Immediate, delayed and late spinal cord ischemia after extended endovascular thoracoabdominal aortic repair

Reinhard Kopp, Karin Pfister, Beatrix Cucuruz, Konstantinos Gallis, Piotr M Kasprzak
Disclosure

Speaker name:

Reinhard Kopp

I have the following potential conflicts of interest to report:

- Consulting
- Employment in industry
- Stockholder of a healthcare company
- Owner of a healthcare company
- Other(s)

☒ I do not have any potential conflict of interest
Thoracoabdominal aortic aneurysms (TAAA)

- Treatment options

Open surgery

Hybrid procedure

BEVAR
Thoracoabdominal aortic aneurysms (TAAA)

- risk of spinal cord ischemia

5 - 20 %

adjuncts
- normotension, hemoglobin
- CSFD
- early iliac reperfusion
- open branch concept / TASP
Treatment of TAAA with branched EVAR
- risk of spinal cord ischemia

**open branch concept with TASP** (temporary aneurysm sac perfusion)

09/2007 – 03/2017
n = 156

neurological outcome

- spinal cord ischemia (SCI)

<table>
<thead>
<tr>
<th>08/2007 - 03/2017</th>
<th>single step n = 69</th>
<th>staged TASP n = 87</th>
<th>P</th>
<th>staged TASP completed n = 75</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>stroke</td>
<td>1</td>
<td>3</td>
<td>0.3</td>
<td>3</td>
<td>0.3</td>
</tr>
<tr>
<td>paresthesia</td>
<td>5</td>
<td>12</td>
<td>0.84</td>
<td>12</td>
<td>0.79</td>
</tr>
<tr>
<td>postOP SCI</td>
<td>16</td>
<td>10</td>
<td>0.41</td>
<td>10</td>
<td>0.34</td>
</tr>
<tr>
<td>SCI d30</td>
<td>16 (23.2 %)</td>
<td>4 (4.6 %)</td>
<td>0.001</td>
<td>4 (5.3 %)</td>
<td>0.005</td>
</tr>
</tbody>
</table>

SCI: Tarlov 0-2 score
BEVAR for TAAA: open branch + TASP concept + other adjuncts

spinal cord ischemia (%)

<table>
<thead>
<tr>
<th>Time Period</th>
<th>earlySCI</th>
<th>delayedSCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>07/2007 - 04/2009</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>05/2009-04/2011</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>05/2011-04/2014</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>05/2014-06/2016</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

early SCI (< 48 h)
delayed / late SCI

Tarlov 0-2
Spinal cord ischemia (SCI) during complex and extended endovascular aortic repair

**BEVAR** \( (n = 156; 08/2007 - 03/2017) \)

delayed and late SCI (temporary and permanent)
after BEVAR: 13/146 (8.9 %, permanent 3.4 %)

