EVALUATION AND TREATMENT OF BLUNT CEREBROVASCULAR INJURIES

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University of Colorado

BCI - HISTORICAL EXPERIENCE

1980 – 113 Reported Cases
Mortality 28%
Morbidity 56%

Krajewski 1980, Perry 1980
BCI - HISTORICAL EXPERIENCE

1980 – 113 Reported Cases
Mortality 28%
Morbidity 56%
Krajewski 1980, Perry 1980

Multicenter Reviews:  
Mortality 23%
Morbidity 48%
Incidence 0.1%

BCVI – CLINICAL PRESENTATION

- Arterial Hemorrhage
- Expanding Hematoma
- Bruit (< 50 yrs)
- Cerebral Infarction
- Transient Ischemic Attack
- Lateralizing Deficit Incongruous with CT
BCI INCIDENCE

Memphis 0.33% Fabian 1996
Cincinnati 0.24% Parikh 1997
Louisville 0.14% Carrillo 1999
Peoria, IL 0.27% Kraus 1999
Tyler, TX 0.40% Berne 2001

Increasing Incidence vs Awareness?

“TRUE” INCIDENCE OF BCI

Prospective Study - Denver
Nov 1994 - Aug 1996
Thoracic Aortography
171 Patients
6 BCI - 3 Unsuspected

3.5% Incidence in Severely Injured
Prall, Neurosurgery 1998; 42:495
**BCI - MEMPHIS EXPERIENCE**  
*Fabian, Ann Surg 1996; 223:513*

67 Patients (0.33%):  
- Mortality 31%  
- Morbidity 37%

**Systemic Anticoagulation**  
**Improved Outcome**

93% Symptomatic at Diagnosis

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**BCVI - PRESENTATION**

**Latent Period Prior to Symptoms**
- 58% >10 hr, 36% >24 hr  
  *Krajewski 1980*
- 23% >24 hr  
  *Perry 1980*
- 50% >3 days  
  *Mokri 1988*
- 33% >12 hr  
  *Fabian 1990*
BCVI - MECHANISM

Crissey & Bernstein 1974
I Direct Cervical Blow
II Hyperextension/Rotation
III Intraoral Trauma
IV Basilar Skull Fracture

Cervical Spine Fracture

BCVI SCREENING – WHO?

- Hyperextension / Hyperflexion
  - Facial Fractures
- Diffuse Axonal Brain Injury
- Near-Hanging
- Soft Tissue Trauma
- Basilar Skull Fx
- Cervical Spine Fx / Distraction
<table>
<thead>
<tr>
<th></th>
<th>Pre-Screening</th>
<th>Screening</th>
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<tbody>
<tr>
<td></td>
<td>1/90-7/96</td>
<td>8/96-10/01</td>
</tr>
<tr>
<td><strong>Incidence</strong></td>
<td>0.1%</td>
<td>1.6%</td>
</tr>
<tr>
<td><strong>Symptomatic</strong></td>
<td>100%</td>
<td>24%</td>
</tr>
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</table>

### BCVI - IMPACT OF SCREENING

<table>
<thead>
<tr>
<th>Location</th>
<th>Rate (%)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Columbia, SC</td>
<td>1.1%</td>
<td>Kerwin, J Trauma 2001; 51:308</td>
</tr>
<tr>
<td>Denver, CO</td>
<td>1.6%</td>
<td>Biffl, Ann Surg 2002; 235:699</td>
</tr>
<tr>
<td>Memphis, TN</td>
<td>1.0%</td>
<td>Miller, Ann Surg 2002; 236:386</td>
</tr>
<tr>
<td>Vancouver, BC</td>
<td>1.4%</td>
<td>Schneidereit, J Trauma 2006; 60:209</td>
</tr>
<tr>
<td>Dallas, TX</td>
<td>1.3%</td>
<td>Eastman, J Trauma 2006; 60:925</td>
</tr>
<tr>
<td>Tyler, TX</td>
<td>1.2%</td>
<td>Berne, J Trauma 2006; 60:1204</td>
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</tbody>
</table>

