REGION

Strategies to reduce SCI in cAAA repair: do we need them all always?

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I have no conflict of interest

Scientific evidence

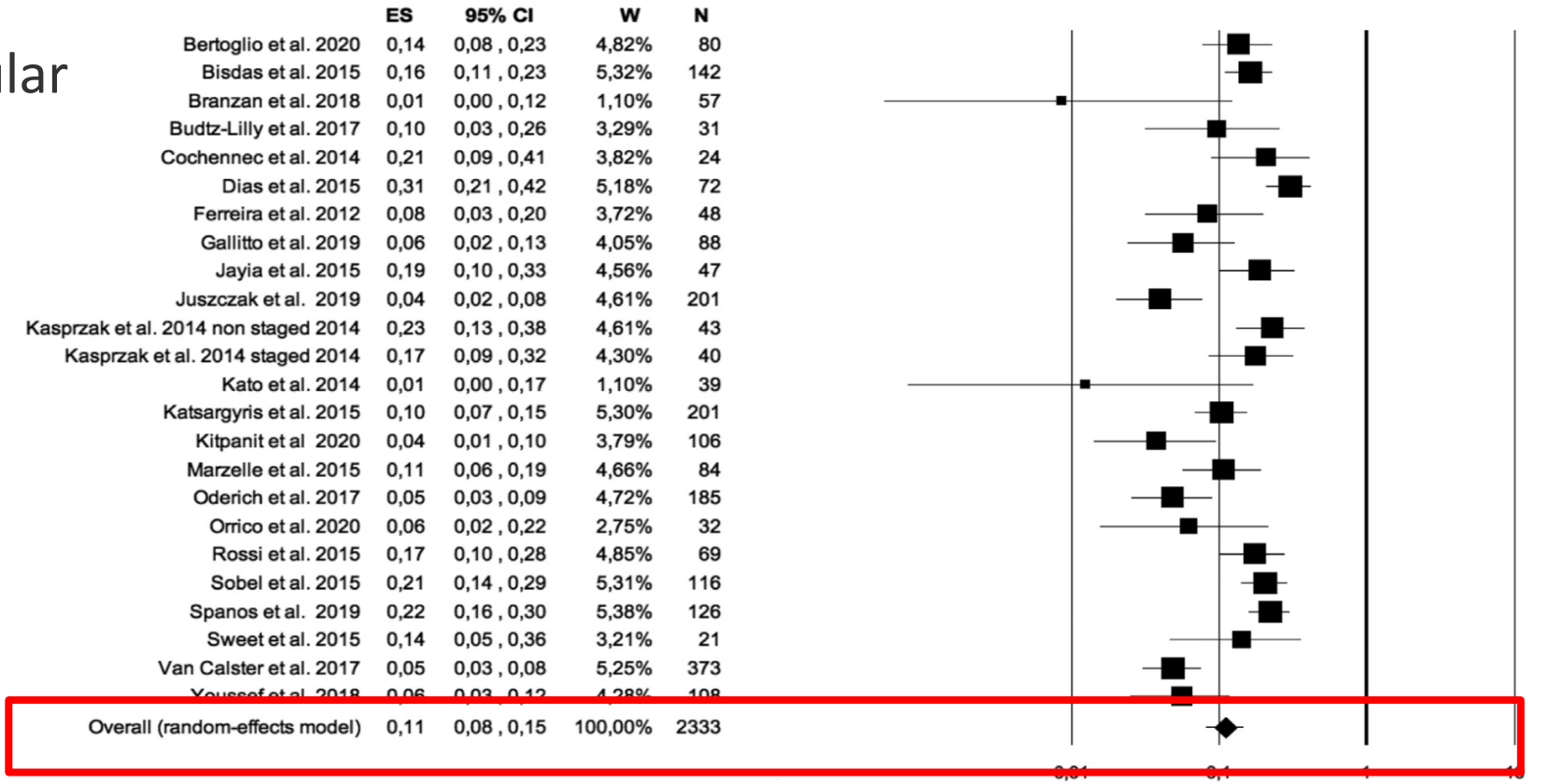
- A few andomized control trial (OR) from -90s
- Data from registries
- Retrospective
- Metaanalyses
- Single center studies comparing pre and post protocol
- Questionnaires

A systematic review and meta-analysis of the occurrence of spinal cord ischemia after endovascular repair of thoracoabdominal aortic aneurysms

Journal of Vascular Surgery
April 2022

Rodolfo Pini, MD, PhD,[a] Gianluca Faggioli, MD, PhD,[a] Kosmas I. Paraskevas, MD, PhD,[b] Moad ,

Risc of SCI in endovascular repair of TAAA : **5-30 %**



	ES	95% CI	W	N
Bertoglio et al. 2020	0,14	0,08 , 0,23	4,82%	80
Bisdas et al. 2015	0,16	0,11 , 0,23	5,32%	142
Branzan et al. 2018	0,01	0,00 , 0,12	1,10%	57
Budtz-Lilly et al. 2017	0,10	0,03 , 0,26	3,29%	31
Cochennec et al. 2014	0,21	0,09 , 0,41	3,82%	24
Dias et al. 2015	0,31	0,21 , 0,42	5,18%	72
Ferreira et al. 2012	0,08	0,03 , 0,20	3,72%	48
Gallitto et al. 2019	0,06	0,02 , 0,13	4,05%	88
Jayia et al. 2015	0,19	0,10 , 0,33	4,56%	47
Juszczak et al. 2019	0,04	0,02 , 0,08	4,61%	201
Kasprzak et al. 2014 non staged 2014	0,23	0,13 , 0,38	4,61%	43
Kasprzak et al. 2014 staged 2014	0,17	0,09 , 0,32	4,30%	40
Kato et al. 2014	0,01	0,00 , 0,17	1,10%	39
Katsargyris et al. 2015	0,10	0,07 , 0,15	5,30%	201
Kitpanit et al 2020	0,04	0,01 , 0,10	3,79%	106
Marzelle et al. 2015	0,11	0,06 , 0,19	4,66%	84
Oderich et al. 2017	0,05	0,03 , 0,09	4,72%	185
Orrico et al. 2020	0,06	0,02 , 0,22	2,75%	32
Rossi et al. 2015	0,17	0,10 , 0,28	4,85%	69
Sobel et al. 2015	0,21	0,14 , 0,29	5,31%	116
Spanos et al. 2019	0,22	0,16 , 0,30	5,38%	126
Sweet et al. 2015	0,14	0,05 , 0,36	3,21%	21
Van Calster et al. 2017	0,05	0,03 , 0,08	5,25%	373
Youssef et al. 2018	0,06	0,03 , 0,12	4,28%	108
Overall (random-effects model)	0,11	0,08 , 0,15	100,00%	2333

Fig 2. Forest plot of the pooled estimate rate of spinal cord ischemia (SCI) after endovascular repair of thoracoabdominal aortic aneurysms (TAAA-ER). *CI,* Confidence interval; *ES,* effect size; *N,* sample size; *W,* weighting.

