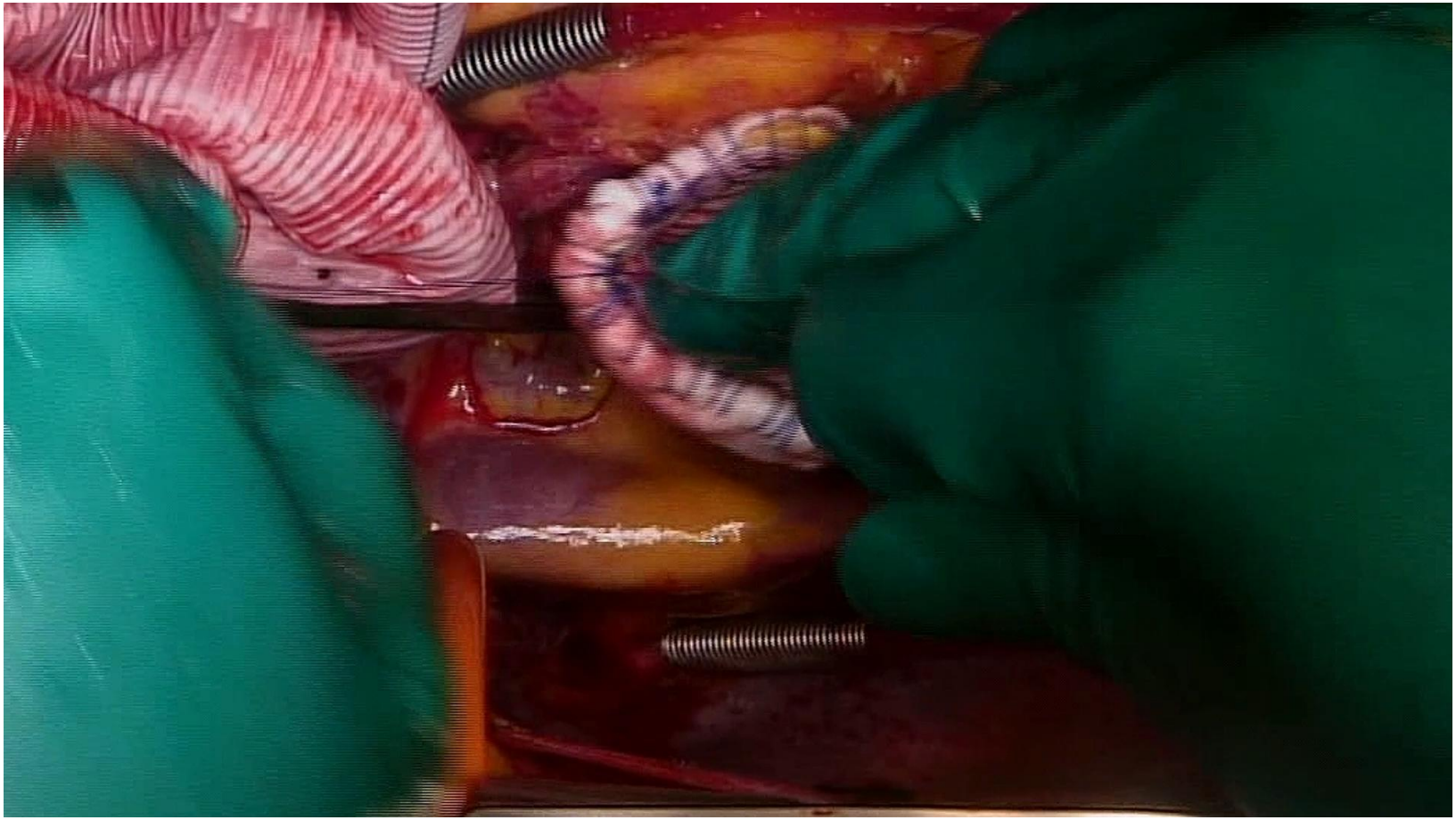


Aorta Surgery

Complications



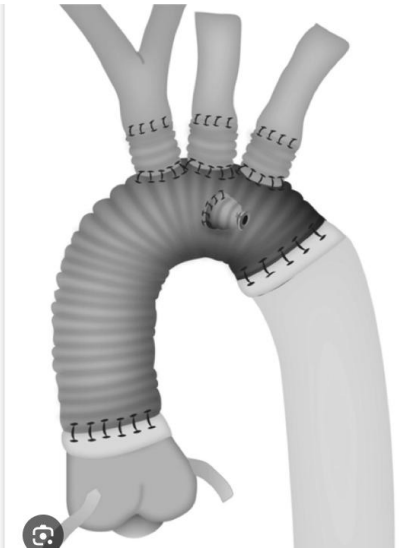
Aorta Surgery



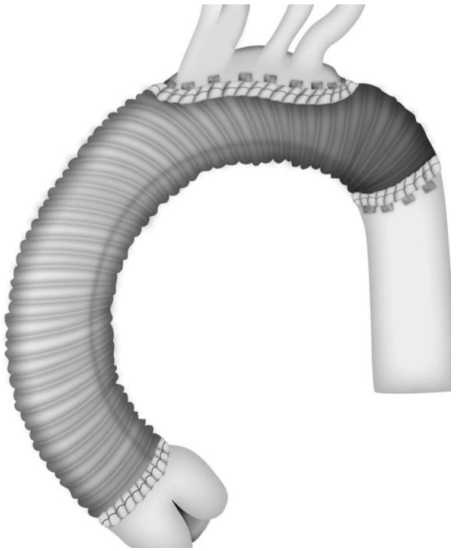
Aorta Surgery

Arch surgery

- **Total arch replacement**
- **Total arch replacement**
  - **Elephant trunk**
  - **Frozen Elephant trunk**



Zone 1-2-3
Single vessel/anastomosis



Zone 0-1
Single vessel anastomosis

Branched

Trifurcated

Aorta Surgery

Arch surgery

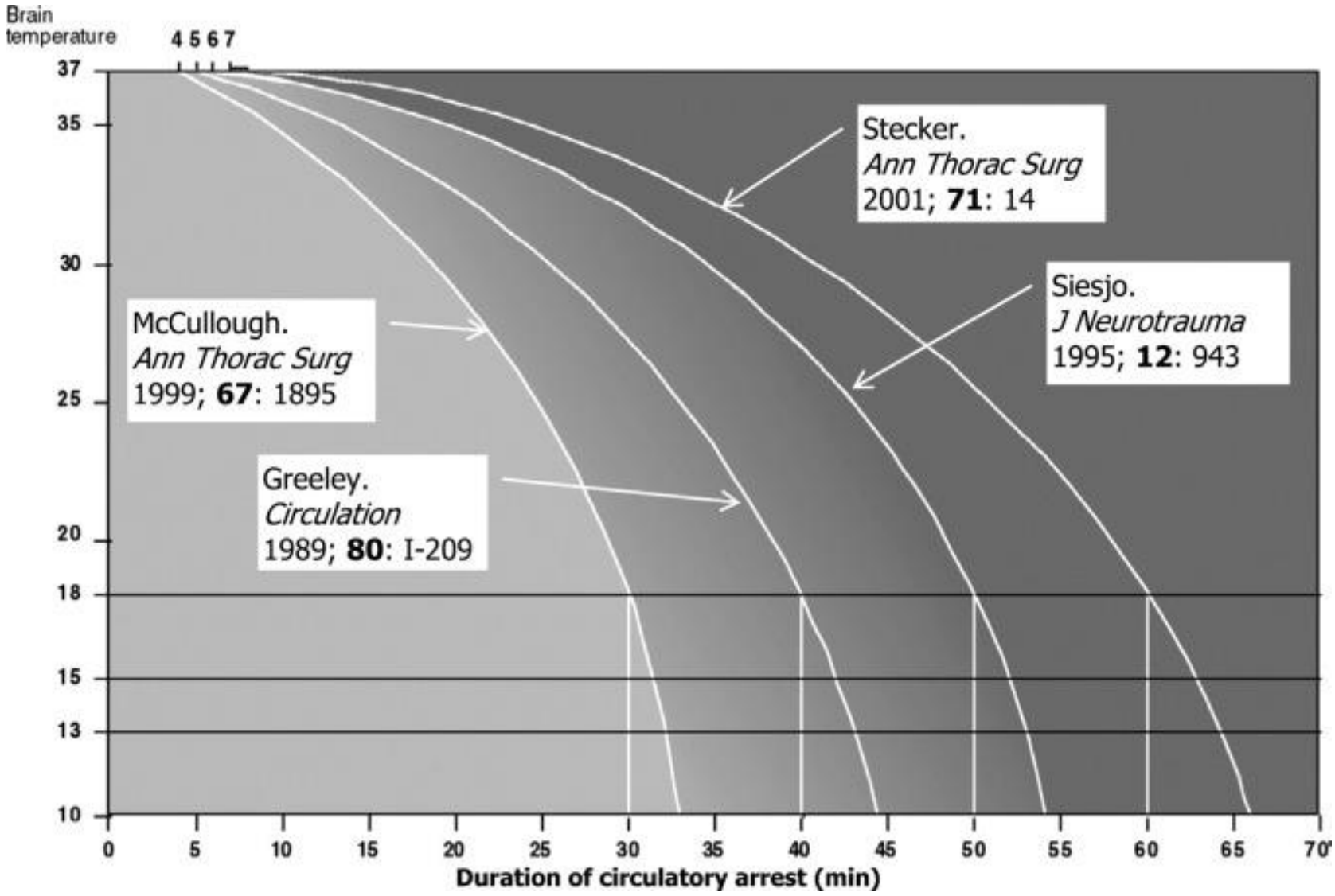
- **CPB initiated / ACC**
- **Circulatory arrest**
- **Distal anastomosis**
- **Head vessel/Proximal anastomosis**
- **CPB weaning**

Aorta Surgery

Arch surgery

- **CPB initiated / ACC**
- **Circulatory arrest**
  - **Circulatory arrest**
  - **Circulatory arrest with Cerebral perfusion**
    - **= Lower body ischemia**
- **Distal anastomosis**
- **Head vessel/Proximal anastomosis**
- **CPB weaning**

