Mild & Moderate Traumatic Brain Injury

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University of Arizona Medical Center,
Tucson, Arizona USA
Who & needs a repeat Head CT scan in TBI?
Traumatic Brain Injury

- 1.7 million head injuries per year (USA)
- 1.4 million ED visits
- 275,000 patients hospitalized
- 53,000 deaths annually
Traumatic Brain Injury

• Most at risk groups
  – 0-4 years
  – 15-19 years
  – Over 65 years old

• Estimated DIRECT costs over $76 billion
The problem

• If the only tool that you have is a hammer....
The problem

- Then everything will look like a nail....
The problem

- The Neurosurgeon’s hammer..... CT scanner
The problem

- The nail
The consultation

- Typical Neurosurgical Consult
  - Patient seen by junior doctor
  - Discussed with senior
    * +/- review of CT scan
  - Repeat CT scan ordered for 4-6 hrs
Why do we order so many repeat CT scans?

- Previous experience
- Medicolegal
- Treatment plan not yet clear
- Inexperienced junior doctors
- Patients with severe TBI don’t show changes
- Higher risk of progression for some lesions
What are the disadvantages of Repeat CT?

- Cost
- Transportation
- Irradiation
  - Risk of cancer from 1 head CT – 1 in 10,000
- Wasteful and unnecessary
Literature?

- Conflicting
- Depends on the type of lesion
- Majority of studies - little if any benefit
A Prospective Evaluation of the Value of Repeat Cranial Computed Tomography in Patients With Minimal Head Injury and an Intracranial Bleed

Ziad C. Sifri, MD, Adena T. Homnick, MPAS, Artem Vaynman, MD, Robert Lavery, MA, MICP, Wesley Liao, BA, Alicia Mohr, MD, Carl J. Hauser, MD, Allen Manniker, MD, and David Livingston, MD

- 161 patients with minor TBI
- 130 had repeat CT scan

- 99 patients had normal neuro exam
  - Repeat CT scan
  - Showed NO lesions requiring intervention

J Trauma Oct 2006 p862-867
The Role of Early Follow-Up Computed Tomography Imaging in the Management of Traumatic Brain Injury Patients With Intracranial Hemorrhage

Justin S. Smith, MD, PhD, Edward F. Chang, MD, Guy Rosenthal, MD, Michele Meeker, RN, BSN, Cornelia von Koch, MD, PhD, Geoffrey T. Manley, MD, PhD, and Martin C. Holland, MD

- 116 patients with TBI
  - 42% showed progression between CTs

- Only patients with clinical change
  - Needed an operation

- No patient required intervention WITHOUT a change in exam

J Trauma Jul 2007 p75-82
Indications for Routine Repeat Head Computed Tomography (CT) Stratified by Severity of Traumatic Brain Injury

Carlos V. R. Brown, MD, Gabriel Zada, MD, Ali Salim, MD, Kenji Inaba, MD, Georgios Kasotakis, MD, Pantelis Hadjizacharia, MD, Demetrios Demetriades, MD, and Peter Rhee, MD, MPH

- 274 patients
- 163 patients underwent 241 repeat scans
  - 43% unchanged
  - 22% better
  - 35% worse

J Trauma Jun 2007 p1339-1345
Indications for Routine Repeat Head Computed Tomography (CT) Stratified by Severity of Traumatic Brain Injury

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<table>
<thead>
<tr>
<th>Head Injury</th>
<th>Neurologic Change</th>
<th>Intervention</th>
<th>Routine</th>
<th>Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild (n = 142)</td>
<td>15 Scans</td>
<td>5 (33%)</td>
<td>80 Scans</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Moderate (n = 42)</td>
<td>9 Scans</td>
<td>3 (33%)</td>
<td>34 Scans</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Severe (n = 90)</td>
<td>21 Scans</td>
<td>9 (43%)</td>
<td>82 Scans</td>
<td>2 (2%)</td>
</tr>
<tr>
<td>Total (n = 274)</td>
<td>45 Scans</td>
<td>17 (38%)</td>
<td>196 Scans</td>
<td>2 (1%)</td>
</tr>
</tbody>
</table>

