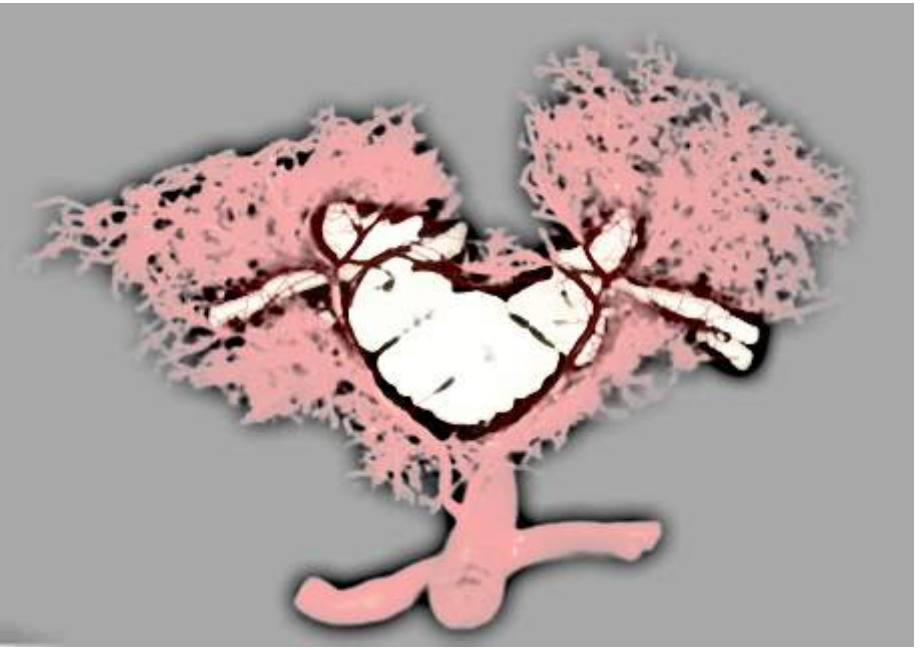
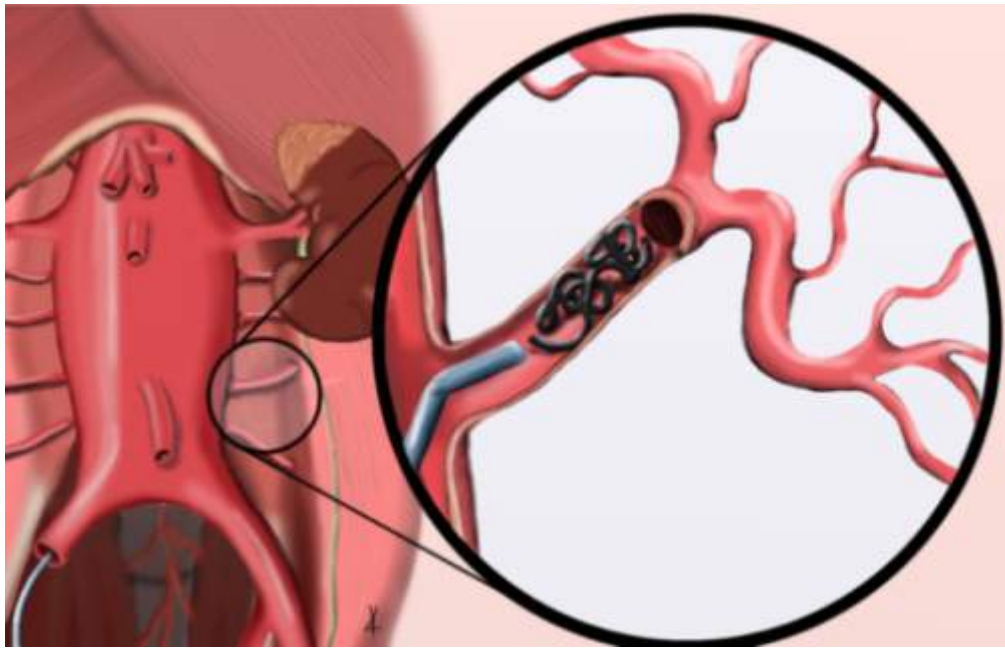
Staging techniques to reduce the risk of ischemic SCI

Professor Dr.
Christian D. Etz
Heisenberg Professor of Aortic Surgery (DFG)





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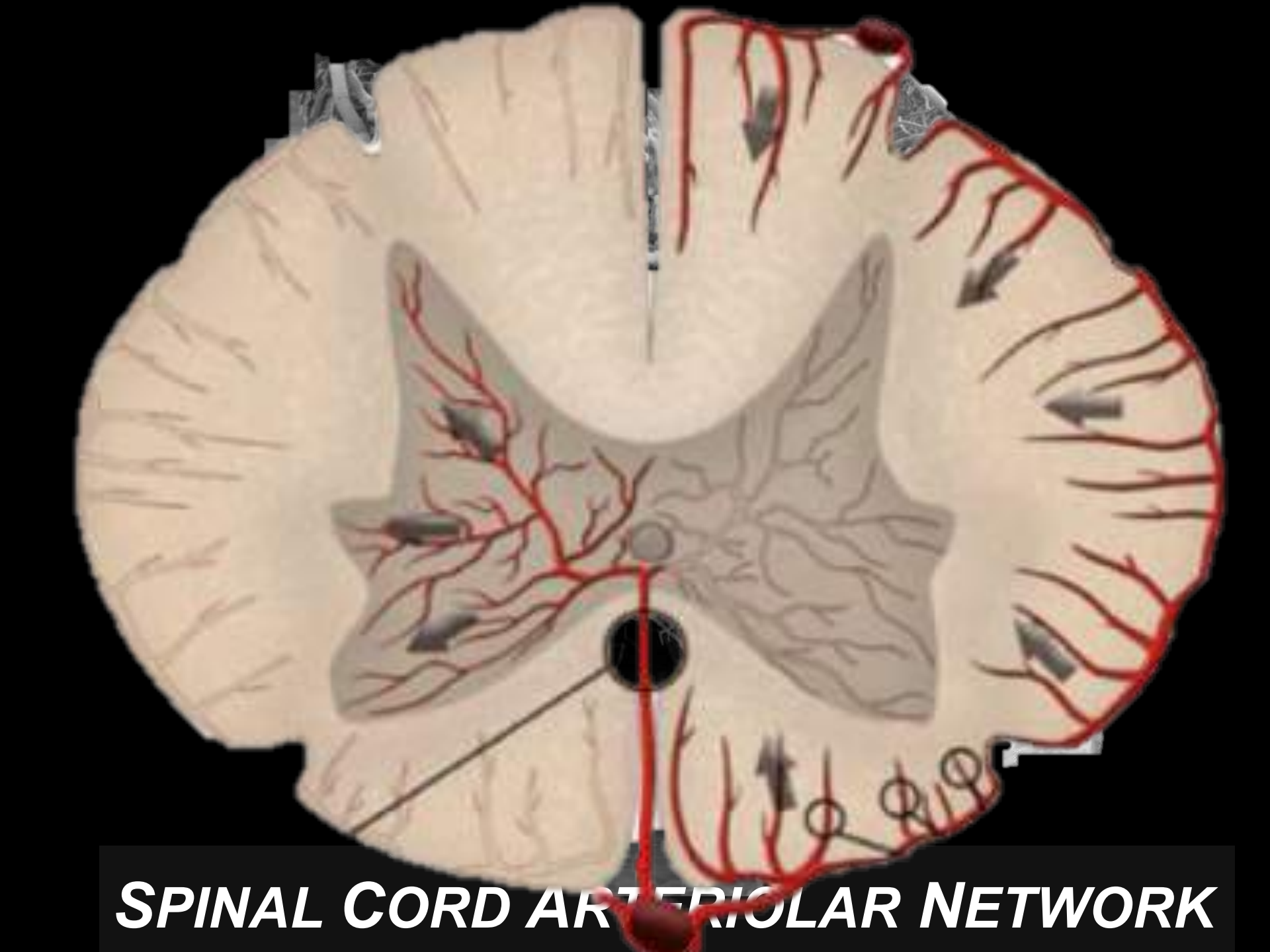
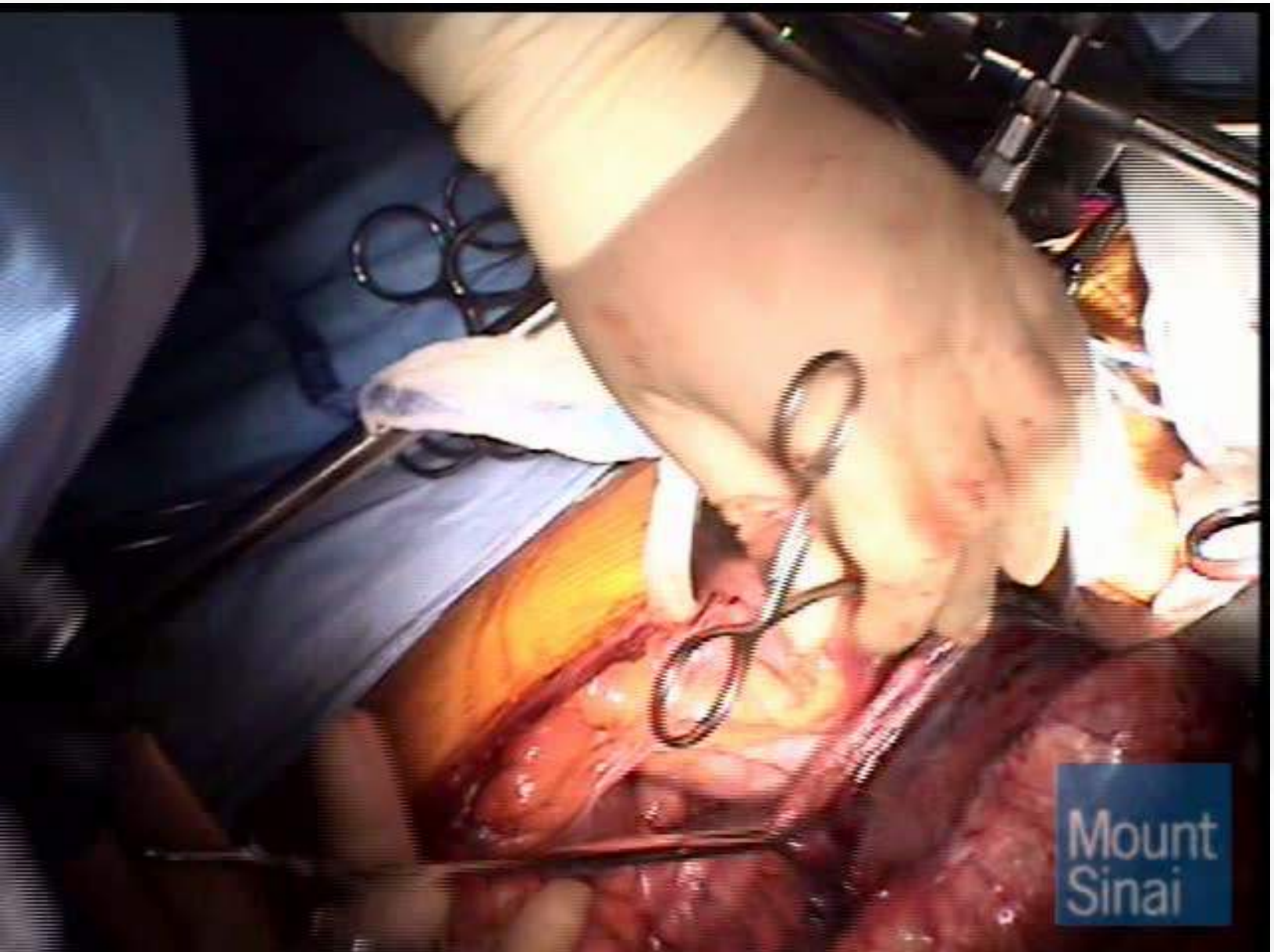

SPINAL CORD ARTERIOLAR NETWORK

Spinal cord perfusion pressure (SCPP)



