Timing of Intervention in Acute Spinal Cord Injury

Central Cord Syndrome

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Acute Spinal Cord Injury

- **Incomplete SCI**
  - Heterogeneous population of patients
    - Varying mechanisms of injury
    - Central cord syndrome – most common
  - Clinical presentation
    - Younger patient - significant traumatic injury
    - Absence of instability / acute disc herniation
    - Elderly with preexisting stenotic spinal canal
  - Controversial subject
    - Studies tend to group these together
      - Timing of surgical intervention
      - Whether to treat with surgery
**Central cord syndrome**

- Hyperextension mechanism
  - Mechanical compression – contusion
    - Somatotopic organization of corticospinal tracts
    - Central gray matter affected more than peripheral white matter tracts
  - Vascular injury
    - anterior spinal artery leading to ischemia
  - Intraparenchymal hematoma
    - Studies lacking

- Schneider 1954
  - Disproportionate UE > LE weakness
  - “Burning hands” syndrome
  - Bladder dysfunction
  - Sensory loss below the level of injury
Acute Spinal Cord Injury

- **Central cord syndrome**
  - Goals of Rx
    - Spare spinal cord from further injury
    - Enhance recovery of function
    - Reduce “collateral” injury
Indications for Surgical Intervention

- **Central cord syndrome**
  - Age / Pathogenesis of CCS?
    - Younger patient - traumatic injury or older patient with worsening = surgery
    - Older patient with CCS – no instability - improving = conservative treatment
    - Older patient with CCS - no instability – stable significant neurologic deficit = ?
Indications for Surgical Intervention

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Timing of Surgical Intervention

- **Central cord syndrome**
  - Older patient with CCS - no instability – stable significant neurologic deficit = ?
    - “Delayed Approach or Waiting” - “Optimization”
      - Does waiting correlate with doing nothing?
      - Is there one best approach for all types of CCS?
      - Is there a “cut off” time?
      - What does the evidence suggest?
Timing of Surgical Intervention

“Timing window”

- Several components play a role in recovery from neurologic injury
  - Early surgery intervention
    - Preclinical / animal models
      - Meta-analysis - 37 / 272 studies\(^1\)
      - 21 adequate data
      - 79 experiments - 873 animals
      - Degree / duration of compression – negative outcome
      - Overall effect size in neurologic improvement -35.1% after earlier decompression
    - Human clinical studies
      - Central cord syndrome – data is limited – anecdotal\(^2\)

\(^1\)Batchelor, et al, Plos One 8:e72659, 2013
\(^2\)Dahdelah, et al Neurosurg Focus 35:E6:, 2013
Timing of Surgical Intervention

- Evidence
  - Surgical Timing in Spinal Cord Injury Study (STASCIS)
    - Multicenter, prospective – adult patients 16-80
    - 2002-2009
    - 313 / 470 patients
      - 131 / 182 “early” < 24 hours (14.2 +/- 5.4)
      - 91 / 131 “late” > 24 hours (48.3 +/- 29.3)
    - Surgical decision-making:
      - Time at arrival
      - Time to diagnosis
      - Surgeon discretion - timing to OR and technique
    - Primary outcome - 6 month change in ASIA

Fehlings, et al, Plos One 7;e32037, 2012
Timing of Surgical Intervention

- Evidence
  - Surgical Timing in Spinal Cord Injury Study (STASCIS)

