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A navigation system for safer surgery
- Lessons learned from aortic vascular surgery -

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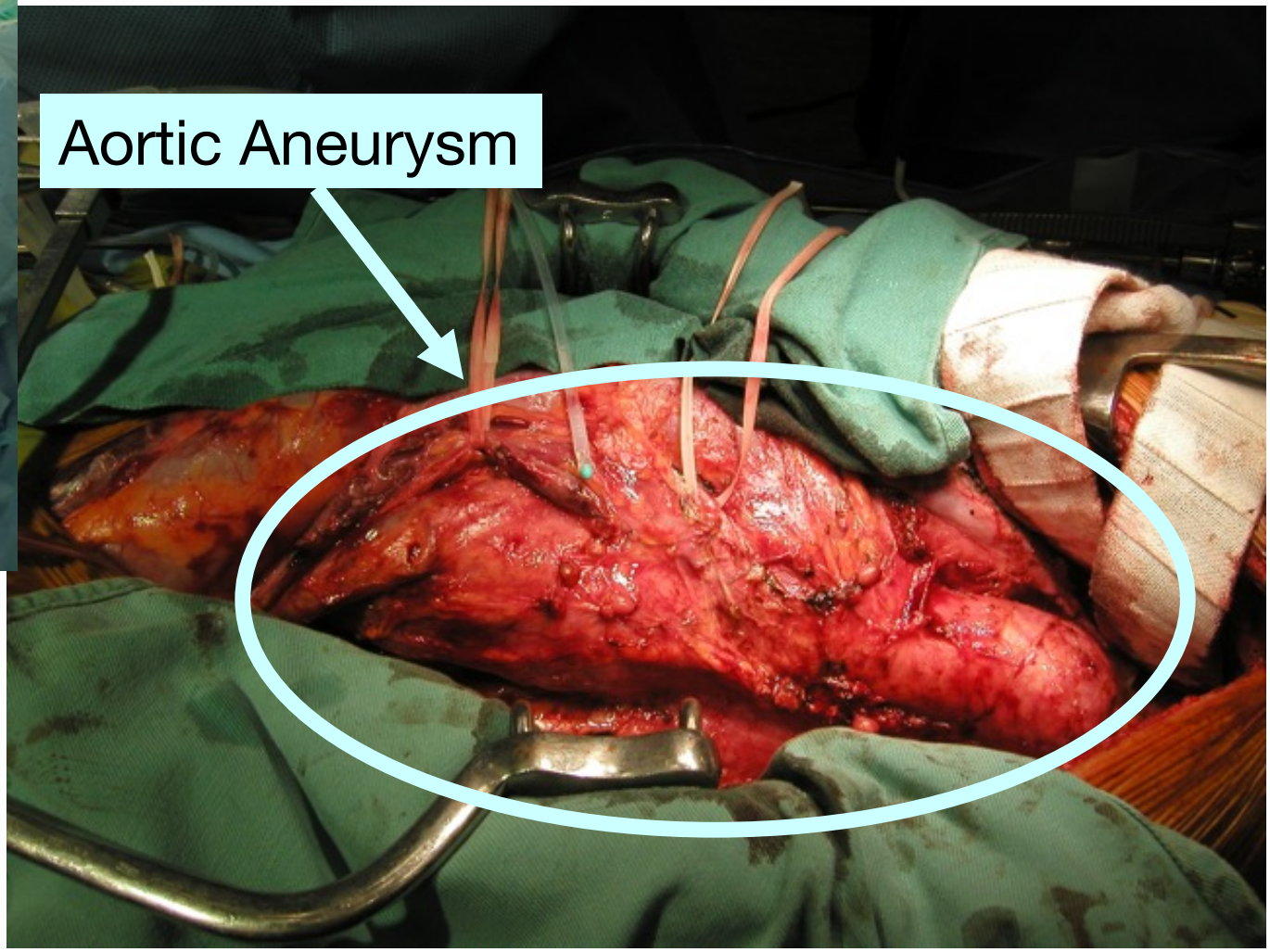
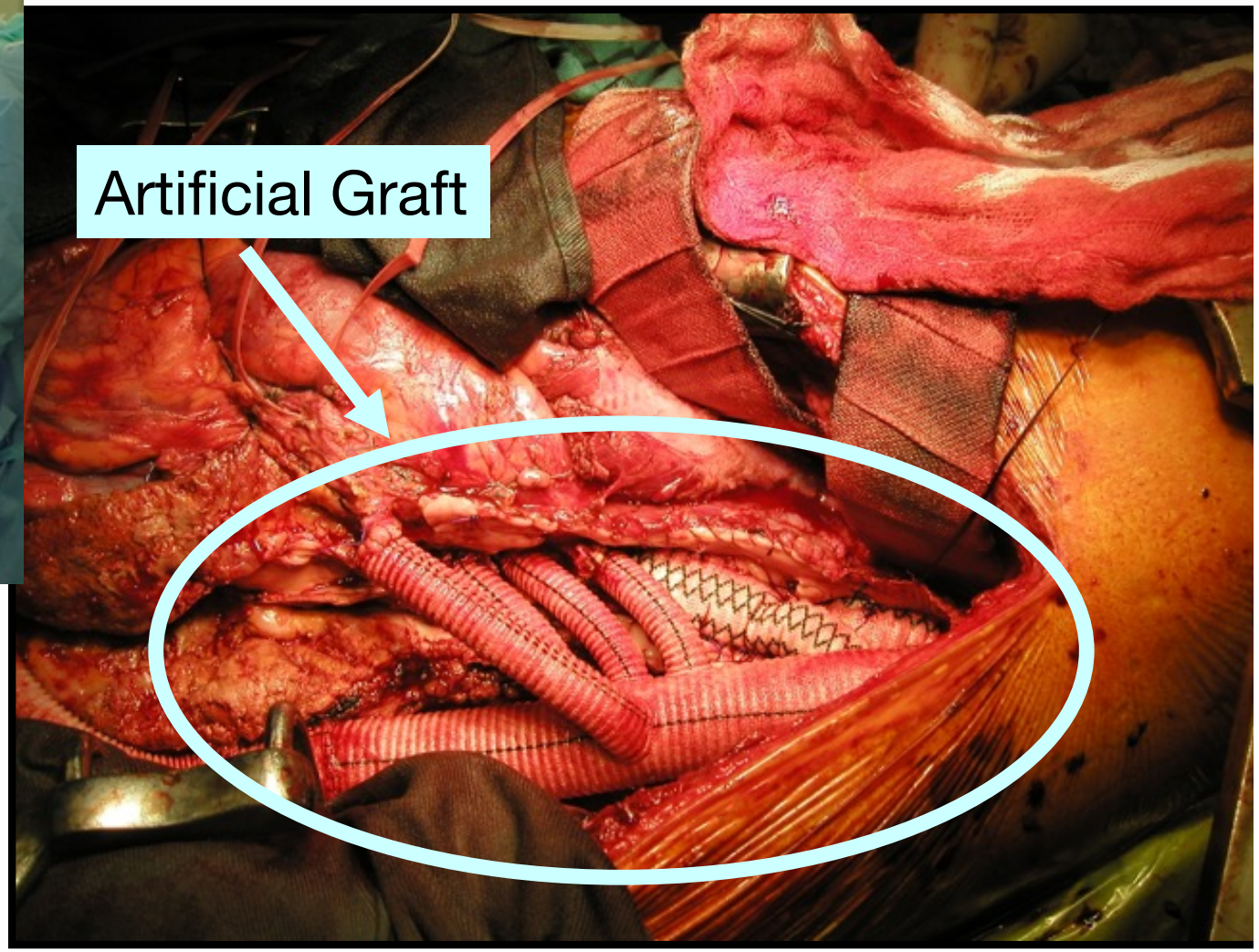
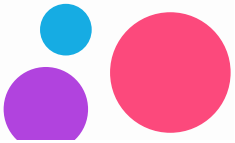
Graft replacement for aortic aneurysm