<table>
<thead>
<tr>
<th>Name</th>
<th>Age</th>
<th>Delay</th>
<th>Type</th>
<th>Duration</th>
<th>Condition(s)</th>
<th>Imp.</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>H.F.</td>
<td>60y</td>
<td>delayed</td>
<td>temporary</td>
<td>4 d</td>
<td>no CSFD/nonfunct</td>
<td>52 cm</td>
<td>staged/TASP</td>
</tr>
<tr>
<td>K.H.</td>
<td>83y</td>
<td>late</td>
<td>permanent</td>
<td>18 d</td>
<td>RR hypotension</td>
<td>24 cm</td>
<td>single step</td>
</tr>
<tr>
<td>F.M.</td>
<td>61y</td>
<td>delayed</td>
<td>temporary</td>
<td>4 d</td>
<td>no CSFD/nonfunct</td>
<td>43 cm</td>
<td>single step</td>
</tr>
<tr>
<td>H.G.</td>
<td>69y</td>
<td>late</td>
<td>permanent</td>
<td>36 mo</td>
<td>hypotension, periop. anemia</td>
<td>51 cm</td>
<td>staged/TASP</td>
</tr>
<tr>
<td>S.P.</td>
<td>81y</td>
<td>delayed</td>
<td>temporary</td>
<td>3 d</td>
<td>hypotension</td>
<td>25 cm</td>
<td>single step</td>
</tr>
<tr>
<td>S.W.</td>
<td>83y</td>
<td>delayed</td>
<td>temporary</td>
<td>5 d</td>
<td>hypotension</td>
<td>30 cm</td>
<td>single step</td>
</tr>
<tr>
<td>W.F.</td>
<td>76y</td>
<td>delayed</td>
<td>permanent</td>
<td>4 d</td>
<td>CPR, hypotension, LSA occluded</td>
<td>42 cm</td>
<td>staged/TASP</td>
</tr>
<tr>
<td>M.B.</td>
<td>74y</td>
<td>delayed</td>
<td>temporary</td>
<td>10 d</td>
<td>hypotension, COPD, anemia</td>
<td>46 cm</td>
<td>staged/TASP</td>
</tr>
<tr>
<td>A.N.</td>
<td>78y</td>
<td>delayed</td>
<td>permanent</td>
<td>7 d</td>
<td>hyper/hypotens, cerebral bleeding</td>
<td>39 cm</td>
<td>staged/TASP</td>
</tr>
<tr>
<td>R.S.</td>
<td>64y</td>
<td>delayed</td>
<td>permanent</td>
<td>4 d</td>
<td>endoleak type III, hypotension</td>
<td>35 cm</td>
<td>single step</td>
</tr>
<tr>
<td>B.I.</td>
<td>56y</td>
<td>delayed</td>
<td>temporary</td>
<td>3 d</td>
<td>hypotension</td>
<td>41 cm</td>
<td>single step</td>
</tr>
<tr>
<td>R.L</td>
<td>75y</td>
<td>delayed</td>
<td>temporary</td>
<td>4d</td>
<td>TASP nonfunct., hypotension</td>
<td>33 cm</td>
<td>non-intend. sing.st.</td>
</tr>
<tr>
<td>H.S.</td>
<td>75y</td>
<td>delayed</td>
<td>temporary</td>
<td>3d</td>
<td>hypotension ?</td>
<td>38 cm</td>
<td>staged/TASP</td>
</tr>
<tr>
<td>A.S.</td>
<td>69y</td>
<td>FEVAR/late</td>
<td>temporary</td>
<td>7 mo</td>
<td>antihypertensive treatment, hypotension, anemia, diarrhea</td>
<td>32 cm</td>
<td>single step</td>
</tr>
</tbody>
</table>
Spinal cord ischemia (SCI) during complex and extended endovascular aortic repair

**BEVAR** (n = 156; 09/2007 - 03/2017)

delayed and late SCI (temporary and permanent)

after BEVAR: 13/146 (8.9 %, permanent 4.1 %)

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**Pat. H.G.  69y**  
late SCI after 36 mo, permanent

- Crawford II
- infrarenal bifurcated graft
- 4 branched EVAR (51 cm stent graft length)
- staged procedure/\text{TASP}  
  - step 1: temp. SCI
  - step 2: temp. SCI

- **36 months later** – femoral artery TEA
  periop. hypotension, anemia (> 6 h)
  -> paraplegia
  -> volume, EC, no CSFD,
  -> no improvement
Spinal cord ischemia (SCI) during complex and extended endovascular aortic repair

Late SCI after FEVAR

Pat. A.W.  late temporary SCI  42 d  antihypertensive treatment, hypotension, anemia,

- type B aortic dissection
- chronic aortic expansion
- 4 fenestrated EVAR (FEVAR)

- 42 days later  volume loss
  anemia, diarrhea
  antihypertensive therapy
  -> paraparesis

  -> therapy initiated (< 6h)
  volume, EC,
  CSFD

  -> neurologic symptoms disappeared
Delayed/late SCI after endovascular thoracoabdominal aneurysm repair

SCI after extended endovascular aortic repair

- **Immediate early** postop awake with SCI (< 48 h)
- **Delayed** postop normal, awake
  -> **Secondary SCI (2-14 days)**
- **Late** postop normal, awake
  -> **Secondary SCI (>14 days)**
Delayed or late SCI after endovascular thoracoabdominal aneurysm repair

Risk factors for delayed or late SCI
(n = 13/146; temporary/permanent: 4.8 vs 4.1 %)
periop mortality: 7.7 %