Persistent SCI

- Morbidity:
  - Loss of bowel and/or bladder autonomy
  - Weakness or paralysis in lower limbs, loss of walking ability
- Reduced survival

Journal of Vascular Surgery
June 2023

Predictors and outcomes of spinal cord injury following complex branched/fenestrated endovascular aortic repair in the US Aortic Research Consortium

Victoria J. Aucoin, MD,[a] Claire M. Motyl, MD,[a] Zdenek Novak, MD, PhD,[a] Matthew J. Eagleton, MD,[b] Mark A. Farber, MD,[c] Warren Gasper, MD,[d] Gustavo S. Oderich, MD,[e] Bernardo Mendes, MD,[e] Andres Schanzer, MD,[f] Emanuel Tenorio, MD, MPH,[e] Carlos H. Timaran, MD,[g] Darren B. Schneider, MD,[h] Matthew P. Sweet, MD,[i] Sara L. Zettervall, MD, MPH,[i] *and* Adam W. Beck, MD,[a] on behalf of the U.S. Aortic Research Consortium, *Birmingham, AL; Boston and Worcester, MA; Chapel Hill, NC; San Francisco, CA; Houston and Dallas, TX; Philadelphia, PA; and Seattle, WA*

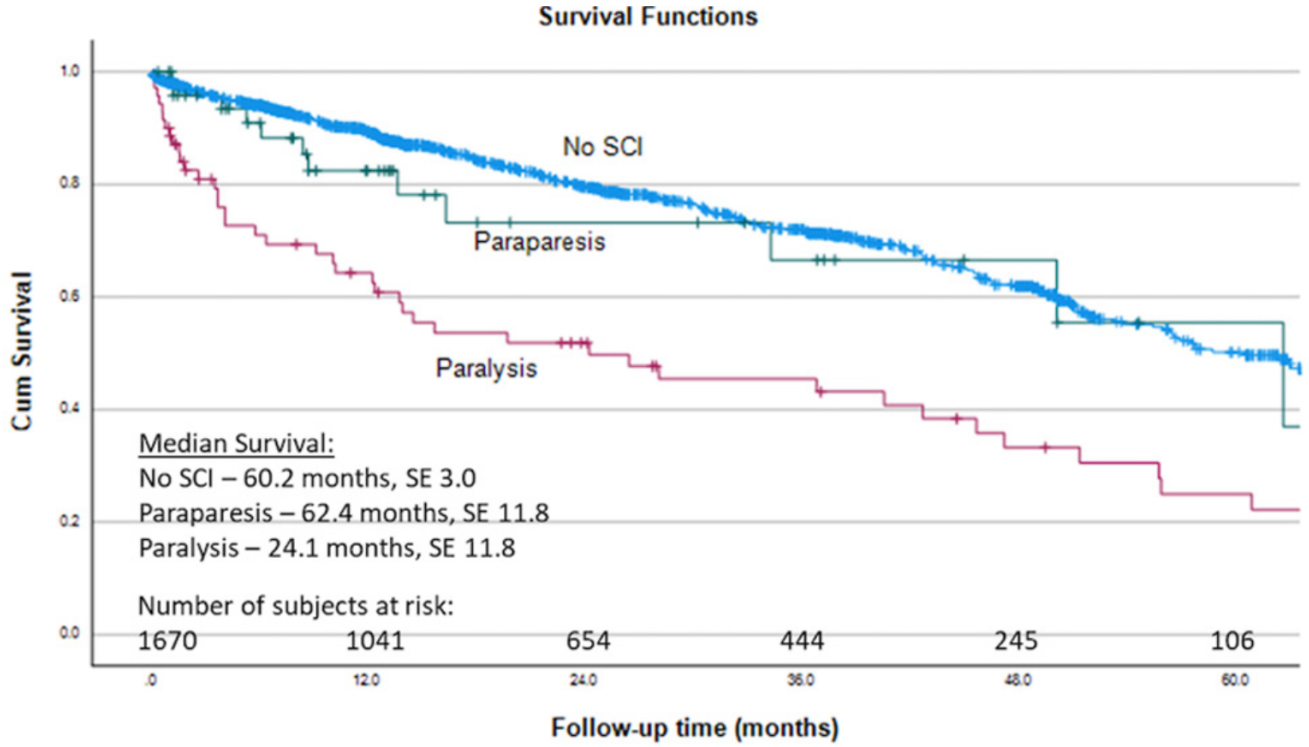


Fig 2. Kaplan-Meier survival analysis, stratified by degree of neurological deficit.