Hypothermia and safety time



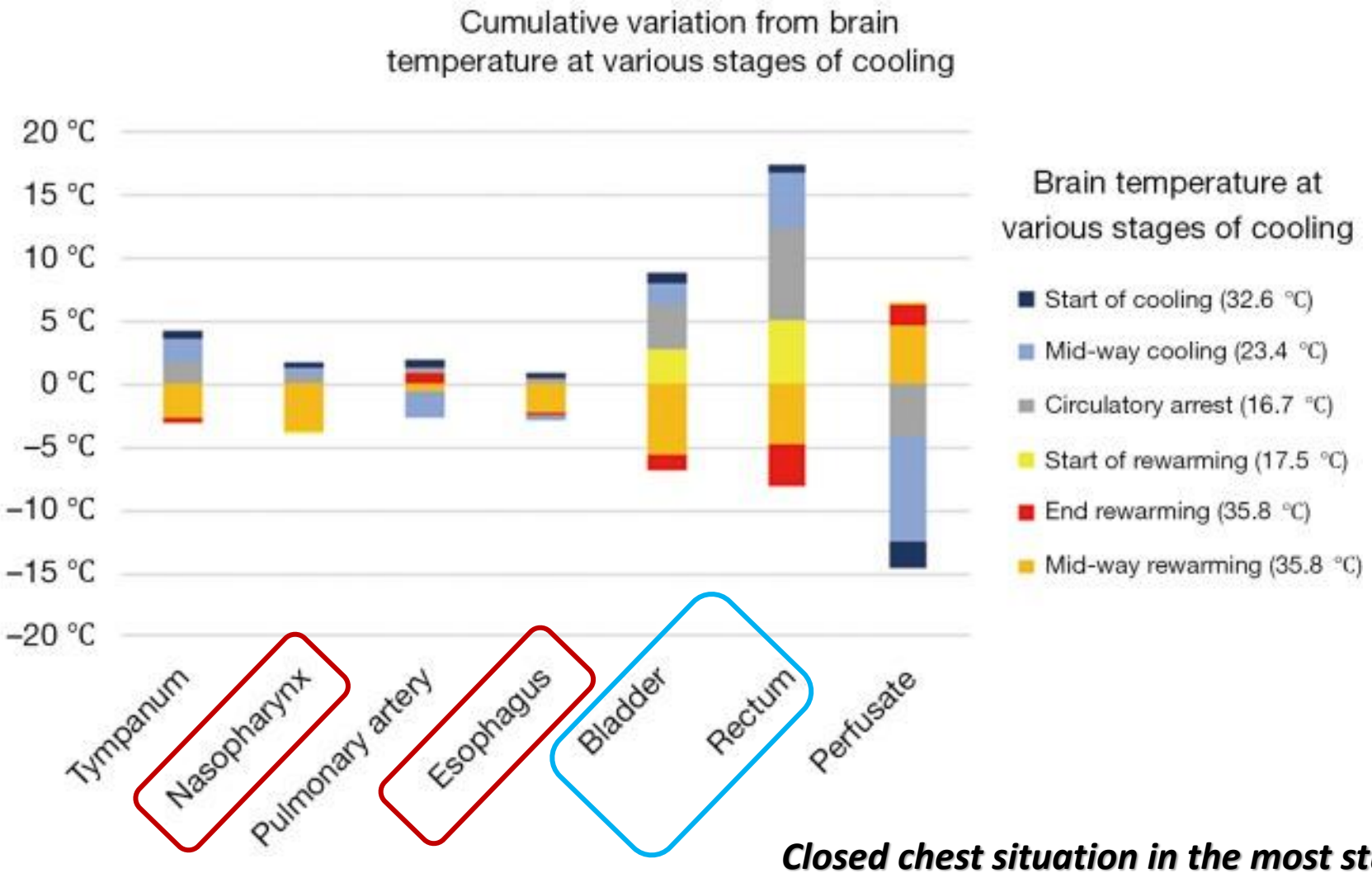
Classification of Hypothermia

Table 1 Expert consensus on classifications of hypothermia in circulatory arrest during aortic arch surgery

Category	Nasopharyngeal temperature
Profound hypothermia	≤14 ℃
Deep hypothermia	14.1-20 ℃
Moderate hypothermia	20.1-28 ℃
Mild hypothermia	28.1-34 ℃

Reproduced with permission from Yan *et al*. (10)

Hypothermia monitoring



Closed chest situation in the most studies

Hypothermia monitoring

- **NP , Esophagus, PA (swan catheter)**
  - Close to brain temperature
- **Bladder, rectum**
  - Higher than brain during cooling
  - Lower than brain during rewarming
  - **Close to lower body temperature**
    - **Associated with lower body protection**

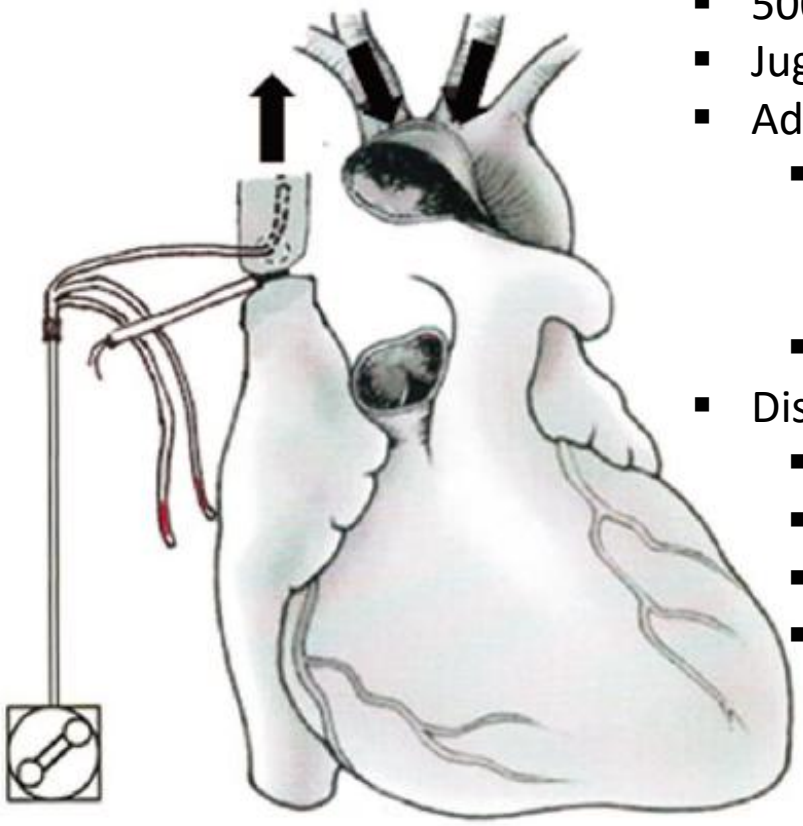
Hypothermic circulatory arrest

Profound & Deep

- 14~20 Celsius degree
- Safe up to 30 min without any cerebral perfusion strategy
- Advantage
  - Technically easy
- Disadvantage
  - Prolonged CPB time
    - Cooling / rewarming time
    - Coagulopathy
      - CPB time
      - Degree of hypothermia

Hypothermic circulatory arrest

Retrograde



- 500ml/min
- Jugular pressure 15~25 mmHg
- Advantages
  - Evenly distributed cooling (not perfusion)
    - 70% of cerebral blood in venous system
  - Flushing atheromatous debris
- Disadvantage
  - Non physiologic perfusion
  - Heterogenous cerebral perfusion
  - Bloody surgical field
  - Not appropriate for complex surgery
    - Shorter safe time

Hypothermic circulatory arrest

Retrograde

Deep Hypothermia With Retrograde Cerebral Perfusion Versus Moderate Hypothermia With Antegrade Cerebral Perfusion for Arch Surgery

Circulatory arrest time 20 min

Bradley G. Leshnower, MD, Srikant Rangaraju, MD, Jason W. Allen, MD, PhD, Anthony Y. Stringer, PhD, Thomas G. Gleason, MD, and Edward P. Chen, MD

Division of Cardiothoracic Surgery, Emory University School of Medicine, Atlanta, Georgia; Department of Neurology, Emory University School of Medicine, Atlanta, Georgia; Division of Neuroradiology, Emory University School of Medicine, Atlanta, Georgia; Division of Neuropsychology and Behavioral Health, Emory University School of Medicine, Atlanta, Georgia; and Department of Cardiothoracic Surgery, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania

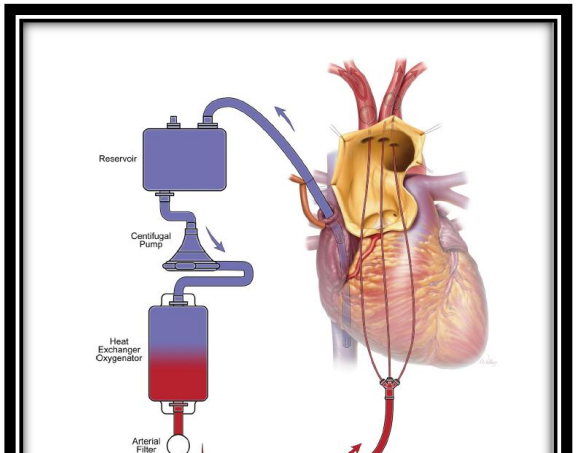
Table 4. Neurologic Outcomes After Hemiarch Replacement Using Deep Hypothermic Circulatory Arrest With Retrograde Cerebral Perfusion or Moderate Hypothermic Circulatory Arrest With Antegrade Cerebral Perfusion

Variable[a]	DHCA+RCP (n = 11)	MHCA+ACP (n = 9)	*p* Value
Composite of stroke, TIA, MRI DWI lesions	5 (45)	9 (100)	0.01[b]
Stroke	1 (9)	1 (11)	0.28
Transient neurologic dysfunction	0	2 (22)	0.19
TIA	0	0	1
S-100 level, ng/mL			
Postoperative day 1	123 ± 66	132 ± 58	0.77
Postoperative day 3	62 ± 38	67 ± 46	0.79
Postoperative day 7	53 ± 34	49 ± 24	0.66
Patients with MRI DWI lesions	5 (45)	9 (100)	0.01[b]
Number of DWI lesions	1.2 ± 2.1	4 ± 3.5	0.01[b]
Volume of DWI lesions, cm^3	0.54 ± 0.72	1.29 ± 3.01	0.63

Hypothermic circulatory arrest

Antegrade cerebral perfusion

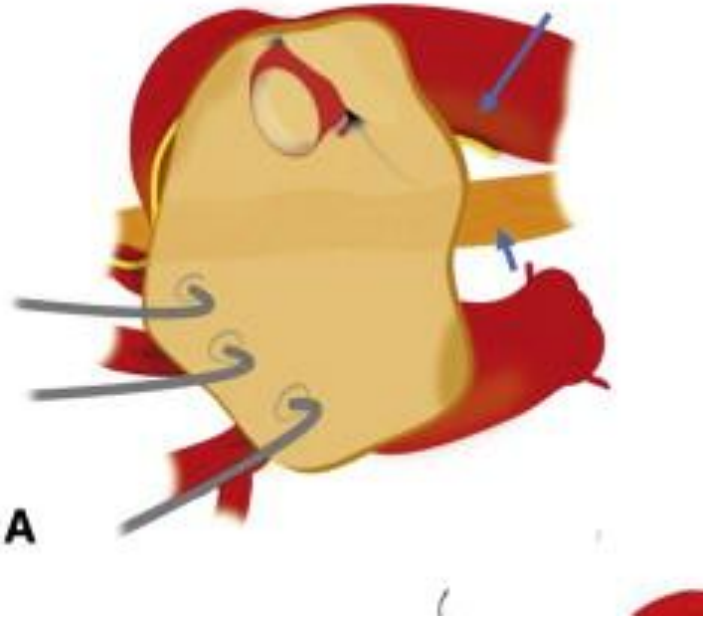
- Unilateral antegrade cerebral perfusion
  - Usually moderate hypothermia (23~25)
  - Axillary artery perfusion
    - 10 ~12ml/kg/min
    - Rt radial artery pressure 40~60mmHg
- Bilateral antegrade cerebral perfusion
  - Axillary artery perfusion + LCCA balloon catheter perfusion
    - 10~12 ml/kg/min
    - Rt radial artery pressure 40~60mmHg