Graft replacement for aortic aneurysm



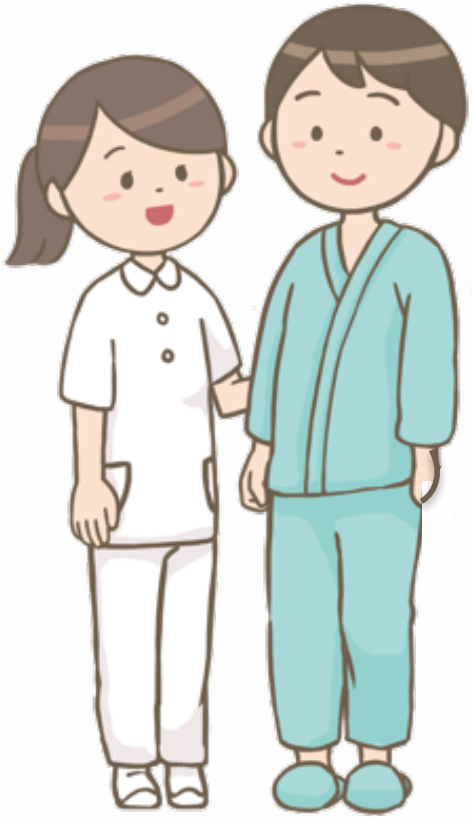
Clinical Needs



A serious sequela in open surgical repair for thoracoabdominal aortic aneurysm

10% of the patients suffering from **paraplegia**

BEFORE surgery



Walk on his own

Reason

Spinal cord ischemia during surgery

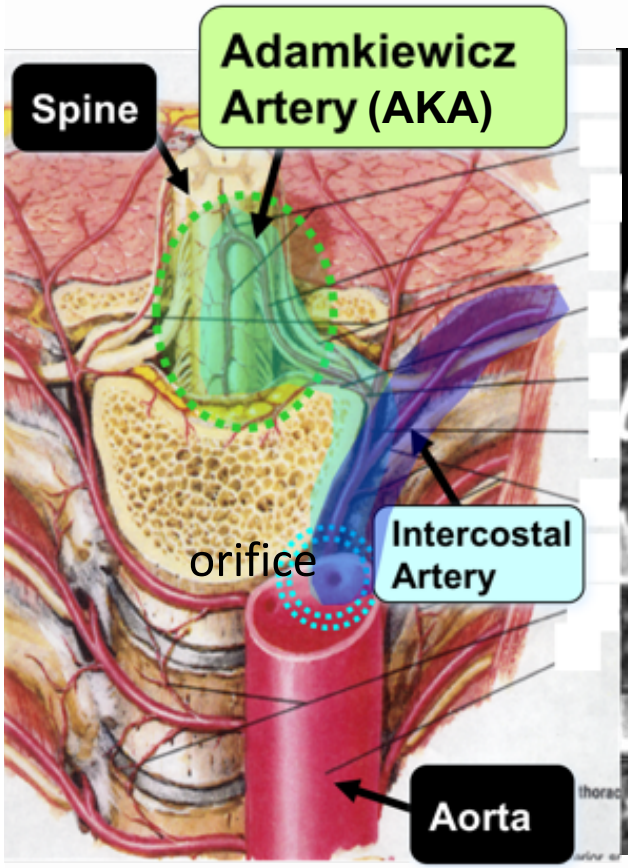
AFTER surgery

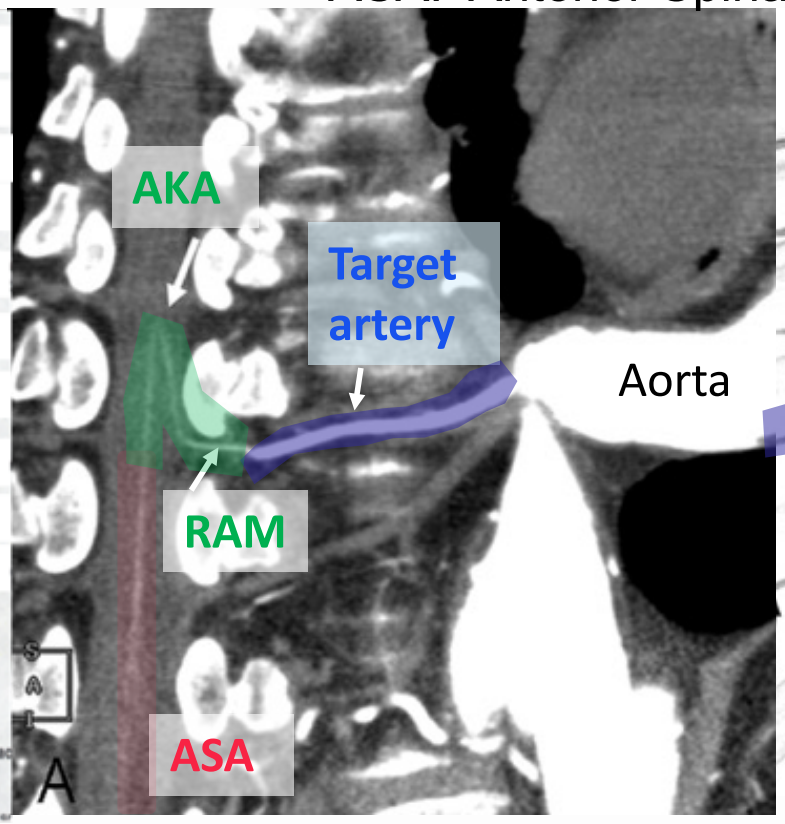
Need assistance walking

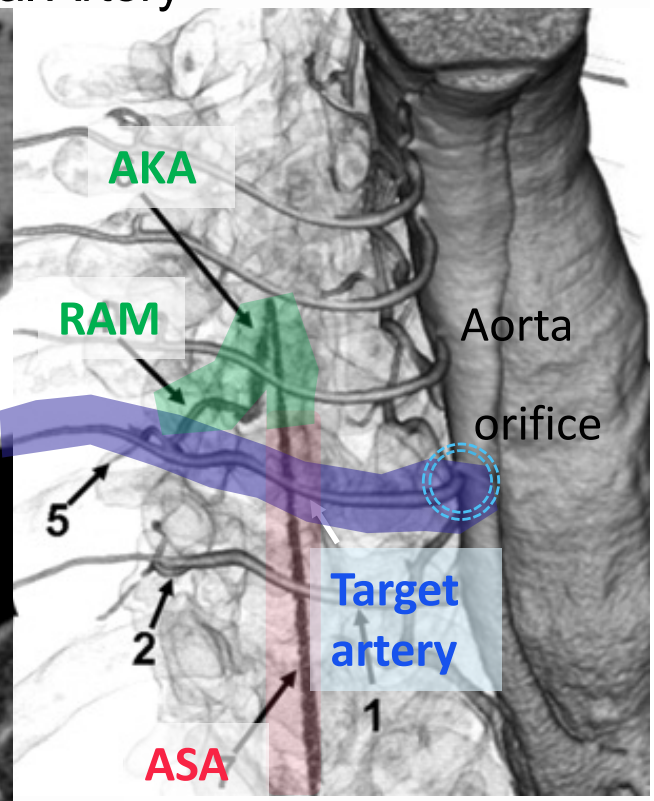
Key to prevent palaplegia

Detect and reconstruct the most important artery to maintain sufficient blood flow to the spine

RAM: Radiculomedullary artery
ASA: Anterior Spinal Artery







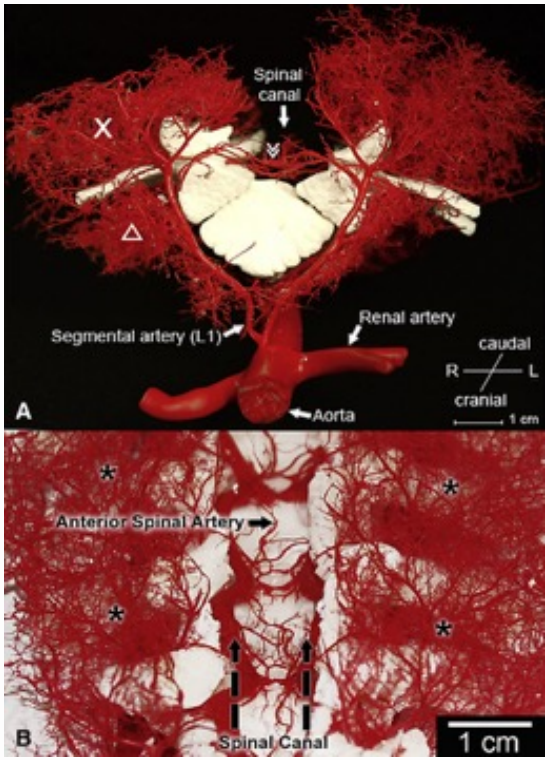
F.H.Netter: Atlas of Human Anatomy

K. Uotani et al. AJNR Am J Neuroradiol 29:314-318, 2008

Collateral network concept

An extensive collateral network of arteries which link the circulation of the spinal cord, the paravertebral tissues, and the skeletal muscles of the back both axially and transversely exists.