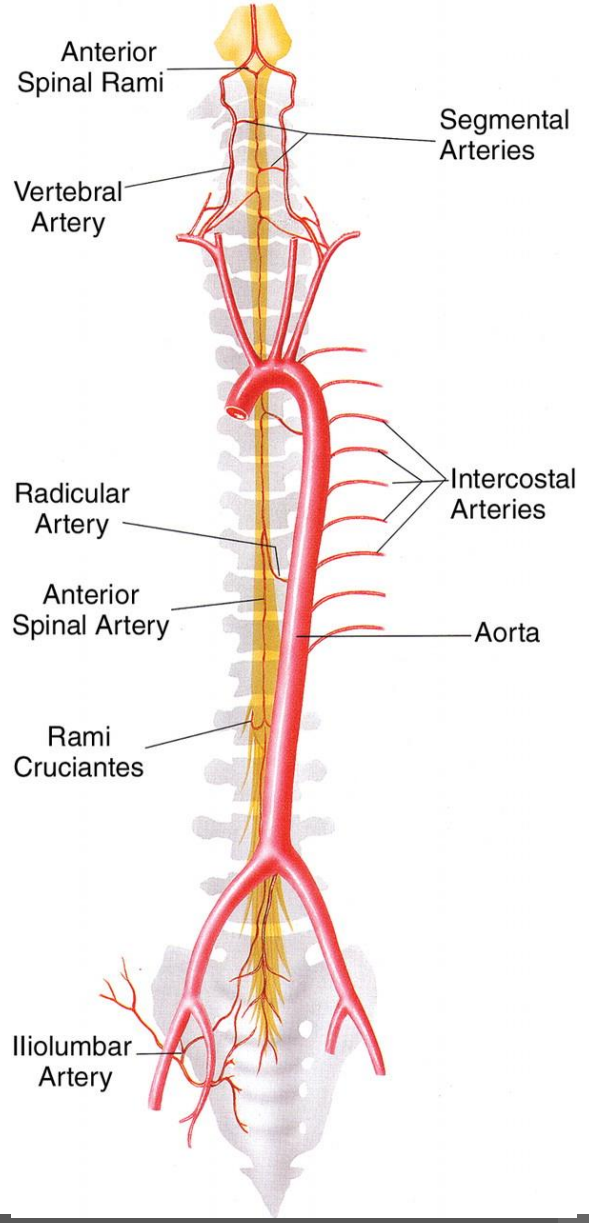
Risc factors for SCI

- Age > 65/70 y
- Co-morbidities: renal insuff, CPOD
- Atherosclerotic severity: collaterals, access, wall thrombi (shaggy aorta)
- Extent of repair
- Perop ”difficulties” : transfusion, extended op duration
- Emergent procedures, ruptures

What stategies do we have to reduce SCI?

What stategies do we have to reduce SCI?

- **Preserve collaterals**
  - LSA: branch, Lfen, bypass
  - Hypogastric: IBD
- **Pre condition collaterals**
  - stageing, segmental artery embolisation
- **Increase perfusion**
  - decrase intrathecal pressure