J Trauma Jun 2007 p1339-1345
Utility of routine follow-up head CT scanning after mild traumatic brain injury: a systematic review of the literature

Martina Stippler,¹ Carl Smith,² A Robb McLean,² Andrew Carlson,¹ Sarah Morley,³ Cristina Murray-Krezan,⁴ Jessica Kraynik,⁵ George Kennedy²

- Review of all available studies
- 1630 patients from 19 papers

- Routine CT scans
  - Showed progression in 20% of patients

- Follow-up CT – intervention in 0.7%
  - In cases with neuro changes – 43%
90% of TBI is NON-OPERATIVE

How Well Do Neurosurgeons Care for Trauma Patients? A Survey of the Membership of the American Association for the Surgery of Trauma
Alex B. Valadka, M.D., Brian T. Andrews, M.D., M. Ross Bullock, M.D., Ph.D.

70% agree that Trauma Surgeons can take charge of Non-operative TBI
Utility of Neurosurgical Consultation for Mild Traumatic Brain Injury

NO DEFINITIVE GUIDELINES

Management of Patients With Traumatic Intracranial Injury in Hospitals Without Neurosurgical Service

Yoram Klein, MD, Valery Donchik, MD, Dena Jaffe, PhD, Daniel Simon, MD, Boris Kessel, MD, Leon Levy, MD, Hanooh Kashtan, MD, and Kobi Peleg, PhD
Recent work at Arizona

- Attempt to create guidelines
  - For neurosurgical consultation
  - Repeat Head CT scans

- Retrospective study
  - 3803 patients over 3 years
  - CT scans reviewed, type of injury, anticoagulation
Recent work at Arizona

- 1232 with abnormal head CT

<table>
<thead>
<tr>
<th>BIG score</th>
<th>LOC</th>
<th>Neuro Exam</th>
<th>ETOH or drugs</th>
<th>Anticoagulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>YES</td>
<td>NORMAL</td>
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<td>NO</td>
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<tr>
<td>N=112</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>YES</td>
<td>NORMAL</td>
<td>YES OR NO</td>
<td>NO</td>
</tr>
<tr>
<td>N=330</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>YES</td>
<td>ABNORMAL</td>
<td>YES OR NO</td>
<td>YES</td>
</tr>
<tr>
<td>N=790</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
### BIG guidelines

#### CT scan Findings

<table>
<thead>
<tr>
<th>BIG score</th>
<th>Skull fracture</th>
<th>SDH</th>
<th>EDH</th>
<th>IPH/Contusion</th>
<th>SAH</th>
<th>IVH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 N=112</td>
<td>NO</td>
<td>≤3mm</td>
<td>≤3mm</td>
<td>≤3mm single location</td>
<td>Trace</td>
<td>NO</td>
</tr>
<tr>
<td>2 N=330</td>
<td>SIMPLE NON-DISPLACED</td>
<td>3-10mm</td>
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2.7% of patients in BIG2 had worsening of CT scans
# BIG guidelines

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NO patients required an intervention
### BIG guidelines

**CT scan Findings**

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</table>

**ALL patients who required an intervention (13%) were in BIG3**
CONCLUSION

ACS can independently care for mild TBI with ICH without obtaining a formal NC. Given the rarity of neurosurgical intervention in this subset of patients, ACS are trained and currently care for these patients. The difficulty will be setting the standard that ACS are the leading provider for patients with mild TBI even in the presence of ICH. Prospective evaluation of strict guidelines will help support this change in practice.
NO PROSPECTIVE ASSESSMENT
<table>
<thead>
<tr>
<th>BIG Score</th>
<th>Hospitalization</th>
<th>Repeat Head CT</th>
<th>Neurosurgical consultation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>2</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
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<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>
AIM and HYPOTHESIS

- **AIM:** Validate Brain Injury Guidelines (BIG 1) for managing patients with TBI without neurosurgical consultation (NC).