Etz et al: J Thorac Cardiovasc Surg 2011;141:1020–8
Etz et al: J Thorac Cardiovasc Surg 2011;141:1029–36



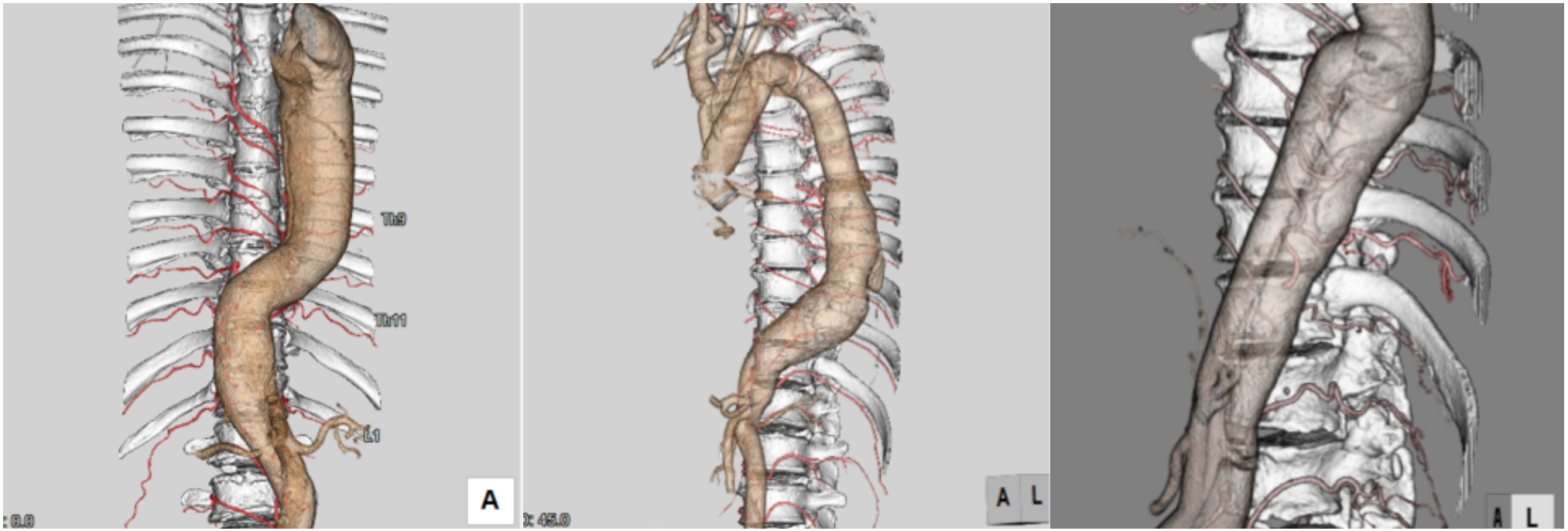
Some surgeons say that
“it is not necessary to identify the Adamkiewicz artery. “

→ Is it true?
Don’t they have any clues that could confirm the location of the artery during surgery?

Difficult decisions - aortic vascular surgery

Arrangement of aorta and intercostal arteries

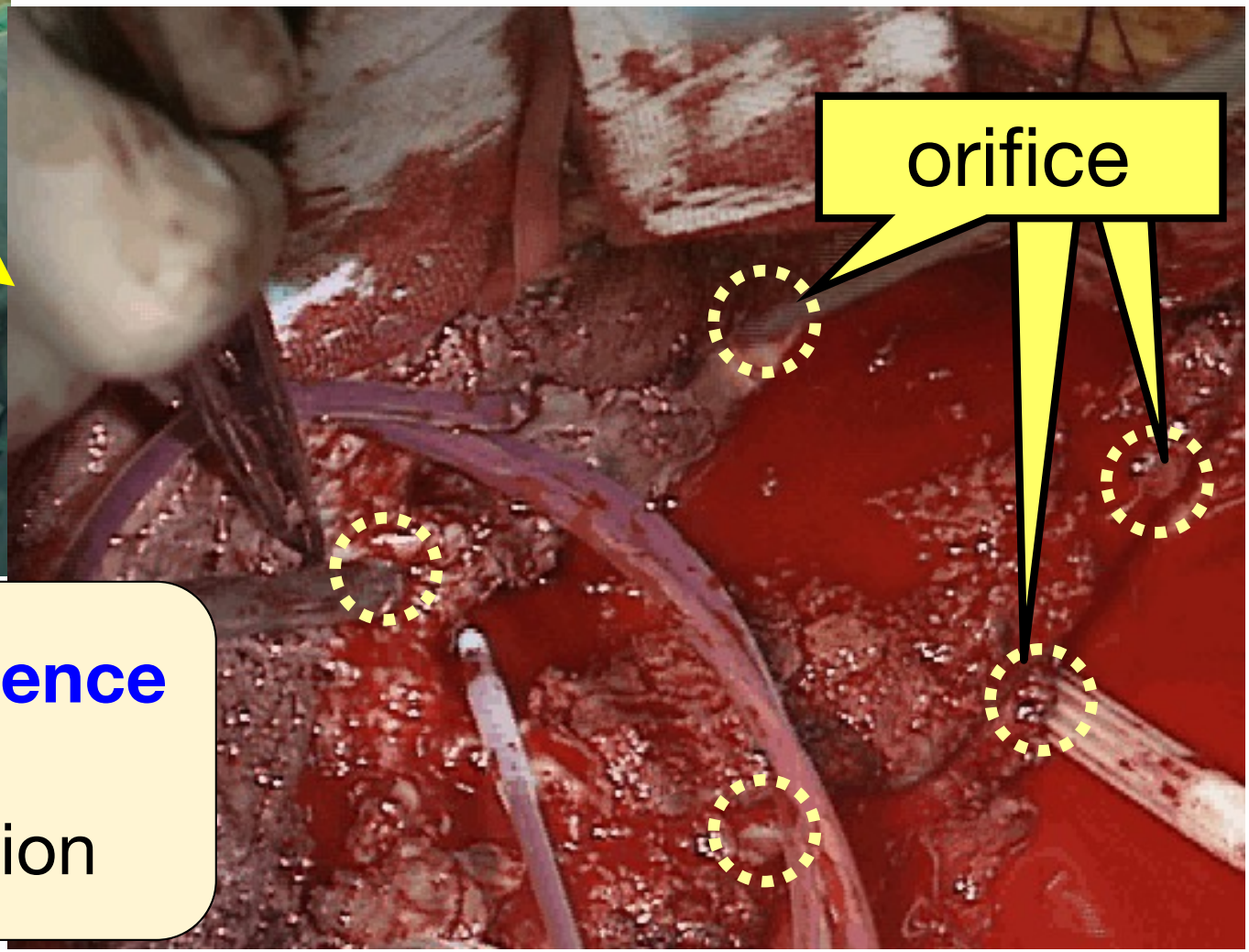
”depend on each patient”



difficulties in correct anatomical orientation

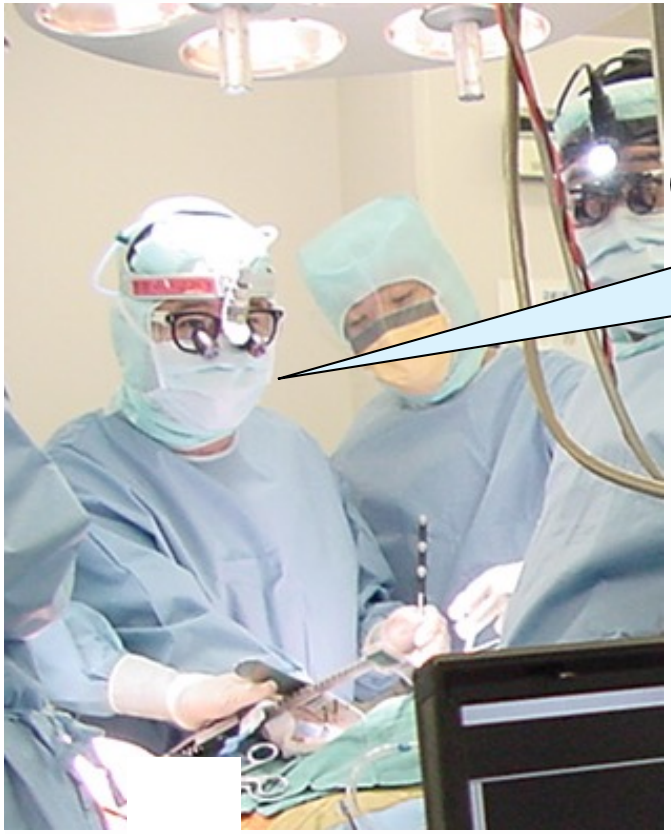
Difficult decisions - aortic vascular surgery

Which orifice should I reconstruct to artificial graft?