  - increase BP
  - Hb



Preconditioning of collaterals: Stageing

A systematic review and meta-analysis of the occurrence of spinal cord ischemia after endovascular repair of thoracoabdominal aortic aneurysms

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Rodolfo Pini, MD, PhD,[a] Gianluca Faggioli, MD, PhD,[a] Kosmas I. Paraskevas, MD, PhD,[b] Moad Alaidroos, MD,[a] Sergio Palermo, MD,[a] Enrico Gallitto, MD, PhD,[a] *and* Mauro Gargiulo, MD, PhD,[a] *Bologna, Italy; and Athens, Greece*

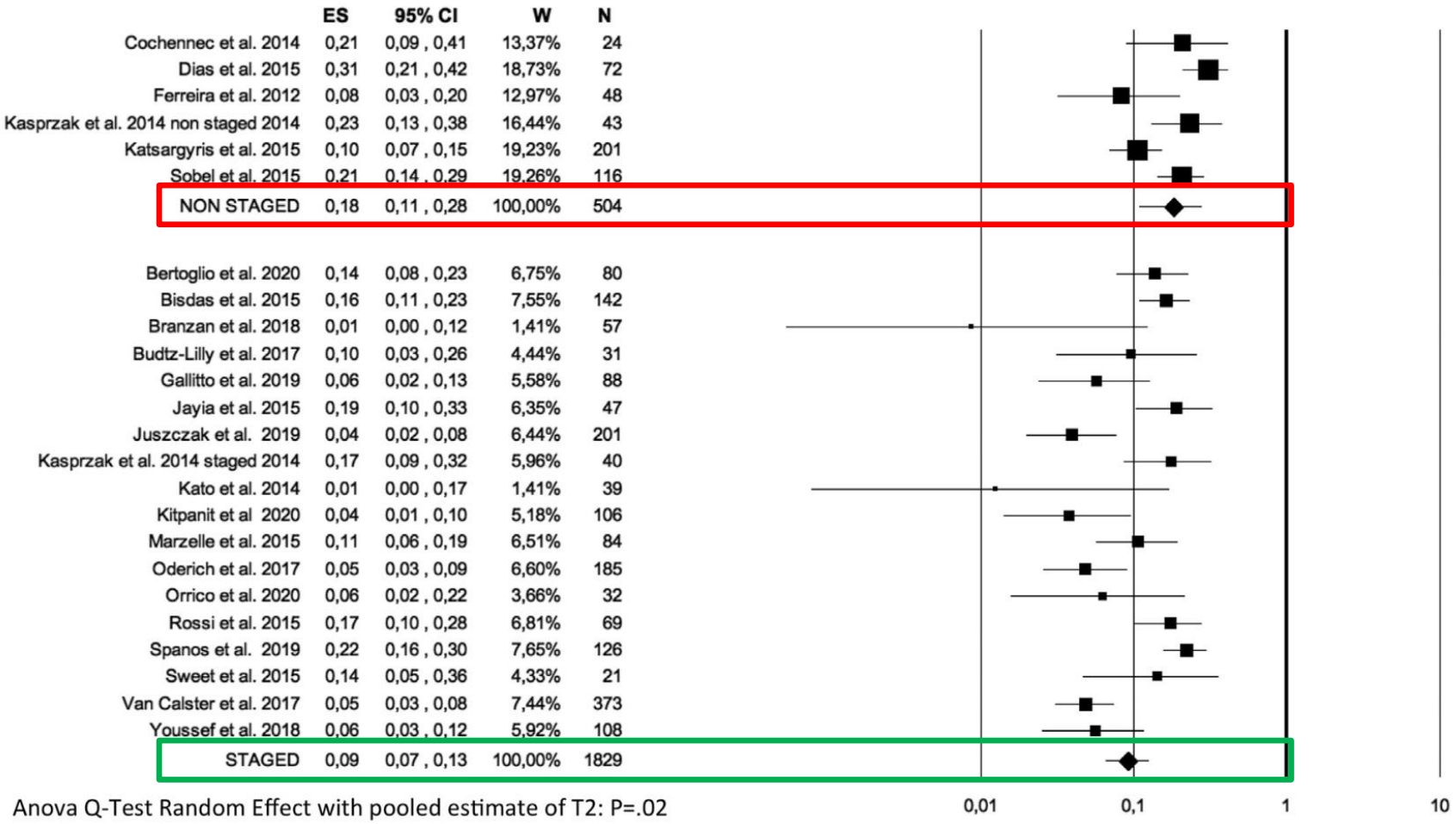
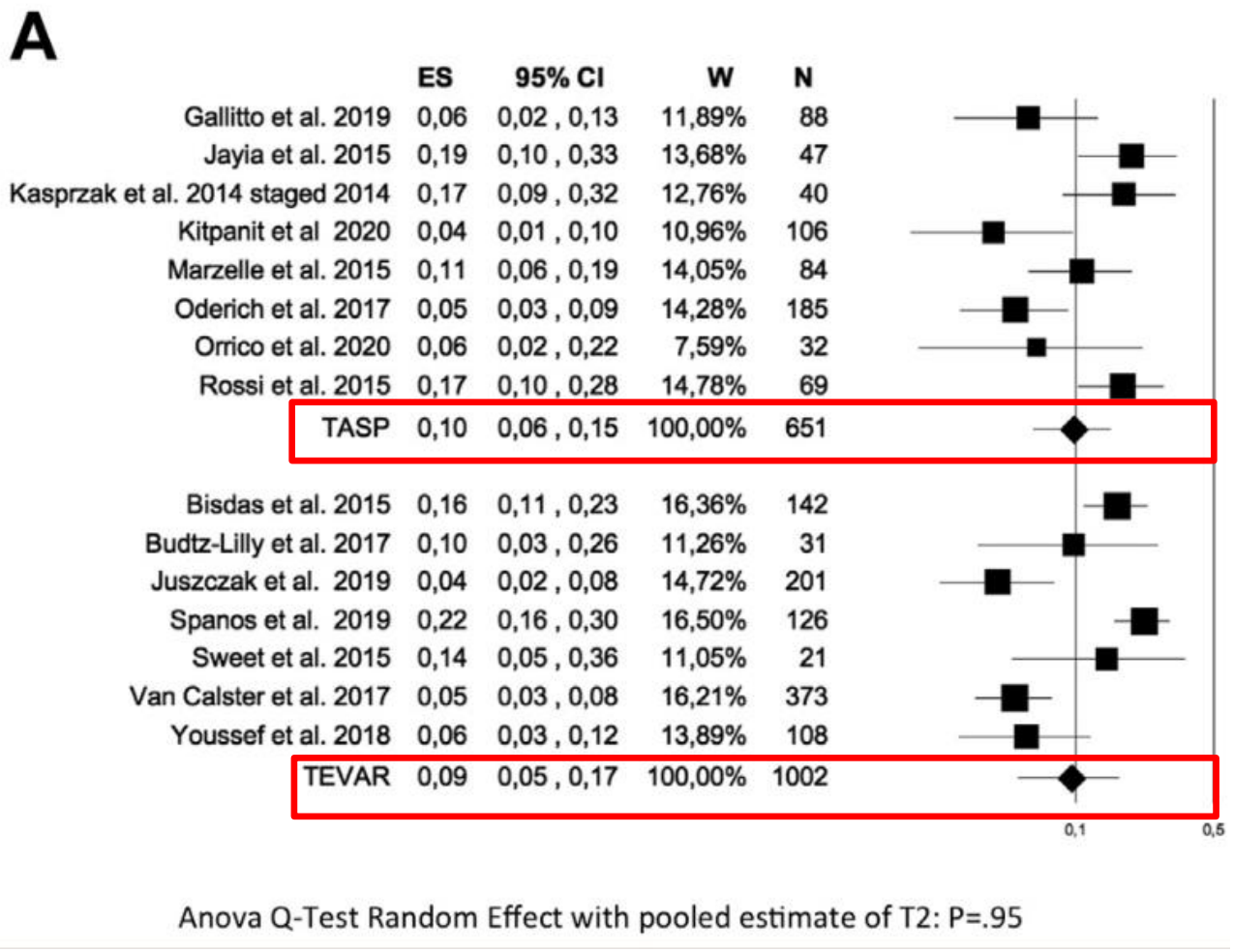