Hypothermic circulatory arrest

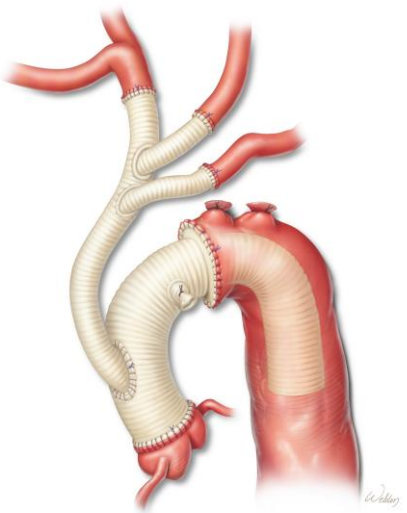
Antegrade cerebral perfusion

- Tri vessel antegrade cerebral perfusion
  - Axillary artery perfusion + LCCA + LSA balloon catheter perfusion
    - 10~12 ml/kg/min
    - Rt radial artery pressure 40~60mmHg
    - Most physiologic
    - Spinal cord protection
    - More manipulation of head vessel
    - Crowded surgical field

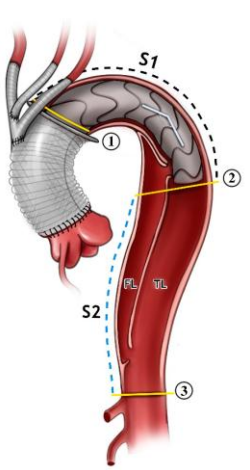


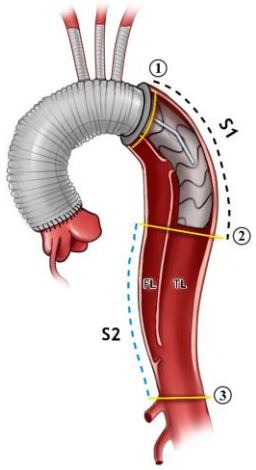
Aorta Surgery

Arch surgery



- **TAR+ET**
  - **For second stage DTA surgery**
- **TAR+FET**
  - **Simultaneous distal arch ~DTA pathology**
  - **For Second stage DTA surgery**
  - **<u>Spinal cord injury</u>**
- **Distal anastomosis**
  - **Exposure**
  - **RLN injury**
  - **Bleeding**
  - **Circulatory arrest time (Lower body ischemic time)**





Aorta Surgery

Arch surgery

- **Difficulties in distal anastomosis (- T4~T5)**
  - **Exposure**
  - **RLN injury**
  - **Bleeding**
  - **Circulatory arrest time (Lower body ischemic time)**
- **Technique ?**
  - **Distal anastomosis proximalization**
    - **TAR+FET**
  - **RLN protection**
  - **Lower body perfusion**

Aorta Surgery

Arch surgery

Aorta Surgery

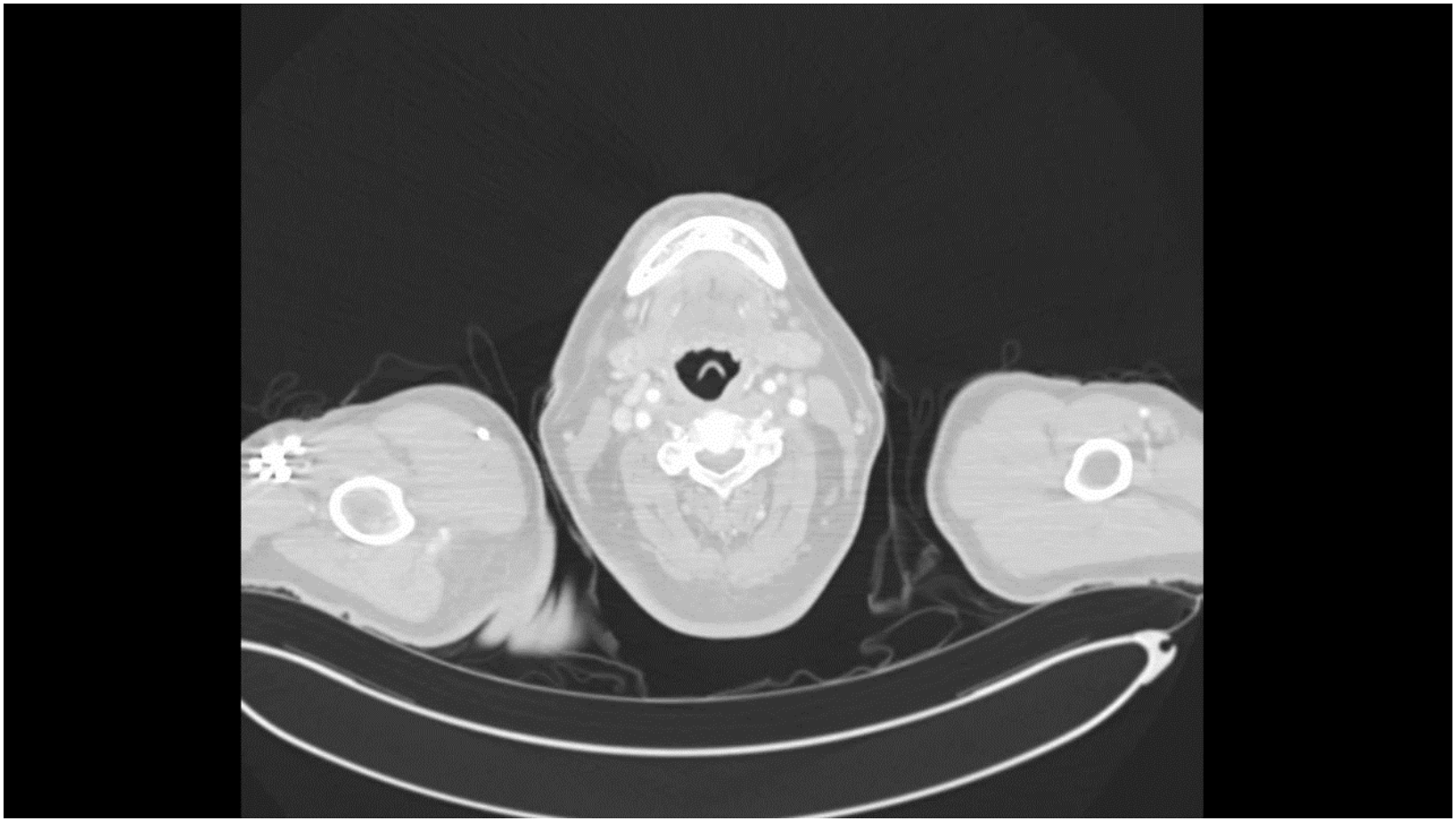
Arch surgery complication

- **Cerebral complication**
- **Multiorgan function**
- **Myocardial dysfunction**
- **Hoarsness/Aspiration**
- **Bleeding**

