Pre-Hospital Cervical Spine Immobilization in Trauma

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EM3
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“RESUS TEAM ROOM 1”
Introduction

- MVCs count for the majority of spinal injuries, due to speeding, intoxications, or no seatbelt
- There are 250,000 victims of spinal injury in the US, and 11,000 join that group yearly
- Life cost to care for patients range from 50K to 3M
- Total cost to society and from medical expenses and lost productivity is estimated to be more than 35 B
- THE DEVASTATING EMOTIONAL AND PSYCHOLOGICAL IMPACT ON THE VICTIMS AND FAMILY IS INCALCULABLE
Spine Immobilization

- C-collar application is the hallmark of our state-of-the-art prehospital trauma care
- Until 15-20 years ago, thought to be benign
- All current guidelines state that collars are effective in limiting spinal motion and should remain until patient is properly assessed and cleared
The American Association for Neurological Services (AANS) and the Congress of Neurological Surgeons (CNS) Joint Guidelines Committee recently published guidelines for acute cervical spine injury. Of 112 recommendations, 77 were level III recs. In the prehospital setting, they recommend spinal immobilization in all suspected cervical spine injury or spinal cord injury. These are inline with ATLS and PHTLS, from the National Association of EMTs.
Highly Questionable

- Paucity of Randomized, controlled trials
  - Difficult in that acute setting
  - This is on top of navigating current guidelines, which are essentially dogma
- Many studies are performed using healthy volunteers or cadavers
- Current data paints a very mixed picture
Objectives

- Discuss effectiveness of prehospital C-collar use using three separate questions
  - C-collar effect on degree of spinal immobilization
  - C-collar effect on neurological injury stemming from C spine injury
  - C-collar potential harmful effect on trauma patient
“Prehistoric humans undoubtedly suffered little in the way of significant spinal injury. Their semierect posture, combine with well-developed posterior cervical muscles protected the cervical spine against the day-to-day trauma. Evolution, however, did much to undo this initial protective state. As humans assumed an upright posture, the shoulders dropped away from the newly elevated head and the hypertrophied paraspinous muscles atrophied. This increased the head’s range of motion, but diminished the spine’s protection. Although civilization heightened man’s inventiveness, it unfortunately did little to curb his aggressiveness. Automobiles replaced carriages, and fists and clubs gave way to knives and guns, making spinal injuries more common in the modern era.”
Cervical Spine Movement

Is C-Collar Effective in Prevent Significant Cervical Spine Movement in Cervical Injury?
Spinal immobilization, with collars or otherwise, is primarily used to prevent an unstable cervical spine injury to cause a spinal cord injury.
Cervical spine instability was created at C5-C6 in cadavers. A repeated measures design was used to compare bed transfer techniques: manual transfer vs using the On3 lateral transfer device. Both techniques were tested under four collar conditions.

An electromagnetic motion analyses device was applied to measure the amount of segmental motion between C5-C6 during the transfers.

3 different collars were used, as well as no C collar
Figure 1. The manual technique is being used to transfer a cadaver on a sheet. Note that all six team members are involved in the transfer.

Figure 2. Volunteer being transferred for demonstration purposes using the On3 device. For this technique, only two members of the team participate (On3 operator and person to maintain in-line stabilization).
• Technique did not produce significantly different movement in any of the planes: flexion ($p = 0.325$), AR ($p = 0.590$), and LB ($p = 0.112$). No significant differences were noted among the three collars used for flexion ($p = 0.462$), AR ($p = 0.434$) or LB ($p = 0.250$).

• For all transfers, using no collar resulted in more motion than using a collar; however, this difference was not statistically significant.
<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Technique, N = 3 Cadavers</th>
<th>Mean (Degree)</th>
<th>Standard Deviation (Degree)</th>
<th>Difference From No Collar (%)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>No collar</td>
<td>4.78</td>
<td>4.61</td>
<td>100</td>
<td>0.462</td>
</tr>
<tr>
<td></td>
<td>Aspen</td>
<td>3.34</td>
<td>2.43</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Miami J</td>
<td>3.30</td>
<td>2.36</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sierra</td>
<td>2.98</td>
<td>1.85</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>Axial rotation</td>
<td>No collar</td>
<td>4.26</td>
<td>1.64</td>
<td>100</td>
<td>0.434</td>
</tr>
<tr>
<td></td>
<td>Aspen</td>
<td>3.59</td>
<td>1.35</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Miami J</td>
<td>3.55</td>
<td>1.68</td>
<td>83</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sierra</td>
<td>3.59</td>
<td>1.53</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>Lateral bending</td>
<td>No collar</td>
<td>3.81</td>
<td>2.34</td>
<td>100</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>Aspen</td>
<td>3.02</td>
<td>2.13</td>
<td>79</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Miami J</td>
<td>2.71</td>
<td>1.90</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sierra</td>
<td>1.84</td>
<td>1.07</td>
<td>48</td>
<td></td>
</tr>
</tbody>
</table>

