Carotid and Vertebral Artery Injuries

6th Nordic Course

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Objectives

- Review the clinical impact of cerebrovascular injuries
- Review the imaging strategies for evaluating patients with potential cerebrovascular injuries
- Focus on MDCT angiography
- Imaging examples
Incidence of BCVI

- Once thought to be rare = 0.08%
- Updated literature = 1.1-1.6%
  - Biffl Ann Surg 2002
    - “Pre-screening” = 0.1%, 100% symptomatic
    - “Post-screening” = 1.6%, 24% symptomatic
- Severe / “high risk” = 33-93%
- Multi-vessel involvement 18%–38%

Stroke Related Morbidity/Mortality

- Blunt carotid artery injuries:
  - Morbidity 32-67%
  - Mortality 17-38%
- Blunt vertebral artery injuries:
  - Morbidity 14-24%
  - Mortality 8-18%
- BCVI-related mortality 25-38%
Mechanisms of Injury

- Hyperextension/Contralateral Rotation
- Cervical Spine Fracture/Dislocation
- Basilar Skull Fractures
- Direct Cervical Blow
- Intraoral Trauma

Cothren CC and Moore EE. Clinics 2005;60(6):489–496.

“High Risk” for BCVI

- C-spine fracture / subluxation / dislocation
- Basilar skull fracture
- Severe facial fractures
- Horner’s syndrome
- Neck seat-belt mark
- Carotid & vertebral artery perivascular hematoma
- GCS < or = 6 @ 24 hr. post injury
- Neurologic exam not compatible with brain imaging
- Stroke or transient ischemia
- Hanging attempt with cervical hematoma or c-spine fracture

Cothren CC and Moore EE. Clinics 2005;60(6):489–496.
Probability of BCVI vs Risk Factors

Table 1. Conditional probability of blunt carotid and vertebral arterial injuries based on multiple logistic regression analysis.

<table>
<thead>
<tr>
<th>Carotid arterial injury (Risk factors: GCS ≤ 6; petrous fracture; DAI; LaFleur II or III fractures)</th>
<th></th>
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<tbody>
<tr>
<td>No risk factors</td>
<td>20%</td>
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<td>Any one risk factor</td>
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<td>Vertebral arterial injury</td>
<td></td>
</tr>
<tr>
<td>No cervical spine fracture</td>
<td>3%</td>
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<tr>
<td>Cervical spine fracture</td>
<td>33%</td>
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GCS: Glasgow Coma Score; DAI: diffuse axonal brain injury.


BCVI Grading Scale

- Biffl (Denver, CO)

<table>
<thead>
<tr>
<th>Injury grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Luminal irregularity or dissection with &lt;25% luminal narrowing</td>
</tr>
<tr>
<td>II</td>
<td>Dissection or intramural hematoma with ≥25% luminal narrowing, intraluminal thrombus, or raised intimal flap</td>
</tr>
<tr>
<td>III</td>
<td>Pseudoaneurysm</td>
</tr>
<tr>
<td>IV</td>
<td>Occlusion</td>
</tr>
<tr>
<td>V</td>
<td>Transaction with free extravasation</td>
</tr>
</tbody>
</table>

Biffl Injury Grade Correlates with Outcomes

<table>
<thead>
<tr>
<th>Worst injury grade</th>
<th>BCI</th>
<th>BVLI</th>
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<tbody>
<tr>
<td></td>
<td>Stroke (%)</td>
<td>Mortality (%)</td>
</tr>
<tr>
<td>I</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>II</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>III</td>
<td>33</td>
<td>11</td>
</tr>
<tr>
<td>IV</td>
<td>44</td>
<td>22</td>
</tr>
<tr>
<td>V</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

BCI: blunt carotid arterial injury; BVLI: blunt vertebral arterial injury.


Whole Body vs Dedicated Neck CTA?

- 77 WB-MDCT and 48 neck MDCTA exams compared with angio.
- Internal carotid artery injuries
  - Sensitivities WB-MDCT and neck MDCTA = 69% and 64%
  - Specificities = 82% and 94%
- Vertebral artery injuries
  - Sensitivities = 74% and 68%
  - Specificities = 91% and 100%
- 17 patients scanned with both protocols, no statistical difference
- “Whole-body 16-MDCT and neck MDCTA can be used to diagnose blunt cerebrovascular injuries with comparable accuracy.