Aorta Surgery

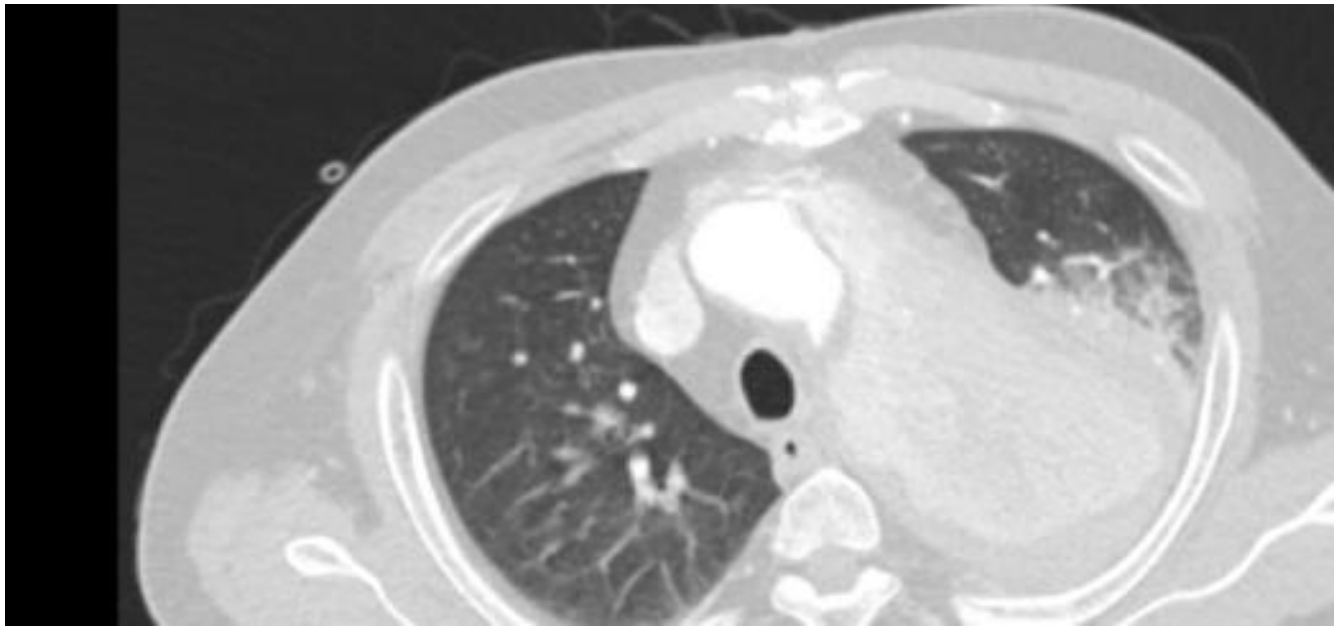
Arch surgery

- ✓ **M/55 Ruptured arch aneurysm**



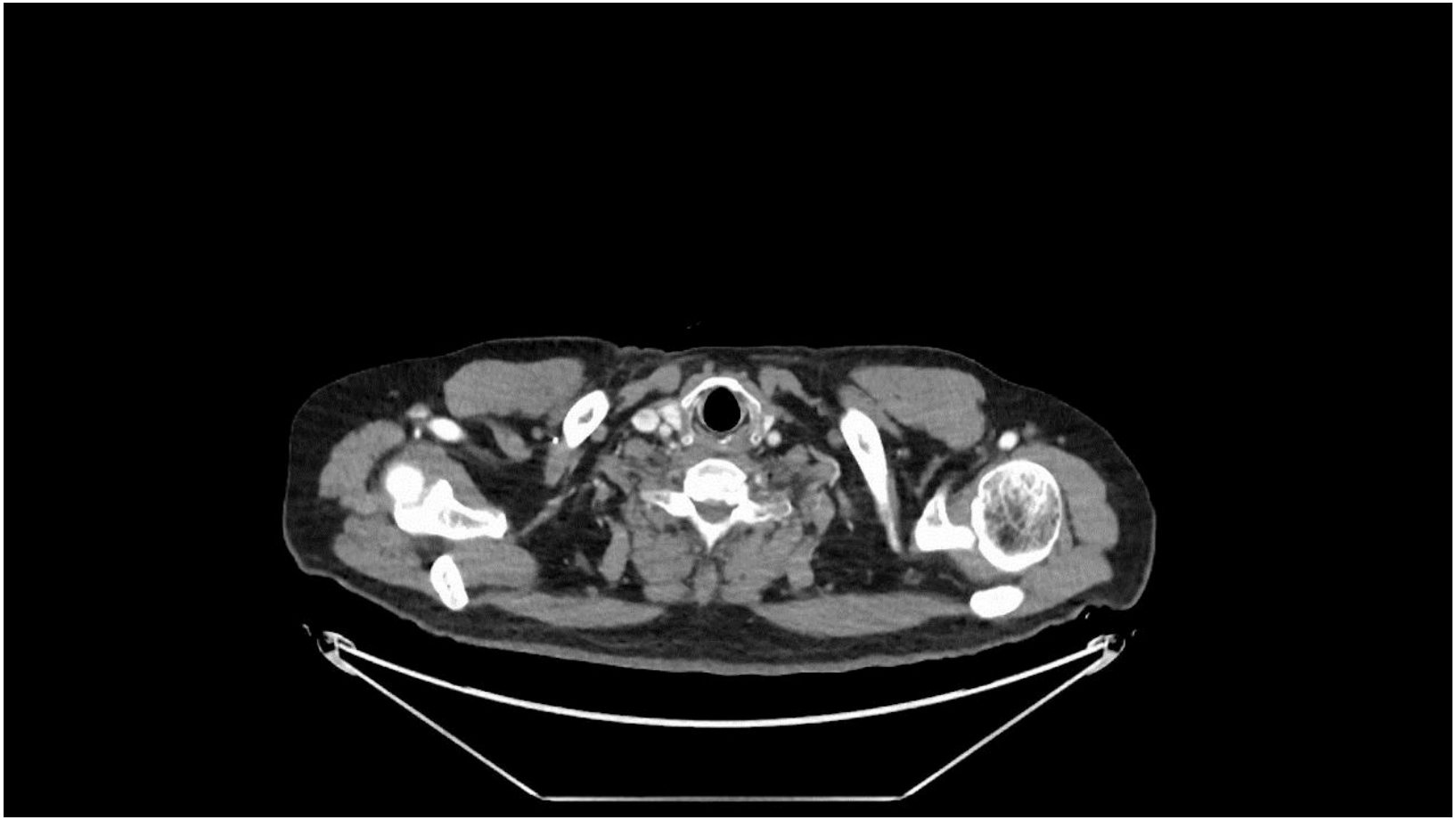
Aorta Surgery

Arch surgery



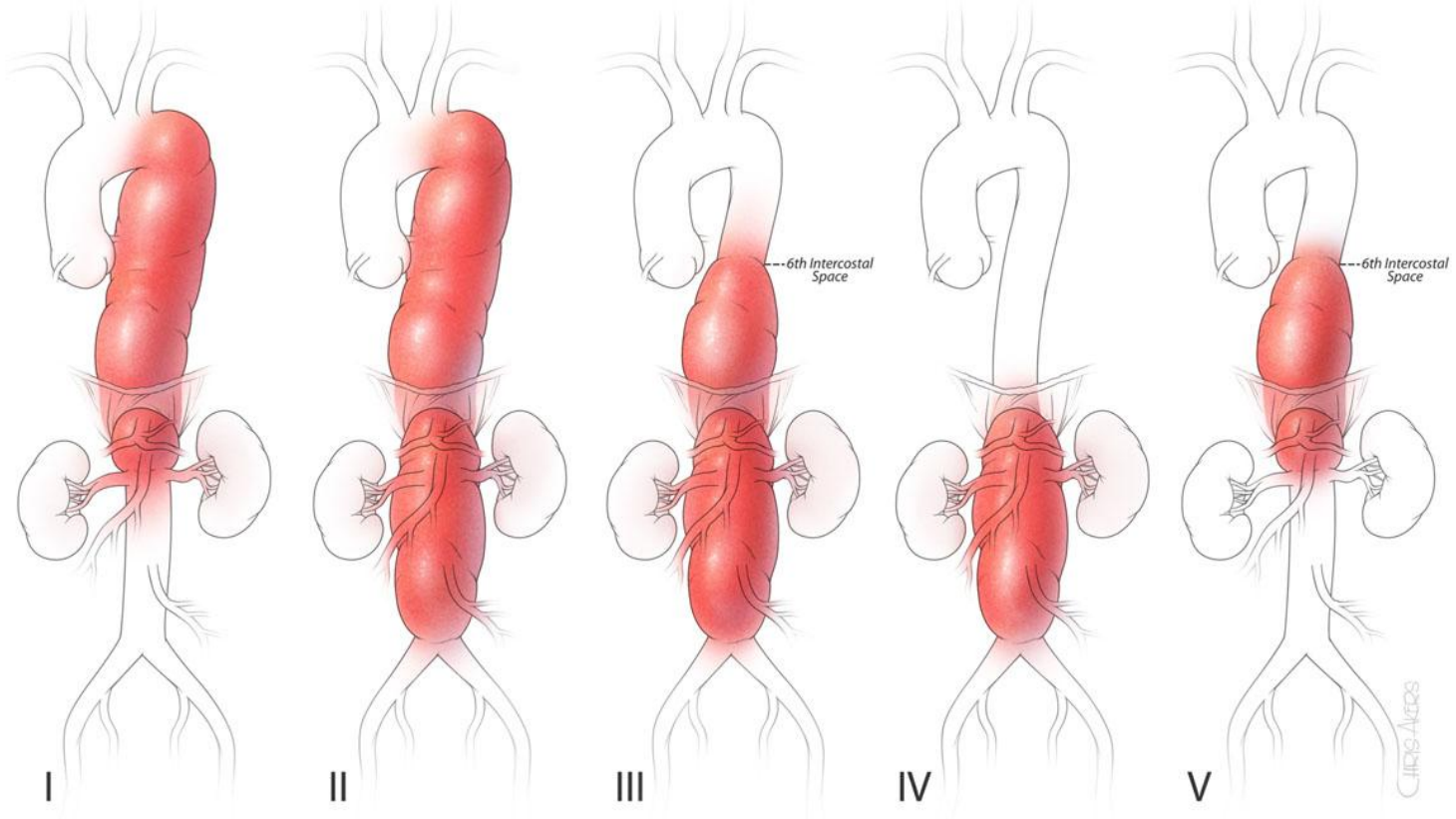
Aorta Surgery

Arch surgery



Aorta Surgery

TAAA open repair

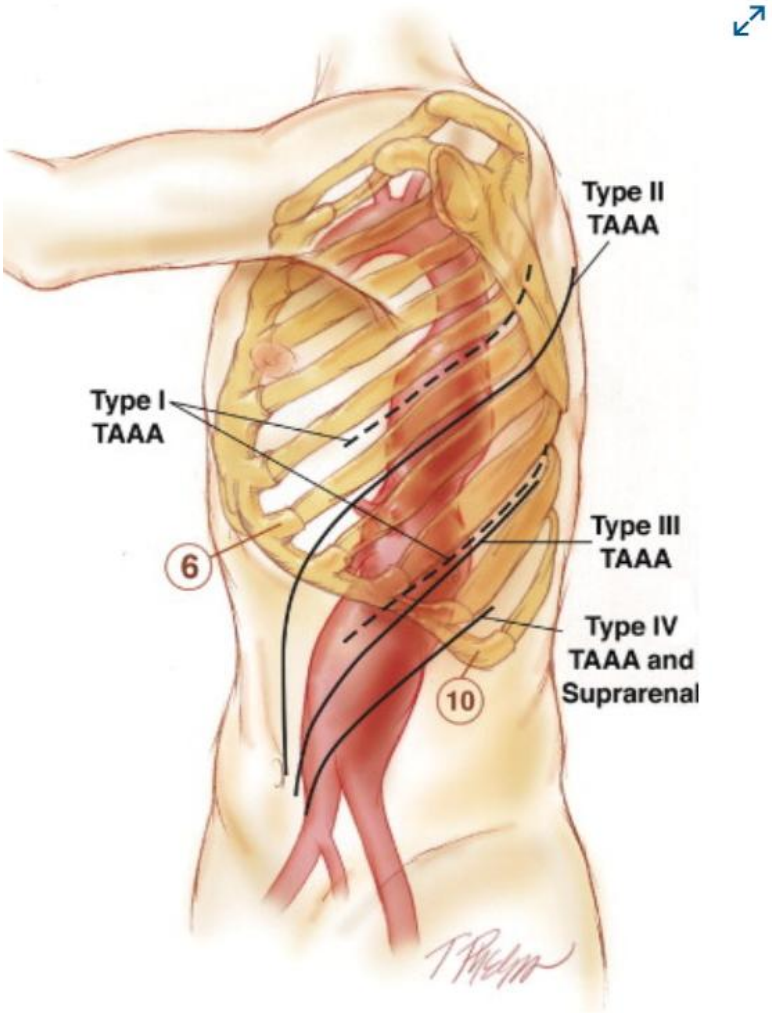


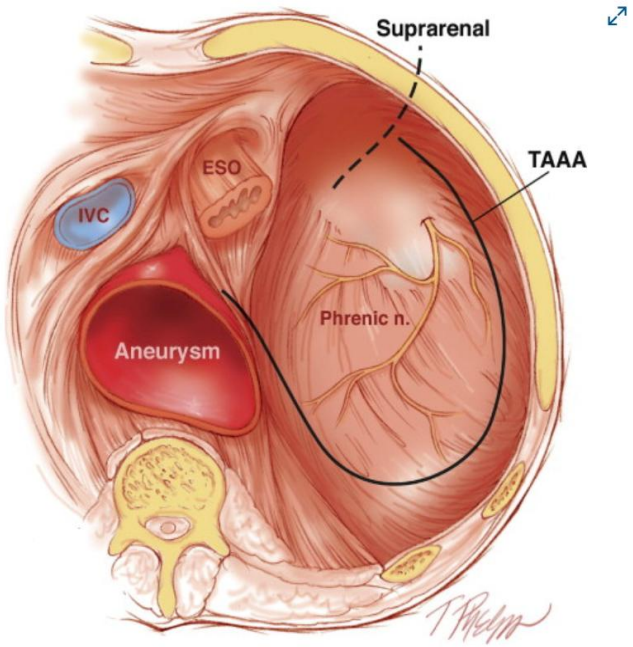
Crawford Classification

Aorta Surgery

TAAA open repair

- Extensive incision

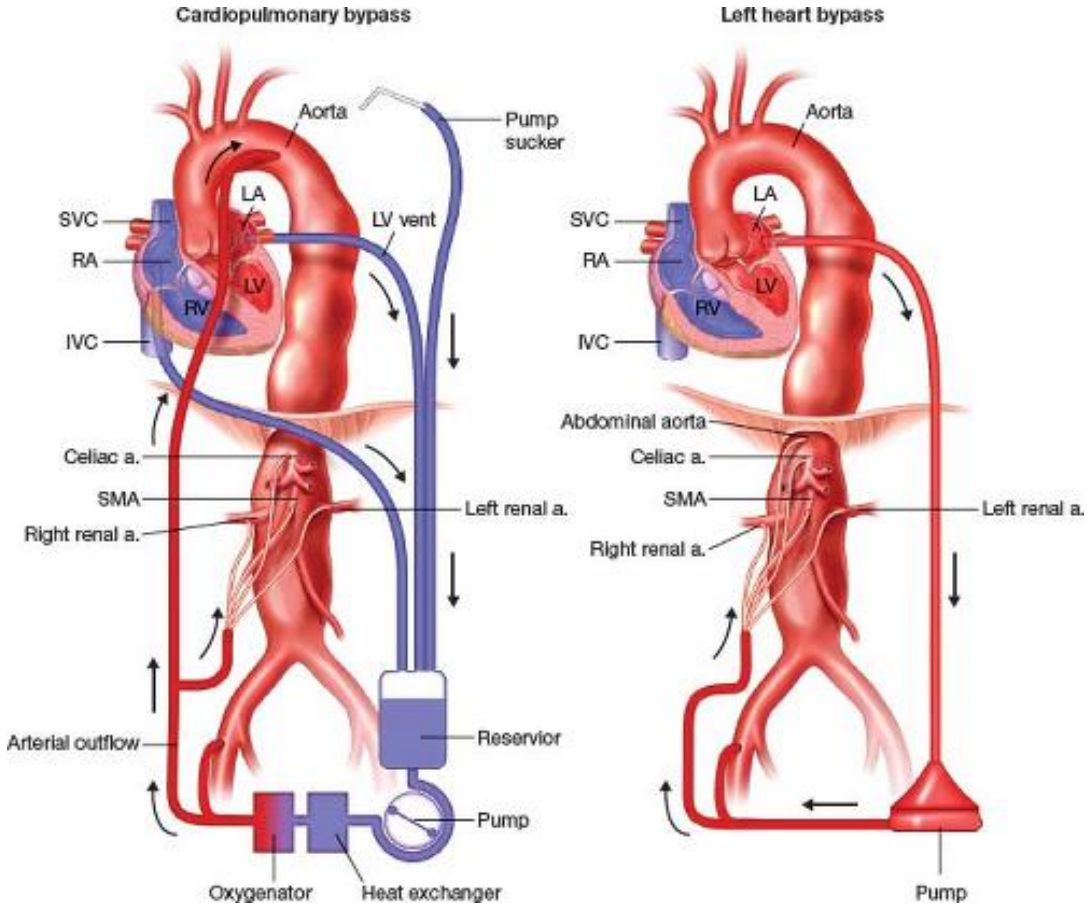




Aorta Surgery

TAAA open repair