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>OR</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASA 3/4</td>
<td>6.1</td>
<td>0.018</td>
</tr>
<tr>
<td>length covered aorta</td>
<td>5.2</td>
<td>0.030</td>
</tr>
<tr>
<td>aneurysm type</td>
<td>8.76</td>
<td>0.033</td>
</tr>
</tbody>
</table>

BEVAR for TAAA

periop mortality: 7.7 %
open branch with TASP (temporary aneurysm sac perfusion)

various causes of delayed and late spinal cord ischemia (SCI)

- coverage of intercostal/lumbar arteries
- hypotension
  - volume loss - bleeding (periop, gastrointestinal)
  - diarrhea, vomiting
- antihypertensive treatment
- individual variability of spinal cord perfusion
Various causes of delayed and late SCI

- hypotension

antihypertensive treatment

A Randomized Trial of Intensive versus Standard Blood-Pressure Control

The SPRINT Research Group

Abstract

BACKGROUND—The most appropriate targets for systolic blood pressure to reduce cardiovascular morbidity and mortality among persons without diabetes remain uncertain.

METHODS—We randomly assigned 9361 persons with a systolic blood pressure of 130 mm Hg or higher and an increased cardiovascular risk, but without diabetes, to a systolic blood-pressure target of less than 120 mm Hg (intensive treatment) or a target of less than 140 mm Hg (standard treatment). The primary composite outcome was myocardial infarction, other acute coronary syndromes, stroke, heart failure, or death from cardiovascular causes.

RESULTS—At 1 year, the mean systolic blood pressure was 121.4 mm Hg in the intensive-treatment group and 136.2 mm Hg in the standard-treatment group. The intervention was stopped early after a median follow-up of 3.26 years owing to a significantly lower rate of the primary composite outcome in the intensive-treatment group than in the standard treatment group (hazard ratio 0.79; 95% CI, 0.64 to 0.94; P=0.007). All-cause mortality was lower in the intensive-treatment group (hazard ratio 0.74; 95% CI, 0.61 to 0.91; P=0.006).

moderate antihypertensive treatment in patients with extensive endovascular aortic repair

MAP > 85 mmHg
Spinal cord ischemia (SCI) during complex and extended endovascular aortic repair

**BEVAR**  
(n = 156; 08/2007 - 03/2017)

delayed and late SCI (temporary and permanent)  
after BEVAR: 13/146 (8.9 %, permanent 3.4 %)

<table>
<thead>
<tr>
<th>Treatment initiated</th>
<th>within 6 h</th>
<th>later than 6 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>normotension (volume, EC, vasopressor)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>spinal drainage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>treat cause of hypotension</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SCI permanent

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0 / 7 (0 %)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 / 6 (83.3 %)</td>
<td></td>
<td>p = 0.005</td>
</tr>
</tbody>
</table>
open branch with TASP (temporary aneurysm sac perfusion)

Conclusions

- **Delayed and late SCI** have to be considered as a life long risk after extended TAAA repair and prevention of hypotension, perioperative anemia and consideration of moderate antihypertensive therapy is important

- Patients and medical professionals have to be aware of the risk of **delayed and late SCI** after endovascular TAAA repair. Immediate treatment can frequently restore neuromuscular function and prevent paraplegia
Delayed SCI and thoracoabdominal aneurysm repair

Preoperative and operative predictors of delayed neurologic deficit following repair of thoracoabdominal aortic aneurysm

SCI
- immediate: postop awake with SCI 4.6 %
- delayed: postop normal, -> secondary SCI (1-14 days) 2.7 %

Results: Twenty-one of 790 (2.7%) patients had delayed neurologic deficit. Significant univariate predictors included preoperative renal dysfunction (odds ratio 5.9; \( P < .006 \)), acute dissection (odds ratio 3.9; \( P < .05 \)), extent II thoracoabdominal aorta (odds ratio 3.0; \( P < .03 \)), and use of adjuncts (cerebrospinal fluid drainage and distal aortic perfusion; odds ratio 7.7; \( P < .03 \)).

Twelve of 21 (57%) patients recovered neurologic function with optimization of blood pressure and cerebrospinal fluid drainage.