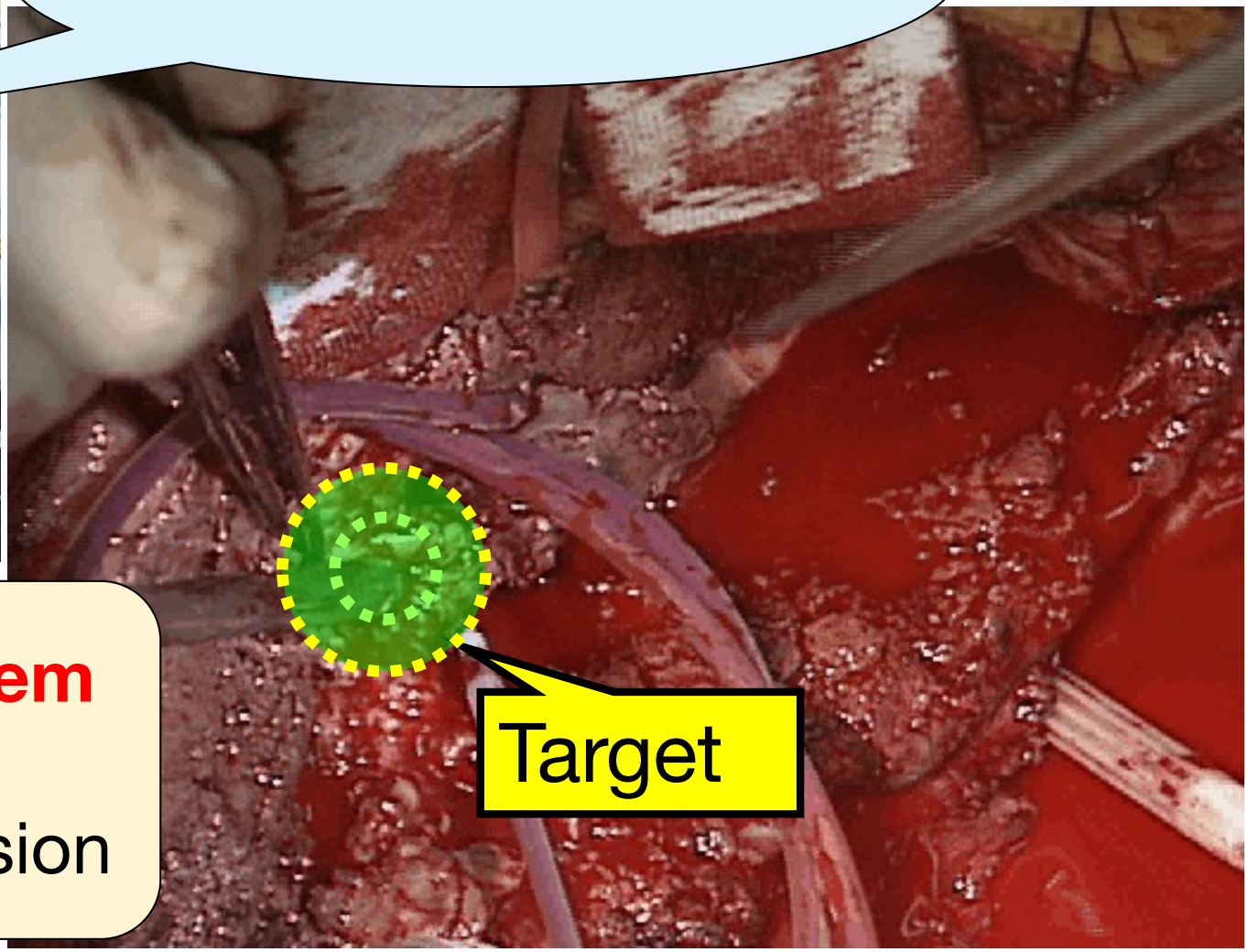


Skills and **Experience**
support
a surgeon's decision

Support for a surgeon's decision making

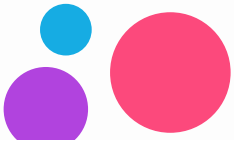


Here it is !!