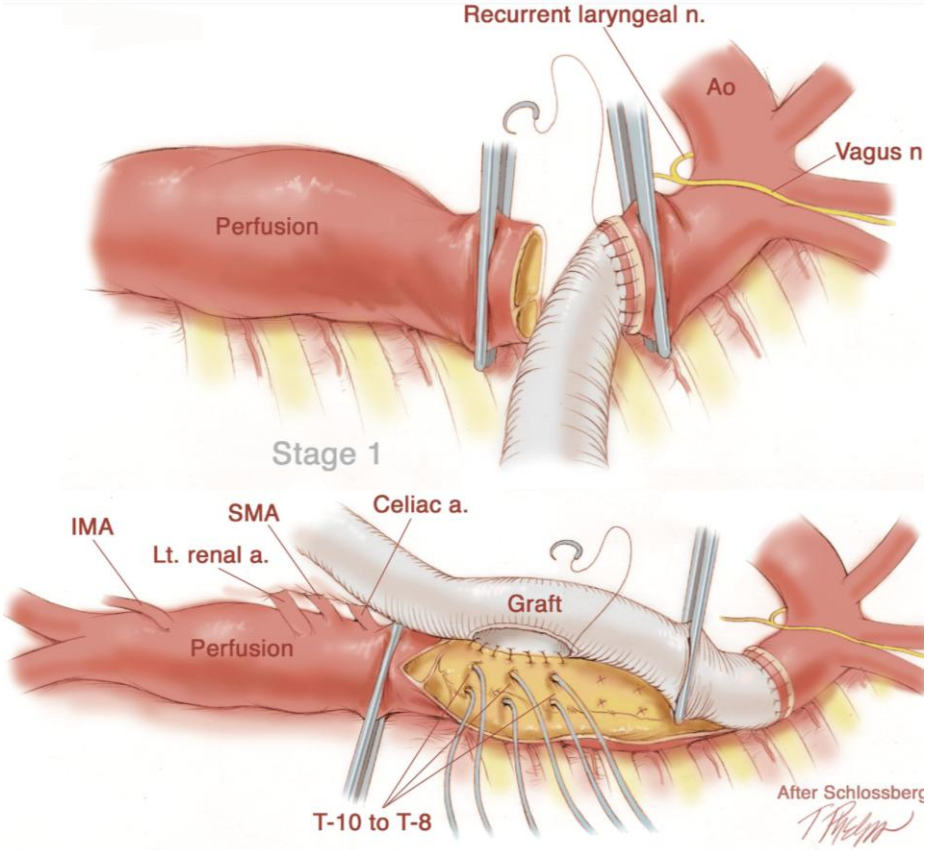
- **Clamp and sew**
- **CPB**
- **Left heart bypass**



Aorta Surgery

TAAA open repair

- **Sequential clamp**
- **ICA reimplantation**
- **CSF drain**
- **Visceral perfusion**



Aorta Surgery

TAAA open repair

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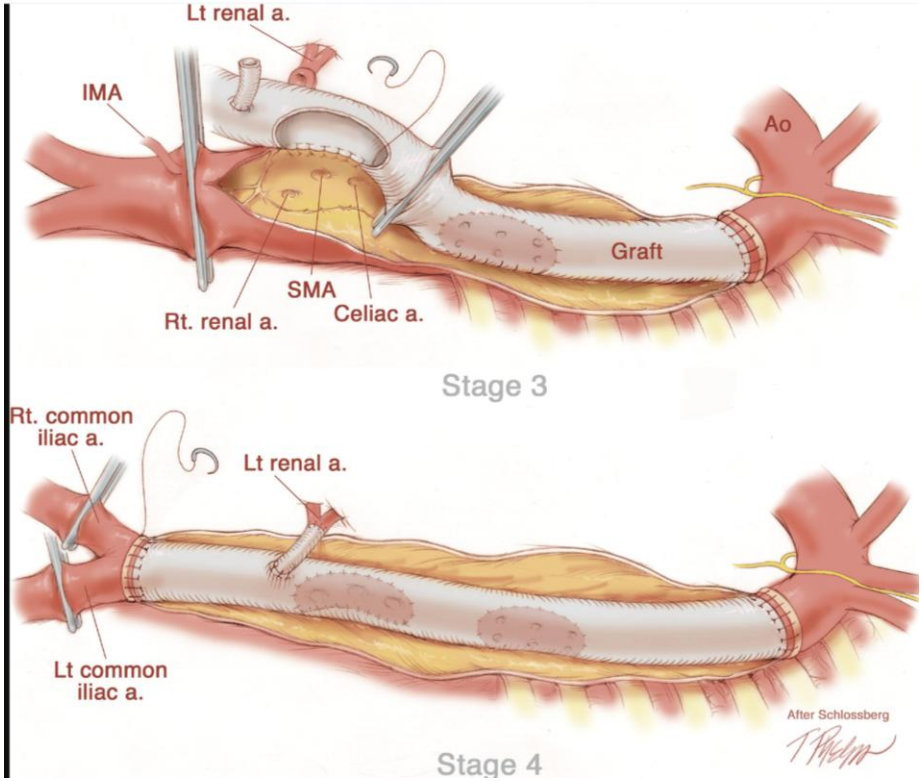


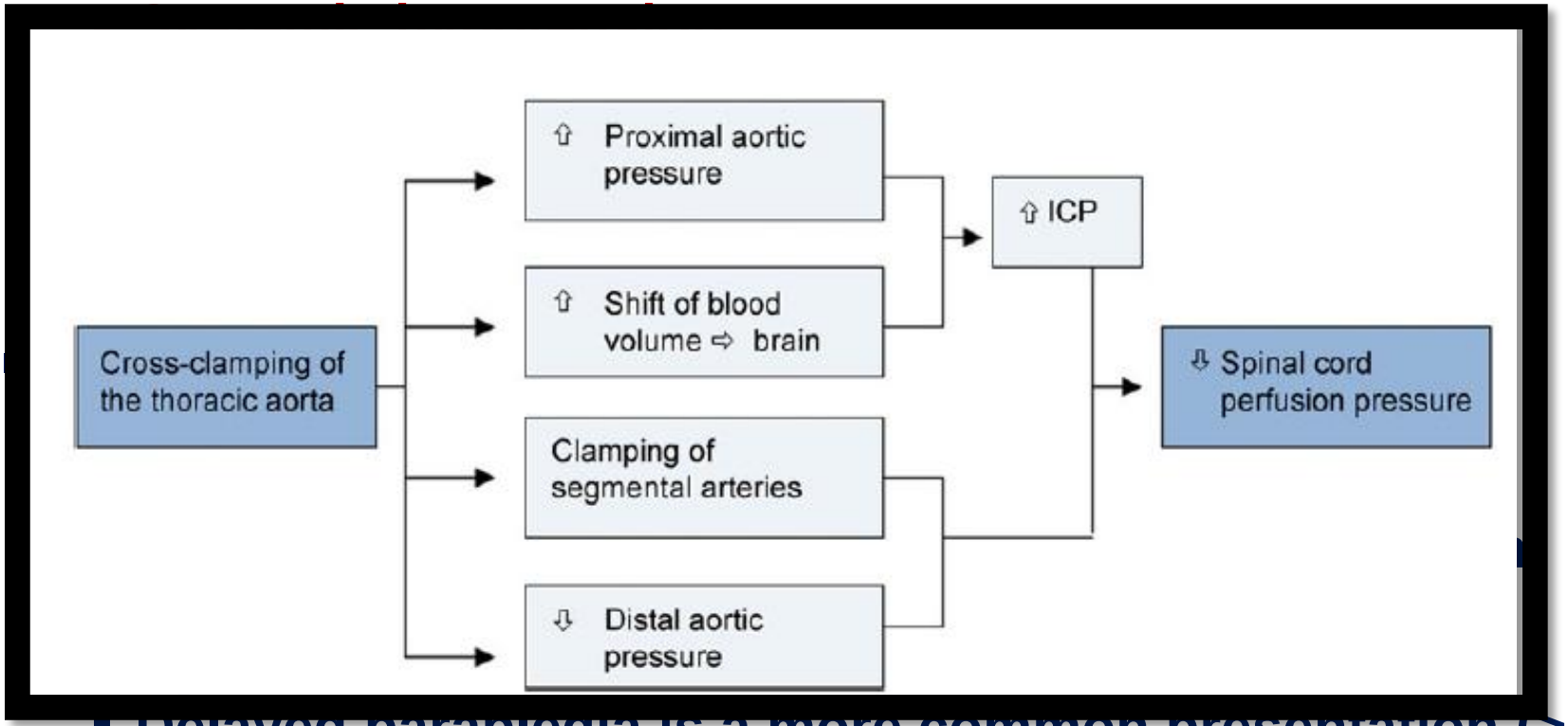
Aorta Surgery

TAAA open repair complication

- **Spinal cord ischemia**
- Renal failure
- Bleeding
- Graft kinking
- Respiratory failure