### So What?

Mayberry, Velmahos et al
**STROKE PREVENTION**

Patients Treated While Asymptomatic

**Heparin:** 1 of 84 (1%) Stroke

**Antiplatelet:** 3 of 33 (9%) Stroke

\[ p = .07 \]

**None:** 22 of 43 (51%) Stroke


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**STROKE PREVENTION – MEMPHIS**

Patients Treated While Asymptomatic

Carotid Artery injuries

**Heparin:** 1 of 9 (11%) Stroke

**Antiplatelet:** 1 of 6 (17%) Stroke

**Overall:** 33% Stroke

Miller, Ann Surg 2002; 236:386
STROKE PREVENTION - BCI

Asymptomatic Patients

Heparin / Antiplatelet: 1 of 187 (0.5%) Stroke

No Treatment: 10 of 48 (21%) Stroke


BCI STROKE PREVENTION - MEMPHIS

Heparin / Antiplatelet: 6 of 65 (9%) Stroke

77% of Strokes Occurred Prior to Diagnosis and Treatment

### BCVI HIGH-RISK FACTORS

<table>
<thead>
<tr>
<th>Factor</th>
<th>p</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>GCS ≤6</td>
<td>.029</td>
<td>1.98 (1.07-3.65)</td>
</tr>
<tr>
<td>Petrous Fx</td>
<td>.025</td>
<td>2.64 (1.13-6.19)</td>
</tr>
<tr>
<td>DAI</td>
<td>.030</td>
<td>3.09 (1.12-8.57)</td>
</tr>
<tr>
<td>LeFort II / III Fx</td>
<td>.033</td>
<td>3.70 (1.12-12.29)</td>
</tr>
<tr>
<td>C-Spine Fx</td>
<td>&lt;.001</td>
<td>14.50 (5.30-39.63)</td>
</tr>
</tbody>
</table>


20% Had None of These

### BVI - CERVICAL SPINE INJURIES

1/96 - 6/02: 92 BVI Patients

71 (77%) C-Spine Fxs

- 38 (49%) Subluxation
- 18 (25%) Foramen Transversarium
- C1 (8 Pts), C2/3 (5 Pts)

Cothren, J Trauma 2003
WHO TO SCREEN - SUMMARY

1. **Selective Criteria** Will Miss Injuries
2. **Liberal Criteria** Have High Yield-
   27% of Asymptomatic Pts Had BCVI
   
3. **Institutional Guidelines Should be**
   Established Based on Rational
   Assessment of Literature and
   Resources

BCVI SCREENING – HOW?

- Cerebral Arteriography
- Duplex Scanning
- Computed Tomographic
  Angiography (CTA)
- Magnetic Resonance
  Angiography (MRA)
BCVI - PATHOGENESIS

DUPLEX SCANNING

- Imaging Modality of Choice for Extracranial Carotid Artery

Role in BCVI Screening (?)
  Davis 1990, Martin 1991, Fry 1994

- Inaccurate at Base of Skull
- Relies on Flow Disturbances

WTA Multicenter Review
  86% Sensitivity
  Cogbill 1994
MRA

- No Need for **Contrast**
- No **Bony Interference**
- Detect **Infarction** Sooner

Role in BCVI Screening (?)

BCVI Identified by MRA


DENVER MRA RESULTS (n=16)

<table>
<thead>
<tr>
<th>ART (+)</th>
<th>ART (-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRA (+)</td>
<td>3</td>
</tr>
<tr>
<td>MRA (-)</td>
<td>1</td>
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</table>

**SENS 75%**  **SPEC 67%**

Biffl, J Trauma 2002; 53:850
MEMPHIS MRA RESULTS (n=21)

<table>
<thead>
<tr>
<th>Artery</th>
<th>Dx'ed (%)</th>
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</thead>
<tbody>
<tr>
<td>Carotid</td>
<td>2 / 4 (50%)</td>
</tr>
<tr>
<td>Vertebral</td>
<td>8 / 17 (47%)</td>
</tr>
</tbody>
</table>