Fig 4. Forest plot of pooled estimate rate of spinal cord ischemia (SCI) for studies of the nonstaged and staged approaches. *Anova,* Analysis of variance; *CI,* confidence interval; *ES,* effect size; *N,* sample size; *W,* weighting.

Stageing

- Mode of stageing?
  - TEVAR first
  - Temporary perfusion of aneurysm sac (TASP)

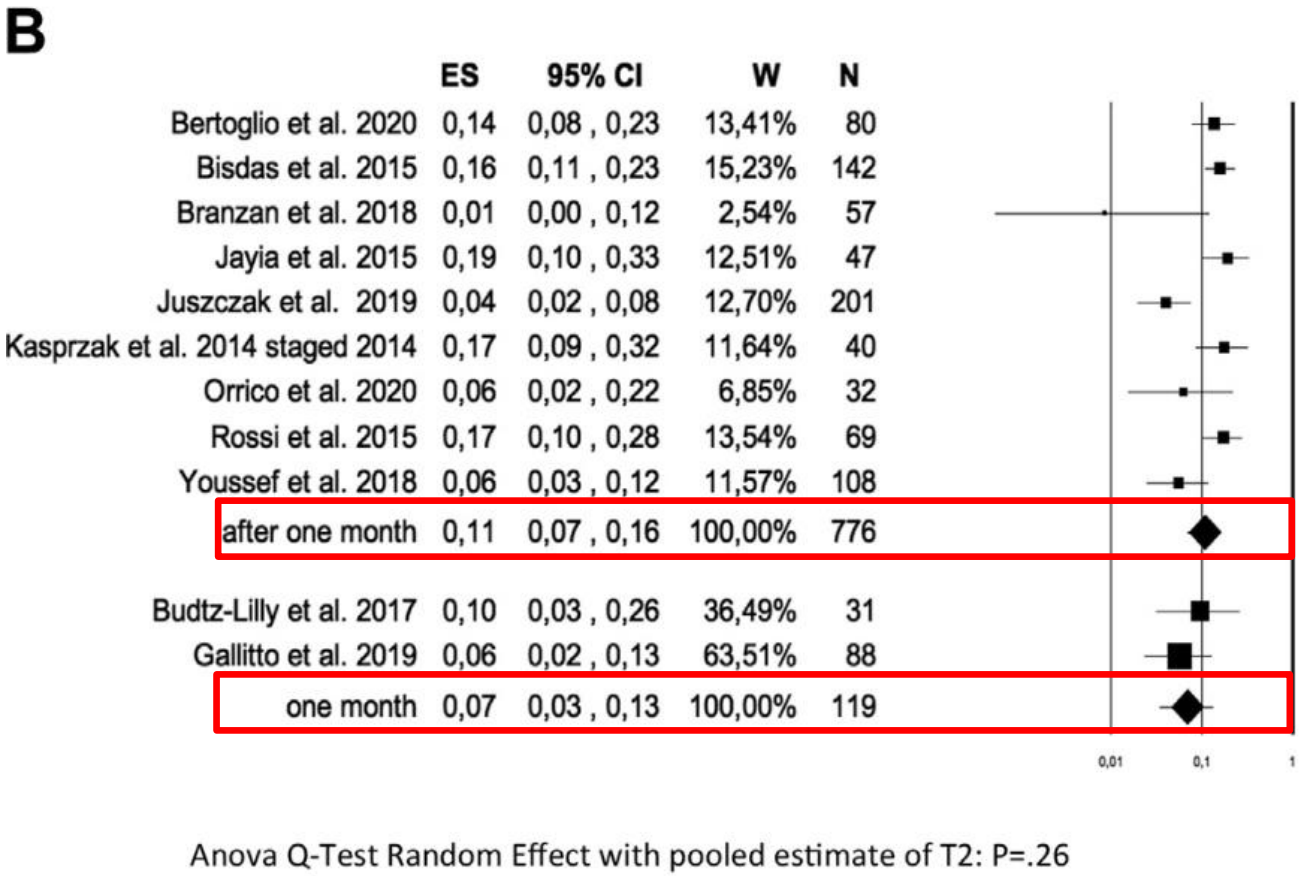
Pini et al JVS -22



Stageing

- **Interval between procedures?**
  - > 1month
  - within one month
- **Rupture between procedures?**
  - 0,6 - 1,6 % ???

Pini et al JVS -22



Preconditioning of collaterals: Pre-embolization of segmental arteries

- Performed i LA
- NIRS/Backpain
- Max 7 SA emb at each procedure, 21 d between emb.
- Final repair 5 days after emb
- PAPAartis results…

Minimally invasive staged segmental artery coil embolization (MIS^{2}ACE) for spinal cord protection

Josephina Haunschild[1], Tilo Köbel[2], Martin Misfeld[1,3,4,5,6,7], Christian D. Etz[1]

Annals of Cardiothoracic Surgery, Vol 12, No 5 September 2023

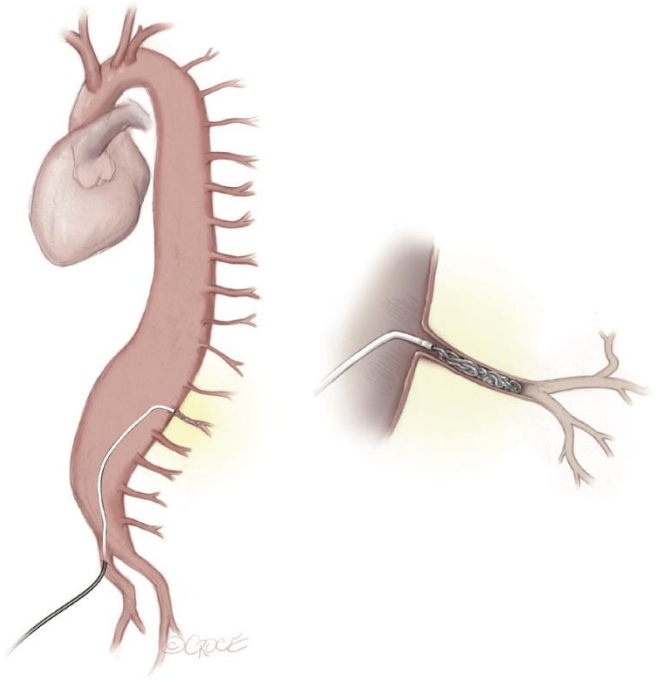


Figure 4 Thoracoabdominal aorta with sheath and microcatheter in one of the preoperatively identified segmental artery, accessed from the femoral artery.

Increase perfusion by decreasing intrathecal pressure: Cerebro Spinal Fluid Drain (CSFD)

JOURNAL OF VASCULAR SURGERY
April 2002

Cerebrospinal fluid drainage reduces paraplegia after thoracoabdominal aortic aneurysm repair: Results of a randomized clinical trial

Joseph S. Coselli, MD, Scott A. LeMaire, MD, Cüneyt Köksoy, MD, Zachary C. Schmittling, MD, and **Patrick E. Curling, MD,** *Houston, Tex*

Table IV. Postoperative lower extremity neurologic deficits after repair of extensive thoracoabdominal aortic aneurysms

Neurologic injury	*CSFD (n = 76)*	*Control (n = 69)*	P *value*	*Risk reduction*	
				Absolute	*Relative*
All lower extremity neurologic deficits	2 (2.6%)	9 (13.0%)	.03	10.4%	80%
Immediate neurologic deficits	1 (1.3%)	7 (10.1%)	.03	8.8%	87.1%
Paraplegia	0	6 (8.7%)	.01	8.7%	100%
Paraparesis	1 (1.3%)	1 (1.4%)	1.0		
Delayed neurologic deficits	1 (1.3%)	2 (2.9%)	.60		
Paraplegia	1 (1.3%)	1 (1.4%)	1.0		
Paraparesis	0	1 (1.4%)	.48		

CSFD, Cerebrospinal fluid drainage.

CSFD

- Pressure directed: drains intrathecal pressure > 7-15 mm Hg
- Drain volume 10-20 ml/h
- Increase drain volume if SCI
- Larger drained volumes increase risc for complications
- Removal: 24-72 h postop if no SCI

Systematic Review of the Effect of Cerebrospinal Fluid Drainage on Outcomes After Endovascular Descending Thoracic/Thoraco-Abdominal Aortic Aneurysm Repair

EJVES -23

Jelle Frankort [a,b,*], Barend Mees [b], Panagiotis Doukas [a], Andràs Keszei [c], Nikolaos Kontopodis [d], George A. Antoniou [e,f], Michael J. Jacobs [a,b], Alexander Gombert [a]