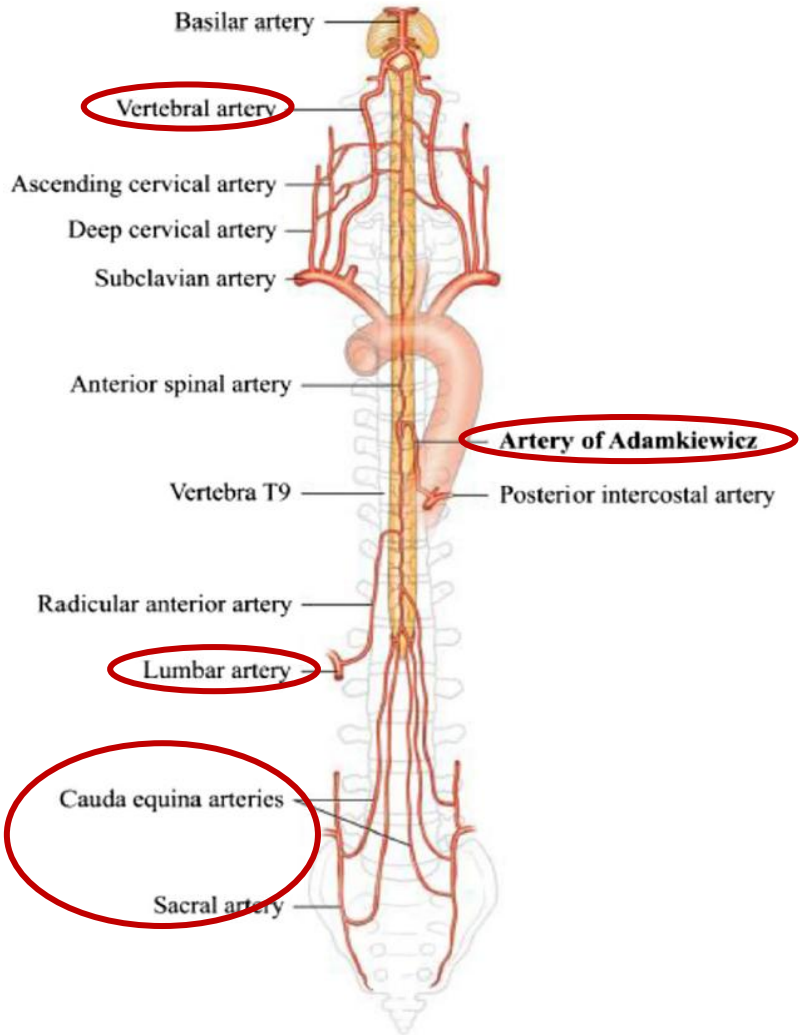
Spinal cord ischemia (SCI)

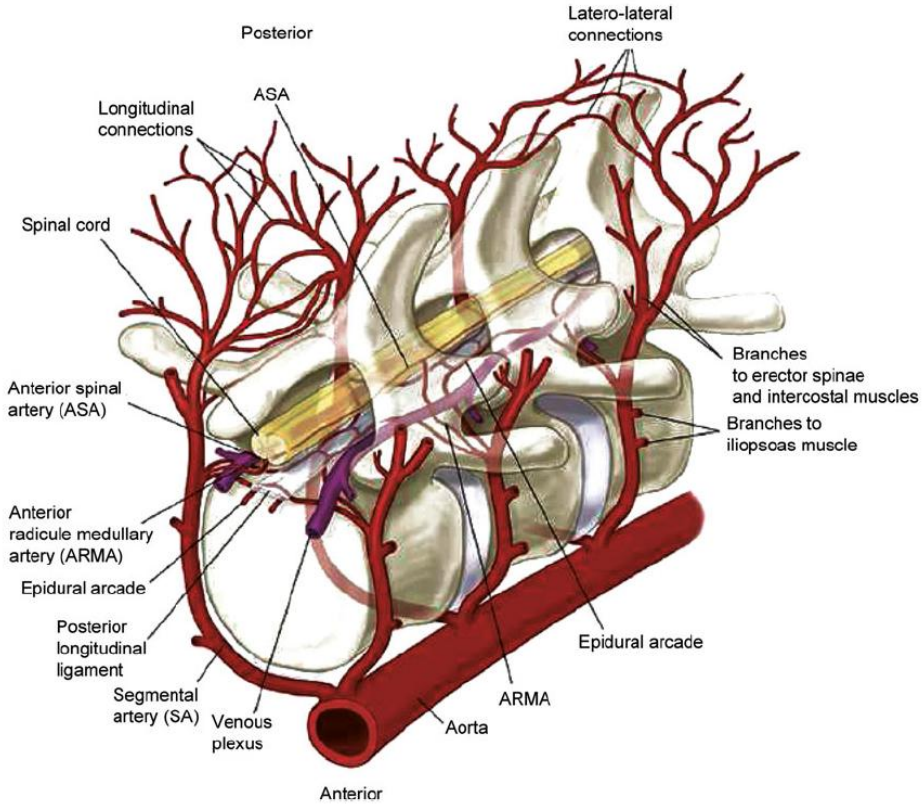
- **Mechanism for SCI in Open repair**
  - **Segmental blood supply (temporary and permanent)**
    - **Aortic cross clamp and length of replacement**



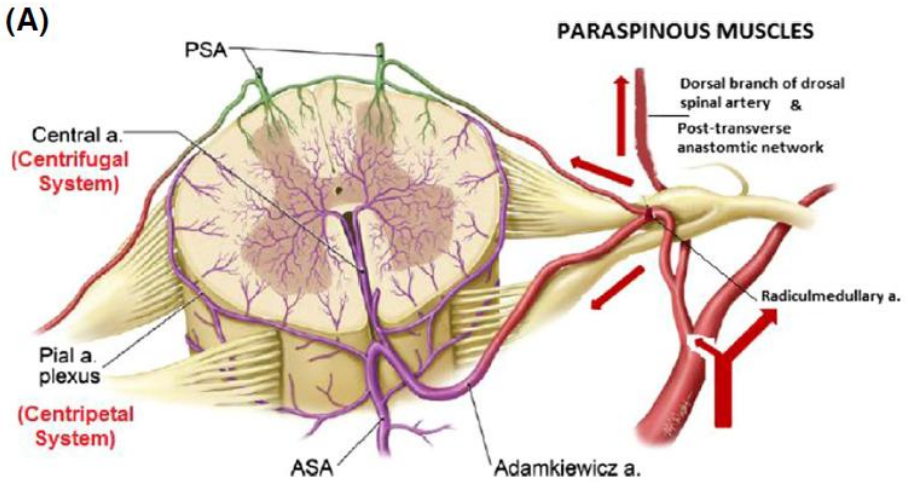
  - **Delayed paraplegia is a more common presentation (> 66%)**