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MEDICINE

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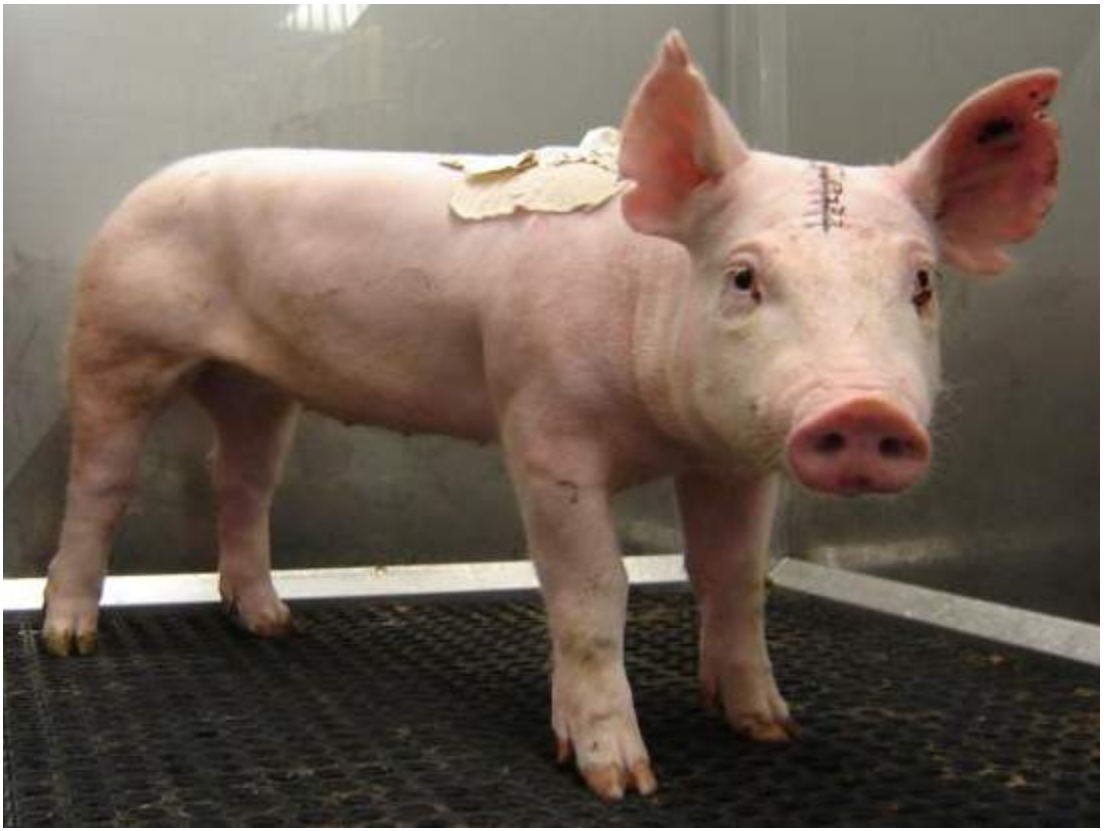
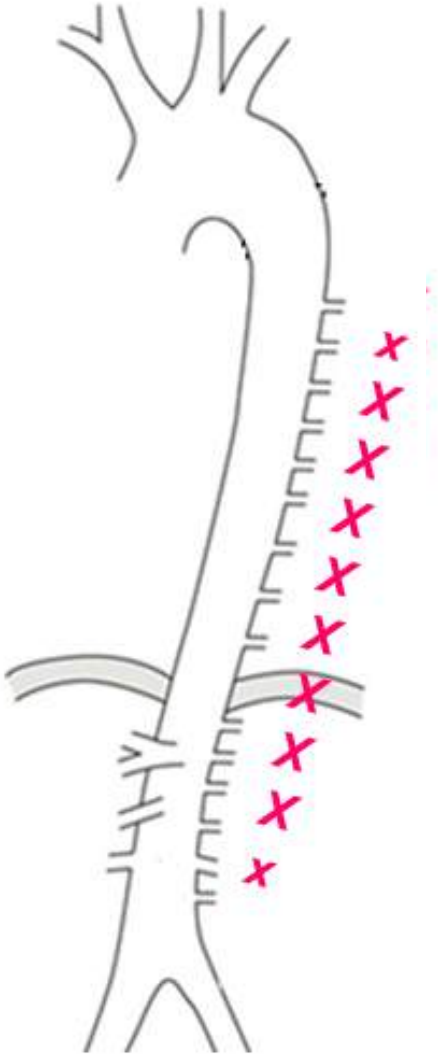
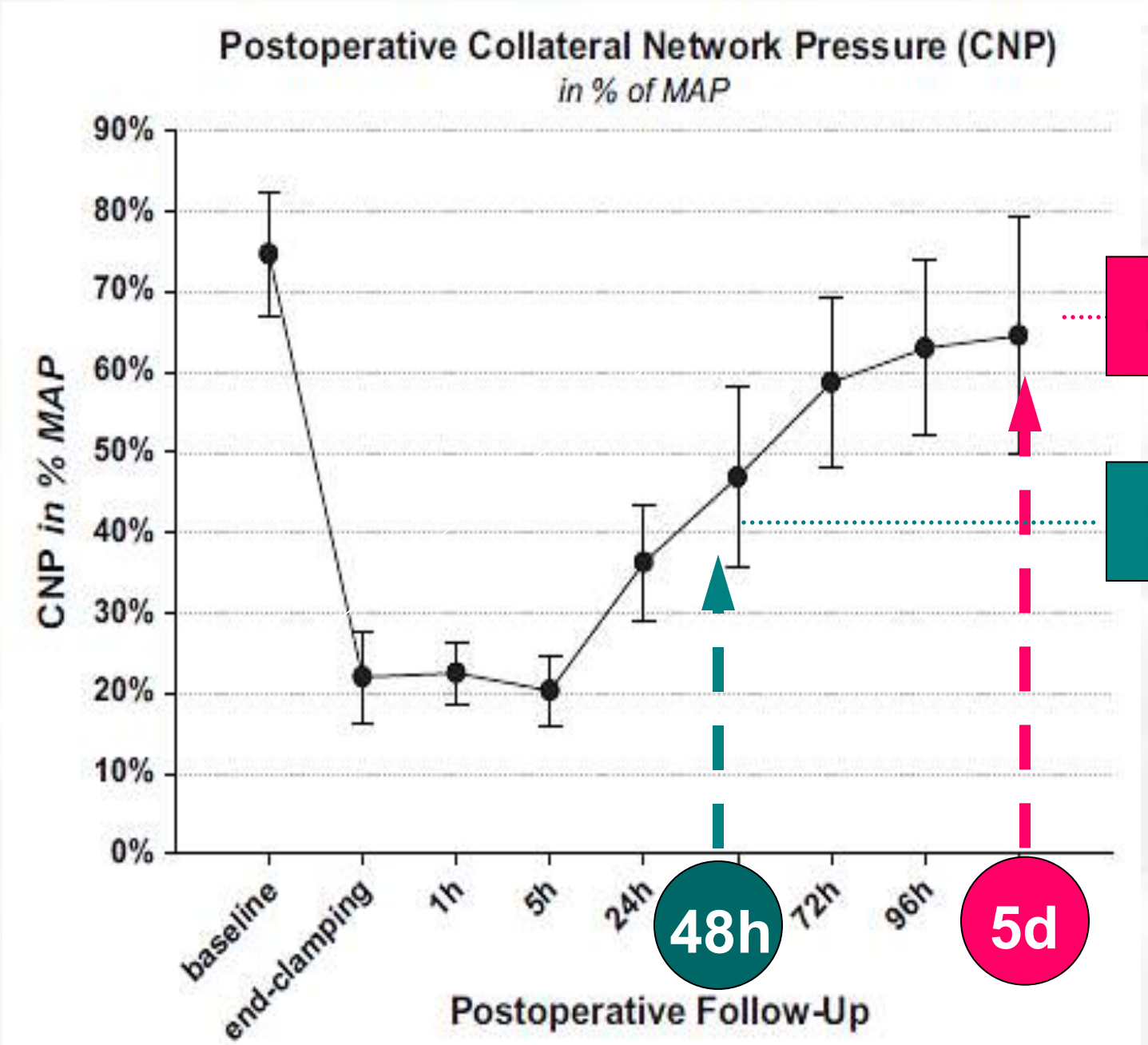
Experimental Segmental Artery Occlusion





Yorkshire pigs



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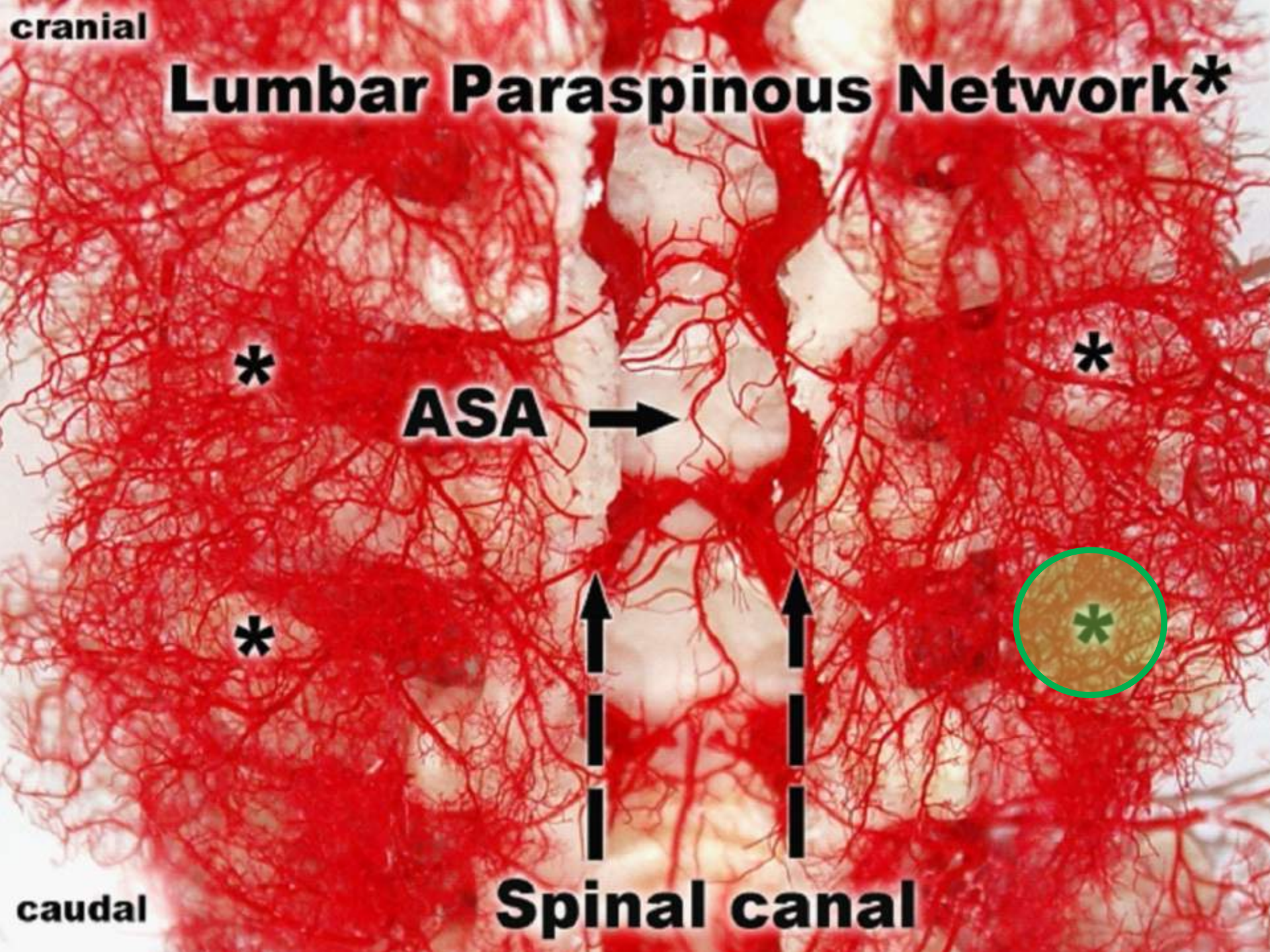
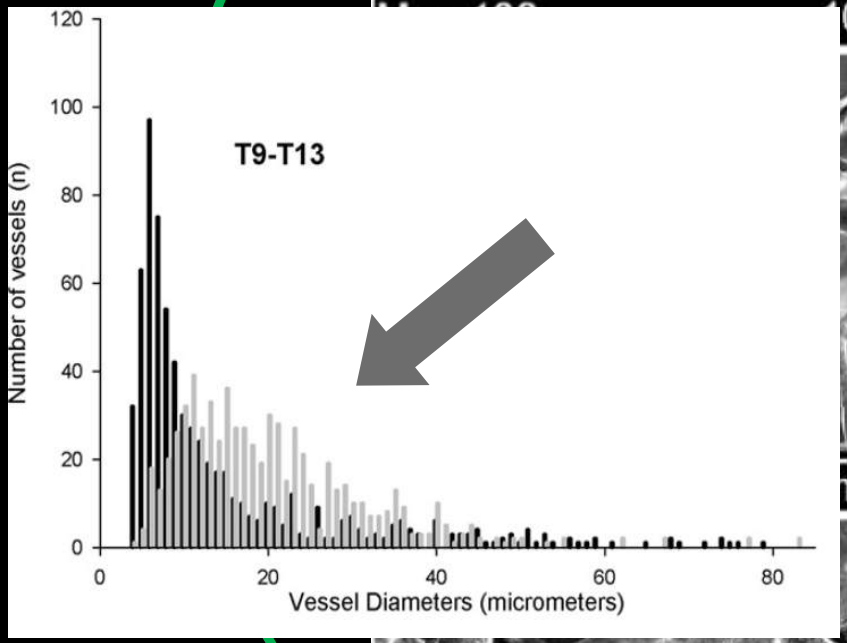
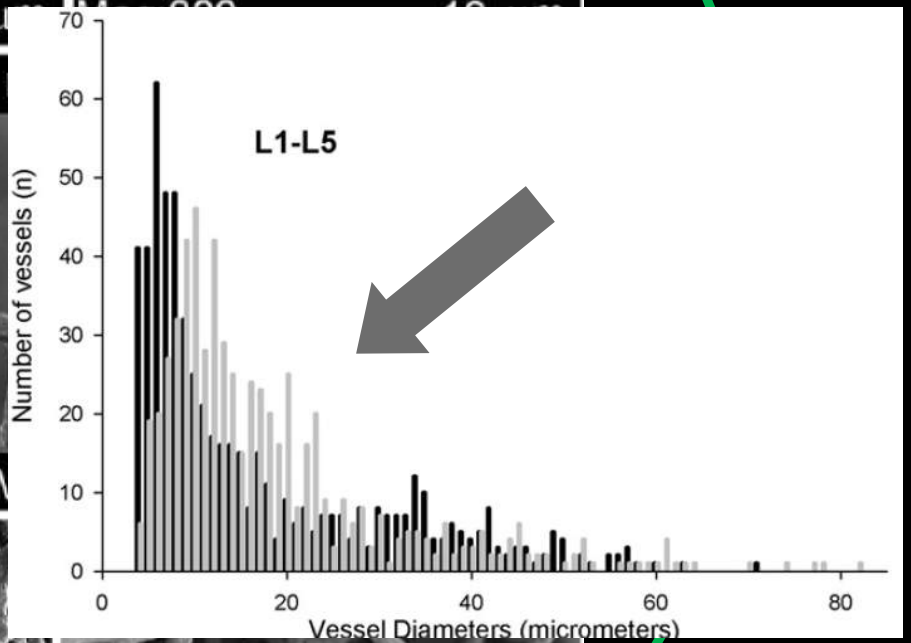
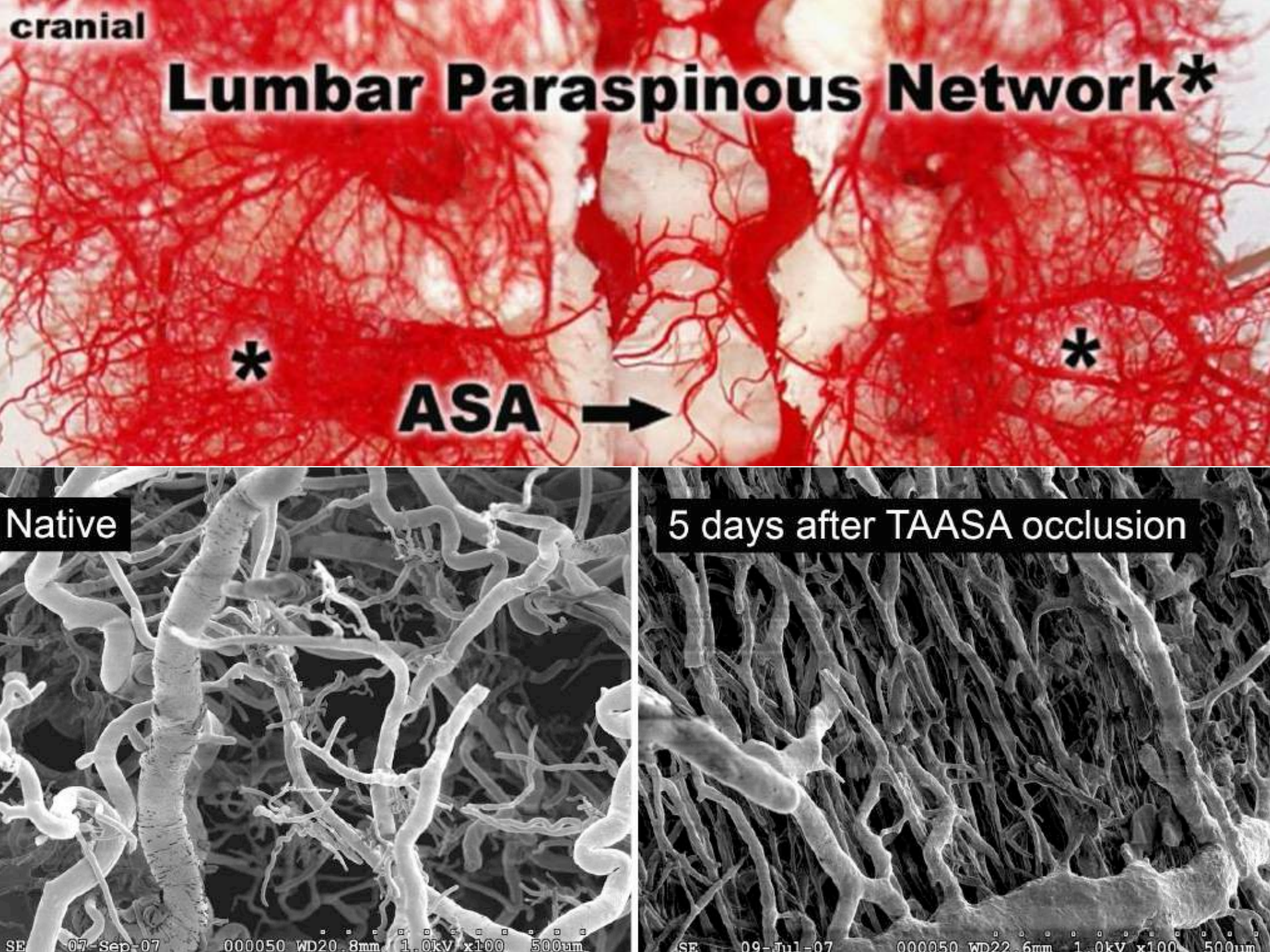