### Table 2. Patient Demographics and Injury Characteristics.

<table>
<thead>
<tr>
<th>characteristics</th>
<th>Overall N = 313</th>
<th>Early surgery N = 182</th>
<th>Late Surgery N = 131</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean age ± SD</td>
<td></td>
<td></td>
<td></td>
<td>P&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>47.4±16.9</td>
<td>45.0±17.2</td>
<td>50.7±15.9</td>
<td></td>
</tr>
<tr>
<td>Gender n(%)</td>
<td></td>
<td></td>
<td></td>
<td>p&gt;0.05</td>
</tr>
<tr>
<td>Male</td>
<td>236 (75.4%)</td>
<td>140 (76.9%)</td>
<td>96 (73.3%)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>77 (24.6%)</td>
<td>42 (23.1%)</td>
<td>35 (26.7%)</td>
<td></td>
</tr>
<tr>
<td>Etiology</td>
<td></td>
<td></td>
<td></td>
<td>p&gt;0.05</td>
</tr>
<tr>
<td>Motor Vehicle Accident</td>
<td>119 (38.0%)</td>
<td>76 (41.8%)</td>
<td>43 (32.8%)</td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>121 (38.7%)</td>
<td>64 (35.1%)</td>
<td>57 (43.5%)</td>
<td></td>
</tr>
<tr>
<td>assault – blunt</td>
<td>13 (4.2%)</td>
<td>8 (4.4%)</td>
<td>5 (3.8%)</td>
<td></td>
</tr>
<tr>
<td>Sports</td>
<td>3 (9.6%)</td>
<td>16 (8.8%)</td>
<td>12 (9.2%)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>3 (9.6%)</td>
<td>18 (9.9%)</td>
<td>14 (10.7%)</td>
<td></td>
</tr>
<tr>
<td>Baseline ASIA Impairment Scale grade</td>
<td></td>
<td></td>
<td></td>
<td>P&lt;0.01</td>
</tr>
<tr>
<td>A</td>
<td>101(32.3%)</td>
<td>65 (35.7%)</td>
<td>36 (27.5%)</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>54 (17.3%)</td>
<td>40 (22.0%)</td>
<td>14 (10.7%)</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>66 (21.1%)</td>
<td>32 (17.6%)</td>
<td>34 (26.0%)</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>92 (29.4%)</td>
<td>45 (24.7%)</td>
<td>47 (35.9%)</td>
<td></td>
</tr>
</tbody>
</table>

Fehlings, et al, Plos One 7;e32037,2012
Timing of Surgical Intervention

- **Evidence**
  - **STASCIS**
    - Primary outcome - 6 month change in ASIA

*Fehlings, et al, Plos One 7;e32037,2012*
Timing of Surgical Intervention

- Evidence
  - STASCIS
    - Adverse events

### Table 7. Inpatient Postoperative Complications.

<table>
<thead>
<tr>
<th>Complication</th>
<th>Total Population</th>
<th>Early Surgery</th>
<th>Late Surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiopulmonary</td>
<td>66 (68.0%)</td>
<td>32 (66.7%)</td>
<td>34 (69.4%)</td>
</tr>
<tr>
<td>Construct Failure Requiring Surgery</td>
<td>4 (4.1%)</td>
<td>3 (6.3%)</td>
<td>1 (2.0%)</td>
</tr>
<tr>
<td>Deep Wound Infection</td>
<td>2 (2.1%)</td>
<td>0</td>
<td>2 (4.1%)</td>
</tr>
<tr>
<td>Neurologic Deterioration</td>
<td>5 (5.2%)</td>
<td>4 (8.3%)</td>
<td>1 (2.0%)</td>
</tr>
<tr>
<td>Pulmonary Embolism</td>
<td>4 (4.1%)</td>
<td>2 (4.2%)</td>
<td>2 (4.1%)</td>
</tr>
<tr>
<td>Systemic Infection</td>
<td>14 (14.4%)</td>
<td>6 (12.5%)</td>
<td>8 (16.3%)</td>
</tr>
<tr>
<td>Wound Dehiscence</td>
<td>1 (1.0%)</td>
<td>1 (2.1%)</td>
<td>1 (2.0%)</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>97</strong></td>
<td><strong>48</strong></td>
<td><strong>49</strong></td>
</tr>
</tbody>
</table>