Injury Morphology

- Intimal injury
- Raised intimal flap
- Intramural hematoma
- Pseudoaneurysm
- Vascular occlusion
- Focal dissection
- Active bleeding
- Arteriovenous fistula

Grade I vs spasm

Admission vs 10 hr follow up
59 yo male MVC

Bilateral Grade II ICA Injuries
54 yo F MVC

Follow up day 3
Grade II L CCA with infarct

18 yo male pedestrian struck
Grade II BCI with embolic infarcts

39 yo F MCC
Bilateral Grade II BVI with cerebellar infarcts

3 days later

24 yo female MVC

Admission CTA
24 yo female MVC

Follow up 20 days

Progressive Grade III ICA Injury

Admission  Follow-up 20 days
Grade III ICA Pseudoaneurysm

Male MVC
Grade IV R ICA with infarction
30 yo F MVC

10 hrs follow-up
10 hrs follow-up

10 hrs follow-up
Grade IV ICA with recanalization and cerebral infarction

MVC
Grade V Vertebral Artery Injury
with Craniocervical Distraction

Multiple skull base fractures

Grade V cavernous ICA injury
with active hemorrhage into sphenoid sinus and nasal cavity
Blunt head trauma.
Admission CT skull base fracture, normal ICA

Cavernous-Carotid Fistula
### The Great Debate: CTA vs Catheter Angiography?

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<th>Catheter angiography:</th>
<th>CT angiography:</th>
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<tbody>
<tr>
<td>“gold standard”</td>
<td>Fast</td>
</tr>
<tr>
<td>Angiography teams</td>
<td>Reliable</td>
</tr>
<tr>
<td>High cost</td>
<td>Available</td>
</tr>
<tr>
<td>Invasive</td>
<td>Non-invasive</td>
</tr>
<tr>
<td>Availability?</td>
<td>MDCT (&gt;16)</td>
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<tr>
<td>Impractical for</td>
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### The Great Debate: CTA vs Catheter Angiography?

- **Direct comparison:** 16-MDCT-A vs Angio
- **Eastman 2006:**
  - Sensitivity of 97.7%
  - Specificity of 100%.
- **Malhotra 2007:**
  - Sensitivity of 74%
  - Specificity of 84%
  - 1st half of study, sens and spec = 67% and 78%
  - 2nd half of study, sens and spec = 100% and 86%
Impact of Screening?

**Stroke prevention!**
- Biffl 2002
  - Heparin: 1 of 84 (1%) Stroke
  - Antiplatelet: 3 of 33 (9%) Stroke
  - None: 22 of 43 (51%) Stroke
- Cothren 2005
  - Heparin / Antiplatelet: 1 of 187 (0.5%) Stroke
  - No Treatment: 10 of 48 (21%) Stroke
- Edwards 2007
  - Heparin / Antiplatelet: 6 of 65 (9%) Stroke
  - 77% of Strokes Occurred Prior to Diagnosis and Treatment

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**Impact of Screening?**

- Eastman et al J. Trauma 2009
  - CTA reduces time to diagnosis 12 x
  - CTA reduces stroke related complications 4 x

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Edwards NM, Fabian TC, Carrillo JA, et al. Antithrombotic therapy and endovascular stents are effective treatment for blunt carotid injuries. results.

Impact of Screening?

- Eastman et al. J. Trauma 2009

Early diagnosis and therapy reduces complications


Who Should Get Screening?

- Selective criteria = will miss injuries
- Liberal criteria = will have high yield

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GCS: Glasgow Coma Score; DAI: diffuse axonal brain injury.
Conclusions

- Incidence of BCVI is higher than originally thought
- Untreated BCVI associated with significant stroke-related morbidity and mortality
- Treating BCVI significantly reduces risk of stroke
- Accuracy of MDCT is similar to but not yet comparable to catheter angiography

Conclusions

- Liberal screening is advocated because:
  - BCVI can be clinically silent
  - Treatment of asymptomatic BCVI improves neurologic outcome
  - Up to 1/5 of patients with BCVI do not fall into “high risk” category
References