cranial
Lumbar Paraspinous Network*
*
*
ASA
*
*
caudal
Spinal canal

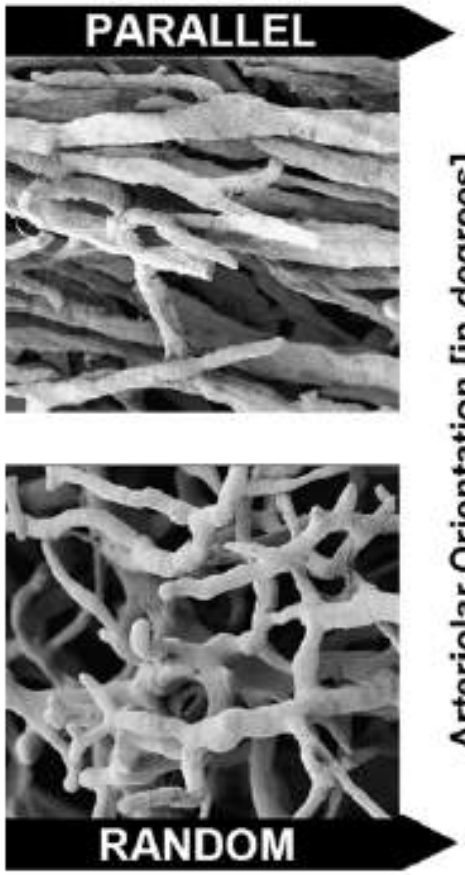

T9-T13
Number of vessels (n)
Vessel Diameters (micrometers)
0
20
40
60
80
100
120

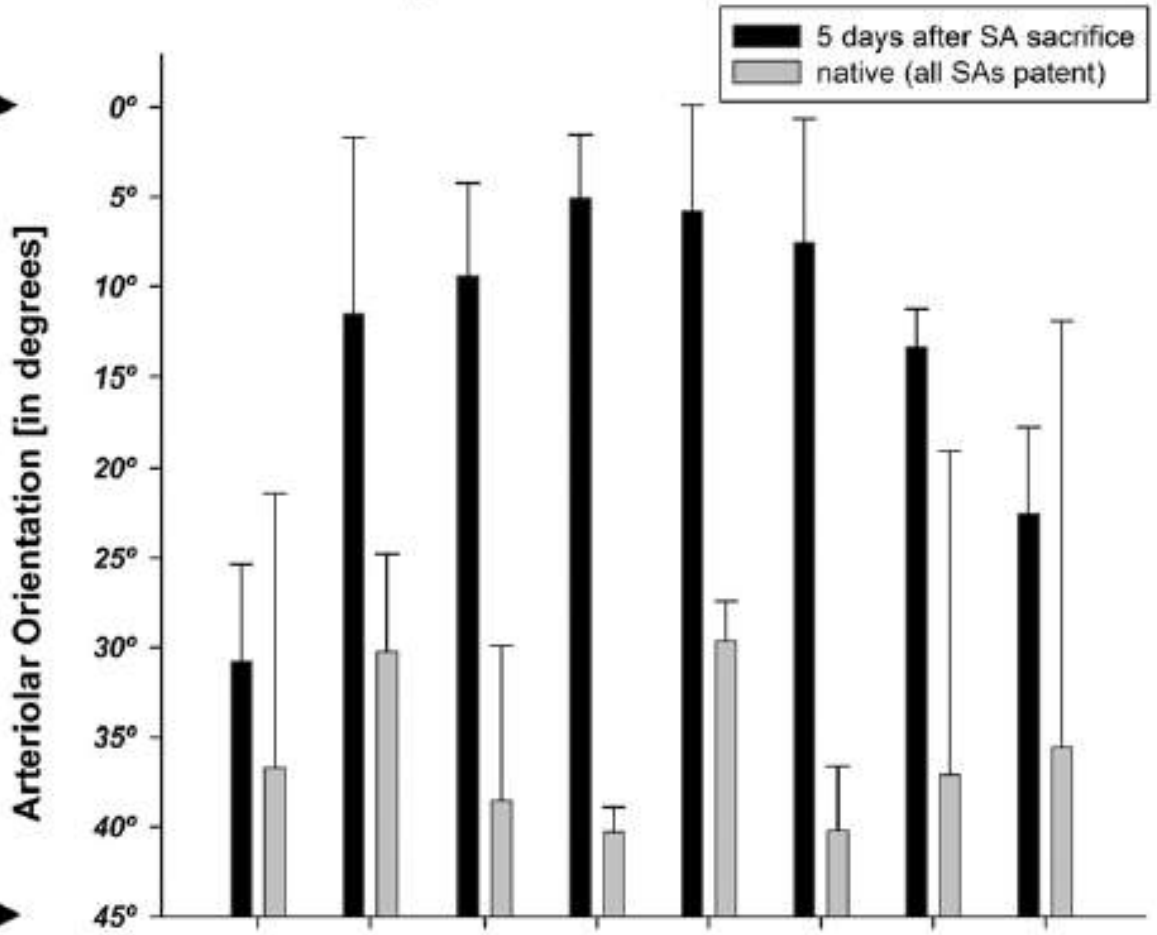

L1-L5
Number of vessels (n)
Vessel Diameters (micrometers)
0
10
20
30
40
50
60
70

A
B
L 1 - 4.65µm
100 µ
Mag:150
100µm
Mag:250
100 µm


cranial
Lumbar Paraspinous Network*
*
*
ASA
Native
5 days after TAASA occlusion
SE 07-Sep-07 000050 WD20.8mm 1.0kV x100 500µm
SE 09-Jul-07 000050 WD22.6mm 1.0kV x100 500µm

Orientation of the *Paraspinous* Collateral Network
Arterioles *prior to* and *after* complete SA sacrifice





Etz *et al., J Thorac Cardiovasc Surg.* ***2011*** *Apr;141*
Etz *et al., J Thorac Cardiovasc Surg.* ***2015*** *Apr;14*

IMPLICATION:
STAGED THERAPY

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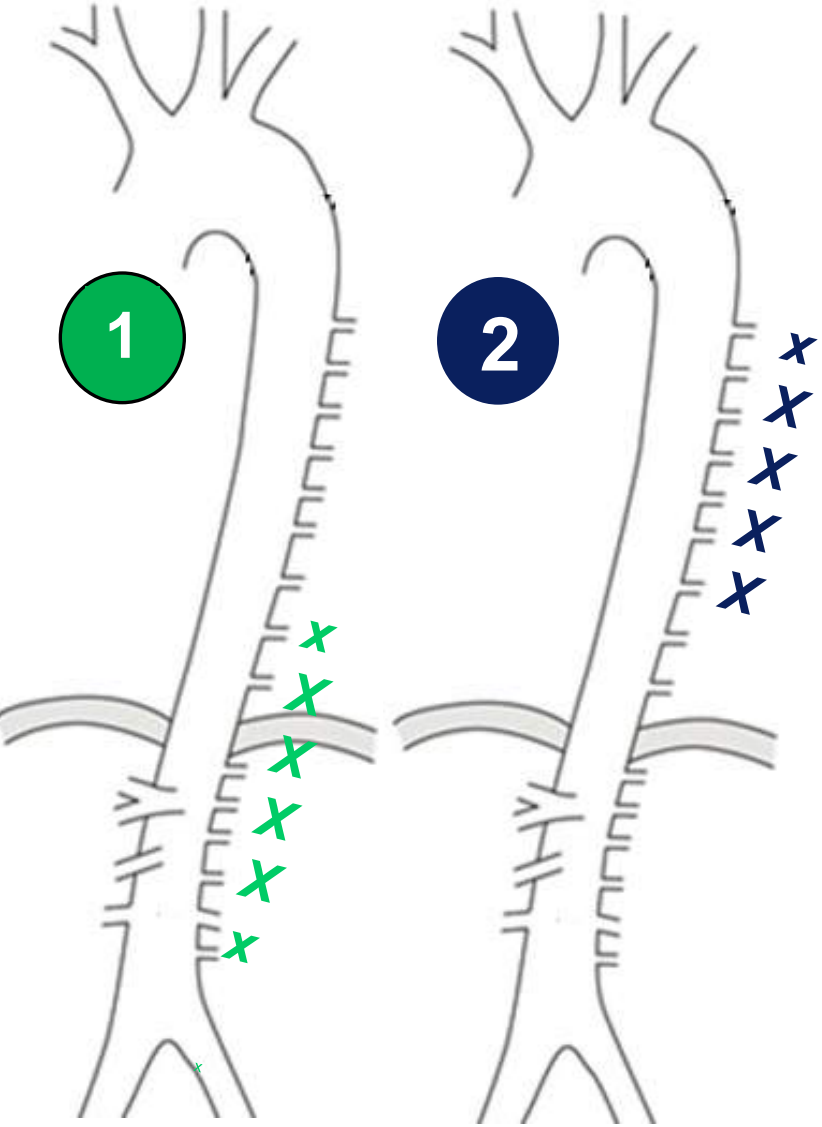
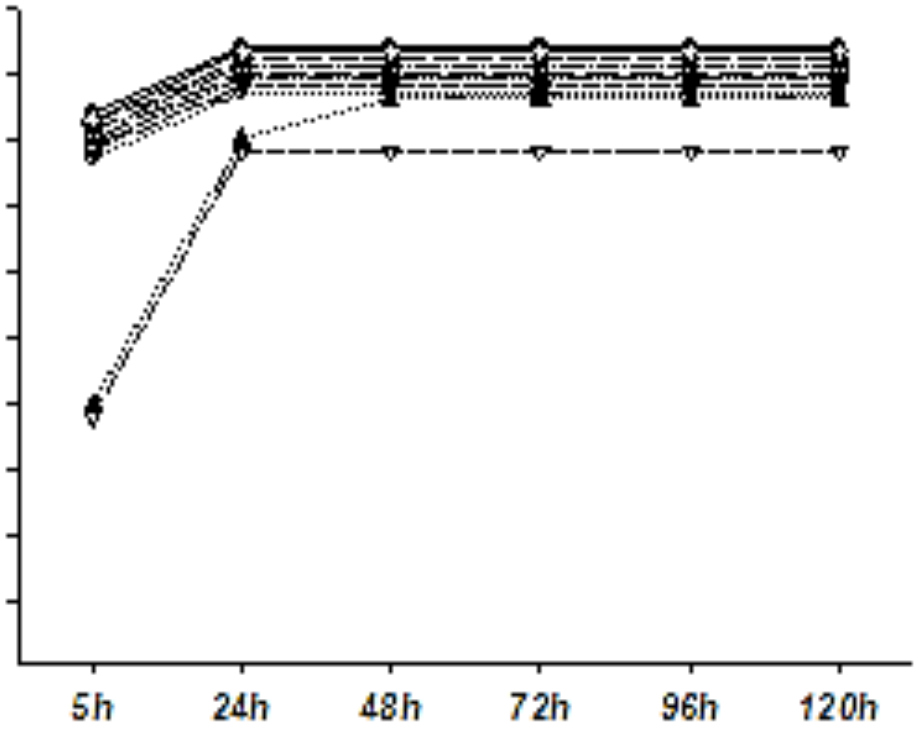
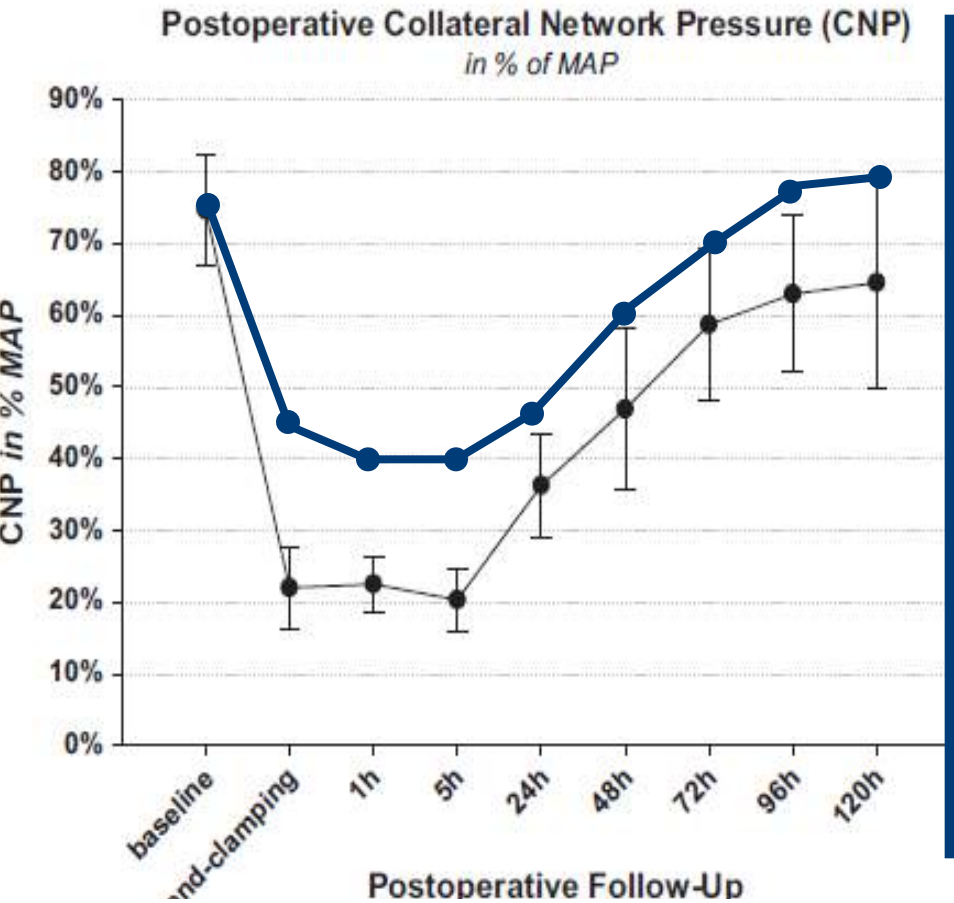
Staged therapy