Fehlings, et al, Plos One 7;e32037,2012
Timing of Surgical Intervention

- Evidence
  - STASCIS
    - Considerations:
      - Type of incomplete SCI?
      - 27% lost to follow-up
        - 47 early vs. 39 late cohort
      - Early cohort - younger - less co-morbidity
      - Surgeon discretion
        - ASIA A/B – early n=105 vs. late n=50
      - Powered for one vs. two grade change?
        - NO difference was noted between early vs. late when one grade considered
        - ASIA D patients?
        - ASIA A, B, C – 97 < 24 vs. 59 > 24 hours (p=0.071)

Van Middendorp TSJ12:540542, 2012
Timing of Surgical Intervention

Evidence

- Older patient with CCS - no instability – stable significant neurologic deficit = ?
  - Meta-analysis – 1940 - 2012
    - 5 / 1653 publications on timing of surgery in acute CCS
    - Retrospective only
    - <12 month follow-up – early surgery slightly improved motor scores
    - > 12 month follow-up - no difference in clinical outcome

<table>
<thead>
<tr>
<th>Source</th>
<th>No. of patients</th>
<th>Mean age at injury, y (range)</th>
<th>Disease entity</th>
<th>Early surgery (d)</th>
<th>Mean follow-up, mo (range)</th>
<th>Outcome measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lenahan et al</td>
<td>73</td>
<td>57.7 (21.8-86.7)</td>
<td>Spondylosis (73)</td>
<td>&lt;1</td>
<td>12</td>
<td>ASIA motor score, functional independence measure, SF 36, bladder management status, walking ability</td>
</tr>
<tr>
<td>Quest et al</td>
<td>50</td>
<td>45 (14-77)</td>
<td>Spondylosis (24), acute disk herniation (16), fracture and/or dislocation (10)</td>
<td>&lt;1</td>
<td>36 (13-48)</td>
<td>PSI/MFS, length of ICU stay, length of hospital stay</td>
</tr>
<tr>
<td>Chen et al</td>
<td>49</td>
<td>55.9 (22-76)</td>
<td>Spondylosis (27), acute disk herniation (13), fracture and/or dislocation (9)</td>
<td>&lt;=4</td>
<td>56 (25-84)</td>
<td>ASIA motor score, WSCI, SF 36, bladder management status, spasticity, neurogenic pain, satisfaction</td>
</tr>
<tr>
<td>Stevens et al</td>
<td>67</td>
<td>34 (16-82)</td>
<td>Not specified</td>
<td>&lt;1</td>
<td>32 (1-210)</td>
<td>Proneal grading, length of the ICU stay, length of hospital stay, complication rates</td>
</tr>
<tr>
<td>Yamazaki et al</td>
<td>23</td>
<td>59.0 ± 11.9</td>
<td>Spondylosis (21), acute disk herniation (2)</td>
<td>&lt;=54</td>
<td>Mean 41.3 ± 25.9</td>
<td>NDA score</td>
</tr>
</tbody>
</table>

Timing of Surgical Intervention

**Evidence**

- Older patient with CCS - no instability – stable significant neurologic deficit = ?
  - Meta-analysis – 1966 -2013 - 16 / 77 / 1675 publications
  - Type of treatment, timing, prognostic factors
    - 6 retrospective studies on timing
Timing of Surgical Intervention

- Evidence
  - Older patient with CCS - no instability – stable significant neurologic deficit = ?
    - ACS National Trauma Bank Research Data Set
      - 2011-2012- ICD9 - 1060 patients
      - Multivariate logical regression model
      - All treated during index hospitalization
    - “Is early surgery safe?”

