Emergency Department Intracranial Pressure Monitoring in Severe Traumatic Brain Injury

S Pan¹, N Kannan¹, J Wang¹, RB Mink², MS Wainwright³, JI Groner⁴, MJ Bell⁵, CC Giza⁶, DF Zatzick¹, RG Ellenbogen¹, LN Boyle¹, PH Mitchell¹, A Rowhani-Rahbar¹, MS Vavilala¹

¹Harborview Injury Prevention & Research Center, University of Washington, Seattle, WA
²Harbor-UCLA and Los Angeles BioMedical Research Institute, Torrance, CA
³Ann & Robert H. Lurie Children's Hospital of Chicago, Chicago
⁴Ohio State University College of Medicine, Columbus, OH
⁵University of Pittsburgh, Pittsburgh, PA
⁶Mattel Children’s Hospital, UCLA, Los Angeles, CA

for the PEGASUS (Pediatric Guideline Adherence and Outcomes) Study

NINDS # R01 NS072308-05 (PI: Vavilala)
Background

- Almost half a million (473,947) ED TBI visits annually in children <14 years from 2002-06

- 2012 BTF Guidelines (Level III evidence) states ICP monitoring may be considered in children with severe TBI

- Vavilala 2014 paper examined ICP monitoring in PICU

- Routine ED ICP monitoring not addressed by Guidelines

- Paucity of information on ED ICP monitoring and its benefits in children with severe TBI

- ED ICP monitoring associated with outcomes is not yet known
Aim
- Examine the clinical characteristics, treatments and outcomes associated with initiation of ED ICP monitoring

Hypothesis
- Initiation of ED ICP monitoring would be uncommon but may be associated with higher frequency of TBI related care and better discharge outcomes

Inclusion criteria
1. Age < 18 years
2. Admission Glasgow Coma Scale (GCS) score < 9
3. Head Abbreviated Injury Score (AIS) ≥ 3
4. Alive with ICU tracheal intubation ≥ 48 hours
5. Trauma history
6. Abnormal admission head CT findings
Data Abstracted and Main Exposure

- Documented ED data from 224 medical records abstracted for parent PEGASUS study

- PEGASUS study: Retrospective multicenter cohort study (N=236)

- Data from 5 pediatric trauma centers in 2007-2011 time period

- Exposure: Initiation of ED ICP monitoring
Outcomes

- **Primary**
  - In-hospital mortality
  - Discharge Glasgow Outcome Scale (GOS) score
    - Poor (vegetative & major impairment)
    - Good (minor impairment & return to baseline status)

- **Secondary**
  - ED TBI care measures
  - ED LOS
Initiation of ICP Monitoring by Center

Percent monitoring

- Center 1: N=47
- Center 2: N=35
- Center 3: N=40
- Center 4: N=56
- Center 5: N=46
- Total: N=224
# Results

Clinical and Outcome Characteristics of 224 Children Admitted to Emergency Department (ED) by Initiation of ICP Monitoring Across 5 Study Centers

<table>
<thead>
<tr>
<th></th>
<th>Initiation of ED ICP Monitoring N = 62 (28%)</th>
<th>Initiation of OR/PICU ICP Monitoring N = 85 (38%)</th>
<th>No ICP Monitoring N = 77 (34%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head AIS Score 5 &amp; 6 N (%)</td>
<td>41 (66)</td>
<td>53 (62)</td>
<td>30 (39)</td>
</tr>
<tr>
<td>Head CT Findings N (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subarachnoid Hemorrhage</td>
<td>32 (52)</td>
<td>43 (51)</td>
<td>29 (38)</td>
</tr>
<tr>
<td>Cerebral Edema</td>
<td>38 (61)</td>
<td>49 (58)</td>
<td>36 (47)</td>
</tr>
<tr>
<td>Diffuse Axonal Injury</td>
<td>19 (31)</td>
<td>25 (29)</td>
<td>22 (29)</td>
</tr>
<tr>
<td>Decompressive craniectomy for high ICP</td>
<td>23 (37)</td>
<td>31 (38)</td>
<td>14 (18)</td>
</tr>
<tr>
<td>Ventriculostomy for high ICP</td>
<td>25 (40)</td>
<td>43 (51)</td>
<td>27 (35)</td>
</tr>
<tr>
<td>ED Hypotension (SBP &lt; 70 +2*Age) N (%)</td>
<td>10 (16)</td>
<td>6 (7)</td>
<td>13 (17)</td>
</tr>
<tr>
<td>In-Hospital Mortality N (%)</td>
<td>6 (10)</td>
<td>9 (11)</td>
<td>12 (16)</td>
</tr>
<tr>
<td>Poor discharge GOS N (%)</td>
<td>44/56 (79)</td>
<td>47/76 (62)</td>
<td>37/65 (57)</td>
</tr>
</tbody>
</table>
Select TBI Care Measures for 224 Children by Initiation of ICP monitoring