- **HYPOTHESIS:** Trauma surgeons can safely manage TBI patients meeting BIG 1 criteria.
METHODS - INCLUSION

- Implemented BIG in March 2012
- IRB Approved
- Prospective cohort analysis - level 1 trauma center (1st March 2012 - 31st December 2013)

**Inclusion:**
- TBI with ICH on initial head CT
- Examinable patients with normal neuro-exam
- No anti-platelet or anti-coagulation therapy
- ICH ≤ 4 mm and No skull fracture
METHODS - EXCLUSION

**Exclusion:**
- Transferred from other institution
- Unexaminable (altered mental status, intubated)
- Abnormal neuro-exam on presentation

**Abnormal Neuro-Exam:**
- Altered mental status
- Focal neurological deficits
- Abnormal pupillary examination
STUDY POPULATION

- Post BIG1 (No-NC) matched retrospectively to patients Pre-BIG 1 (NC)

- Propensity score matching in a 1:1 ratio
  - Demographic and injury variables
METHODS – OUTCOME

- **Primary outcome:**
  - Need for neurosurgical intervention

- **Secondary outcome:**
  - Repeat head CT scan requirement
  - Hospital and ICU admissions
  - In-hospital mortality
  - 30 day re-admission.
# RESULTS

<table>
<thead>
<tr>
<th></th>
<th>No-NC (n=127)</th>
<th>NC (n=127)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>41.2 ± 21.6</td>
<td>39.4±24.8</td>
<td>0.71</td>
</tr>
<tr>
<td>Male</td>
<td>64.6%</td>
<td>62.2%</td>
<td>0.69</td>
</tr>
<tr>
<td>ED SBP</td>
<td>132.5 ± 28.1</td>
<td>136.1 ± 22.4</td>
<td>0.89</td>
</tr>
<tr>
<td>Mechanism of injury</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MVC</td>
<td>46.5%</td>
<td>42.5%</td>
<td>0.52</td>
</tr>
<tr>
<td>Fall</td>
<td>33.8%</td>
<td>36.2%</td>
<td>0.68</td>
</tr>
<tr>
<td>ISS</td>
<td>14 [8-16]</td>
<td>14 [9-17]</td>
<td>0.91</td>
</tr>
<tr>
<td>Head AIS</td>
<td>2 [2-3]</td>
<td>2 [2-3]</td>
<td>0.94</td>
</tr>
</tbody>
</table>
RESULTS

DISTRIBUTION of GCS

- GCS 15: 68.5%
- GCS 14: 21.2%
- GCS 13: 10.2%

No-NC: 9.4%
NC: 68.5%
# RESULTS – CT SCANS

<table>
<thead>
<tr>
<th></th>
<th>No-NC (n=127)</th>
<th>NC (n=127)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDH</td>
<td>28.3%</td>
<td>30%</td>
<td>0.76</td>
</tr>
<tr>
<td>Size (mm)</td>
<td>3.1 ± 2.9</td>
<td>3.3 ± 3</td>
<td>0.62</td>
</tr>
<tr>
<td>EDH</td>
<td>5.5%</td>
<td>7.9%</td>
<td>0.45</td>
</tr>
<tr>
<td>Size (mm)</td>
<td>2.9 ± 2.5</td>
<td>3.1 ± 2.8</td>
<td>0.59</td>
</tr>
<tr>
<td>SAH</td>
<td>37.8%</td>
<td>35.4%</td>
<td>0.69</td>
</tr>
<tr>
<td>IPH</td>
<td>26.7%</td>
<td>24.4%</td>
<td>0.67</td>
</tr>
<tr>
<td>IVH</td>
<td>7%</td>
<td>9.4%</td>
<td>0.48</td>
</tr>
<tr>
<td>Event</td>
<td>No-NC (n=127)</td>
<td>NC (n=127)</td>
<td>p</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------------</td>
<td>------------</td>
<td>-------</td>
</tr>
<tr>
<td>RHCT</td>
<td>9.4%</td>
<td>51.2%</td>
<td>0.001</td>
</tr>
<tr>
<td>Progression on RHCT</td>
<td>1%</td>
<td>2.3%</td>
<td>0.64</td>
</tr>
<tr>
<td>Neurosurgical intervention</td>
<td>0%</td>
<td>0%</td>
<td>0.9</td>
</tr>
<tr>
<td>Hospital admission</td>
<td>56%</td>
<td>74%</td>
<td>0.02</td>
</tr>
<tr>
<td>ICU admission</td>
<td>6.3%</td>
<td>25.2%</td>
<td>0.01</td>
</tr>
</tbody>
</table>
## RESULTS – 30 DAY OUTCOMES

