Diagnosis and Treatment of Blunt Cerebrovascular Injuries

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Role of the Radiologist

• Endovascular treatment
• Diagnosis
Treatment of Blunt Cerebrovascular Injuries

Endovascular Treatment

Endovascular Treatment

• Blunt carotid artery injuries (BCI)
• Blunt vertebral artery injuries (BVI)
Blunt Carotid Artery Injuries

- Few studies
- Reported experience growing
- Stents

**Procedure complications** – either no or subtherapeutic anticoagulation.

Follow-up mean 72 days.

All stent occlusion anticoagulated.

Stents and antiplatelet therapy.

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<table>
<thead>
<tr>
<th>Patients – total</th>
<th>Complications of Procedure</th>
<th>Treatment Failure (Break-through stroke)</th>
<th>Arterial Occlusion</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen JE et al <em>(Stroke 2005)</em></td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Cohen CC et al <em>(Arch Surg 2005)</em></td>
<td>23</td>
<td>3</td>
<td>0</td>
<td>8</td>
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</table>
Blunt Carotid Artery Injuries

<table>
<thead>
<tr>
<th>Patients total</th>
<th>Complications of Procedure</th>
<th>Treatment Failure (Breakthrough stroke)</th>
<th>Arterial Occlusion</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edwards et al (J Am Coll Surg 2007)</td>
<td>18</td>
<td>0</td>
<td>1</td>
<td>0</td>
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<tr>
<td>Stein et al (J Trauma – In Press)</td>
<td>21</td>
<td>?</td>
<td>1</td>
<td>?</td>
</tr>
</tbody>
</table>

- Small number of patients
- Cothren et al highest complication rate
  - Suboptimal peri-procedural anticoagulation
  - May be technique-related
Questions

- What is the true role of stents?
- Hemodynamically significant or symptomatic BCI
  - Should stents be first-line treatment options?

Questions

- Best adjuvant medical therapy?
  - Antiplatelet therapy?
  - Anticoagulation?
- Long term stent patency?
- Long term neurologic outcomes?
Blunt Vertebral Artery Injuries

- Little objective data
- Mainly case series describing therapeutic options

Veras LM (Spine 2000)
- Six Grade IV BVI (occlusions)
  - 3 not treated
    - 2 asymptomatic
    - 1 TIA
  - 3 anticoagulated
    - 2 asymptomatic
    - 1 stroke
Blunt Vertebral Artery Injuries

• 75% Grade IV BVI may recanalize
• May explain Veras et al. data
• Justification for coil occlusion

1 Parbhoo et al (Injury 2001)

Blunt Vertebral Artery Injuries

• Stein DM et al (J Trauma – In Press)
  – 12 BVI treated with coils
    • All Grade IV (i.e. – segmental occlusions)
    • Four also receive antiplatelet therapy
  – No symptomatic patients
  – 1 asymptomatic posterior fossa stroke
    • Incidentally discovered on follow-up MRI
Questions

• What is the true role of endovascular treatment?
• Does permanent occlusion influence outcomes with Grade IV injuries?
  – Better than medical therapy alone?

Questions

• Endovascular treatment may be best for:
  – Transections
  – Symptomatic AVFs
  – Symptomatic pseudoaneurysms
• What about other lesions?
  – Intimal flaps
  – Thrombi
  – Enlarging pseudoaneurysms
Conclusions

• Many unanswered questions
• Routine use
  – Role needs to be defined
  – May not be first-line in many lesions
• Long-term neurologic consequences uncertain

Conclusions

• Antiplatelet agents & anticoagulation improve outcomes
• Symptomatic probably benefit most
  – Hemodynamically significant lesions
  – Transections
  – Refractory to medical treatment
Diagnosis of Blunt Cerebrovascular Injuries

Diagnostic Imaging Options

- Angiography
- Ultrasound
- MRA
- Computed Tomography
Angiography

• Digital subtraction angiography (DSA)
• Four-vessel examination
• Diagnostic reference standard

Angiography

• Invasive
• Safe with *experienced* operators
• Risk of stroke 0.07%-1.3%
    • 727 patients screened for BCVI
    • One (0.1%) procedure-related stroke
Angiography

- Time consuming
- Labor intensive
- Expensive
- Limited availability
  - Small institutions
  - *Busy* large institutions