No significant differences between conditions. Means are an average of the two techniques.
• Limitations
  ○ 3 Cadavers: no nature muscle tone
  ○ Angular movement vs translational movement
  ○ Statistically insignificant movement maybe harmful

• Conclusion
  ○ There maybe no significant difference in amount of restriction in cervical motion with a c-collar vs no c-collar
5 lightly embalmed cadavers with no history of cervical pathology were used. An electromagnetic motion-tracking system captured segmental motion at C5–C6 while the spine was maneuvered through the range of motion in each plane. Testing was carried out in intact conditions after a global instability was created at C5–C6.

Three collar conditions were tested: a one-piece extraction collar, a two-piece collar (Aspen), and no collar. Gardner-Wells tongs were affixed to the skull and used to apply motion in flexion-extension, lateral bending, and rotation. Statistical analysis was carried out to evaluate the conditions: Collar vs no collar in stable as well as normal spine.
Neither the one- nor the two-piece collar was effective at significantly reducing segmental motion in the stable or unstable condition.

There was dramatically more motion in the unstable state, as would be expected. In the unstable spine, the amounts of motion occurring in the one-piece, two-piece, and no-collar tests were not significantly different; however, the collars restricted motion better than no collar for five of the six conditions.
Figure 1. Degrees of flexion possible in intact and unstable cervical spines during bed transfer were significantly different ($p = 0.013$). Values are mean and error bars show standard deviation. Differences between collar conditions were not statistically significant.

Figure 2. Degrees of extension possible in intact and unstable cervical spines during bed transfers did not differ significantly ($p = 0.059$). Values are mean and error bars show standard deviation. Differences between collar conditions were not statistically significant.
- **Limitations**
  - Cadavers
  - Maximal C spine injury

- **Conclusion**
  - Collars do not effectively reduce motion in an unstable cervical spine cadaver model
How effective is prehospital use of C-collar use in preventing neurologic injury?
Retrospective study of patients who sustained lightweight motorcycle injuries in an expansive urban area between 2008 and 2009, with incidence of cervical spine damage.

Patients were divided into 2 groups: those who were immobilized by cervical collar brace and those who were not.

5,138 motorcycle crash victims were reviewed. Brought in by EMTs who were trained to bring in all patients with suspected severe injuries with a long backboard and a cervical collar brace.

In the Hospital all patients were evaluated by trauma surgeons using the NEXUS criteria, and those that had suspected injury underwent CT scan of C-spine.

Cervical Spine injury was defined as any recorded change in neurologic status or spinal cord injury, visualized on CT or MRI.
NEXUS criteria

Meets all low-risk criteria?

1. No posterior midline cervical-spine tenderness
2. No evidence of intoxication
3. A normal level of alertness
4. No focal neurologic deficit
5. No painful distracting injuries

Fig. 1: NEXUS criteria for radiography of C-spine
### Injury Severity Score

#### TABLE 1. Abbreviated Injury Scale (AIS)

<table>
<thead>
<tr>
<th>AIS score</th>
<th>Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Minor</td>
</tr>
<tr>
<td>2</td>
<td>Moderate</td>
</tr>
<tr>
<td>3</td>
<td>Serious</td>
</tr>
<tr>
<td>4</td>
<td>Severe</td>
</tr>
<tr>
<td>5</td>
<td>Critical</td>
</tr>
<tr>
<td>6</td>
<td>Probably lethal*</td>
</tr>
</tbody>
</table>

#### Region Details

<table>
<thead>
<tr>
<th>Region</th>
<th>Injury Description</th>
<th>AIS</th>
<th>Square Top Three</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head &amp; Neck</td>
<td>Cerebral Contusion</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Face</td>
<td>No Injury</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Chest</td>
<td>Flail Chest</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>Abdomen</td>
<td>Minor Contusion of Liver Complex Rupture Spleen</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Extremity</td>
<td>Fractured femur</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>External</td>
<td>No Injury</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

**Injury Severity Score:** 50
Immobilized and mobilized patients were then compared by age, sex, spinal cord injuries using chi square analysis.