<table>
<thead>
<tr>
<th>TABLE 1. Patient Demographic and Comorbidities</th>
<th>(n = 1060)</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean = 55.6), yr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18–39</td>
<td>133</td>
<td>12.55</td>
<td></td>
</tr>
<tr>
<td>40–49</td>
<td>180</td>
<td>16.98</td>
<td></td>
</tr>
<tr>
<td>50–59</td>
<td>201</td>
<td>26.51</td>
<td></td>
</tr>
<tr>
<td>60–69</td>
<td>249</td>
<td>23.49</td>
<td></td>
</tr>
<tr>
<td>70–79</td>
<td>144</td>
<td>13.58</td>
<td></td>
</tr>
<tr>
<td>80 +</td>
<td>73</td>
<td>6.89</td>
<td></td>
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</table>

Comorbidities*

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Hypertension</td>
<td>413</td>
<td>38.96</td>
</tr>
<tr>
<td>Alcoholism</td>
<td>235</td>
<td>22.17</td>
</tr>
<tr>
<td>Diabetes</td>
<td>197</td>
<td>18.58</td>
</tr>
<tr>
<td>Respiratory disease</td>
<td>85</td>
<td>8.11</td>
</tr>
<tr>
<td>Obesity</td>
<td>49</td>
<td>4.62</td>
</tr>
</tbody>
</table>

Timing of Surgical Intervention

- Evidence
  - Central cord syndrome
    - ACS National Trauma Bank Research Data Set
      - 19% decrease risk of mortality with each 24 hour period of time up to day 7

<table>
<thead>
<tr>
<th>Outcome: death</th>
<th>Adjusted OR* (95% Confidence Interval)</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to surgery (d)</td>
<td>0.81 (0.67–0.99)</td>
<td>0.039</td>
</tr>
</tbody>
</table>

$P = 0.039$

*Adjusted OR* (95% Confidence Interval)
Timing of Surgical Intervention

- Evidence
  - Central cord syndrome
    - ACS National Trauma Bank Research Data Set
      - SAEs - not effected by delayed intervention
      - Increased CCI - risk of death / SAE / MAE

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<td>0.039</td>
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<tr>
<td>Charlson Comorbidity Index</td>
<td>1.45 (1.24–1.71)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Injury severity score</td>
<td>1.03 (0.99–1.06)</td>
<td>0.175</td>
</tr>
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<tr>
<th>Outcome: SAEs</th>
<th>Adjusted OR* (95% Confidence Interval)</th>
<th>P</th>
</tr>
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<tbody>
<tr>
<td>Time to surgery (d)</td>
<td>1.03 (1.00–1.07)</td>
<td>0.085</td>
</tr>
<tr>
<td>Charlson Comorbidity Index</td>
<td>1.25 (1.13–1.38)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Injury severity score</td>
<td>1.04 (1.02–1.06)</td>
<td>&lt; 0.001</td>
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<table>
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<tr>
<th>Outcome: minor adverse events</th>
<th>Adjusted OR* (95% Confidence Interval)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to surgery (d)</td>
<td>1.07 (1.03–1.10)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Charlson Comorbidity Index</td>
<td>1.12 (1.02–1.22)</td>
<td>0.012</td>
</tr>
<tr>
<td>Injury severity score</td>
<td>1.04 (1.02–1.06)</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

Timing of Surgical Intervention

- **Central cord syndrome**
  - Effect of T2 hyperintensity on recovery
    - Retrospective study – ASIA motor score – 7 days
    - Surgery < 24 hours vs. within index hospitalization
      - Presence of T2 signal
        - More significant neurologic injury upon presentation
        - No effect motor score within first week

Timing of Surgical Intervention

- **Central cord syndrome**
  - Older patient with CCS - no instability – stable significant neurologic deficit = ?
  - Initial management
    - Cervical orthosis
    - Respiratory protection
    - Hemodynamic stability
      - Vasopressors - Mean arterial pressure -80-90
      - Assessment – neurologic status / function
  - Patients who are medically optimized
    - eligible for “early” surgery - within first few days
    - Surgical indications?
    - Surgical intervention:
      - Safe time
      - Team prepared
      - Anesthesia prepared
Thank you