Mechanisms Of Neuronal Death In SCI With Aortic Repairs And What Can Be Done To Minimize It: CSF Drainage And High BP Will Not Stop All SCI: An Anesthesiologist’s Perspective

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Disclosure

None

Objectives

- History of first case of paralysis after TEVAR
- Current state regarding the incidence of paralysis
- Current state regarding the role of spinal drain
- Spinal cord Edema as cause of paralysis after TEVAR
- Future directions to treat edema and reduce paralysis

First Case of Paralysis After TEVAR

Delayed onset of ascending paralysis after thoracic aortic stent graft deployment

Karthiknakavoor Karve Rajan, MD, Bart Dolschmeh, MD, Kenneth Duriel, MD, and Daniel Cline, MD, Cleveland, Ohio

- Spinal cord Infarction from C4
- Dense paraplegia
- Spinal drain did not prevent paralysis!!!

First Experience with TEVAR

- 13 patients
- No CSF drain
- Induced Hypotension: Vasodilators and Beta blockers

60 YEARS LATER


384: 591-597.
Spinal Drainage Practice in Centers of Excellence

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Status</th>
</tr>
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<tbody>
<tr>
<td>Greenberg et al.</td>
<td>2008</td>
<td>Yes</td>
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<tr>
<td>Gravereaux et al.</td>
<td>2001</td>
<td>Yes, with extensive coverage</td>
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<tr>
<td>Conrad et al.</td>
<td>2008</td>
<td>Yes</td>
</tr>
<tr>
<td>Bavaria et al.</td>
<td>2007</td>
<td>NOT CONSISTENT</td>
</tr>
<tr>
<td>Freezer et al.</td>
<td>2008</td>
<td>SOME IN MOST PATIENTS</td>
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<tr>
<td>Stone et al.</td>
<td>2006</td>
<td>NOT REPORTED</td>
</tr>
</tbody>
</table>

References for 2010 Guidelines


2010 Guidelines

22.5. Recommendations for Spinal Cord Protection During Descending Aortic Open Surgical and Endovascular Repairs

Class I
1. Cerebrospinal fluid drainage is recommended as a spinal cord protective strategy in open and endovascular thoracic aortic repair for patients at high risk of spinal cord ischemic injury (188–190). (Level of Evidence: B)

References for 2010 Guidelines

Endovascular Repair

1-No Reference
2-No Reference
3-No Reference

Position Paper 2015

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

Conflicts of interest

The experts declared no conflicts of interest.

CSF drainage should be considered in patients undergoing TEVAR at high risk for SCl (this panel of experts)

Level of Evidence

Aa Weight of evidence/opinion is in favour of usefulness/efficacy. Suggested wording to use—should be considered
B Consensus of opinion of experts and/or small studies, retrospective studies, registries
C Not Randomized Controlled Trials

Back to the basics:

What is the Mechanism of Neuronal damage?

http://neuroangio.org/spinal-vascular-anatomy/spinal-arterial-anatomy

Back to the basics:

How does the stent in the thoracic aorta affect the blood supply of the microcirculation in the grey matter in the spinal cord?

MRI findings following TAA repair

Spinal drain for 48 hours

Drainage stopped on day 3

Catheter removed on day 4

Patient developed paralysis on day 4 after the catheter was removed

MRI showed extensive edema despite spinal drain placement and drainage

Edema and paralysis

Cause and effect relationship

Versus

Association after inflammation

The debate about the edema 18 YEARS ago

“We suggest that this complication is a result of a spinal cord compartmental syndrome that may arise from unstable blood pressure, increased cerebrospinal fluid pressure, or both.”


“The development of a compartmental syndrome is an attractive hypothesis for the abnormalities and responses observed, but we are not aware of any clinical or experimental studies of spinal cord ischemia after aortic clamping that have shown spinal cord edema and the presence of a compartmental syndrome.”

Back To The Basics
JL Dopmann
Radiology 1993 Oct

- Paraplegia after surgery for TAAA: Russian Roulette for vascular surgeons
- The blood supply to the spinal cord is more variable anatomically & more complex hemodynamically than the blood supply to any other vital organs.

"We desperately need an animal model in which each therapeutic maneuver or combination of maneuvers can be controlled and tested. Currently, we do not know why 15% of patients wake up from successful aneurysmectomy with paraplegia…"

As long as we don’t understand the pathophysiology, we can propose no reasonable remedy, and resection of thoracoabdominal aneurysms will continue to be the surgical version of Russian roulette”.

"Paraplegia after surgery for thoracoabdominal aneurysms: Russian roulette for the vascular surgeon."

The size of infarcted lesion is smaller in miR-155 knockout paralyzed mice

Wild type
Wild type
miR-155 knockout
miR-155 knockout

Further Evidence supporting edema

"The density of the capillary bed is **5 times greater in gray matter** than in white matter."

"As the **pia** is relatively firm, the edema causes increased interstitial pressure with resulting ischemia”.

Edema Dependent Injury?!!

Our Next Steps in The Preclinical Mouse Model

- We believe that understanding the dynamics of leakage at the microcirculation of the spinal cord at the gray matter will help us understand the cause of death of the neurons.

  - Osmotic Stress causing
    - Cytotoxic edema (reversible damage)
    - Vasogenic edema (irreversible damage)
    - Neuronal death

Future direction

- Understanding the cellular and molecular mechanism of the leakage and the edema formation from the gray matter microcirculation of the spinal cord.

- We have several molecular targets to reduce edema formation and prevent paralysis in our mouse model.

Thank You!