Conclusion:
that a period of increased spinal cord vulnerability persists several days postoperatively.

In the patients with DND, the 30-day mortality rate was 38.1% (8/21). In-hospital mortality in these patients was 47.6% (10/21).
Delayed or late SCI after endovascular thoracoabdominal aneurysm repair

delayed SCI: 12/424 (2.8 %) TEVAR
- permanent SCI: 0.7 %
- periop. mortality: 8.3 %

Table III. Summary of procedural details, intraoperative interventions, and neurologic deficits for cohort of 12 patients with postoperative spinal cord ischemia

<table>
<thead>
<tr>
<th>Patient</th>
<th>Acute Pathology</th>
<th>Acuteness</th>
<th>Procedural details</th>
<th>Aortic Interventions</th>
<th>Neurologic Deficit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dissection</td>
<td>Emergency</td>
<td>Gore TAG No 15</td>
<td>CSF drainage No</td>
<td>Immediate (3.8) Paraplegia Incomplete</td>
</tr>
<tr>
<td>2</td>
<td>Aneurysm</td>
<td>Elective</td>
<td>Gore TAG Yes 50</td>
<td>Yes No</td>
<td>Immediate (0.0) Paraparesis Complete</td>
</tr>
<tr>
<td>3</td>
<td>Aneurysm</td>
<td>Elective</td>
<td>Gore TAG No 35</td>
<td>Yes Yes</td>
<td>Delayed (19.3) Paraparesis Complete</td>
</tr>
<tr>
<td>4</td>
<td>Dissection</td>
<td>Urgent</td>
<td>Gore TAG Yes 55</td>
<td>Yes Yes</td>
<td>Delayed (56.5) Paraparesis Complete</td>
</tr>
<tr>
<td>5</td>
<td>Dissection</td>
<td>Urgent</td>
<td>Gore TAG No 40</td>
<td>Yes Yes</td>
<td>Delayed (229) Paraparesis Incomplete</td>
</tr>
<tr>
<td>6</td>
<td>Dissection</td>
<td>Urgent</td>
<td>Gore TAG No 40</td>
<td>Yes Yes</td>
<td>Delayed (229) Paraparesis Complete</td>
</tr>
<tr>
<td>7</td>
<td>Aneurysm</td>
<td>Urgent</td>
<td>Zornith No 41</td>
<td>Yes Yes</td>
<td>Delayed (56.5) Paraparesis Complete</td>
</tr>
<tr>
<td>8</td>
<td>Aneurysm</td>
<td>Elective</td>
<td>Talent No 23</td>
<td>No No</td>
<td>Delayed (12.8) Paraparesis Complete</td>
</tr>
<tr>
<td>9</td>
<td>Aneurysm</td>
<td>Urgent</td>
<td>Gore TAG No 15</td>
<td>No No</td>
<td>Delayed (2.8) Paraparesis Complete</td>
</tr>
<tr>
<td>10</td>
<td>Aneurysm</td>
<td>Elective</td>
<td>Zornith No 41</td>
<td>Yes Yes</td>
<td>Delayed (44.8) Paraparesis Complete</td>
</tr>
<tr>
<td>11</td>
<td>Aneurysm</td>
<td>Elective</td>
<td>Gore TAG Yes 35</td>
<td>Yes Yes</td>
<td>Delayed (8.0) Paraparesis Complete</td>
</tr>
<tr>
<td>12</td>
<td>Aneurysm</td>
<td>Elective</td>
<td>Talent No 24</td>
<td>Yes No</td>
<td>Delayed (0.8) Paraparesis Complete</td>
</tr>
</tbody>
</table>

CSF: Cerebrospinal fluid, LSA, left subclavian artery; SSEP, somatosensory-evoked potential.

*Use of prophylactic intraoperative CSF drainage to achieve lumbar CSF pressure ~12 mm Hg.

**SSEP changes occurred in all patients consistent with temporary occlusion of blood flow to the femoral or iliac arteries during sheath insertion. These SSEP changes resolved after arteriography closure and repulsion.

*Time after arrival to intensive care unit after procedure.

**In-hospital mortality.
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