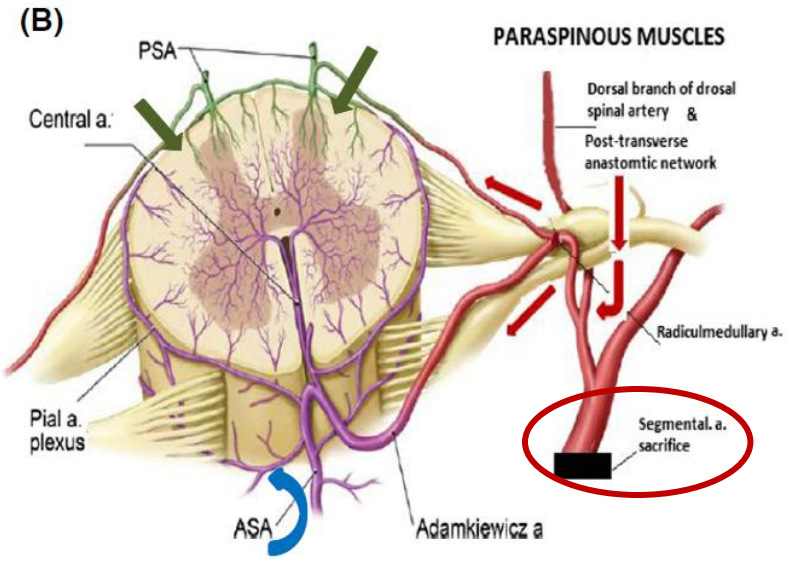
Blood supply of spinal cord

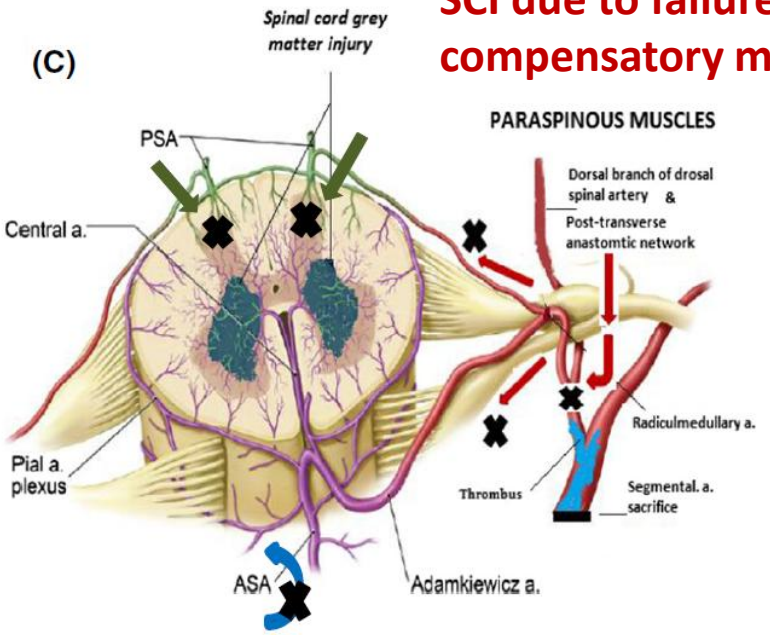




Normal perfusion & collaterals

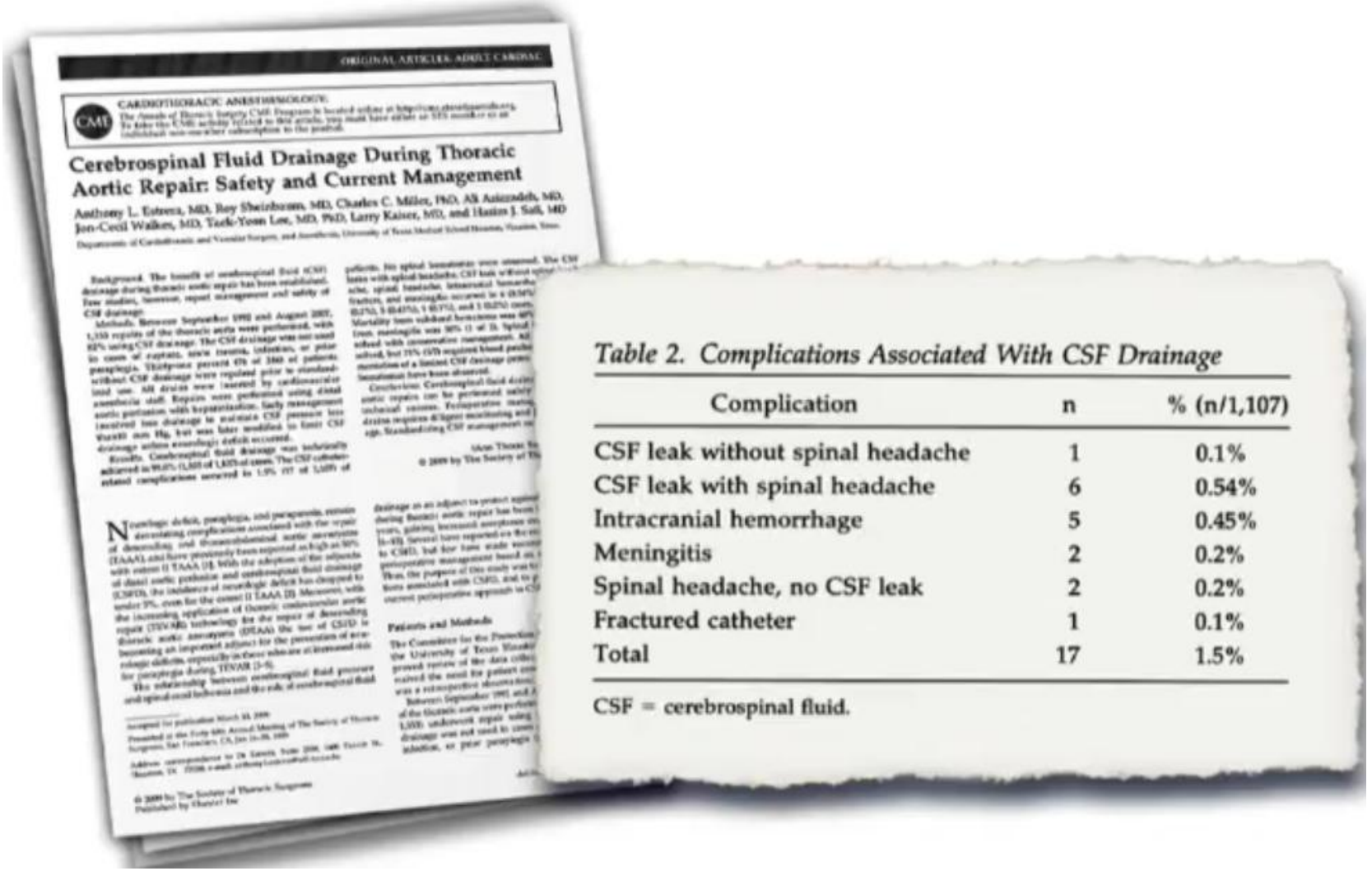






SCI due to failure of compensatory mechanism

Risk of CSF drainage ?



ORIGINAL ARTICLES: ADULT CARDIAC

CARDIOTHORACIC ANESTHESIOLOGY

Cerebrospinal Fluid Drainage During Thoracic Aortic Repair: Safety and Current Management

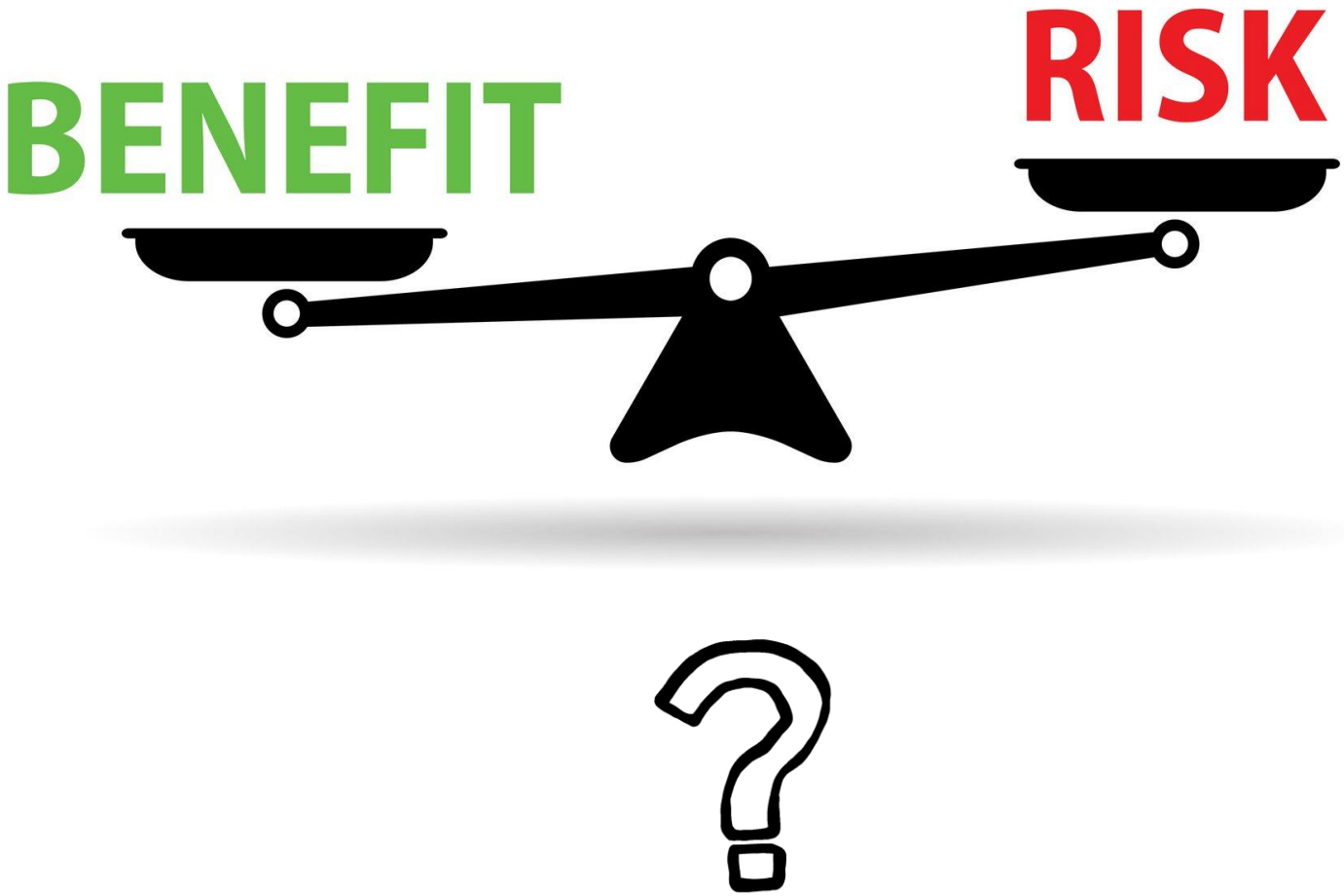
Anthony L. Estrera, MD, Roy Sheinbaum, MD, Charles C. Miller, PhD, Ali Azizzadeh, MD, Jon-Cecil Walkes, MD, Taek-Yoon Lee, MD, PhD, Larry Kaiser, MD, and Hazim J. Safi, MD

Table 2. Complications Associated With CSF Drainage

Complication	n	% (n/1,107)
CSF leak without spinal headache	1	0.1%
CSF leak with spinal headache	6	0.54%
Intracranial hemorrhage	5	0.45%
Meningitis	2	0.2%
Spinal headache, no CSF leak	2	0.2%
Fractured catheter	1	0.1%
Total	17	1.5%

CSF = cerebrospinal fluid.

ATS 2009 Jul; 88(1) :9-15


BENEFIT
RISK

Previous our studies #1
JTD, Jun 2017

Journal of Thoracic Disease

J Thorac Dis. 2017 Aug; 9(8): 2404–2412.
doi: 10.21037/jtd.2017.07.03

PMCID: PMC5594124
PMID: 28932545

Effects of preemptive cerebrospinal fluid drainage on spinal cord protection during thoracic endovascular aortic repair

Seungjun Song,[1] Suk-Won Song,[✉2] Tae Hoon Kim,[2] Kwang-Hun Lee,[3] and Kyung-Jong Yoo[4]

Vertebral artery——left dominant	43 [53]
Aortic pathology	81
Aortic dissection DeBakey Type I (s/p)	2 [3][a]
Aortic dissection DeBakey Type III	46 [57][b]
Aortic aneurysm	25 [31]
PAU	5 [6]
IMH	3 [4]

Acute dissection 11 (13.6%)
Chronic dissection 35 (43.2%)

CSFD-related complications	23 [28]
Spinal headache	11
Puncture site pain	5
Puncture site infection	1
Radiating leg pain	1
Intracranial hypotension	3
Subdural hemorrhage	2
SCI	2 [3]
Transient motor weakness of leg	1 [1]
Paraplegia	1 [1]

SCI : 2/81 (2.5%)