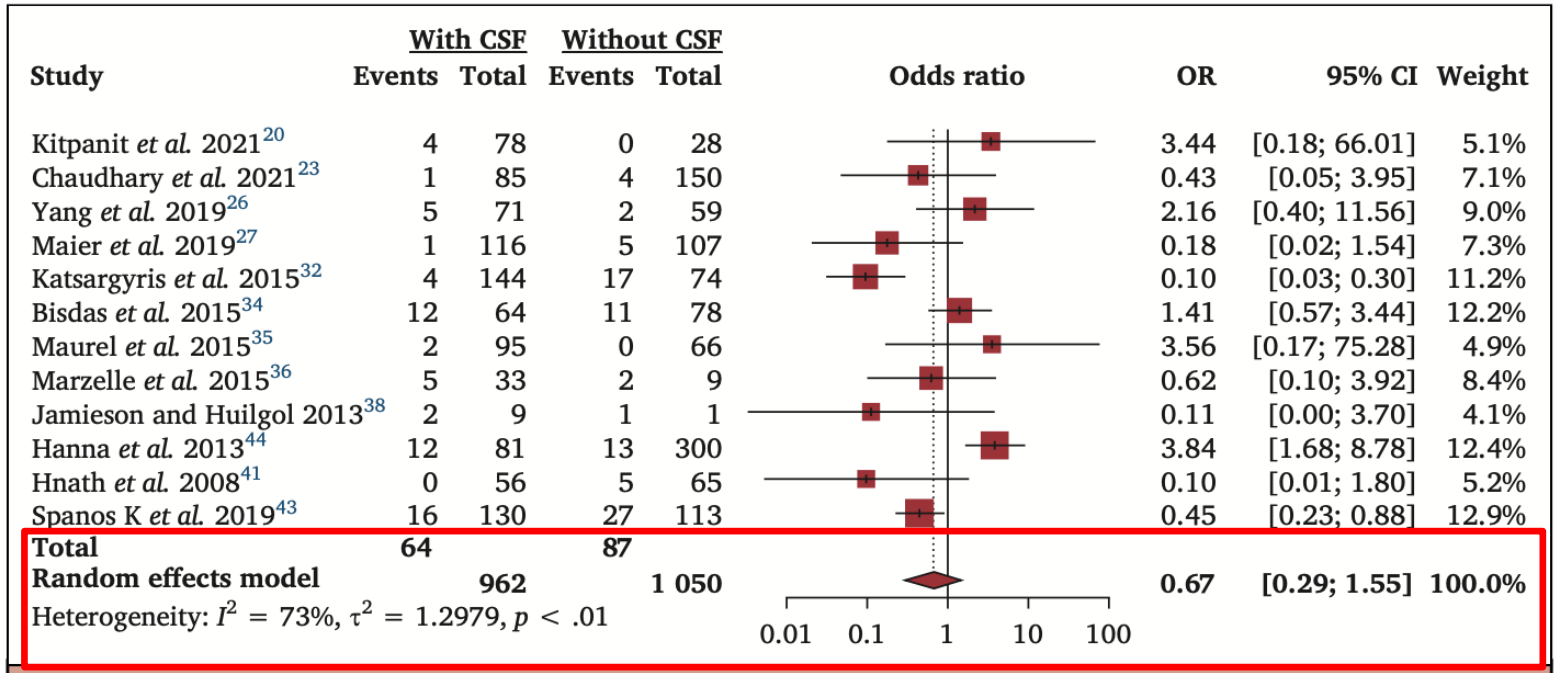


Figure 4. Forest plot of all studies for difference in spinal cord ischaemia with and without the use of cerebrospinal fluid (CSF) drainage after endovascular descending thoracic aortic aneurysm and thoraco-abdominal aortic aneurysm repair. OR = odds ratio; CI = confidence interval.

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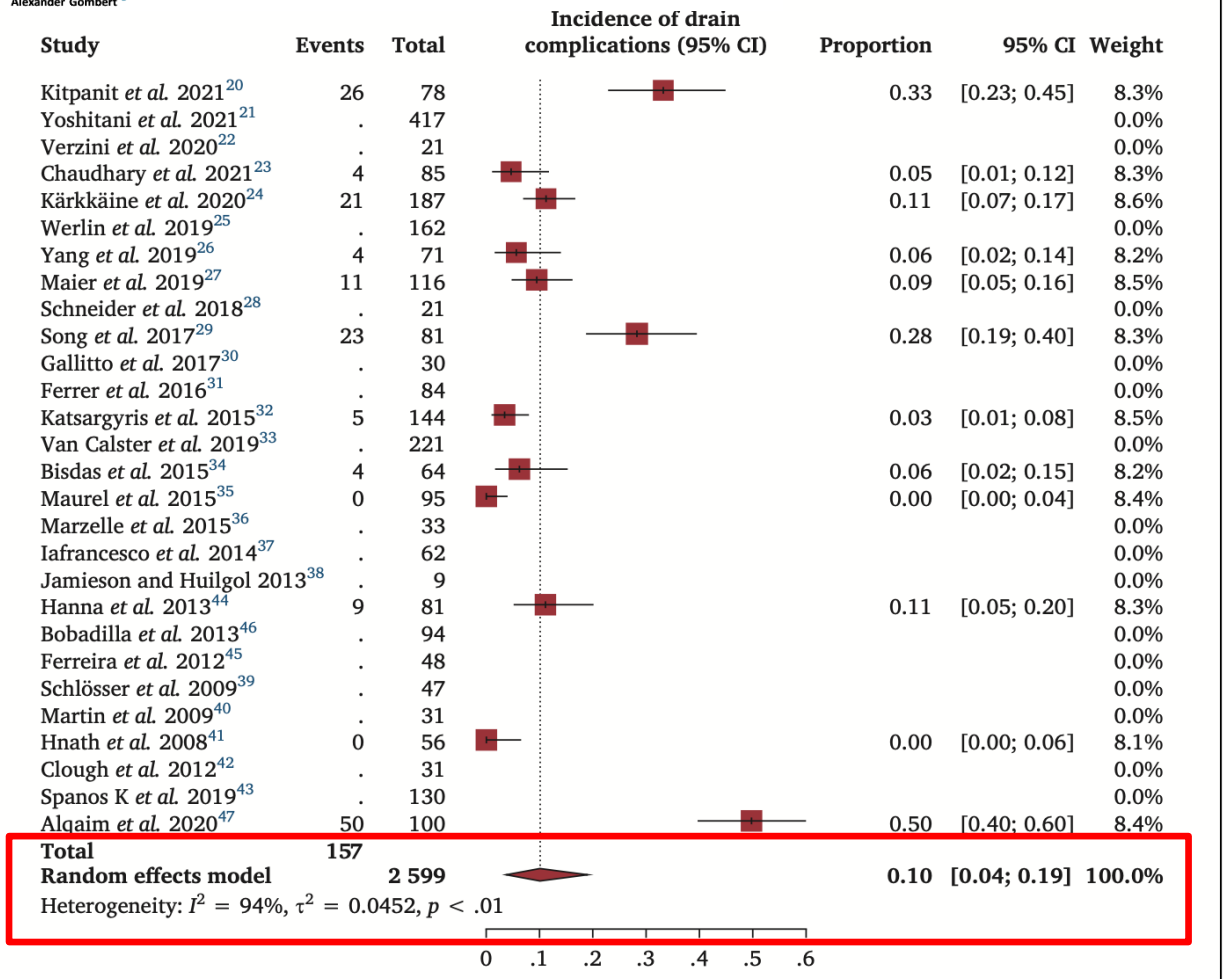