Miller, Ann Surg 2002; 236:386

Accurate for Dissections & Stenoses
Leclerc 1996, Simeone 1997

Accurate for Penetrating Injuries
LeBlang 1997, Munera 2000

Role in BCVI Screening (?)
- Patients Need CT Scans
- Brain, Face and Neck Imaged
- BCVI Identified by CTA
  Rogers 1999, Ofer 2001
DENVER CTA RESULTS (n=46)

<table>
<thead>
<tr>
<th>ART (+)</th>
<th>ART (-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTA (+)</td>
<td>15</td>
</tr>
<tr>
<td>CTA (-)</td>
<td>7</td>
</tr>
</tbody>
</table>

SENS 68%  SPEC 67%

Biffl, J Trauma 2002; 53:850

MEMPHIS CTA RESULTS (n=143)

Carotid  8 / 17 Dx’ed (47%)
Vertebral 16 / 30 Dx’ed (53%)

3 / 9 (33%) Missed BCI Had Stroke

Miller, Ann Surg 2002; 236:386
16-SLICE CTA

East Texas Medical Center

486 Pts Screened
  Basilar Skull Fx
  C-Spine Injury
  Multiple / Severe Facial Fx
  Cervical Abrasion / Hematoma
  GCS <8

2 Yrs - 4 Slice / Rotation
1 Yr - 16 Slice / Rotation

Berne, J Trauma 2004; 57:11

16-SLICE CTA

19 Pts - 25 BCVI (0.6% Blunt Trauma Admissions)

3.7% Yield of Screening

18 True Positive
30 False Positive
438 True Negative*

Berne, J Trauma 2004; 57:11
THE REALITY

- CT Technology is Advancing; **Multi-Detector Row CT** Rivals DSA in Imaging Intracerebral Vessels
  
  *Jayaraman et al, Radiology 2004; 230:510*

- No Support for Prospective Comparative Trials

- **Seeing is Believing**
  
  Difficult to Justify Liberal Screening DSA in Asymptomatic Patients

RIH SCREENING PROTOCOL

- DSA for Signs / Symptoms
- CTA for Patients with High Risk Mechanisms / Injury Patterns

**Liberal Screening of Patients with Cranial or Cervical Trauma Requiring CT Scanning**
CTA SCREENING

June 2004 – May 2005
331 Pts Screened
20 BCVI in 18 (5.4%) Patients
Incidence 0.66%
11 Carotid, 9 Vertebral
1 Bilateral VA; 1 ICA + VA

Biffl et al, J Trauma 2006

CTA ACCURACY

No Pt with Normal CTA Developed
Sx of BCVI
**CTA ACCURACY**

No Pt with Normal CTA Developed Sx of BCVI

2 Pts Who Did Not Meet Screening Criteria Presented w/ Sx

Biffi et al, J Trauma 2006

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**16-SLICE CTA ACCURACY**

435 CTA – Same Results

Berne, J Trauma 2006; 60:1204
16-SLICE CTA vs DSA

Parkland Memorial Hospital
146 Pts CTA + DSA
46 BCVI in 43 Pts
100% Sensitivity for BCI
96% Sensitivity for BVI
Eastman, J Trauma 2006; 60:925

16-SLICE CTA vs DSA

Medical College of Virginia
92 Pts CTA + DSA (27 No DSA)
23 (+) - 10 (43%) False (+)
62 Normal - 6 (9%) False (-)
3 not treated; all in 1st half of study
CONCLUSIONS
Symptomatic Pts Should Undergo Arteriography
16-Slice CTA is a Reliable Noninvasive Screening Test for Clinically Significant BCVI
Clinicians Should Draft Institutional Guidelines Based on Resource Availability and Literature
Multicenter Prospective Trials Need to be Done to Clarify Risk Factors, Assess Accuracy of Noninvasive Screening Tests, and Evaluate Efficacy of Treatment Strategies