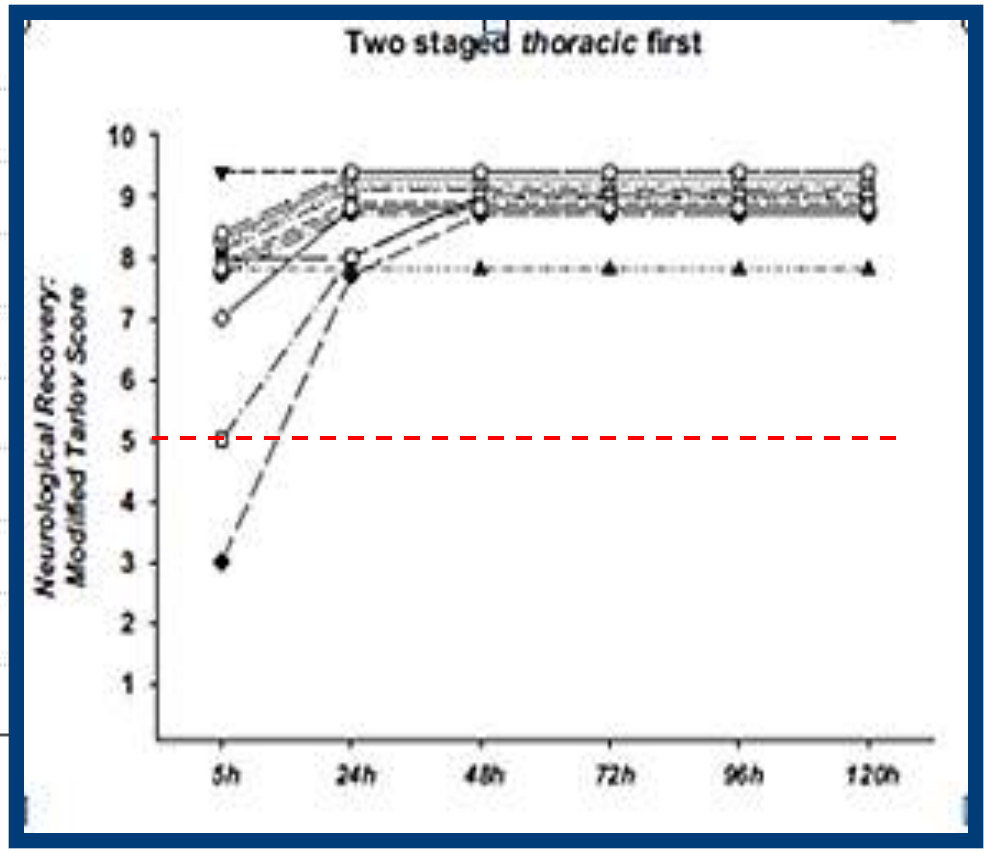


100% recovery!



Total segmental artery occlusion: regeneration of arterial perfusion within 5 days





Etz et al. J Thorac Cardiovasc Surg. 2010 Dec;140(6 Suppl):S125-30

staging: open

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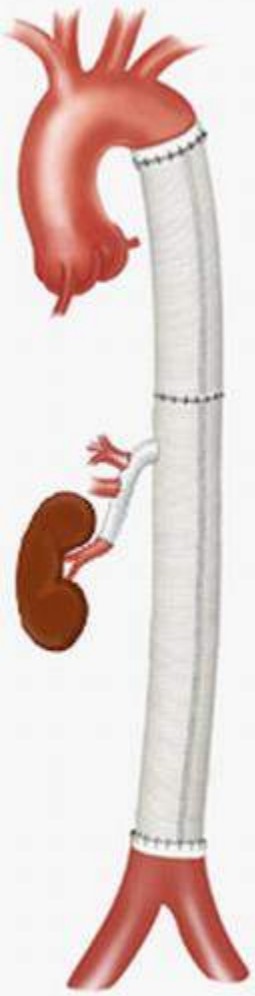
Extent of Segmental Artery Sacrifice in each Patient



With a staged approach, extensive segmental artery sacrifice is possible with zero paraplegia !

staging: endovascular

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Eur J Vasc Endovasc Surg (2015) 49, 248–254

Editor's Choice — The Impact of Early Pelvic and Lower Limb Reperfusion and Attentive Peri-operative Management on the Incidence of Spinal Cord Ischemia During Thoracoabdominal Aortic Aneurysm Endovascular Repair

B. Maurel [a], N. Delclaux [a], J. Sobocinski [a], A. Hertault [a], T. Martin-Gonzalez [a], M. Moussa [a], R. Spear [a], M. Le Roux [a], R. Azzaoui [a], M. Tyrrell [b], S. Haulon [a,*]

[a] Aortic Centre,
[b] King's Health

Staged and adjunctive procedures to preserve spinal cord flow in group 2

Following the demonstration of the potentially beneficial effects of a staged repair to encourage spinal cord pre-conditioning during extensive TAAA repair,[11] the thoracic endovascular component was implanted during the first procedure in all cases in which the anatomy was suitable (i.e., when a distal sealing zone with a maximum diameter <42 mm was present). Every effort was made to maintain the perfusion of at least one internal iliac artery (IIA); if required, iliac branched devices were employed. When left subclavian artery (LSA) coverage was deemed necessary for proximal seal, carotid subclavian transposition or bypass was performed as an initial procedure. These "first stage" procedures were performed 6–10 weeks before definitive TAAA repair.

WHAT
This p
endov
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arterie
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the se
>85 n
Metho
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Result
years]]
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Conclu
management significantly reduces SCI following type I–III TAAA endovascular repair. With the use of these modified protocols, extensive TAAA endovascular repairs are associated with low rates of SCI.

Article history: Received 24 August 2014, Accepted 25 November 2014, Available online 6 January 2015

Keywords: Endovascular repair, Peri-operative management, Spinal cord ischemia, Thoracoabdominal aortic aneurysm

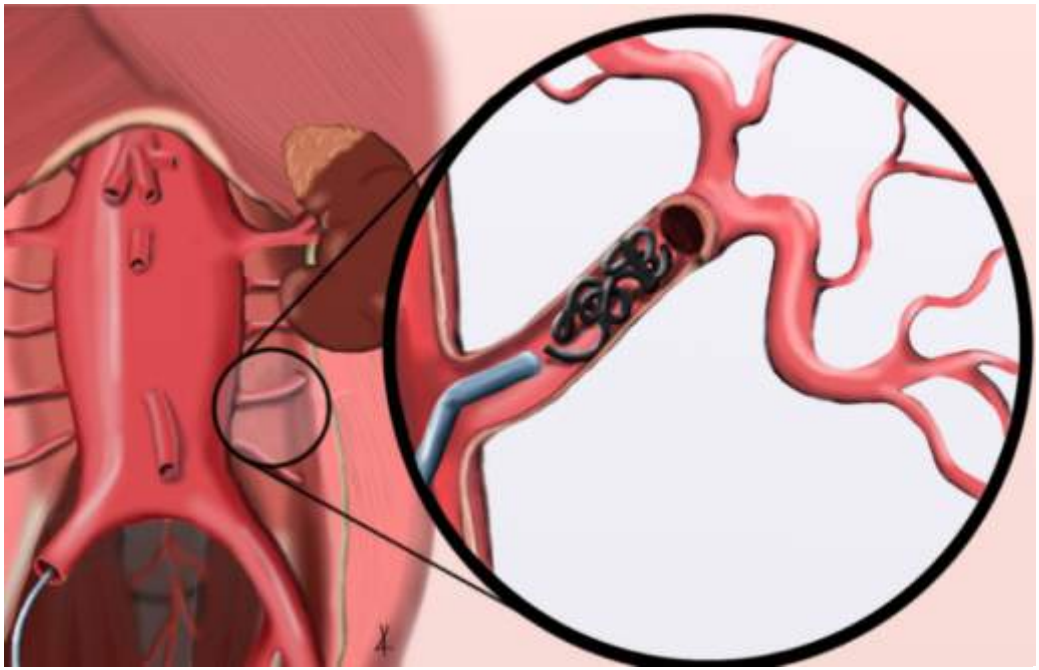
group 1
conventional endo

14.0% SCI

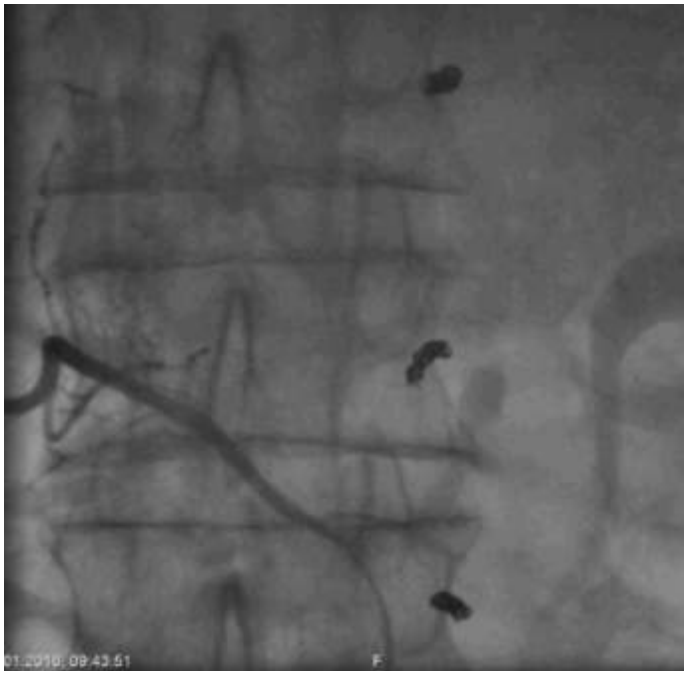
group 2
+ lower limb perfusion
+ post op maintanance of high blood pressure
+ staged procedure

1.2% SCI

MIS²ACE: ‘Minimally invasive *staged* segment artery coil embolization’



Minimally invasive coil deployment - schematically



Coil-occluded (right) / patent SA (left)

Universitäres Herzzentrum Hamburg

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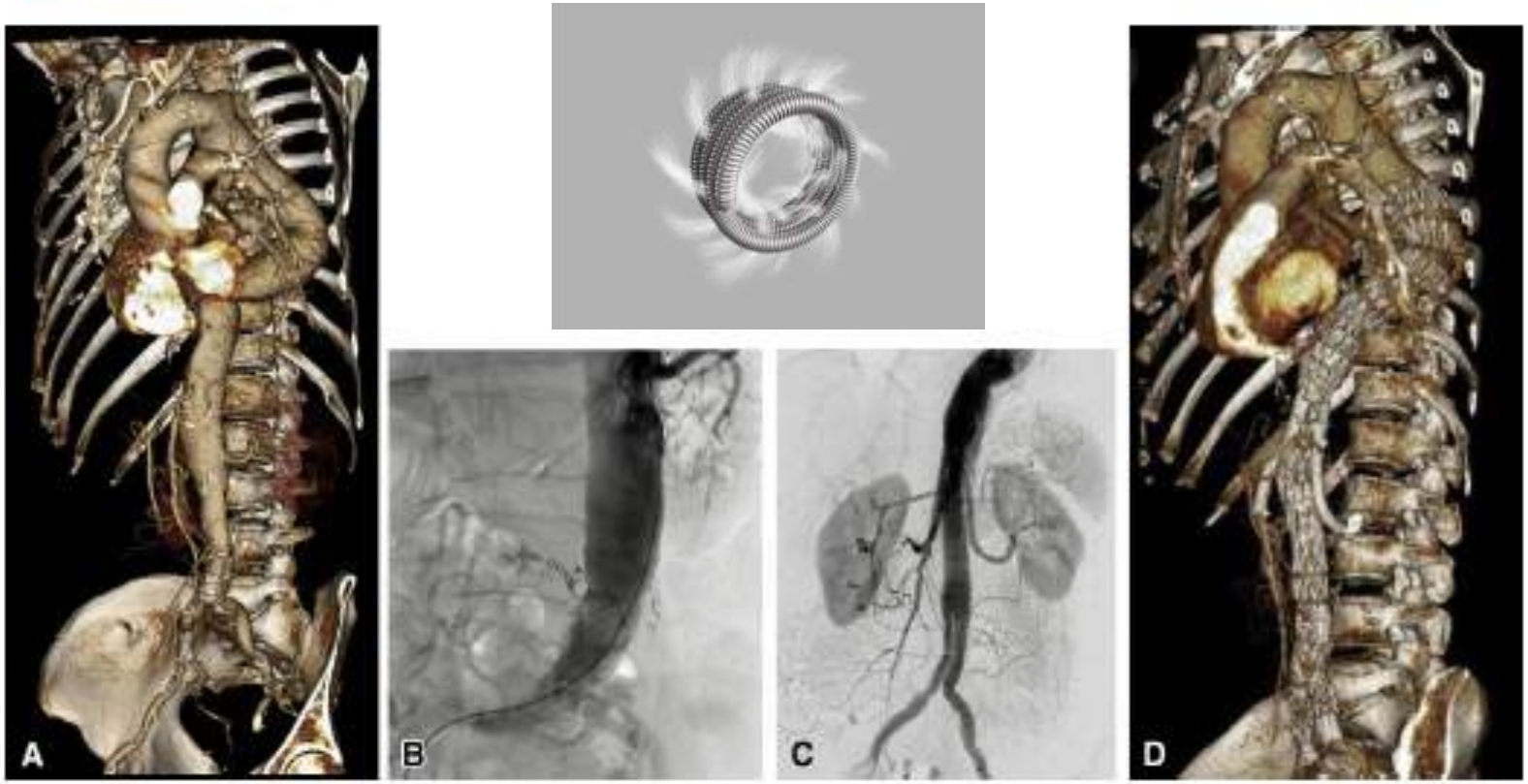
First-in-man endovascular preconditioning of the paraspinal collateral network by segmental artery coil embolization to prevent ischemic spinal cord injury

Christian D. Etz, MD, PhD,[a] E. Sebastian Debus, MD, PhD,[b] Friedrich-Wilhelm Mohr, MD, PhD,[a] and Tilo Kölbel, MD, PhD[b]



Preemptive Conditionig with Minimally Invasive Segmental Artery Coilembolisation (MISACE) prevents SCI

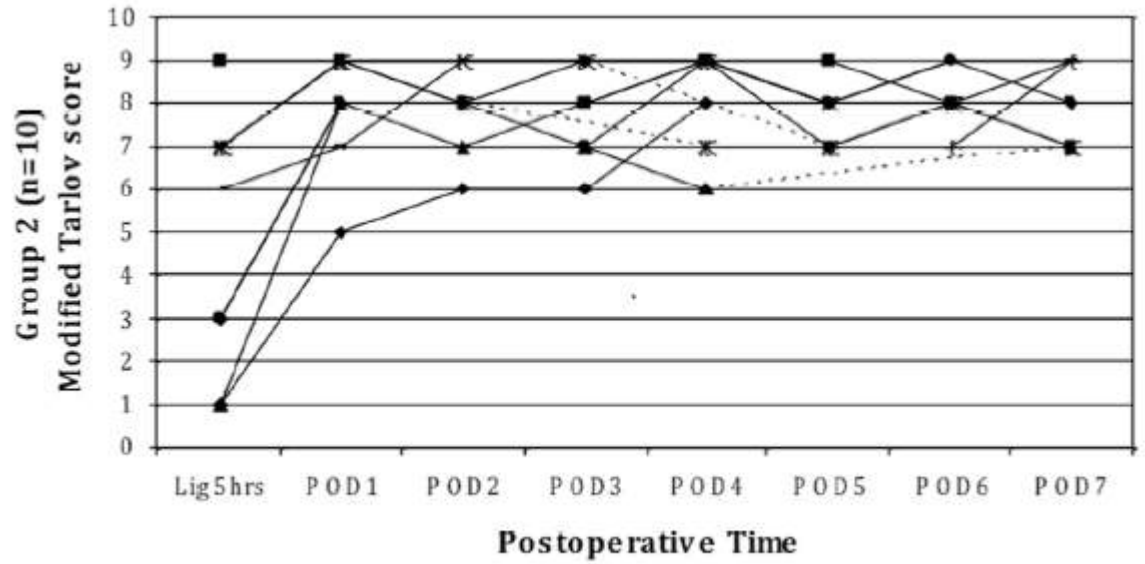
J Thorac Cardiovasc Surg. 2014 January ; 147(1): 220–226. doi:10.1016/j.jtcvs.2013.09.022.