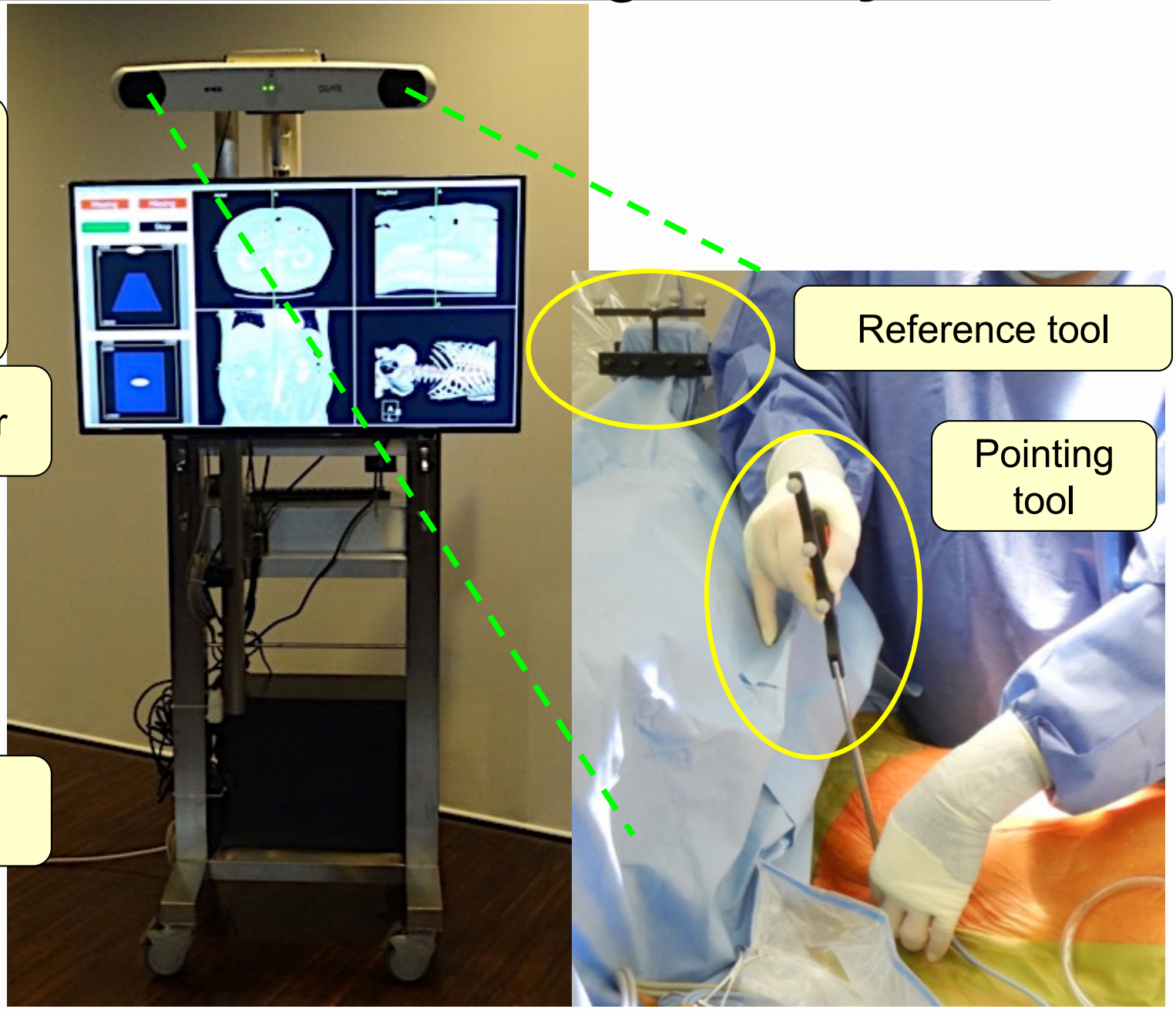


Navigation System
supports
a surgeon's decision

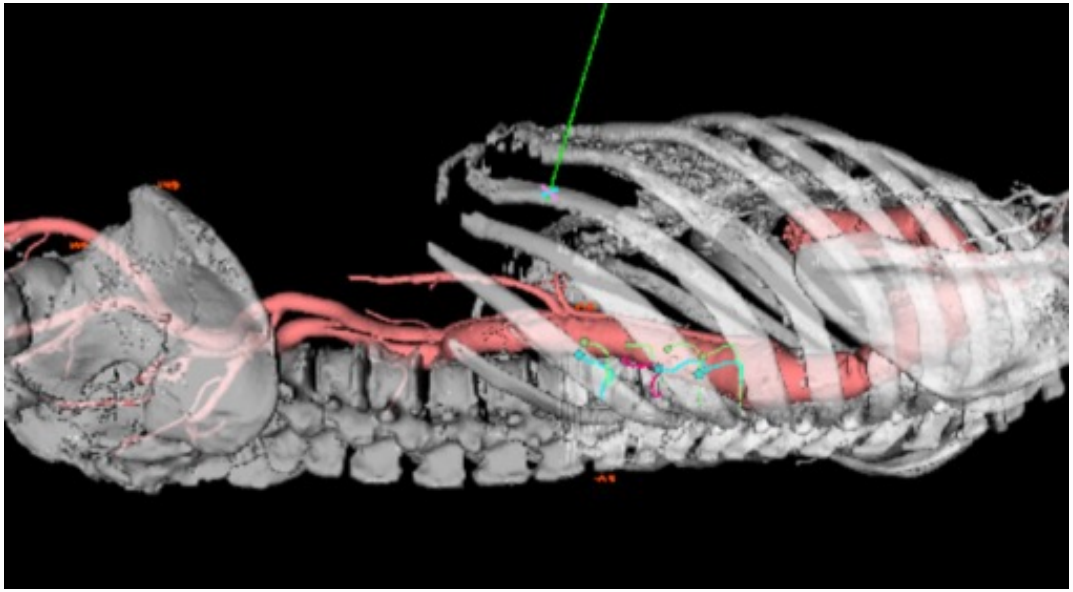
Our navigation system



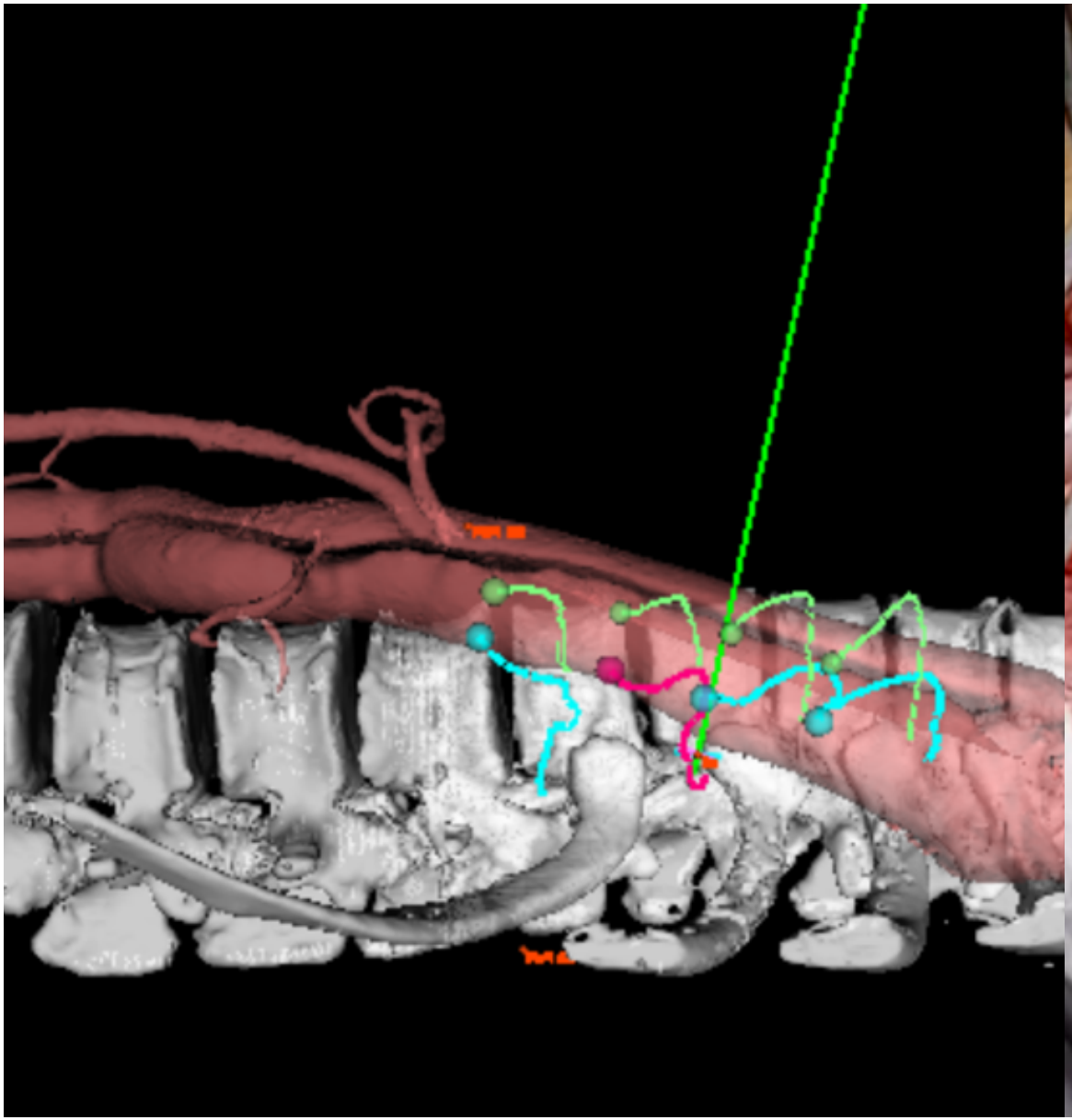
Overview of our navigation system

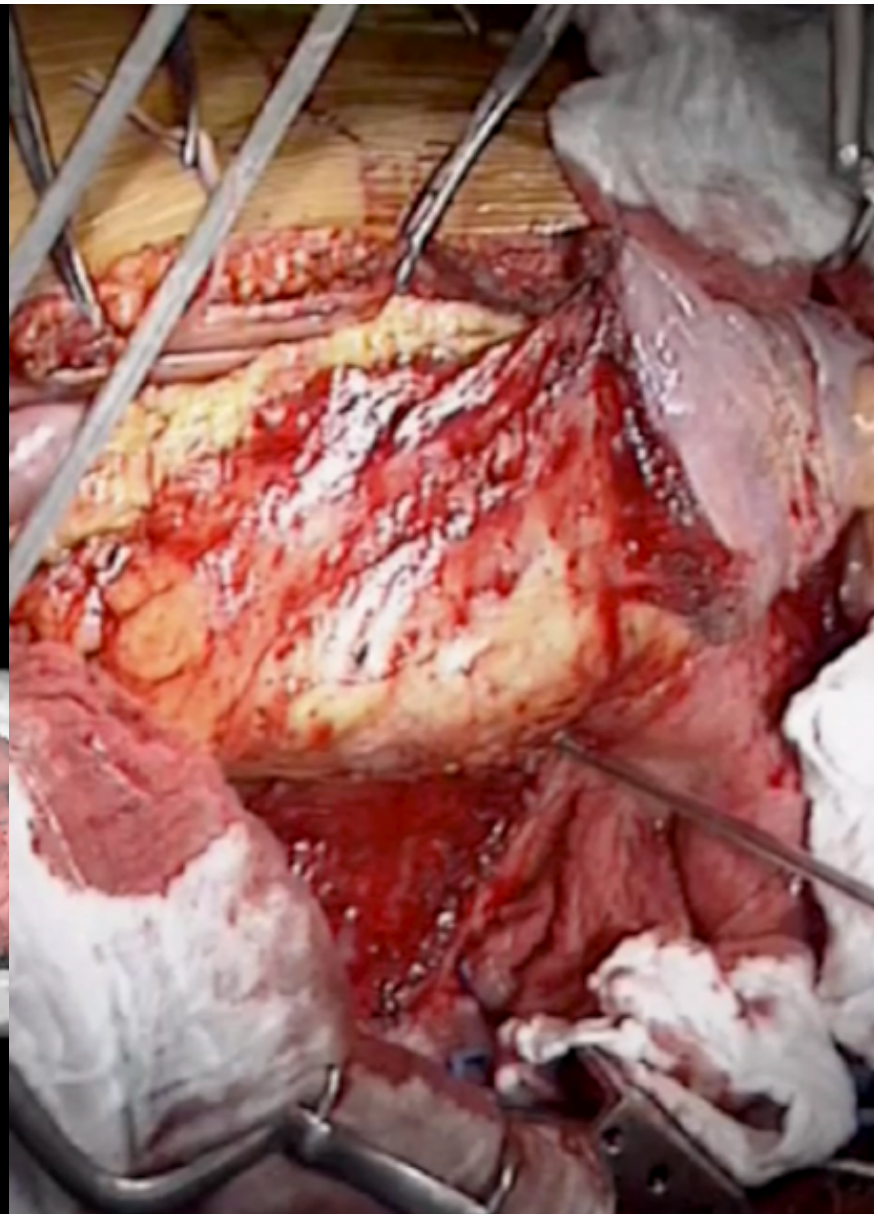


First navigation: before thoracotomy



Second navigation: after adhesiolysis





Clinical Outcomes

Preoperative characteristics of patients who underwent open TAA/TAAA repair

Characteristics	TWMU (Between Feb 2004 and Aug 2016) n=83	All Japan Open Surgery(*) (Between Jan 2000 and Oct 2011) n=1471	P-Value
Age, y.mean(+/-)SD	57±15	64±13	**<.001**
Male sex, n(%)	66(70.0%)	1069(72.7%)	.892
Hypertension, n(%)	44(53.0%)	1213(82.5%)	**<.001**
Hyperlipidemia, n(%)	8(9.6%)	370(25.2%)	**<.001**
Smoking, n(%)	5(6.0%)	827(56.2%)	**<.001**
Coronary artery disease, n(%)	12(14.5%)	254(17.3%)	.653
Renal failure, n(%)	12(14.5%)	202(13.7%)	.870
Dialisys, n(%)	4(4.8%)	51(3.4%)	.533
Cerebrovascualr disease, n(%)	10(12.0%)	189(12.8%)	1
Chronic lung disease, n(%)	12(14.5%)	253(17.2%)	.652
Liver disease, n(%)	1(1.2%)	8(0.5%)	.391
Dissecting	51(61.4%)	539(36.7%)	**<.001**
-D(A)	13(15.7%)		
-D(B)	38(45.8%)		
Nondissecting	30(36.1%)	837(56.9%)	**<.001**
Infected	3(3.6%)	79(3.2%)	.620
Emergency repairs, n(%)	4(4.8%)	253(16.8%)	**.002**
Preoperative AKA identification, n(%)	69(83.1%)	748(50.8%)	**<.001**

* J Thorac Cardiovasc Surg. 2016 Jan;151(1):122-8.

Data were collected from Japanese Study of Spinal Cord Protection in Descending and Thoracoabdominal Aortic Repair investigators.