<table>
<thead>
<tr>
<th></th>
<th>No-NC (n=127)</th>
<th>NC (n=127)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 day readmission</td>
<td>0%</td>
<td>0%</td>
<td>0.9</td>
</tr>
<tr>
<td>30 day ED visits</td>
<td>3.9%</td>
<td>4.7%</td>
<td>0.75</td>
</tr>
<tr>
<td>30 day RHCT</td>
<td>1.5%</td>
<td>2.3%</td>
<td>0.64</td>
</tr>
<tr>
<td>30 day mortality</td>
<td>0%</td>
<td>0%</td>
<td>0.9</td>
</tr>
</tbody>
</table>
# Results – Outcomes

<table>
<thead>
<tr>
<th></th>
<th>No-NC (n=127)</th>
<th>NC (n=127)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length of Stay</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital LOS</td>
<td>1.3 ± 1.1</td>
<td>3 ± 2.8</td>
<td>0.041</td>
</tr>
<tr>
<td>ICU LOS</td>
<td>1 ± 0.9</td>
<td>1.2 ± 1.1</td>
<td>0.85</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital Cost</td>
<td>11,615 ± 10,291</td>
<td>16,238 ± 11,019</td>
<td>0.02</td>
</tr>
<tr>
<td>Hospital Charges</td>
<td>41,528 ± 26,810</td>
<td>48,780 ± 28,140</td>
<td>0.042</td>
</tr>
</tbody>
</table>
CONCLUSIONS

- Prospective validation of the BIG 1 guidelines
- Better clinical and hospital resource utilization
- Acute care surgeons can independently manage patients with ICH <4 mm
Special Circumstances
Severe TBI

• Patients who are comatose (GCS ≤ 8)
  – Not able to manifest clinical changes
  – Up to 50% will have progression on head CT
  – Highest likelihood for intervention

• Unknown HOW lesion itself is important
  – 6-20% of epidurals ultimately require intervention
  • Difficult to predict at initial CT
Special Circumstances
Anticoagulation

• Patients on anticoagulation – repeat Head CT
  – Aspirin
  – Plavix (Clopidogrel)
  – Warfarin
  – Dabigatran (direct thrombin inhibitors)
Special Circumstances
Acquired Coagulopathy

- Platelet count
  - less than 100,000
- Abnormal INR ($\geq 1.3$), PTT ($\geq 35$ secs)
  - Have all been associated with progression
  - Progression of lesion increased odds of death

Abnormal Coagulation Tests Are Associated With Progression of Traumatic Intracranial Hemorrhage

J Trauma Nov 2009
Unanswered questions?

- Children
- Elderly
- Type of bleed – epi/subdural/subarachnoid
  - Size of bleed
- Very early CT scans
Who SHOULD you scan again?

- MENTAL STATUS CHANGES
- Severe TBI – unable to assess
- Anticoagulated patients
- Coagulopathic patients
- Specific lesions e.g. epidural
DON’T scan

- GCS 13-15
- Minor TBI
  - Small subdural
  - Minimal Subarachnoid
  - Small intraparenchymal hemorrhage
Summary

- Repeat Head CT scans not often indicated
- Clinical exam changes are most important
- Special circumstances ARE important
- Need multicenter validation of “BIG”
Questions?

“It's time we face reality, my friends. ... We're not exactly rocket scientists.”