Study	Events	Total	Proportion	95% CI	Weight
Kitpanit *et al.* 2021[20]	26	78	0.33	[0.23; 0.45]	8.3%
Yoshitani *et al.* 2021[21]	.	417			0.0%
Verzini *et al.* 2020[22]	.	21			0.0%
Chaudhary *et al.* 2021[23]	4	85	0.05	[0.01; 0.12]	8.3%
Kärkkäine *et al.* 2020[24]	21	187	0.11	[0.07; 0.17]	8.6%
Werlin *et al.* 2019[25]	.	162			0.0%
Yang *et al.* 2019[26]	4	71	0.06	[0.02; 0.14]	8.2%
Maier *et al.* 2019[27]	11	116	0.09	[0.05; 0.16]	8.5%
Schneider *et al.* 2018[28]	.	21			0.0%
Song *et al.* 2017[29]	23	81	0.28	[0.19; 0.40]	8.3%
Gallitto *et al.* 2017[30]	.	30			0.0%
Ferrer *et al.* 2016[31]	.	84			0.0%
Katsargyris *et al.* 2015[32]	5	144	0.03	[0.01; 0.08]	8.5%
Van Calster *et al.* 2019[33]	.	221			0.0%
Bisdas *et al.* 2015[34]	4	64	0.06	[0.02; 0.15]	8.2%
Maurel *et al.* 2015[35]	0	95	0.00	[0.00; 0.04]	8.4%
Marzelle *et al.* 2015[36]	.	33			0.0%
Iafrancesco *et al.* 2014[37]	.	62			0.0%
Jamieson and Huilgol 2013[38]	.	9			0.0%
Hanna *et al.* 2013[44]	9	81	0.11	[0.05; 0.20]	8.3%
Bobadilla *et al.* 2013[46]	.	94			0.0%
Ferreira *et al.* 2012[45]	.	48			0.0%
Schlösser *et al.* 2009[39]	.	47			0.0%
Martin *et al.* 2009[40]	.	31			0.0%
Hnath *et al.* 2008[41]	0	56	0.00	[0.00; 0.06]	8.1%
Clough *et al.* 2012[42]	.	31			0.0%
Spanos K *et al.* 2019[43]	.	130			0.0%
Alqaim *et al.* 2020[47]	50	100	0.50	[0.40; 0.60]	8.4%
Total	**157**				
Random effects model		**2 599**	**0.10**	**[0.04; 0.19]**	**100.0%**

Heterogeneity: $I^2 = 94\%$, $\tau^2 = 0.0452$, $p < .01$

Figure 5. Overall incidence of drain related complications in patients with cerebrospinal fluid drainage. Events = number of complications; CI = confidence interval. The vertical dotted line represents the mean proportion of all studies.

CSF drain; complications (5-12 %)

More frequent i patients with SCI

- Headache
- Epidural/spinal haematoma
- Intracranial/subdural haematoma
- Meningitis
- CSF leak
- Puncture site infection

Prophylactic or Terapeutic CSFD?

Table IV. Baseline, intraoperative, and postoperative comparative findings between patients managed with prophylactic (*pCSFD*) and therapeutic (*tCSFD*) spinal fluid drainage

Variable	pCSFD (n = 41)	tCSFD (n = 59)	*P* value
Males	33/41 (80.5)	44/59 (74.6)	.80
Age, years	67.6 ± 8.4	67.2 ± 6.1	.63
Positive aortic history	33/41 (80.5)	45/59 (76.3)	.86
Genetically triggered aortic disease	6/41 (14.6)	4/59 (6.8)	.25
Prior open aortic repair	22/41 (53.6)	36/59 (61.0)	.70
Prior endovascular aortic repair	22/41 (53.6)	30/59 (50.8)	.88
Aneurysm classification			
Type I	5/41 (12.2)	21/59 (35.6)	.04
Type II	20/41 (48.8)	30/59 (50.8)	.91
Type III	16/41 (39.0)	8/59 (13.6)	.02
Aneurysm type			
Degenerative	22/41 (53.6)	27/59 (45.8)	.65
Dissective	19/41 (46.3)	32/59 (54.2)	.66
IIA occlusion	4/41 (9.8)	4/59 (6.8)	.62
Staged procedure	14/41 (34.1)	21/59 (35.6)	.92
Spinal drainage	41/41 (100.0)	4/59 (6.8)	<.001
Primary technical success	39/41 (95.1)	54/59 (91.5)	.90
Postoperative complications	21/41 (51.2)	26/59 (44.1)	.67
MACE	3/41 (7.3)	9/59 (15.3)	.28
SCI	3/41 (7.3)	3/59 (5.1)	.66
Grade 3 SCI (paraplegia)	2/41 (4.8)	2/59 (3.3)	.72
Paraplegia with no recovery	1/41 (2.0)	0/59 (0.0)	.37
Length of ICU stay, days	3 (2)	1 (1)	<.001
Length of hospital stay, days	9 (6)	7 (5)	.01
30-day mortality	2/41 (4.9)	2/59 (3.4)	.72

ICU, Intensive care unit; *IIA*, internal iliac artery; *MACE*, major adverse cardiovascular event; *SCI*, spinal cord ischemia.
Data are presented as number/total (%), mean ± standard deviation, or median (interquartile range).

Guidelines

2022 ACC/AHA guideline for the diagnosis and management of aortic disease

Check for updates

A report of the American Heart Association/American College of Cardiology Joint Committee on Clinical Practice Guidelines

Developed in collaboration with and endorsed by the American Association for Thoracic Surgery, American College of Radiology, Society of Cardiovascular Anesthesiologists, Society for Cardiovascular Angiography and Interventions, Society of Thoracic Surgeons, and Society for Vascular Surgery

Endorsed by the Society of Interventional Radiology and Society for Vascular Medicine

Recommendations for TAAA Spinal Cord Protection
Referenced studies that support the recommendations are summarized in the Online Data Supplement.