Endovascular Coil Embolization of Segmental Arteries Prevents Paraplegia After Subsequent TAAA Repair – An Experimental Model

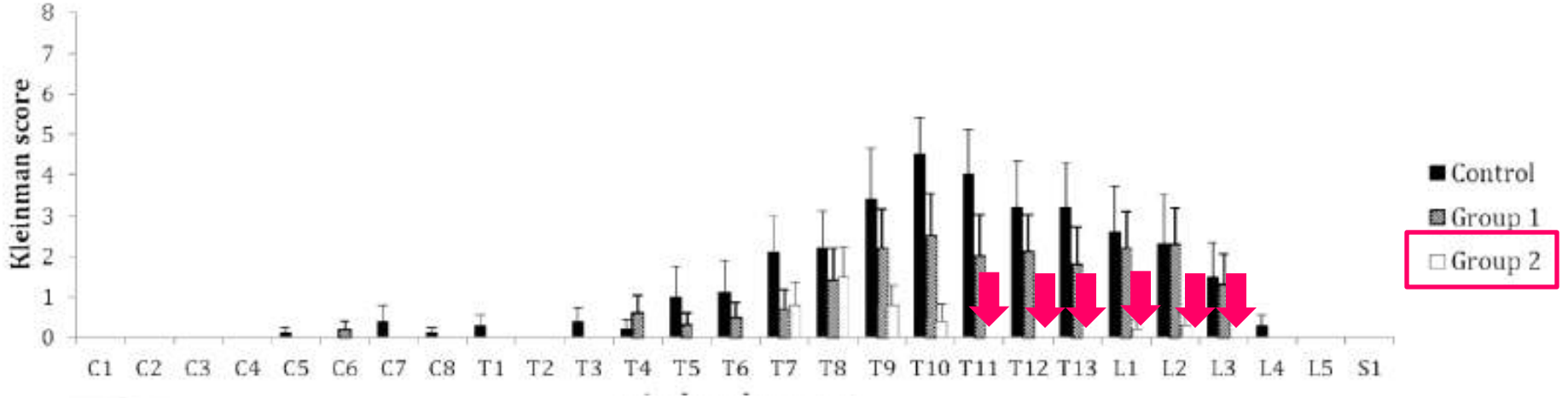
S Geisbüsch, MD[1], A Stefanovic[1], JS Koruth, MD[2], HM Lin, SoD[3], S Morgello, MD[4], DJ Weisz, MD[5], RB Griepp, MD[1], and G Di Luozzo, MD[1]

zero paraplegia after coil embolization

model.



MIS²ACE: safety



Spinal cord damage was most prominent in the T9–T13 region. Almost no necrosis is seen in the coiled region (T11-L3) for Group 2.

Geisbüsch et al.

no histologic damage in coiled areas !

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Universitäres Herzzentrum Hamburg

EDITORIAL COMMENTARY

Setting the stage: Thoracoabdominal aortic aneurysm repair in 2 acts

Grayson H. Wheatley III, MD

See related article on pages 1074-9

Ischemic spinal cord injury associated with thoraco
nal aortic aneurysm (TAAA) repair remains a
concern in patients treated with either open sur
endovasc
network
significan
anatomic
ischemia
collateral
theoretica

of recruiting collateral channels for spinal cord perfusion to compensate for loss of valuable intercostal arteries.[2] However, the practicalities of staging aortic repair in

cord ischemia. Perioperative adjuncts such as intraoperative

The third breakthrough represented by the MISACE tech-

‚…several important breakthroughs relating to managing and **preventing spinal cord injury** have been **simultaneously brought together with the MISACE** technique.‘

From the Div
Philadelph
Disclosures:
Received for
available a
Address for reprints: Grayson H. Wheatley III, MD, Temple Universit
Medicine, 3401 N Broad St, 3rd Fl, Zone C, Ste 301, Philadelphia
(E-mail: grayson.wheatley@tuhs.temple.edu).
J Thorac Cardiovasc Surg 2015;149:1079-80
0022-5223/$36.00

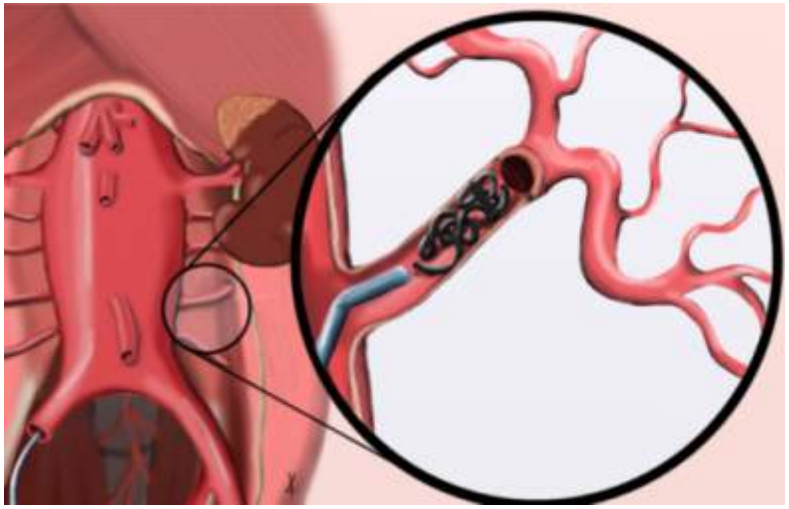
http://dx.doi.org/10.1016/j.jtcvs.2014.12.071

segmental arteries. Although this can be done with percutaneous techniques using local anesthesia, the ability to selectively cannulate a segmental artery is very intricate and not simple. This is especially the case in patients undergoing TAAA with tortuous anatomy and thrombus in the aneurysm sac. The authors note that in 1 of their patients, the tortuous iliac artery anatomy prevented them from coil-embolizing a unilateral segmental artery. Moreover, once the vessel is selectively cannulated, it is important to preserve as much of the collateral network as possible by only occluding the ostium of the segmental artery. These techniques are not within the realm of most aortic surgeons and frequently multidisciplinary collaboration is required.

interventionalists. Etz and colleagues[3] have exposed a new frontier in managing and helping prevent spinal cord injury associated with TAAA repair.

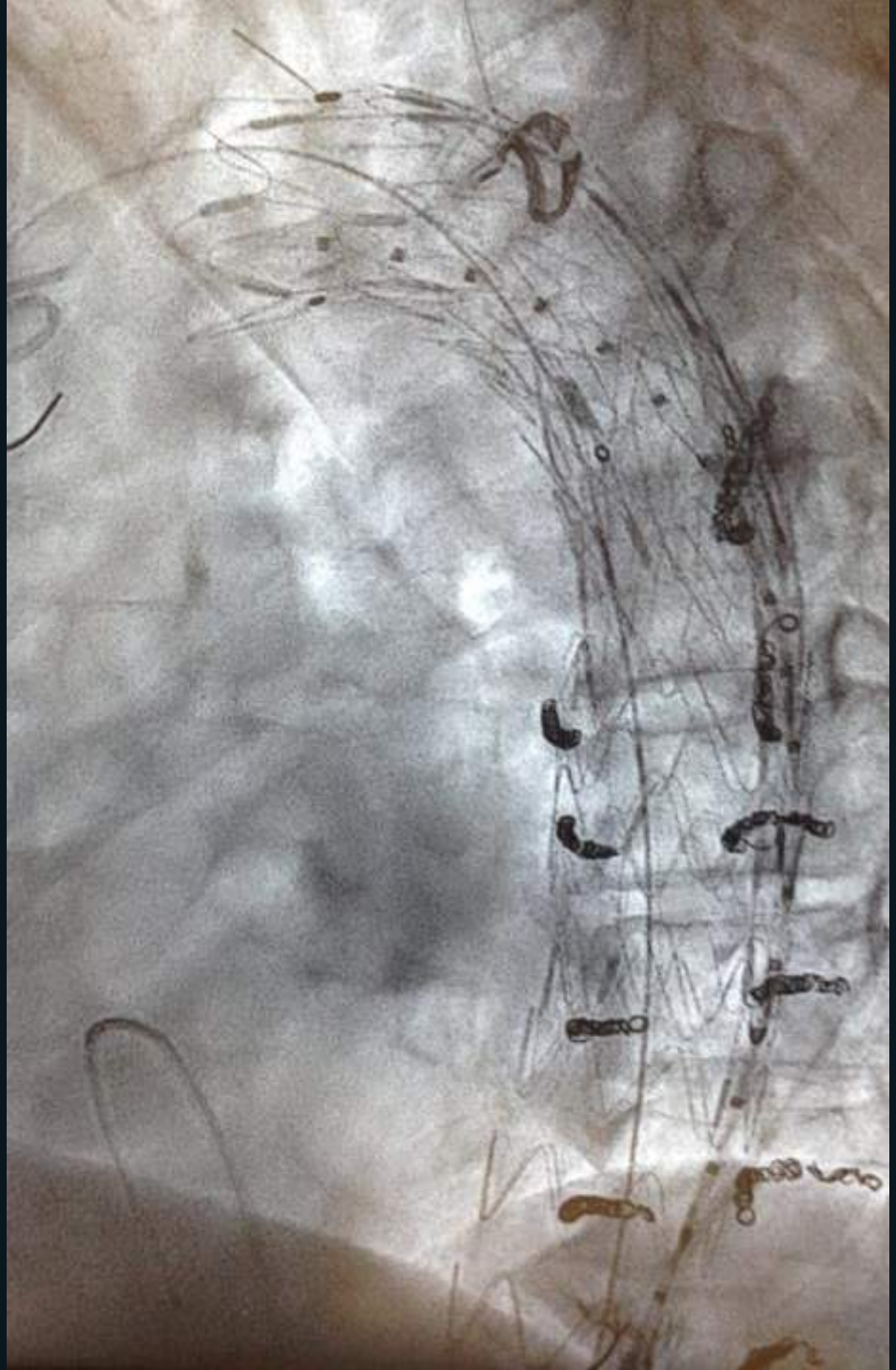
References

1. Griepp RB, Griepp EB. Spinal cord perfusion and protection during descending thoracic and thoracoabdominal aortic surgery: the collateral network concept. *Ann Thorac Surg*. 2007;83(Suppl1:S865-9; discussion S890-2.
2. Etz CD, Kari FA, Mueller CS, Brenner RM, Lin HM, Griepp RB. The collateral network concept: remodeling of the arterial collateral network after experimental segmental artery sacrifice. *J Thorac Cardiovasc Surg*. 2011;141:1029-36.
3. Etz CD, Debus ES, Mohr WF, Kobel T. First in man endovascular pre-conditioning of the paraspinal collateral network by segmental artery coil-embolization to prevent ischemic spinal cord injury. *J Thorac Cardiovasc Surg*. 2015;149:1074-9.



MIS²ACE

1. staged preconditioning — now clinically available
2. staging with only 1-3 sessions in the cath lab
3. reduced steal / clean OR field / shorter OR times
4. reduction of type II endoleakage after endo repair

PAPAartis

fighting spinal cord injury

Paraplegia Prevention in Aortic Aneurysm Repair by Thoracoabdominal Staging with 'Minimally-Invasive Segmental Artery Coil-Embolization (MISACE)': *A randomized controlled multicentre open-label trial (PAPA-ARTiS)*

Principal Investigator: ***Christian D. ETZ***

European Commission

RESEARCH & INNOVATION

Participant Portal

PAPAartis
fighting spinal cord injury

Trial duration	First patient in to last patient out (months): 40 Duration of the entire trial (months): 46 Recruitment period (months): 24

Independent radio-logicial verification of inclusion criteria

screening & choice of open repair or TEVAR

Randomization stratified by surgery/TEVAR

Sample size	To be assessed for eligibility: **n = 450** To be assigned to the trial: **n = 306** To be analysed: **n = 160 (interim 1), 220 (interim 2), 275 (final)**

Efficacy: In the control arm success is expected in 75% of patients compared to 90% in the experimental (MISACE staging) arm.
Description of the primary efficacy analysis and population: Mixed logistic regression

Secondary endpoints: Analysis of binary outcomes will be analogous to the primary analysis. ICU time will be analysed with a linear mixed model. Re-operation and endo-leak will be considered for the subgroups of surgery/TEVAR respectively.