Surgical outcomes

Number of cases

	(Between Feb 2004 and Aug 2016) TWMU n=83	(Between Jan 2000 and Oct 2011) All Japan* n=467
Crawford		
I	13	137
II	43	136
III	27	194

Extent IV: eliminated (due to differences in surgical techniques)

Outcomes

	Mortality (n, %)		Spinal Cord Injuries (n,%)	
	TWMU	All Japan	**TWMU**	All Japan
Crawford				
I	0 (0%)	14 (10.2%)	1 (7.7%)	13 (9.5%)
II	4 (9.3%)	14 (10.3%)	2 (4.7%)	19 (14.0%)
III	0 (0%)	26 (13.4%)	1 (3.7%)	28 (14.4%)

* J Thorac Cardiovasc Surg. 2016 Jan;151(1):122-8.

Data were collected from Japanese Study of Spinal Cord Protection in Descending and Thoracoabdominal Aortic Repair investigators.

AKA image acquisition by MDCTA*

*MDCTA: multidetector computed tomographic angiography

83 cases — Surgery performed on TAAA patients between Feb 13, 2004, and Aug 9, 2016

→ **14** cases — AKA *were not identified* by **'Pre-operative'** MDCT Angiography

ZERO paraplegia

3/14 emergency **11/14 AKA undepicted**

69 cases — AKA *were identified* by **'Pre-operative'** MDCT Angiography

→ **6** cases — **'Post-operative'** MDCT Angiography *was not performed*

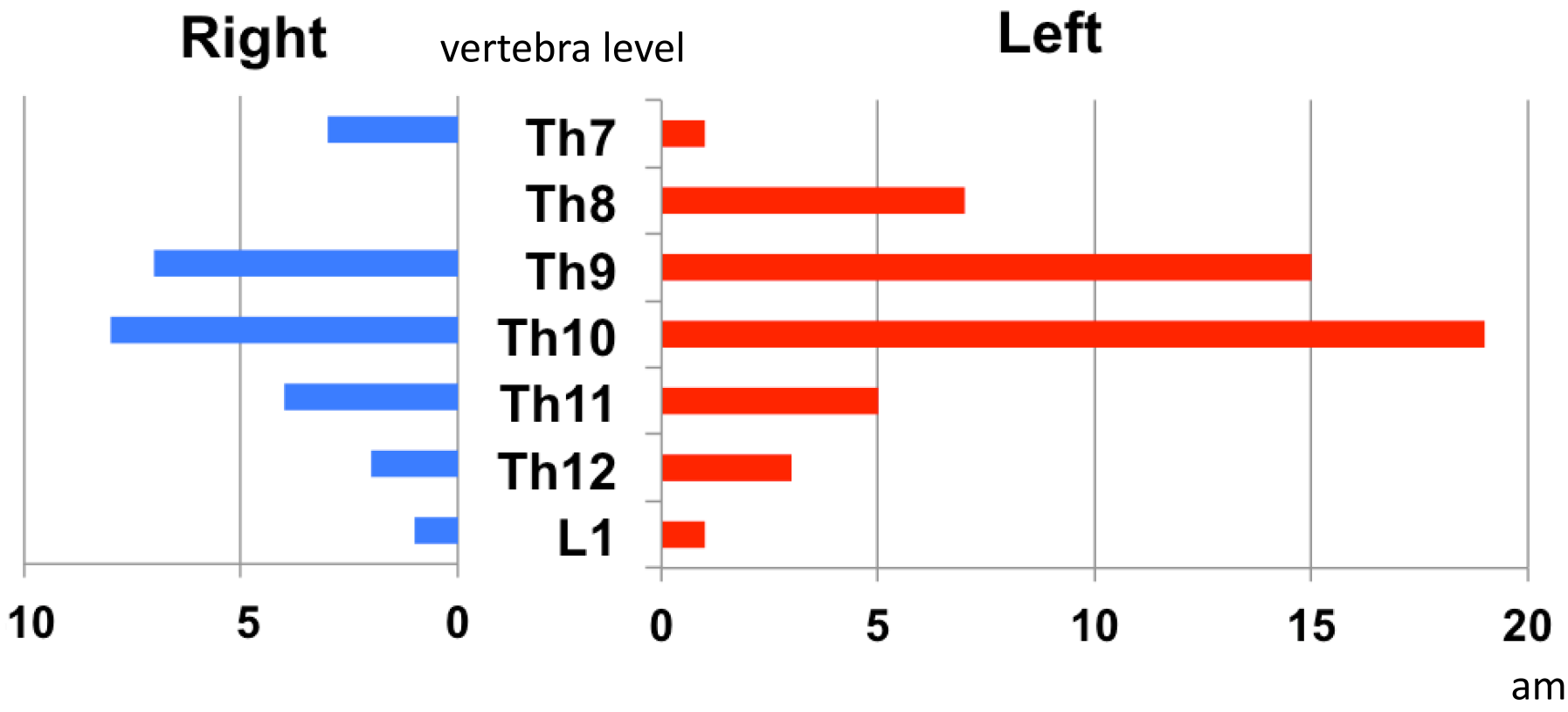
ZERO paraplegia

4/6 death **2/6 AKA undepicted**

63 cases — **'Pre- and Post- operative'** MDCT Angiography *were performed*

Distribution of target artery

In 69 cases, the connectivity of target artery to Adamkiewicz artery were identified, preoperatively.



Maintenance of the patency of the target artery and Adamkiewicz artery

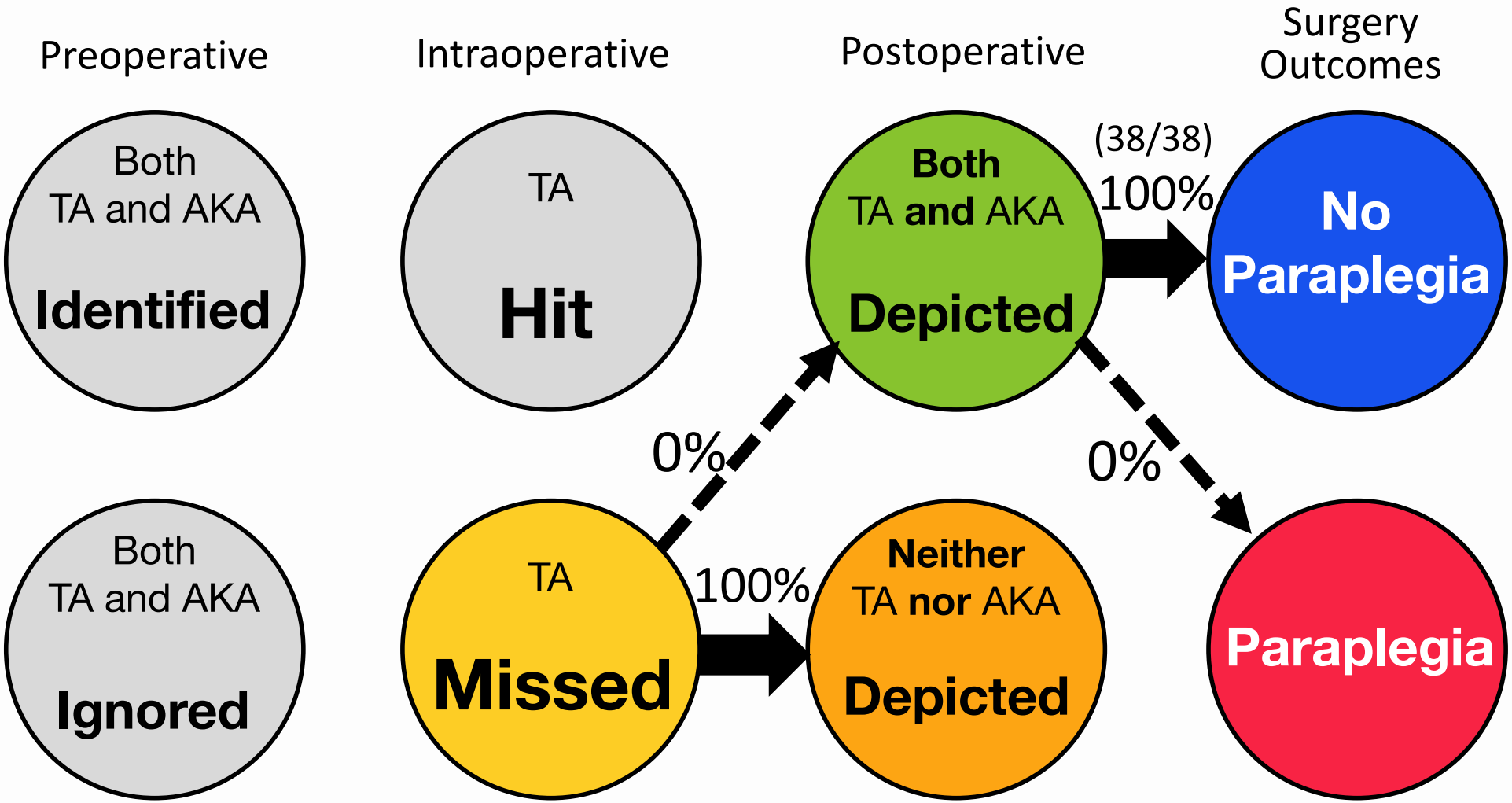
In 38 cases, the connectivity of target artery to Adamkiewicz artery were identified, postoperatively.