Ultrasound

- Established - non-traumatic disease
- Available most trauma centers
- Portable
- Easily integrated initial resuscitation
- Inexpensive
Ultrasound

• Operator dependent
• Acoustic windows limited
  – Cervical collars
  – Soft tissue gas
  – Support tubes and catheters

Ultrasound

• Boney canals obscure injuries
  – Transverse foramina
  – Skull base
Ultrasound

• Small lesions without flow disturbance
  – Intimal flaps or pseudoaneurysms
  – Sites of platelet aggregation
  – Sources of distal emboli

Accuracy

• Few studies
• Results poor
  – Cogbill et al (J Trauma 1994)
  – Mutze et al (Radiology 2005)
Accuracy

• Cogbill et al (J Trauma 1994)
  – Retrospective
  – 49 patients
    • Blunt carotid artery injuries only
  – Sensitivity 86%
    • Injuries limited to neck

 Accuracy

• Mutze et al (Radiology 2005)
  – Prospective observational
  – Sensitivity for BCVI 38.5%
    • US missed 8 injuries
    • All resulted in stroke
Magnetic Resonance Angiography

• Established - non-traumatic disease
• Concurrently evaluate cervical spine
• No intravenous contrast
• No ionizing radiation

MRA

• Time consuming
• Transport from acute care area
• Difficult to monitor severely injured
• Limited availability
  – Small institutions
  – Busy large institutions
Accuracy

- Few studies
- None contemporary
  - Biffl et al (J Trauma 2002)

MRA

<table>
<thead>
<tr>
<th></th>
<th>Patients</th>
<th>Injuries</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biffl et al</td>
<td>16</td>
<td>4</td>
<td>75%</td>
<td>67%</td>
</tr>
<tr>
<td>(J Trauma 2002)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miller PR</td>
<td>21</td>
<td>21</td>
<td>BCI 50%</td>
<td>BCI 100%</td>
</tr>
<tr>
<td>(Ann Surg 2002)</td>
<td></td>
<td></td>
<td>BVI 47%</td>
<td>BVI 97%</td>
</tr>
</tbody>
</table>

- Scanners
  - Biffl et al: 1.5 T
  - Miller et al: 0.2T open
- Do not reflect contemporary scanners
Computed Tomographic Angiography

- Quick
- Accessible
- Operator independent
- Inexpensive
- Diagnose non-vascular injuries

Single Slice Spiral CTA

<table>
<thead>
<tr>
<th></th>
<th>BCI(^1,2)</th>
<th>BVI(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>47-68%</td>
<td>53%</td>
</tr>
<tr>
<td>Specificity</td>
<td>67-99%</td>
<td>99%</td>
</tr>
</tbody>
</table>

- Stroke 33% missed injuries\(^1\)
- Sensitivity insufficient for routine use

\(^1\) Miller et al (Ann Surg 2002), \(^2\) Biffl et al (J Trauma 2002)
Multidetector-row CTA

- Number of recent studies
- General use for screening
- Diagnostic accuracy

Screening

- Schneidereit et al (J Trauma 2006)
  - 8-slice MD-CTA
  - Formal CTA-based screening protocol
    - High-risk patients
    - CTA replace cervical spine CT
Screening

- Schneidereit et al (J Trauma 2006)
  - Incidence BCVI
    - Pre-screening 0.17%
    - Post-screening 1.4%
  - BCVI-specific mortality
    - Pre-screening 38%
    - Post-screening 0%

Accuracy

- 16-slice MD-CTA
  - Most advanced reported
  - Berne JD et al (J Trauma 2006)
  - Biffl WL et al (J Trauma 2006)
  - Eastman AL et al (J Trauma 2006)
### 16-slice MD-CTA

<table>
<thead>
<tr>
<th>Subjects - Total</th>
<th>Subjects - Injured</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>435</td>
<td>24</td>
<td>?</td>
<td>?</td>
<td>Abnormal CTA – angiography Normal CTA – Clinical follow-up Normal CTA – No strokes</td>
</tr>
<tr>
<td>331</td>
<td>17</td>
<td>?</td>
<td>?</td>
<td>Abnormal CTA – angiography Normal CTA – Clinical follow-up Normal CTA – No strokes</td>
</tr>
</tbody>
</table>