PAPAartis
fighting spinal cord injury

1. CH: Bern
2. DE: Freiburg
3. DE: Hamburg
4. DE: Leipzig
5. FR: Bordeaux
6. FR: Lille
7. IT: Bologna
8. IT: Milan
9. NL: Maastricht
10. PL: Zabrze
11. SE: Malmö
12. SE: Örebro
13. UK: Liverpool
14. US: Houston
15. US: Philadelphia
16. DE: Munich
17. DE: Warsaw

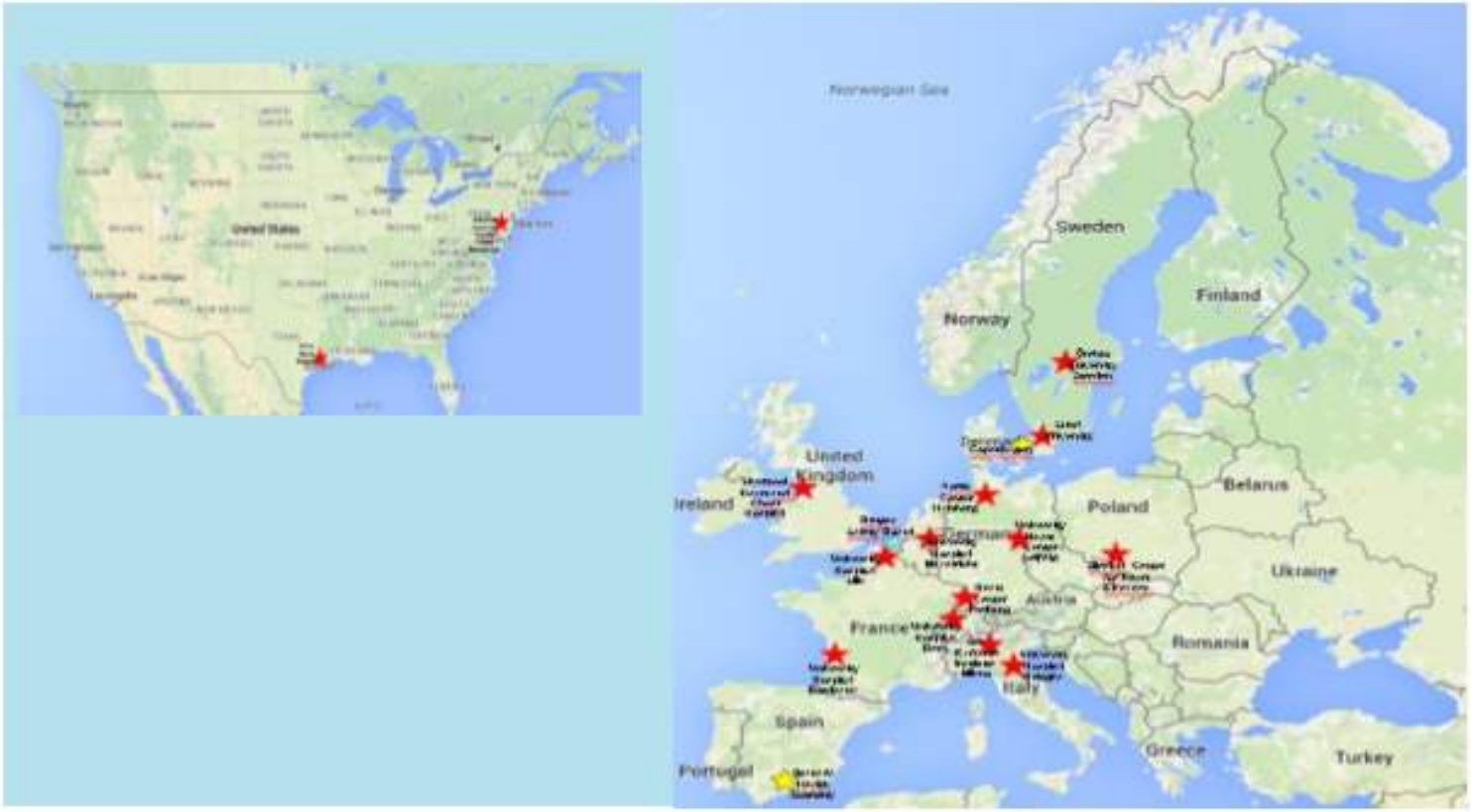


Figure 10 - Participating centres PAPA-ARTiS (EU, Switzerland and the US). Red stars represent recruitment centres and the yellow stars represent the radiology core lab (Copenhagen, WP6) and the health economics group (Grenada, WP3).

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fighting spinal cord injury

1: Aachen
2: Bern
3: Essen
4: Freiburg
5: Hamburg (UKE)
6: Hanover (MHH)
7: Heidelberg
8: Innsbruck
9: Leipzig
10: Munich
11: Münster
12: Nuremberg
13: Vienna
14: Regensburg

PAPAartis
fighting spinal cord injury

… *largest publicly funded RCT in aortic aneurysm repair*

- **17 (+14) Aortic Reference Centres**
- **prospectively collect contemporary real-world data on SCI incidence (type II, III; open + endo)**
- **comparing ‚staged' vs. ‚conventional' approach**
- **evaluating effectiveness of MISACE:**
  - SCI prevention & endoleak type II prevention

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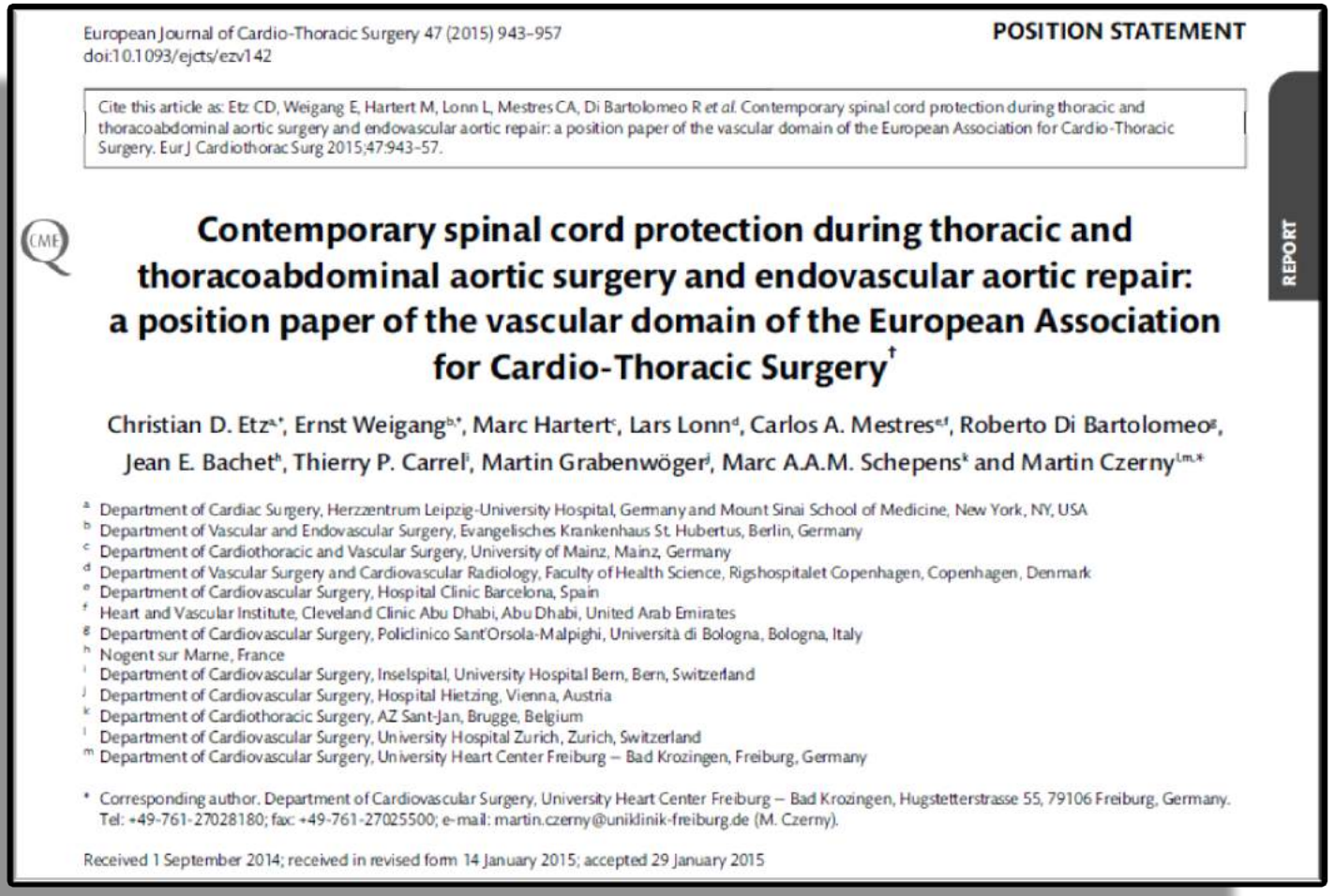
Contemporary Spinal Cord Protection During Thoracic and Thoracoabdominal Aortic Surgery and Endovascular Aortic Repair: *A Position Paper*



European Journal of Cardio-Thoracic Surgery 47 (2015) 943–957
doi:10.1093/ejcts/ezv142

POSITION STATEMENT

Cite this article as: Etz CD, Weigang E, Hartert M, Lonn L, Mestres CA, Di Bartolomeo R *et al.* Contemporary spinal cord protection during thoracic and thoracoabdominal aortic surgery and endovascular aortic repair: a position paper of the vascular domain of the European Association for Cardio-Thoracic Surgery. Eur J Cardiothorac Surg 2015;47:943–57.

REPORT

Contemporary spinal cord protection during thoracic and thoracoabdominal aortic surgery and endovascular aortic repair: a position paper of the vascular domain of the European Association for Cardio-Thoracic Surgery†

Christian D. Etz[a,*], Ernst Weigang[b,*], Marc Hartert[c], Lars Lonn[d], Carlos A. Mestres[e,f], Roberto Di Bartolomeo[g], Jean E. Bachet[h], Thierry P. Carrel[i], Martin Grabenwöger[j], Marc A.A.M. Schepens[k] and Martin Czerny[l,m,*]

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[e] Department of Cardiovascular Surgery, Hospital Clinic Barcelona, Spain
[f] Heart and Vascular Institute, Cleveland Clinic Abu Dhabi, Abu Dhabi, United Arab Emirates
[g] Department of Cardiovascular Surgery, Policlinico Sant'Orsola-Malpighi, Università di Bologna, Bologna, Italy
[h] Nogent sur Marne, France
[i] Department of Cardiovascular Surgery, Inselspital, University Hospital Bern, Bern, Switzerland
[j] Department of Cardiovascular Surgery, Hospital Hietzing, Vienna, Austria
[k] Department of Cardiothoracic Surgery, AZ Sant-Jan, Brugge, Belgium
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* Corresponding author. Department of Cardiovascular Surgery, University Heart Center Freiburg – Bad Krozingen, Hugstetterstrasse 55, 79106 Freiburg, Germany. Tel: +49-761-27028180; fax: +49-761-27025500; e-mail: martin.czerny@uniklinik-freiburg.de (M. Czerny).

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Christian D. Etz [1]* on behalf of
the **Vascular Domain of the EACTS**

EACTS
European Association For Cardio-Thoracic Surgery

delayed paraplegia –
p.o. hemodynamic management !

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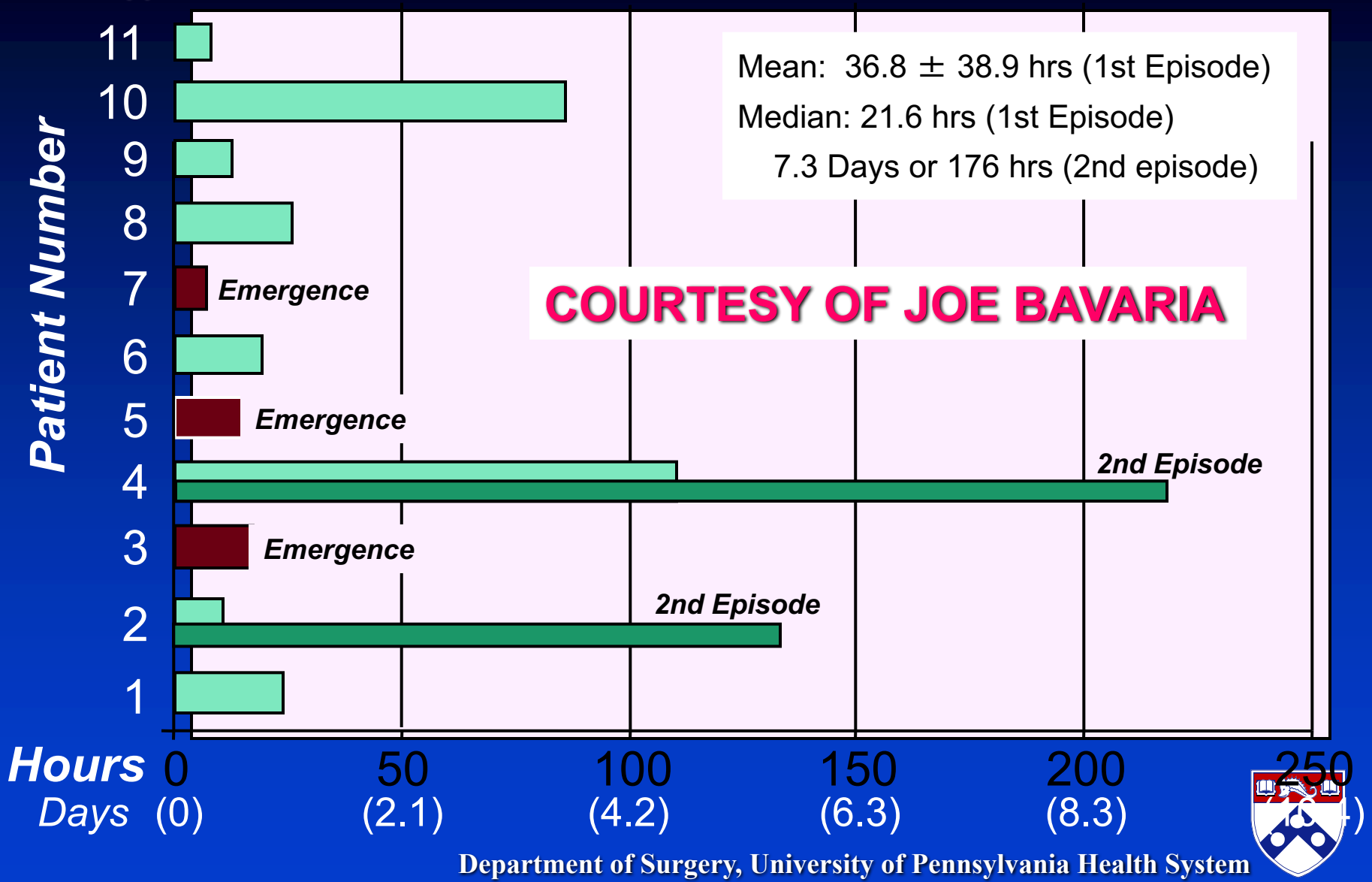
ONSET TIME OF POSTOPERATIVE PARAPLEGIA

Concept: Delayed Paraplegia, timing of delayed paraplegia, and clinical support of the "Griepp/Etz Observation"



Postoperative *corrected* SCPP

(SCPP *minus CSF* pressure)