A total of 2605 patients (50.7%) were immobilized with neck collar, whereas 2534 (49.3%) were not, at the time they arrived. 63 of 5,138 patients had cervical spine injury.

Average ISS was 14.31+/- 8.25

There were no significant differences between the 2 groups in age, sex, and ISS. There was also no significant correlation when comparing cervical spine injury with applied neck collar or not ($\chi^2$, $P = .896$).
• Limitations:
  ○ Mean and SD of the 2 individual groups were not reported
  ○ Single center, single population, low risk (vs USA population)
A 5-year retrospective chart review was carried out at 2 university hospitals. All patients with acute blunt traumatic spinal or spinal cord injuries transported directly from the injury site to the hospital were entered. None of the 120 patients seen at the University of Malaya had spinal immobilization during transport, whereas all 334 patients seen at the University of New Mexico did. The 2 hospitals were comparable in physician training and clinical resources. The area around Malaya did not have Emergency Ambulance.

Neurologic injuries were assigned to 2 categories, disabling or not disabling, based on discharge diagnosis, and the rest by 2 physicians acting independently and blinded to the hospital of origin. (quadriplegia, paraplegia, assisted ambulation, urinary incontinence, catheterization, death)
<table>
<thead>
<tr>
<th></th>
<th>Immobilized</th>
<th>Unimmobilized</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>334</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>Average age</td>
<td>34 yr</td>
<td>35 yr</td>
<td>0.31</td>
</tr>
<tr>
<td>Gender—male</td>
<td>256 (77%)*</td>
<td>106 (88%)</td>
<td>0.009</td>
</tr>
<tr>
<td>Level of injury</td>
<td></td>
<td></td>
<td>0.52</td>
</tr>
<tr>
<td>Cervical</td>
<td>113 (34%)</td>
<td>40 (33%)</td>
<td></td>
</tr>
<tr>
<td>Thoracic</td>
<td>107 (32%)</td>
<td>33 (28%)</td>
<td></td>
</tr>
<tr>
<td>Lumbosacral</td>
<td>113 (34%)</td>
<td>47 (39%)</td>
<td></td>
</tr>
<tr>
<td>Mechanism</td>
<td></td>
<td></td>
<td>0.0001</td>
</tr>
<tr>
<td>Fall</td>
<td>66 (20%)</td>
<td>63 (53%)</td>
<td></td>
</tr>
<tr>
<td>Vehicle crash</td>
<td>248 (74%)</td>
<td>45 (38%)</td>
<td></td>
</tr>
<tr>
<td>Low-mass</td>
<td>9 (3%)</td>
<td>8 (7%)</td>
<td></td>
</tr>
<tr>
<td>impact</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>11 (3%)</td>
<td>4 (3%)</td>
<td></td>
</tr>
<tr>
<td>Significant</td>
<td>70 (21%)</td>
<td>13 (11%)</td>
<td>0.02</td>
</tr>
<tr>
<td>disability</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Percentages are relative to each hospital's total.
- 24 had to be independently classified
- In total, 21% of U.S. patients (70/334) form the US and 11% of Malaysian patients (13/120) were classified with disabling injury
- OR for disability was higher for patients in the United States (all with spinal immobilization) after adjustment for the effect of all other independent variables
- (2.03; 95% CI 1.03-3.99; p = 0.04). The estimated probability of finding data as extreme as this if immobilization has an overall beneficial effect is only 2%. Thus, there is a 98% probability that immobilization is harmful or of no value.
- The analysis was repeated using only the subset of patients with isolated cervical level deficits. Again, there was no protective effect of spinal immobilization shown (OR 1.52; 95% CI 0.64-3.62; p = 0.34).
Limitations
- Sample size
- Heterogeneity of the populations compared
- Mechanisms of injury (ex. ISS)

Conclusion
- Out-of-Hospital immobilization has little to no effect on neurologic outcome in patients with blunt spinal injury
Potential Harm

WHAT HARM CAN APPLICATION OF C-COLLAR CAUSE?
Potential harm

- May exacerbate cervical spine injury
- Increased difficulty managing airway
- Aspiration risk
- Patient discomfort and pressure ulcer
- Increased ICP
Increased Intracranial pressure

- Associated head injuries frequently occur with spinal injury
- ATLS state that 5% of patients with TBI have an associated spinal injury, whereas 25% of patients with spinal injury have a TBI.
- Avoiding or reducing intracranial pressure is fundamental in the management of TBI
What effect does C-Collar placement have on ICP?
A prospective series of 10 head-injured patients with a postresuscitation Glasgow coma scale score of nine or less had ICP measurements before and after cervical hard collar application.