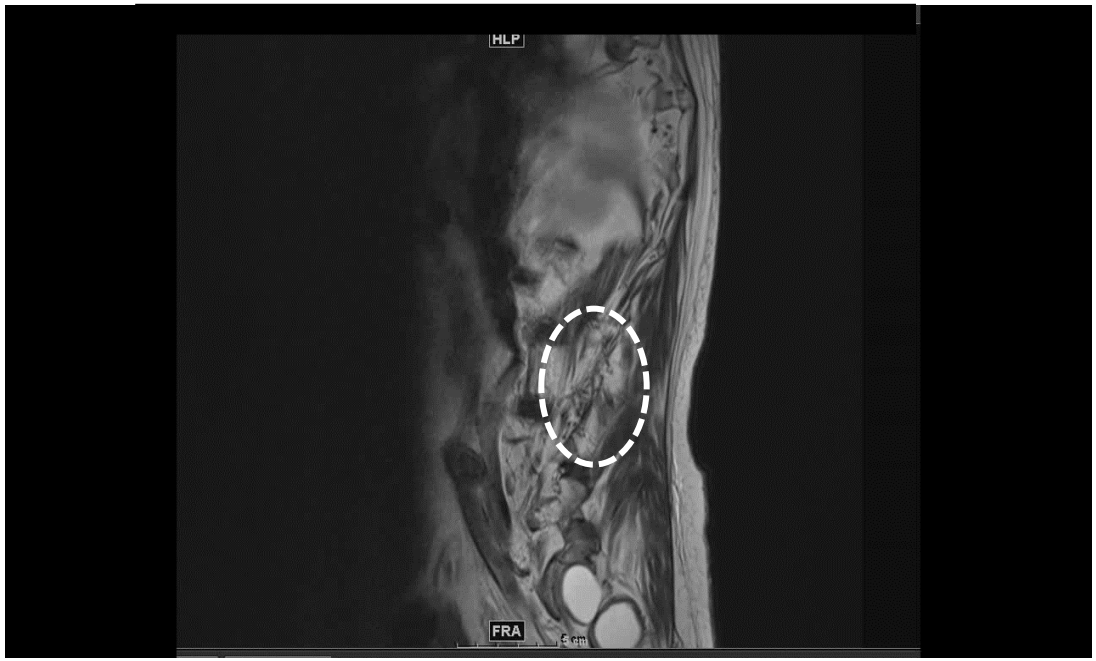
Gangnam Aortic Center

CSFD complication case

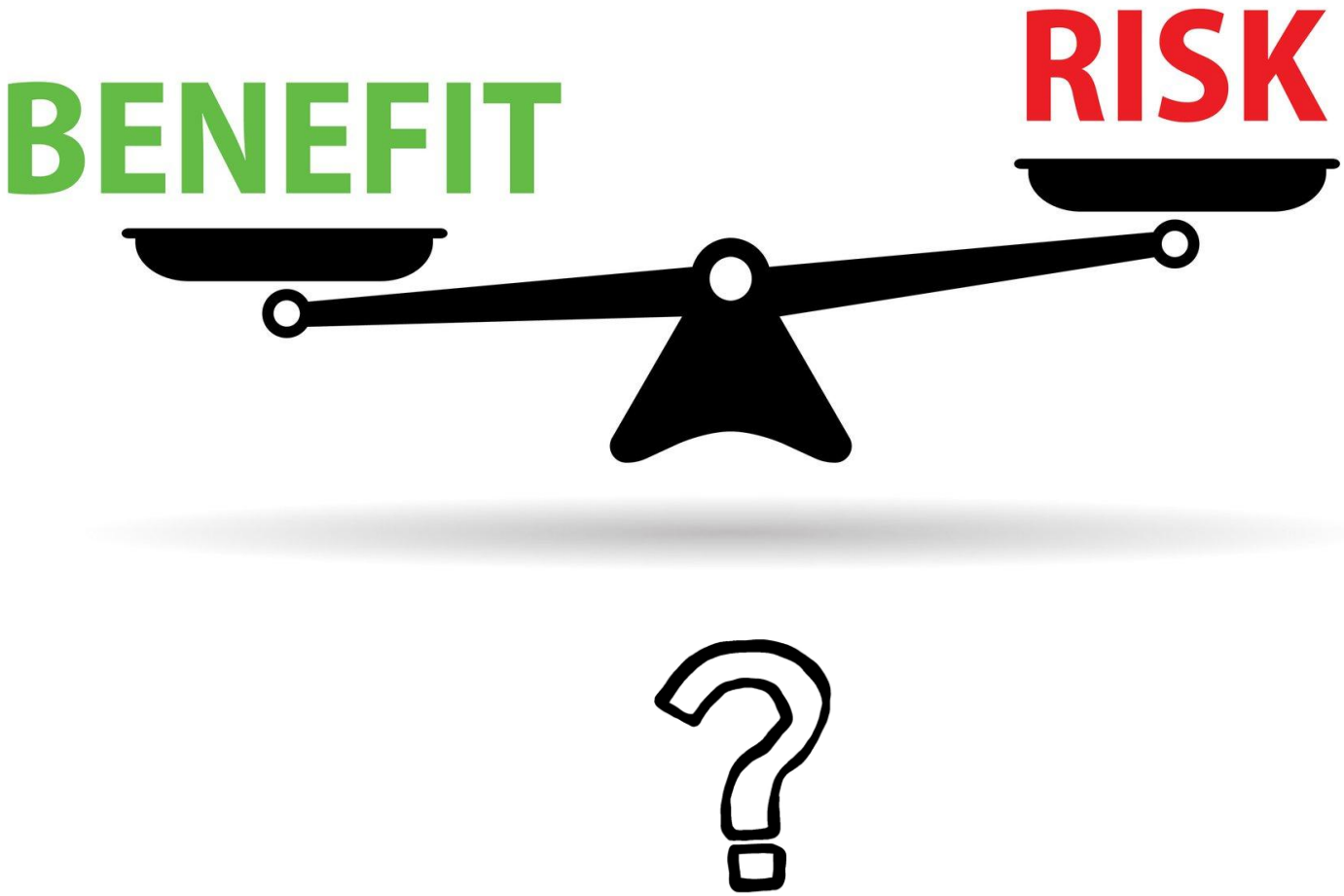
- **F/60**
  - **Marfan SD**
  - **AAA graft replacement, 1995 (Severance Hospital)**
  - **TEVAR for CDIIIb, 2008 (Severance Hospital)**
  - **Bentall operation, 2010 (Severance Hospital)**
  - **Zone 1 TEVAR & LSCA embolization (Gangnam Aortic Center)**

CSFD complication case

Post procedural MRI, POD #8



- ✓ **Findings**
  - ✓ **Subdural hematoma**
  - ✓ **Spinal cord ischemia**

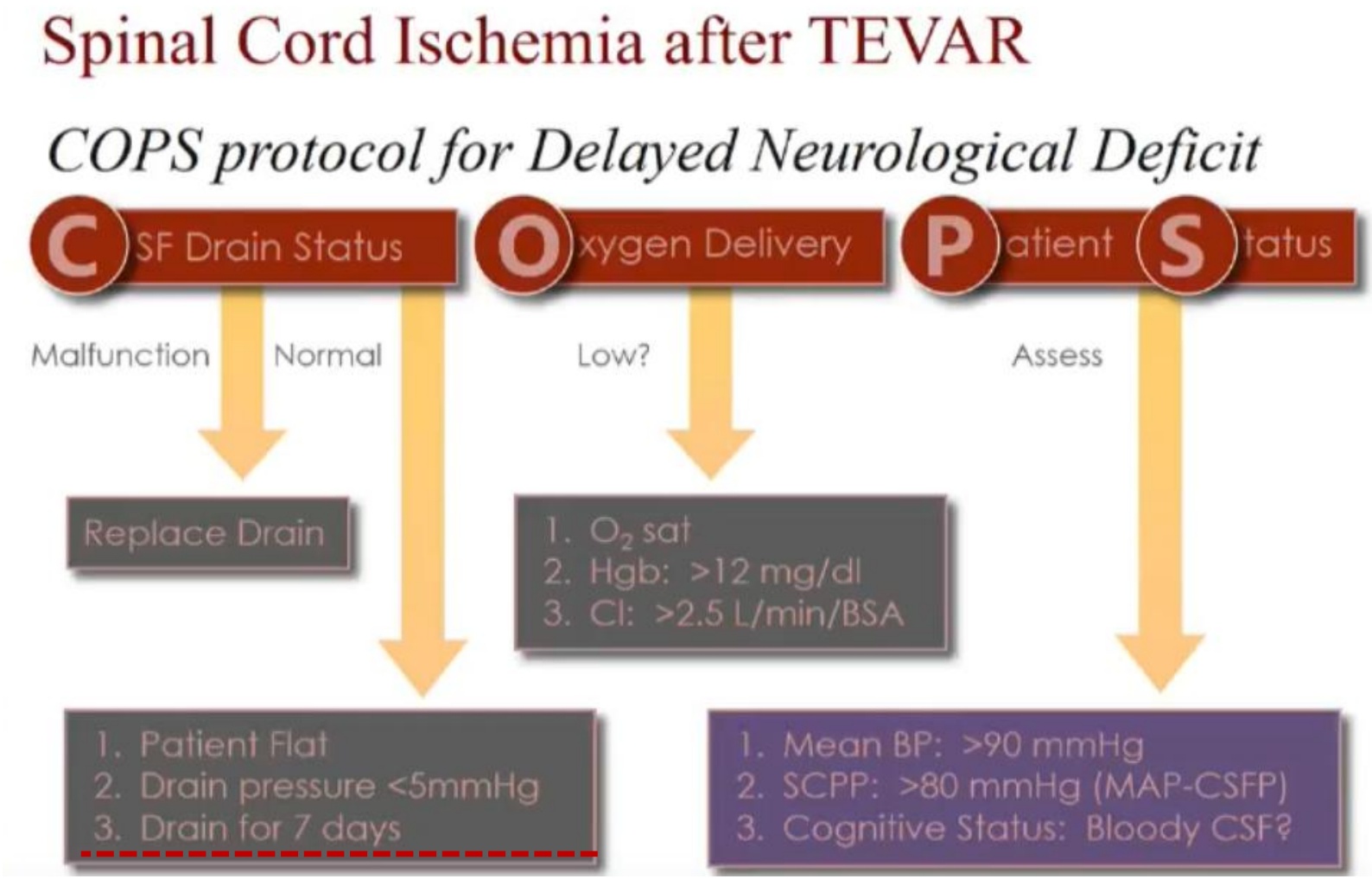

BENEFIT
RISK

Strategy for SCI prevention

- **Strategy of SCI prevention**
  - **LSA revascularization : essential during Zone 1,2**
  - **Prophylactic CSFD is crucial**
  - **Optimal periop management is important**
  - **Indication of prophylactic CSFD**
    - **Expected compromised cord perfusion**
      - **Prior AAA repair (open or endo) or other aortic surgery**
      - **IIA coverage or occlusion**
      - **LSA revascularization is impossible**
    - **Extent aortic coverage (involving T11~L1)**
    - **Expected favor FL thrombosis in acute dissection**

Gangnam Aortic Center

Strategy , periop management



3-4 days, individualized


Severance
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