63 cases AKA *were* identified by **'Pre- and Post- operative'** MDCT Angiography

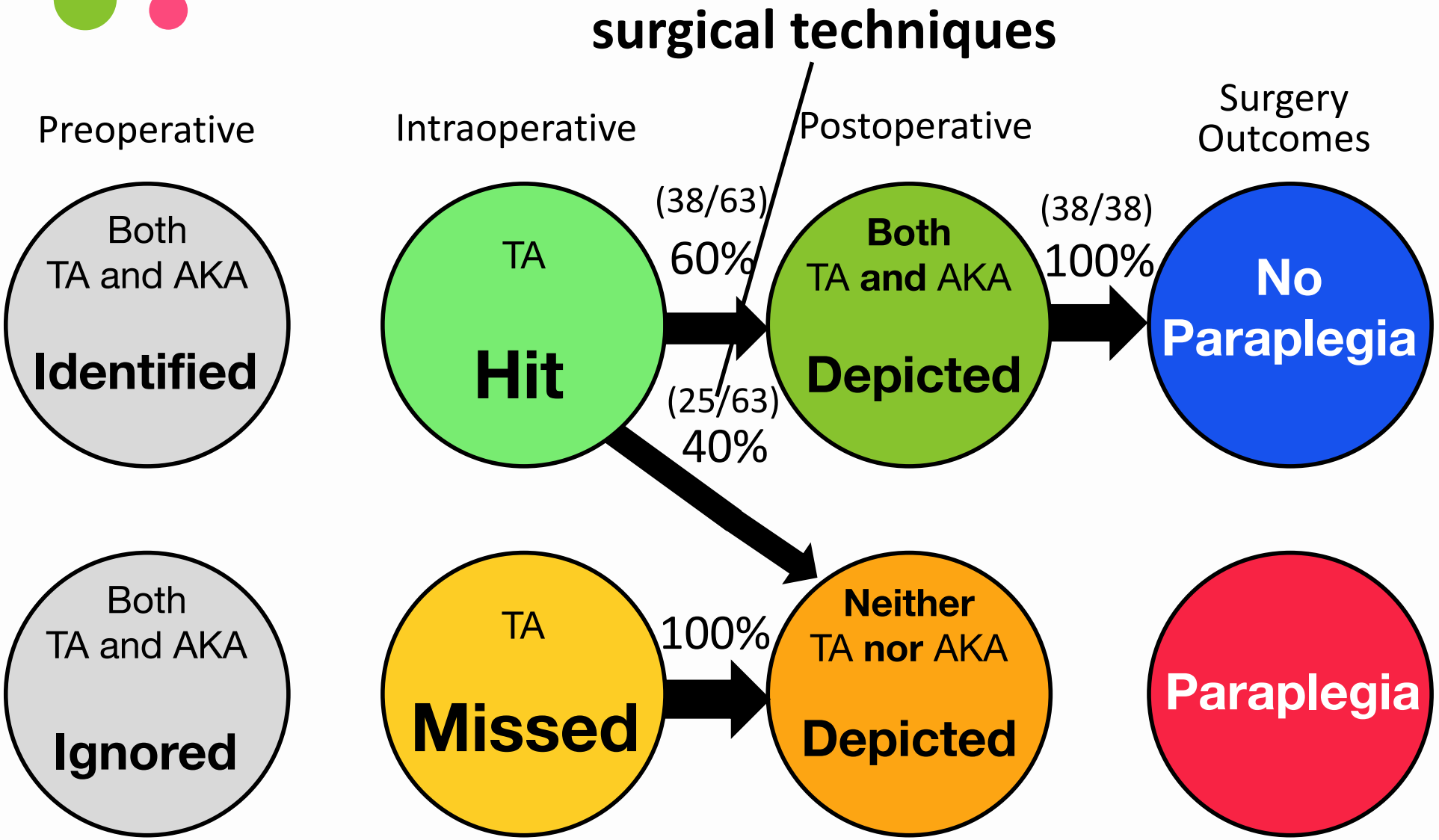
25 cases AKA *were not* identified by **'Post-operative'** MDCT Angiography

38 cases Both Target Artery and Adamkiewicz artery were **Depicted(Patent) postoperatively**

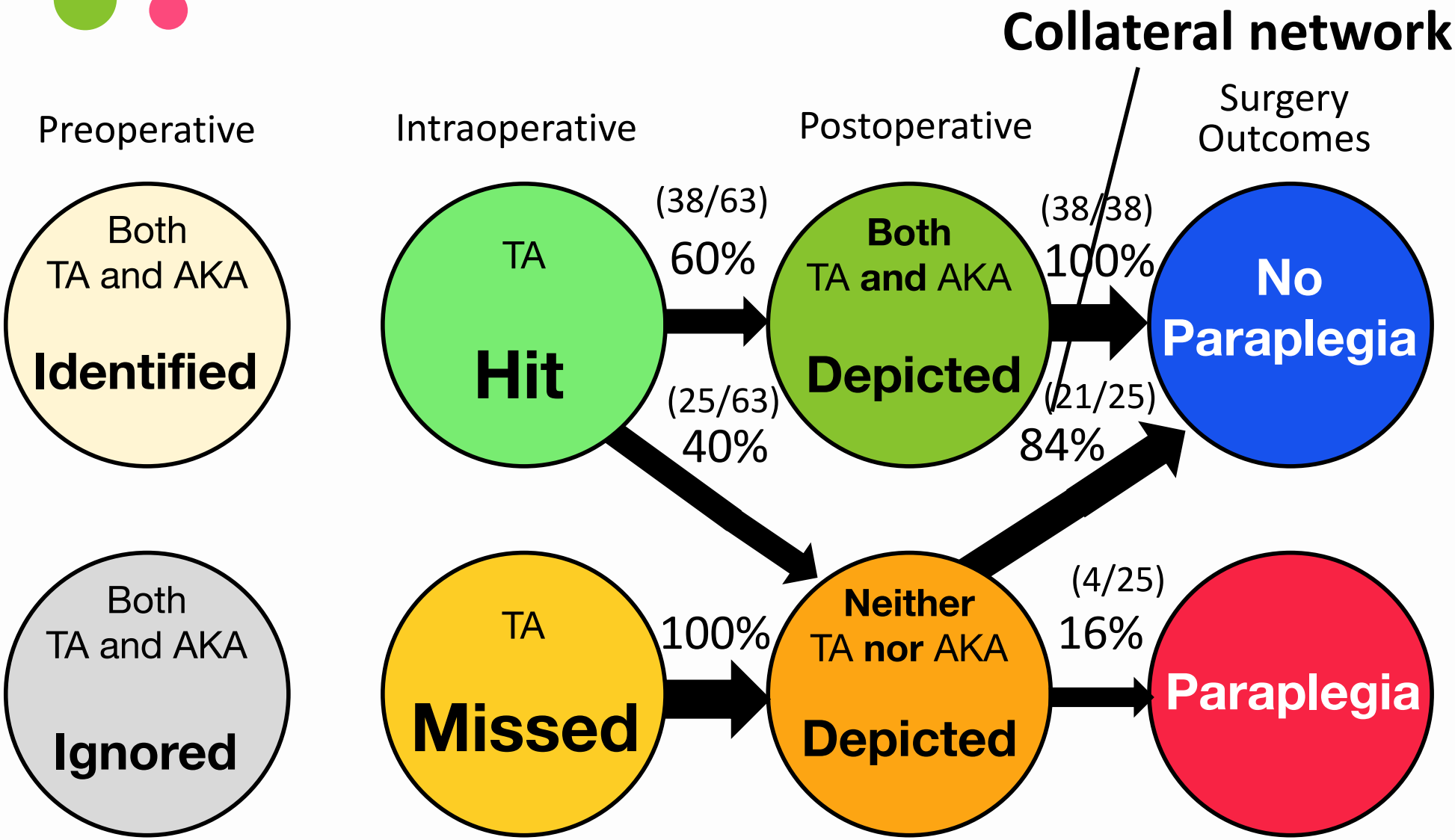
Discussion


Preoperative
Intraoperative
Postoperative
Surgery Outcomes
Both TA and AKA Identified
TA Hit
Both TA and AKA Depicted
(38/38) 100%
No Paraplegia
0%
0%
Both TA and AKA Ignored
TA Missed
100%
Neither TA nor AKA Depicted
Paraplegia