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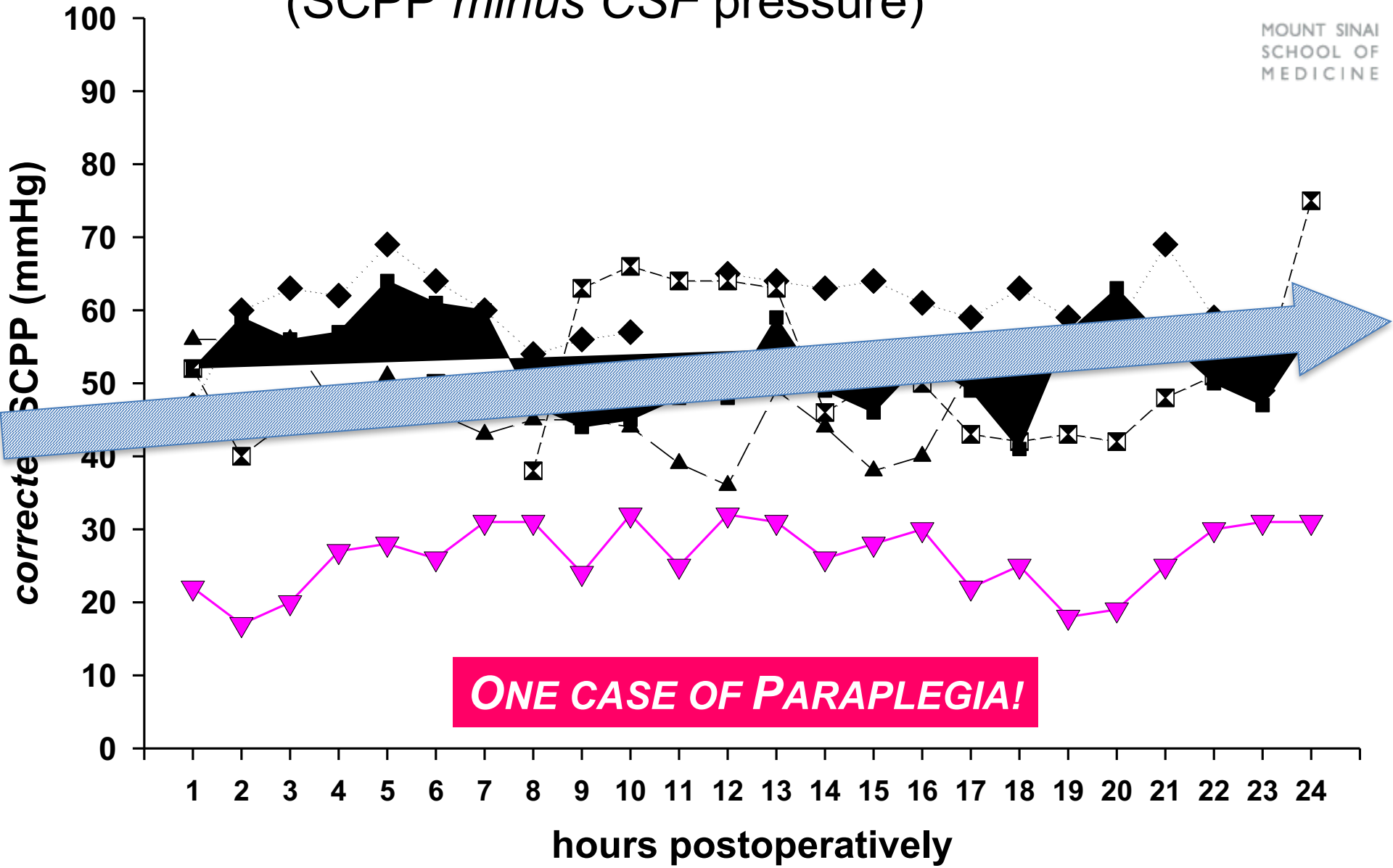

RETROSPECTIVE CLINICAL ANALYSIS

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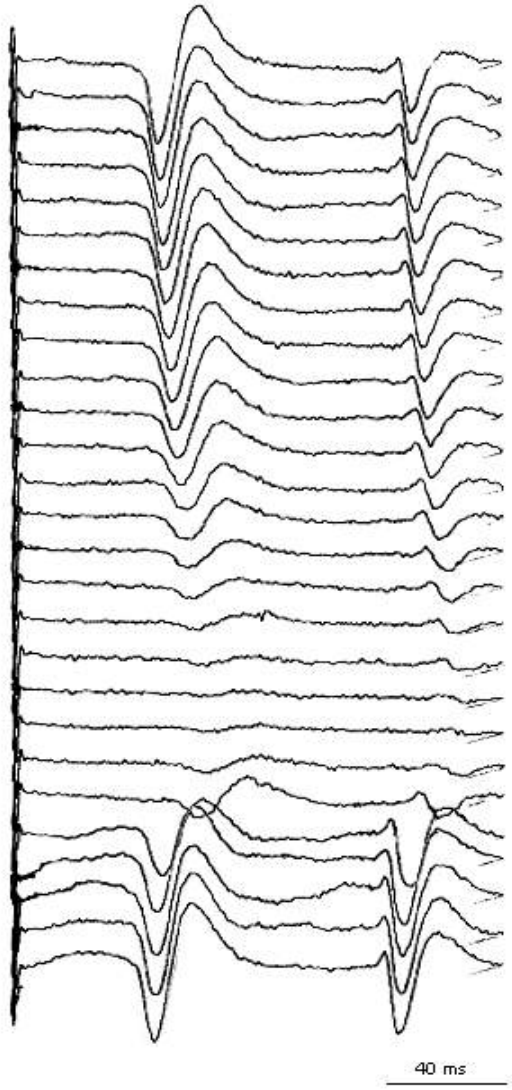


*SSEPs unchanged

= *Ø intra-op SPI**

16 YR PERIOD (1990 – 2006)

> 800 TAA/A REPAIRS

PARAPLEGIA RATE 3.7% *(N=31)*

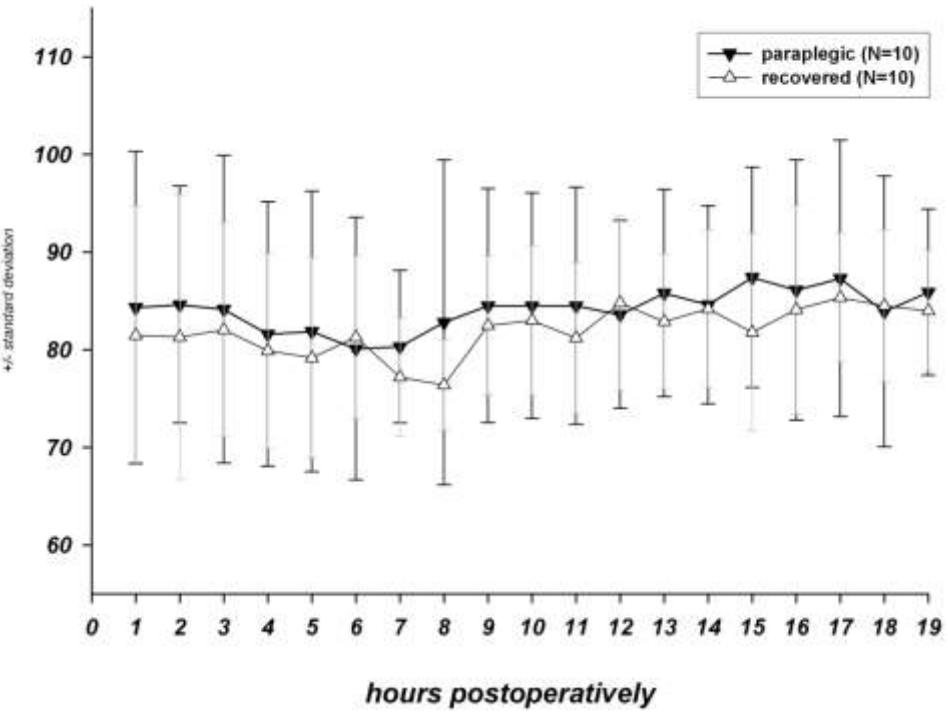
- **10 CASES DELAYED-ONSET PARAPLEGIA**
- **10 MATCHED CONTROLS**

POSTOPERATIVE HEMODYNAMICS

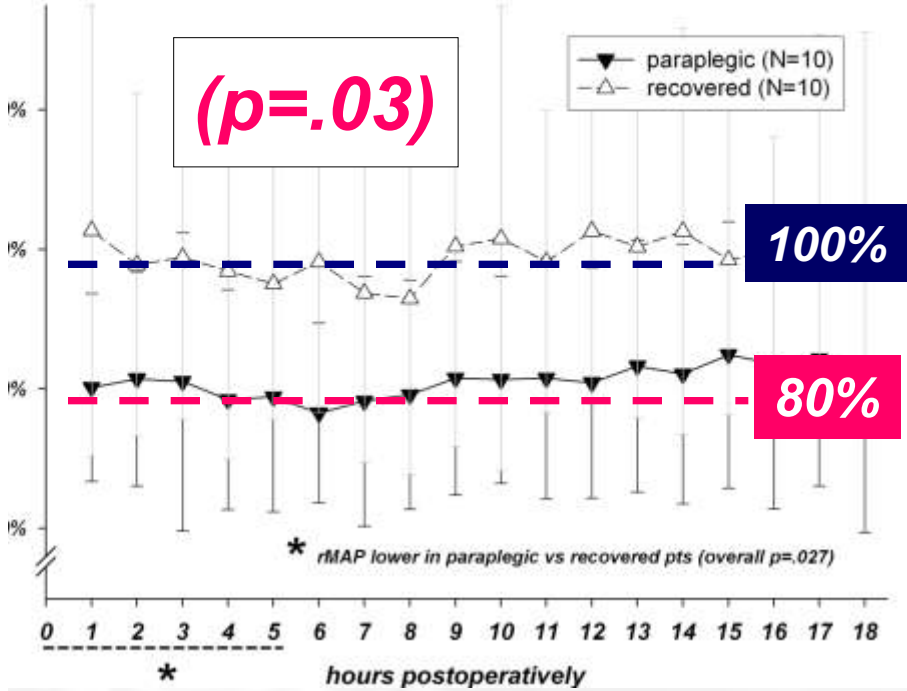
MAP AND *r*MAP

MOUNT SINAI SCHOOL OF MEDICINE

Postoperative Mean Aortic Pressure *(MAP)*



Mean Aortic Pressures In Relation To Antecedent Baseline Systemic Pressures (*r*MAP)



NO DIFFERENCES IN MAP

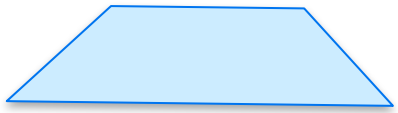
LOWER rMAP !

spinal cord monitoring

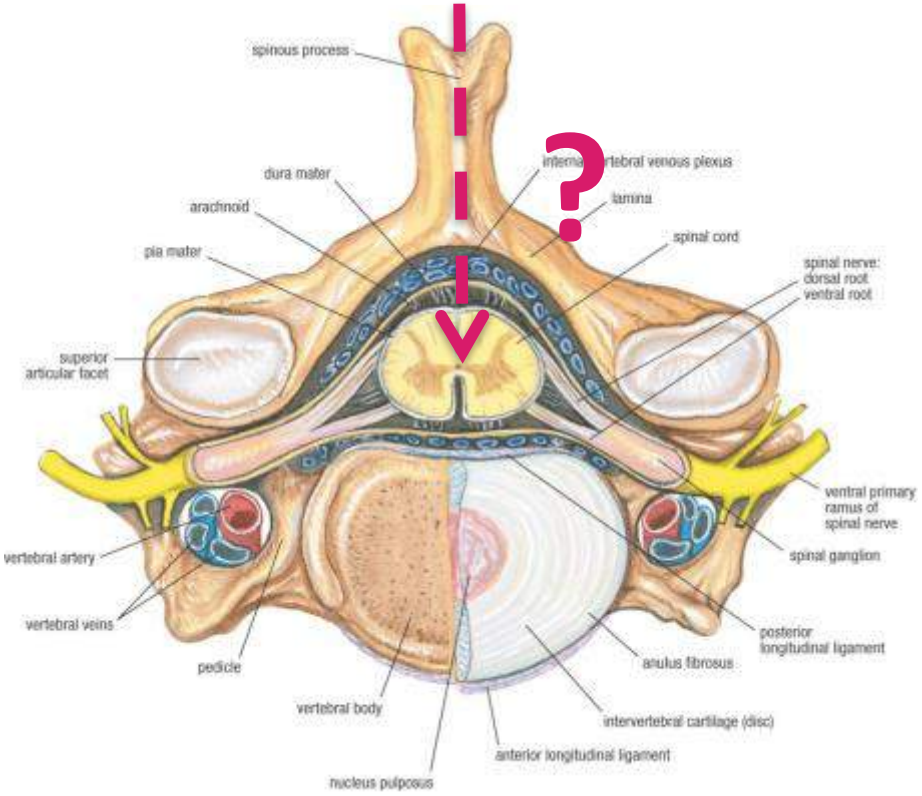
Spinal cord monitoring

Modality						
SSEP	-	-	-	+	-	-
MEP	-	-	-	+	+	-
Direct SCPP	-	+	+	+	+	-
Laser Doppler	-	+	+	+	+	-
cnNIRS	+	+	+	+	+	+

SSEP= Somatosensory evoked potentials; MEP=Motor evoked potentials
SCPP=Spinal cord perfusion pressure; cnNIRS=near-infrared spectroscopy of the collateral network

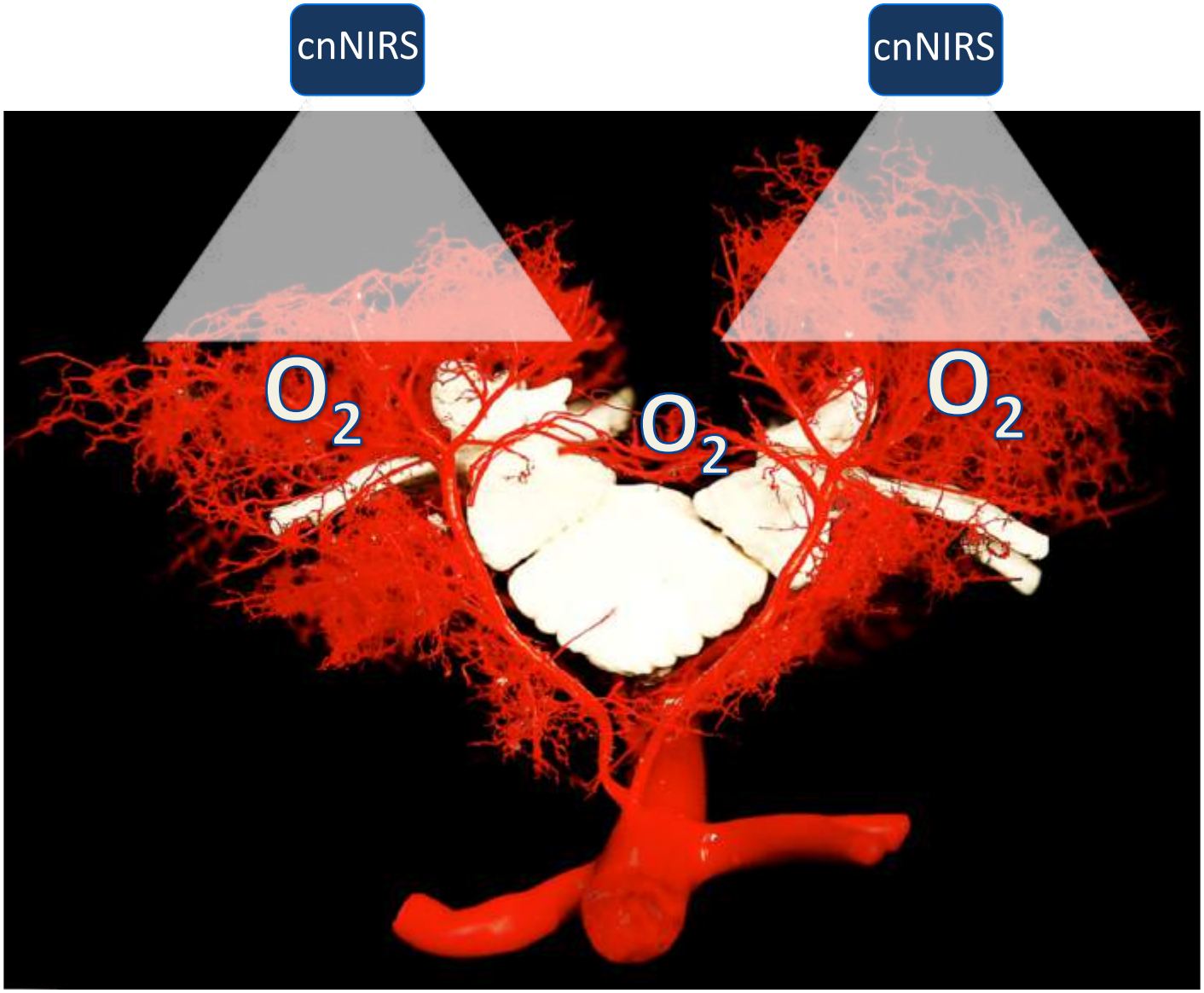


= LIGHT (!)


spinous process
dura mater
arachnoid
pia mater
superior articular facet
vertebral artery
vertebral veins
pedicle
vertebral body
nucleus pulposus
anterior longitudinal ligament
intervertebral cartilage (disc)
anulus fibrosus
posterior longitudinal ligament
spinal ganglion
ventral primary ramus of spinal nerve
spinal nerve: dorsal root
ventral root
spinal cord
lamina
vertebral venous plexus
?