COR	LOE	Recommendations
1	A	1. In patients undergoing open TAAA repair who are at high risk for SCI, cerebrospinal fluid drainage is recommended to reduce the incidence of temporary SCI, permanent SCI, or both.[1-7]
1	B-NR	2. In patients who experience delayed spinal cord dysfunction after either open or endovascular TAAA repair, timely measures to optimize spinal cord perfusion and decrease intrathecal pressure are recommended (Table 19).[1-4,8]

Editor's Choice – European Society for Vascular Surgery (ESVS) 2024 Clinical Practice Guidelines on the Management of Abdominal Aorto-Iliac Artery Aneurysms☆

Recommendation 128	New
For patients undergoing open or endovascular repair of a complex abdominal aortic aneurysm, a policy of reactive (rescue) cerebrospinal fluid drainage may be considered preferable over routine prophylactic cerebrospinal fluid drainage.	
Class	**Level** / **References**
IIb	C / Consensus

Eur J Vasc Endovasc Surg (2017) 53, 4–52

Editor's Choice – Management of Descending Thoracic Aorta Diseases

Clinical Practice Guidelines of the European Society for Vascular Surgery (ESVS)

Recommendation 10	Class	Level of evidence
Patients with planned extensive thoracic aorta coverage (>200 mm) or previous AAA repair have a high risk for spinal cord ischemia and prophylactic cerebrospinal fluid drainage should be considered in endovascular thoracic aorta repair.	IIa	C

Increase perfusion to spinal cord

- MAP > 80 -90 mmHg
  - withheld antihypertension medication
  - fluids iv
    - overload: keep the patient 1-3 L plus postop?
  - vasopressors
  - blood products
  - hypertension 2 weeks-1 month postop?
- Hb > 100 g/l

Ann Vasc Surg 2023; 97: 236–247

Single-Site Review of Spinal Cord Protection Protocols Including the Utilization of Spinal Drains versus Medical Management with Branched Endovascular Aortic Repair

Spencer J. Lucas,[1] Kristopher B. Johnson,[1] Ryan Rykhus,[1] Kirby Hora,[1] Angela VandenHull,[2] Kari Bates,[2] Joni Sengos,[2] and Patrick W. Kelly,[2,] Sioux Falls, South Dakota*

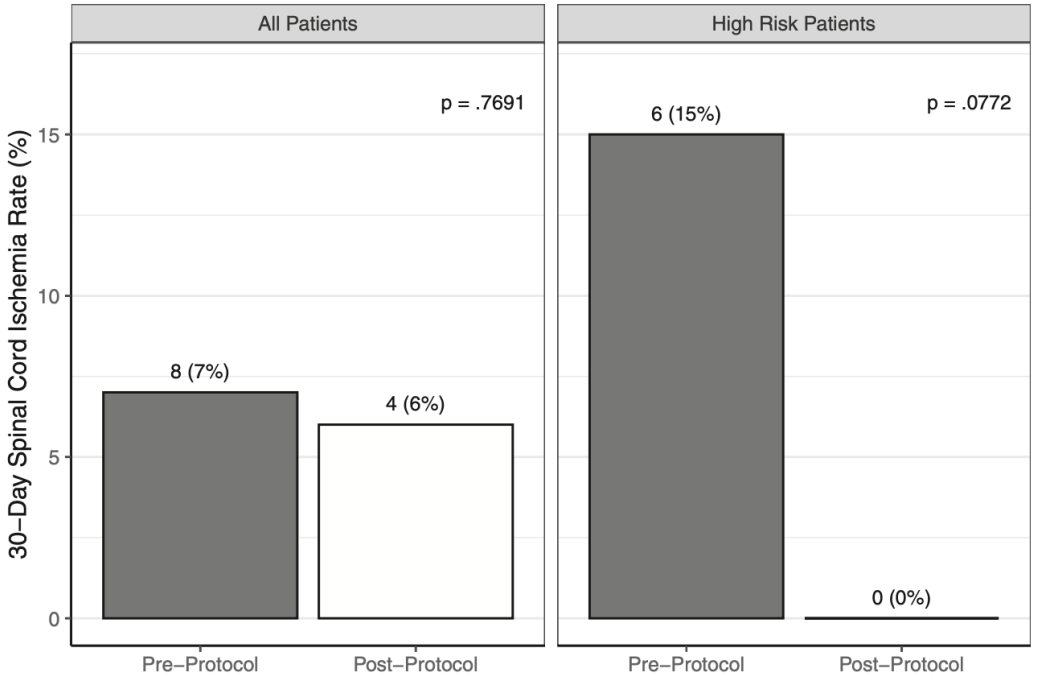

Fig. 1. Reduction in SCI rates for both groups at 30 days postprotocol.

Blood glucose control

From the Vascular and Endovascular Surgery Society

JVS 2017

Lower extremity weakness is associated with elevated blood and cerebrospinal fluid glucose levels following multibranched endovascular aortic aneurysm repair

Jade S. Hiramoto, MD, MAS, Charlene Fernandez, BS, Warren Gasper, MD, Shant Vartanian, MD, Linda Reilly, MD, *and* Timothy Chuter, MD, *San Francisco, Calif*

Eur J Vasc Endovasc Surg (2019) 58, 848–853

Strict Control of Blood Glucose With an Intravenous Insulin Infusion Decreases the Risk of Post-operative Lower Extremity Weakness After Complex Endovascular Aortic Aneurysm Repair☆

Jade S. Hiramoto *, Megan Hoffman, Warren Gasper, Linda Reilly, Timothy Chuter

- Blood and CSF glucose are elevated in SCI
- Hyperglycemia associated with worse outcome in ischemic stroke, head injuries, SAH
- Strict blood glucose control <120 mg/dL 48 h
- Insulin infusion if b-gluc>120 mg/dL
- Reduction in early SCI (within 48 h) from 32 % to 0%

Drugs ?

- **steroids**: reduces inflammation and increasing tolerance for ischemia
- **mannitol**: reduces oedema
- **acetazolamid**: reduces CSF production
- **naloxone**: reduces excitatory amino acids in CSF
- **intrathecal papaverine**: vasodilator; increases peri-spinal blood flow

weak evidence: of clinical effect

Standardized neuroprotective protocol:

- ✅ Preserve collaterals
- ✅ Staged procedure
- ⏸ Preembolization of segmental arteries
- ✅ CSF drain (terapeutic, prophylactic in high risc patients?)
- ✅ Increase MAP (>80-90 mm Hg)
- ✅ Hb > 100 g/l
- ✅ Strict glucose control (<120 mg/dL)
- ❌ acetazolamid, naloxone, steroids

LATE SCI

- Occur after episode of hypotension
- Can occur years after cEVAR
- Often misjudged and treatment is delayed
- Patient education?