Discussion

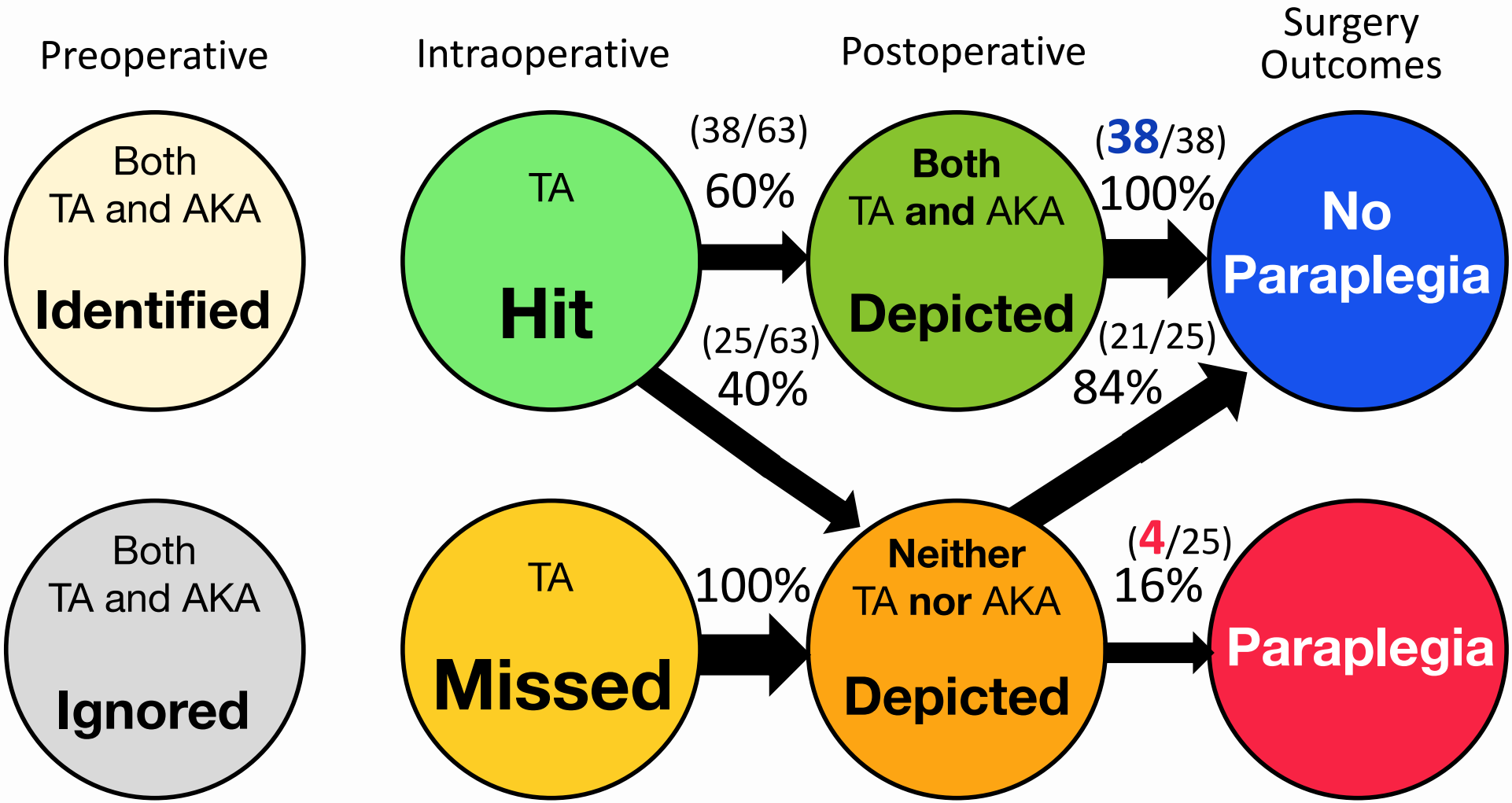

surgical techniques
Preoperative
Intraoperative
Postoperative
Surgery Outcomes
Both TA and AKA Identified
TA Hit
(38/63) 60%
(25/63) 40%
Both TA and AKA Depicted
(38/38) 100%
No Paraplegia
Both TA and AKA Ignored
TA Missed
100%
Neither TA nor AKA Depicted
Paraplegia

Discussion


Collateral network
Preoperative
Intraoperative
Postoperative
Surgery Outcomes
Both TA and AKA Identified
TA Hit
(38/63) 60%
Both TA and AKA Depicted
(38/38) 100%
No Paraplegia
(25/63) 40%
(21/25) 84%
Both TA and AKA Ignored
TA Missed
100%
Neither TA nor AKA Depicted
(4/25) 16%
Paraplegia

Discussion

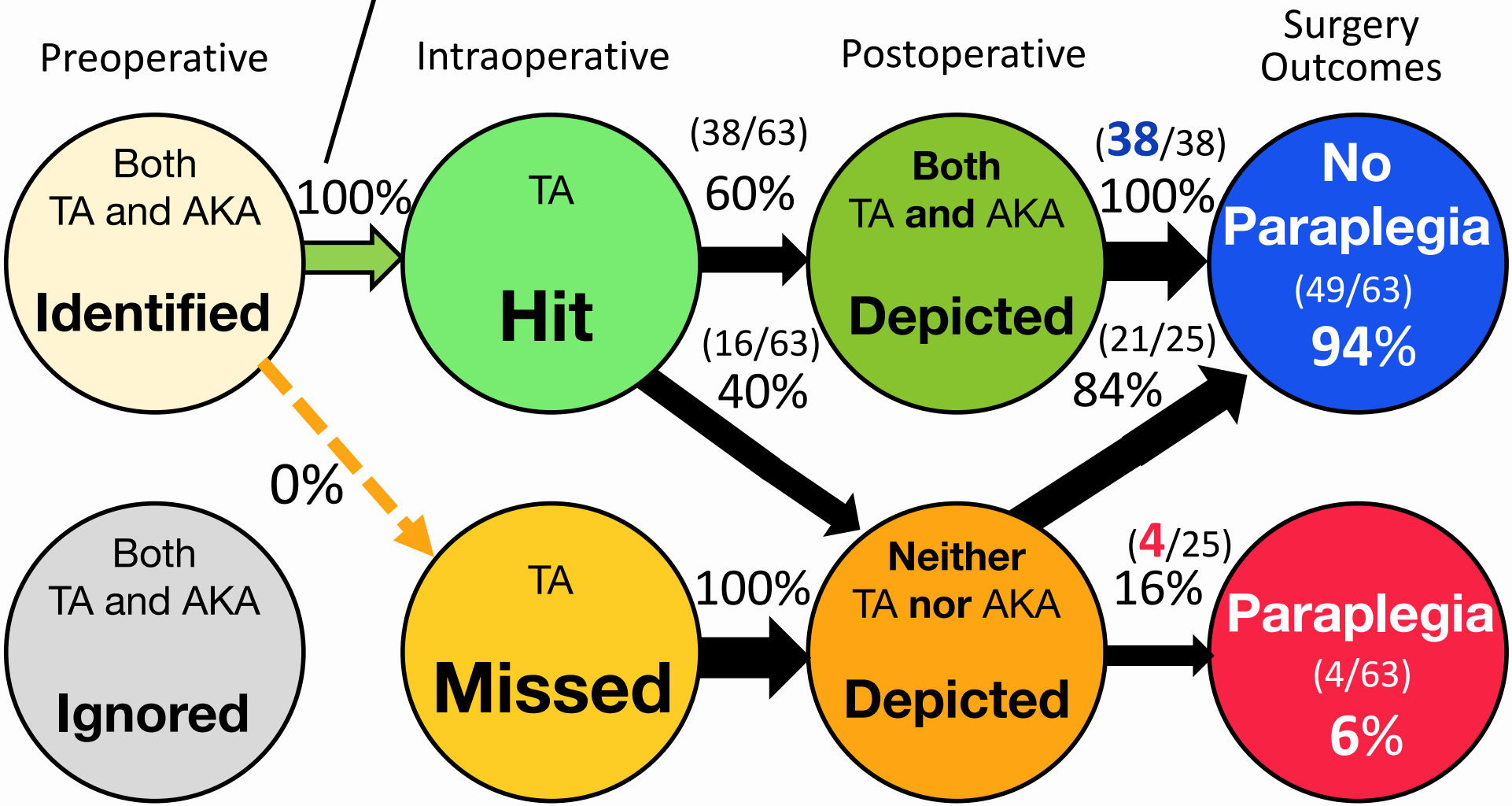
Using the ratio of **38** to **4**, we can therefore say that in approximately **1** out of every **10** cases, paraplegia could have been prevented.



Discussion

Navigation

Our navigation enables an increase in '**the hit probability of the target artery**', if the target artery is identified preoperatively.



The navigation system largely contributed in lowering the risk of paraplegia to one in ten.

Summary

Our navigation system was applied for TAAA repair.

Clinical finding as follows:

(1) Should the target artery be reconstructed?

No. Not always.

Surgeons are required to make a decision by considering individual cases during surgery.

(2) Preoperative CT image acquisition to identify Adamkiewicz artery(AKA) is needed?

Yes, it does.

A surgeons' decision changes, based on whether or not AKA is depicted .

Summary

In TAAA repair,

(2) Preoperative CT image acquisition to identify Adamkiewicz artery(AKA) is needed?

(i) AKA was **not** depicted — Superior: collateral arteries

No paraplegia was occurred regardless of reconstruction of the intercostal artery.

(ii) AKA was depicted — Superior: AKA

The reconstruction of the intended artery is a key to maintaining sufficient blood supply.

Future outlook

Contribution of ‘Artificial Intelligence’ in surgery

- ✓ **selection of appropriate treatments**

  Fair and equitable distribution of health system resources

- ✓ **role in effective surgical procedures**

  guidance driven by such big data will support a surgeons’ existing excellent skills and wealth of experience

Thank you for attention

Acknowledgements

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