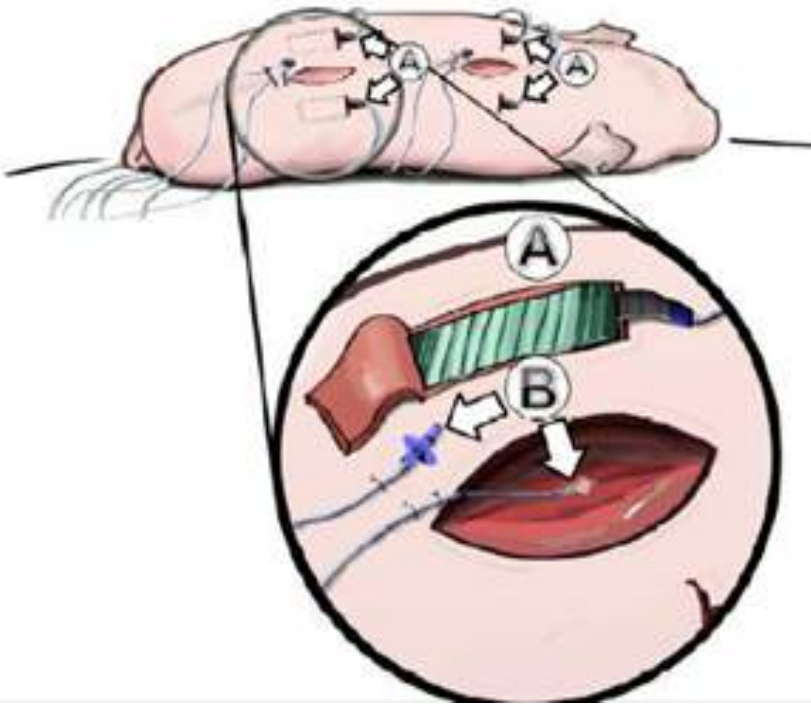
MOUNT SINAI
SCHOOL OF
MEDICINE

Near-infrared spectroscopy (NIRS)



Non-invasive, clinical real-time monitoring

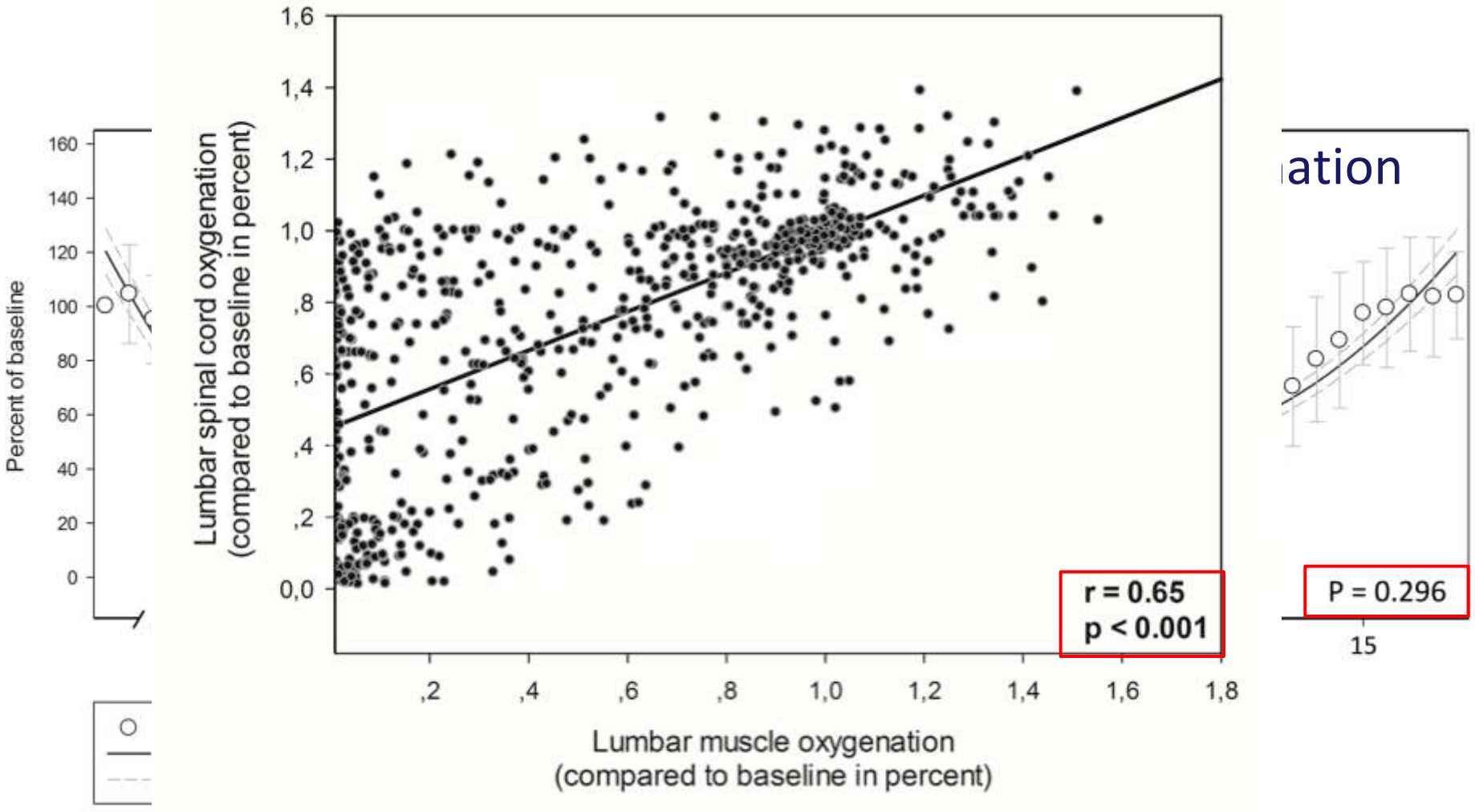
Pilot series[1]



Validation[2]

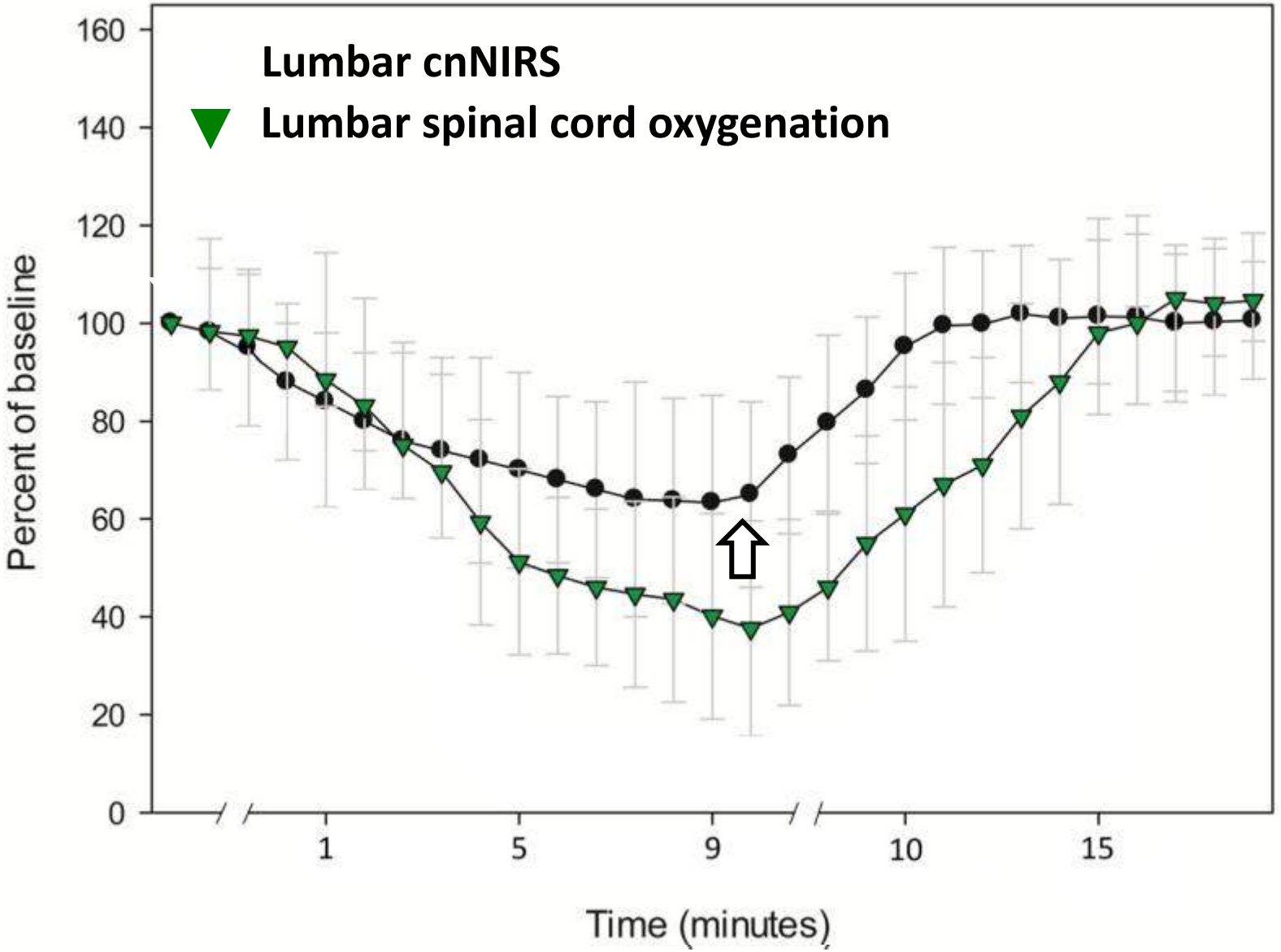
1. Etz *et al., Eur J Vasc Endovasc Surg.* ***2013*** *Dec;46(6):651-6*
2. Etz *et al., Eur J Cardiothorac Surg.* ***2015*** *Jun;47(6):943-57*

Collateral Network vs. Spinal Cord



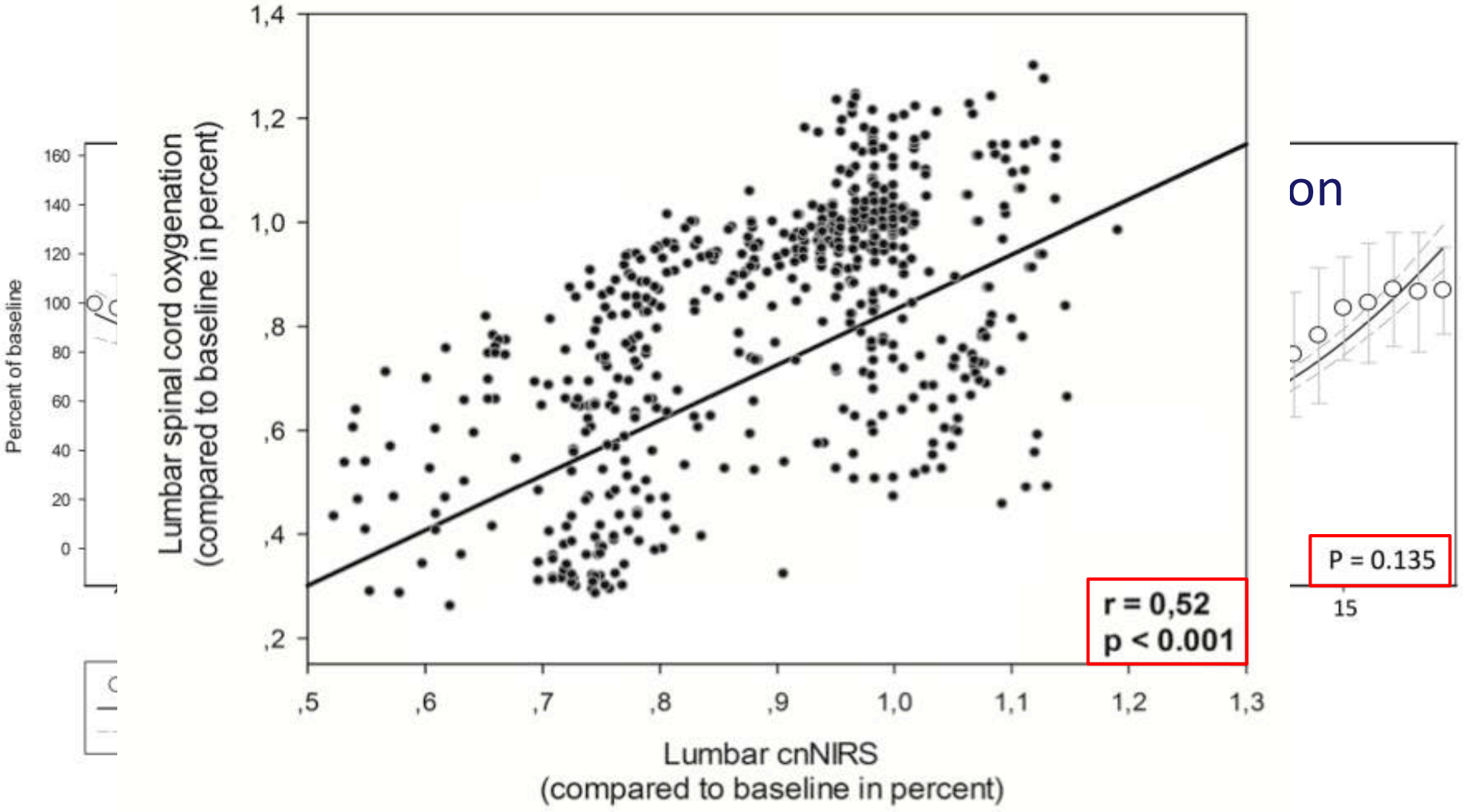
Paraspinous **CN** oxygenation directly reflects **spinal cord** tissue oxygenation

Non-invasive cnNIRS



Question: lumbar **cnNIRS** = **Spinal cord** oxygenation? ☑

cnNIRS vs. Spinal Cord Oxygenation



lumbar **cnNIRS** directly reflects **spinal cord** tissue oxygenation