<table>
<thead>
<tr>
<th>Treatments Received in ED</th>
<th>Initiation of ED ICP Monitoring N = 62 (28%)</th>
<th>Initiation of OR/PICU ICP Monitoring N = 85 (38%)</th>
<th>No ICP Monitoring N = 77 (34%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypotension treatment</td>
<td>16 (26)</td>
<td>8 (9)</td>
<td>20 (26)</td>
</tr>
<tr>
<td><strong>Fluids</strong></td>
<td>10 (16)</td>
<td>5 (6)</td>
<td>12 (16)</td>
</tr>
<tr>
<td>Blood products</td>
<td>4 (6)</td>
<td>2 (2)</td>
<td>6 (8)</td>
</tr>
<tr>
<td>Vasopressors</td>
<td>2 (3)</td>
<td>1 (1)</td>
<td>2 (3)</td>
</tr>
<tr>
<td>Hypertonic saline and/or mannitol for high ICP</td>
<td>29 (47)</td>
<td>41 (48)</td>
<td>7 (9)</td>
</tr>
<tr>
<td>ED Hyperventilation (PaCO2 &lt; 30mmHg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinically not indicated</td>
<td>6 (10)</td>
<td>0 (0)</td>
<td>4 (5)</td>
</tr>
<tr>
<td><strong>Clinically indicated</strong></td>
<td>8 (13)</td>
<td>9 (11)</td>
<td>1 (1)</td>
</tr>
</tbody>
</table>
Initiation of ICP Monitoring and Outcomes for 224 Children with Severe TBI Admitted to ED Across 5 Study Centers

<table>
<thead>
<tr>
<th></th>
<th>ED LOS (hours)* (N = 224)</th>
<th>Discharge Mortality* (N = 224)</th>
<th>Discharge Glasgow Outcome Scale Score* (Alive) (N = 197)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient (95% CI)</td>
<td>aRR (95% CI)</td>
<td>aRR (95% CI)</td>
</tr>
<tr>
<td>No ICP Monitoring</td>
<td>Reference group</td>
<td>Reference group</td>
<td>Reference group</td>
</tr>
<tr>
<td>ICP initiation in ED</td>
<td>2.07 (-1.55, 5.69)</td>
<td>0.40 (0.22, 0.75)</td>
<td>1.25 (0.96, 1.63)</td>
</tr>
<tr>
<td>ICP initiation in OR/PICU</td>
<td>- 0.7 (-1.43, 0.02)</td>
<td>0.83 (0.41, 1.68)</td>
<td>1.03 (0.80, 1.33)</td>
</tr>
</tbody>
</table>

*All models adjusted for age, gender, head AIS, highest non-head AIS, GCS motor score, cerebral edema, diffuse axonal injury and decompressive craniectomy and clustering analysis within institution performed.*
Limitations

- Retrospective data
- Excluded patients who died within 48 hours of admission
- Did not capture some ICP treatment, all secondary insults, all TBI care measures
- No temporal association data between secondary insults sustained and timing of ED ICP monitoring
- Residual confounding despite adjustments
Discussion

- First study to describe ED ICP monitoring
- ED ICP monitoring varied by study center
- Frequent initiation of ED ICP monitoring
- Initiation of PICU ICP monitoring associated with shorter ED LOS
- Initiation of ED ICP monitoring associated with lower in-hospital mortality
Acknowledgements

➢ NINDS for funding support

➢ PEGASUS Team

➢ Project staff
  • Rachelle Bell
  • Kristi Schmidt
  • Alma Ramirez
  • Sheila Giles