- Both studies – Screening for BCVI
  - Patients high-risk for BCVI
- 16-slice MD-CTA vs. angiography
  - Accuracy uncertain
- Does not miss “clinically significant” injuries

### 16-slice MD-CTA

<table>
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<tr>
<th>Subjects - Total</th>
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<th>Sensitivity</th>
<th>Specificity</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>146</td>
<td>43</td>
<td>98%</td>
<td>100%</td>
<td>Prospective observational All CTA followed by angiography</td>
</tr>
<tr>
<td>92</td>
<td>26</td>
<td>74%</td>
<td>84%</td>
<td>Prospective observational All CTA followed by angiography 2nd Half Study: sensitivity 100%, specificity 86%</td>
</tr>
</tbody>
</table>

- Mallhotra et al: 2\textsuperscript{nd} half of study
  - Sensitivity improved – “learning curve”
  - Specificity still relatively low
16-slice Whole-body MDCT

• Whole-body scanning
  – Cervical spine through pelvis
  – One data acquisition
  – One contrast dose

16-slice Whole-body MDCT

• Becoming common at trauma centers
  – Quicker patient through-put
  – Less radiation than segmental approach
16-slice Whole-body MDCT

- Cervical spine contrast-enhanced
  - “Free” CTA of neck
  - More artifact than CTA
    - Diagnostic evaluation of arteries

University of Maryland – Shock Trauma

- Whole-body MDCT
  - Standard
  - Blunt trauma
  - Cervical spine and chest CT’s
    - (+/- abdomen-pelvis CT)
University of Maryland – Shock Trauma

• Neck MD-CTA
  – Head & Neck only sites of concern
  – Equivocal or non-diagnostic WB-MDCT
    • Risk factors for BCVI
    • Clinical or imaging signs of ischemia

Sliker CW et al. (AJR – In Press)

• 16-slice MDCT
• Neck MD-CTA vs. whole-body MDCT
• Angiography reference
Sliker CW et al. (AJR – In Press)

• MD-CTA and whole-body MDCT
  – Reviewed in retrospect
  – Consensus diagnosis among two radiologists
  – Account for “learning curve”

Whole-body MDCT

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<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck MD-CTA</td>
<td>64%</td>
<td>94%</td>
<td>68%</td>
<td>82%</td>
</tr>
<tr>
<td>Whole-body MDCT</td>
<td>69%</td>
<td>82%</td>
<td>74%</td>
<td>91%</td>
</tr>
</tbody>
</table>

• BCVI in 83 of 108 patients
• Neck MD-CTA and whole-body MDCT
  – Statistically comparable accuracy to diagnose BCVI
• Allows for large scale screening for BCVI
Frequency of BCVI at STC

Diagnosis of Blunt Cerebrovascular Injuries

What do they look like?
Appearance

• Varied appearances similar across different modalities
  – Angiography
  – MRA
  – CTA

• Cross-sectional imaging
  – Visualize intramural hematoma.

Grade I – Dissection
Grade I - Dissection


Grade I – Intimal Injury
Grade II –
Intimal Flap & Intramural Thrombus

Grade II –
Intramural Hematoma
“Grade II” - Arteriovenous Fistula

Grade III - Pseudoaneurysm
Grade IV - Occlusion

Grade V - Transection
Grade V – Arteriovenous Fistula

Conclusions

- Angiography reference standard
  - Expensive
  - Invasive
  - Practical limitations
  - Not ideal for screening
Conclusions

• MRA and US not desirable alternatives
  – Practical limitations
  – Accuracy low

Conclusions

• MRA and US may play limited roles
  – US – immediate assessment unstable patient
  – MRA – contrast allergy
Conclusions

• 16-slice MD-CTA
  – Lingering questions of accuracy
  – Probably “good enough” for screening
  – Angiography may be needed some cases
    • Normal CTA
    • High clinical suspicion BCVI

Conclusions

• 16-slice whole-body MDCT
  – May facilitate large scale screening
  – Facilitate selective targeted MD-CTA
Conclusions

• Many imaging manifestations of BCVI
  – Must recognize all
    • Angiography
    • MRA
    • MD-CTA

Thank you.