BCVI MANAGEMENT
To Determine Whether:
a) Systemic Anticoagulation is Superior to Antiplatelet Therapy in Injury Healing, Neurologic Improvement, or Stroke Prevention
b) Routine Follow-Up Arteriography Impacts Therapy
**BCVI ANALYSIS**

Jan 1990 - Oct 2001: 171 Patients

157 BCI / 114 Pts - 43 (38%) Bilat
97 BVI / 79 Pts - 18 (23%) Bilat
22 (13%) BCI + BVI

BCVI Incidence = 1.55%
BCI = 1.11%  BVI = 0.77%


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**DHMC GRADING SCALE**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
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<tbody>
<tr>
<td>I</td>
<td>Irregularity, &lt;25% Luminal Narrowing</td>
</tr>
<tr>
<td>II</td>
<td>&gt;25% Narrowing / Thrombus / Flap</td>
</tr>
<tr>
<td>III</td>
<td>Pseudoaneurysm</td>
</tr>
<tr>
<td>IV</td>
<td>Occlusion</td>
</tr>
<tr>
<td>V</td>
<td>Transection</td>
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</table>

Biffl, J Trauma 1999; 47:845
<table>
<thead>
<tr>
<th>Worst Grade</th>
<th>BCI Stroke</th>
<th>BVI Stroke</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>26%</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>100%</td>
<td></td>
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## BCVI STROKE RATES

<table>
<thead>
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<th>Worst Grade</th>
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<tbody>
<tr>
<td>I</td>
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<tr>
<td>II</td>
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<td>38%</td>
</tr>
<tr>
<td>III</td>
<td>26%</td>
<td>27%</td>
</tr>
<tr>
<td>IV</td>
<td>50%</td>
<td>28%</td>
</tr>
<tr>
<td>V</td>
<td>100%</td>
<td>-</td>
</tr>
</tbody>
</table>

Grade I

[Image of angiography with an arrow pointing to the left]

Grade I
SUMMARY

1. **Heparin** and **Antiplatelet Therapy** Appear **Equivalent** in Healing of Injuries

2. Heparin May be More Effective Than Antiplatelet Therapy in **Neurologic Improvement** and **Stroke Prevention**

3. Follow-up Arteriography Changes Treatment in **65% of Grade I** and **51% of Grade II** Injuries, and Helps Plan Therapy in Grade III Injuries
BCVI MANAGEMENT GUIDELINES

- Signs / Symptoms Mandate Emergent Cervical Arteriography
- High Risk Mechanism or Injuries Warrant Screening for BCVI
- 4-Vessel Cerebral Arteriography is Diagnostic Gold Standard
- 16-Slice CTA Has Become the Preferred Screening Test

BCVI MANAGEMENT GUIDELINES

- Surgical Repair of Accessible Grade II - V Lesions
- Nonoperative Management if Severe Fixed Neurologic Deficit, Coma, or Infarction
- Anticoagulation for Inaccessible Gr I - IV Lesions Unless Contraindicated
ANTICOAGULATION GUIDELINES

- Heparin 15 U/kg/hr; No Bolus
- PTT 40-50 Seconds
- Antiplatelet Rx if Contraindications
- F/U Angio 7-10 Days
- Long-Term Coumadin vs Antiplatelet Rx
  *Prospective Comparison*

ENDOVASCULAR TREATMENT GUIDELINES

- Embolization or Balloon Occlusion for Inaccessible Gr V
- Endovascular Stents for Severe Gr II or Persistent Gr III, but Must be Studied under Controlled Protocols
- Stent 7-10 Days Postinjury, Anticoagulate
CAROTID ARTERY STENTS - RISKS EXCEED BENEFITS

46 Grade III BCI
23 Stents
4 (17%) Complications (3 CVA, 1 SCA Dissection)
8 (45%) Occlusion
1 CVA, 95% Patency with Antithrombotic Rx

Cothren, Arch Surg 2005