Measurements done 24-48 hours after presentation.

Testing of ICPs with c collar was only done if there was no ICP fluctuation greater than 2 mmHG of 5 minutes prior to application.
9/10 patients had increase in ICP

The difference between pre- and post-application ICP was significantly with a mean of 4.4 mmHg, P<0.05

Three patterns of ICP change emerged:
- A: high baseline with minimal change post-collar
- B: raised or normal ICP that had minimal change
- C: raised or normal ICP with large rise
Table 1. Head-injured patients with intracranial pressure monitoring before and after collar application

<table>
<thead>
<tr>
<th>Age/sex</th>
<th>Mechanism of injury</th>
<th>GCS</th>
<th>Baseline ICP (mmHg)</th>
<th>ICP after collar application</th>
<th>% ICP change</th>
</tr>
</thead>
<tbody>
<tr>
<td>28/M</td>
<td>MBA</td>
<td>4</td>
<td>49</td>
<td>52</td>
<td>6</td>
</tr>
<tr>
<td>42/M</td>
<td>MVA</td>
<td>4</td>
<td>42</td>
<td>39</td>
<td>–7</td>
</tr>
<tr>
<td>22/M</td>
<td>MVA</td>
<td>8</td>
<td>21</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>30/F</td>
<td>MBA</td>
<td>4</td>
<td>20</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>24/M</td>
<td>MVA</td>
<td>8</td>
<td>18</td>
<td>26</td>
<td>44</td>
</tr>
<tr>
<td>19/M</td>
<td>MBA</td>
<td>9</td>
<td>15</td>
<td>21</td>
<td>40</td>
</tr>
<tr>
<td>24/F</td>
<td>MBA</td>
<td>9</td>
<td>14</td>
<td>22</td>
<td>57</td>
</tr>
<tr>
<td>47/M</td>
<td>MBA</td>
<td>4</td>
<td>13</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>15/M</td>
<td>PBA</td>
<td>9</td>
<td>7</td>
<td>19</td>
<td>171</td>
</tr>
<tr>
<td>42/M</td>
<td>Fall</td>
<td>9</td>
<td>6</td>
<td>15</td>
<td>150</td>
</tr>
<tr>
<td>8/M, 2/F</td>
<td></td>
<td></td>
<td>20.5 ±14.2</td>
<td>25.8 ± 11.5</td>
<td>51.5 ± 60.6</td>
</tr>
</tbody>
</table>

F, female; GCS, Glasgow coma scale on admission; ICP, intracranial pressure; M, male; MBA, motor bike accident; MVA, motor vehicle bike accident.
• Limitations:
  ○ Small size
  ○ Did not demonstrate correlation b/t collar and outcome

• Conclusion
  ○ Application of C-collar can have a statistically difference in rise of ICP
Table 2. Previous studies of intracranial pressure changes with cervical collars

<table>
<thead>
<tr>
<th>Reference</th>
<th>Patients</th>
<th>Type of collar</th>
<th>Patient population</th>
<th>Mean ICP before (mmHg)</th>
<th>Mean ICP during (mmHg)</th>
<th>Mean change in ICP (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present study</td>
<td>10</td>
<td>Laerdal Stifneck</td>
<td>Head injury: GCS &lt; 9</td>
<td>20.5</td>
<td>24.9</td>
<td>Rise of 4.4</td>
</tr>
<tr>
<td>Kolb et al.⁵</td>
<td>20</td>
<td>Philadelphia</td>
<td>Non-head-injured</td>
<td>17.7</td>
<td>20.1</td>
<td>Rise of 2.4</td>
</tr>
<tr>
<td>Raphael and Chotai⁶</td>
<td>9</td>
<td>Laerdal Stifneck</td>
<td>Non-head-injured</td>
<td>17.2</td>
<td>19.1</td>
<td>Rise of 1.9</td>
</tr>
<tr>
<td>Davies et al.⁵</td>
<td>19</td>
<td>Laerdal Stifneck</td>
<td>Head injury</td>
<td>13.3</td>
<td>18.4</td>
<td>Rise of 4.5</td>
</tr>
<tr>
<td>Kuhnigk et al.⁷</td>
<td>18</td>
<td>Spieth and Philadelphia</td>
<td>Head injury: GCS &lt; 9</td>
<td>17.0</td>
<td>17.7</td>
<td>Rise of 0.7</td>
</tr>
<tr>
<td>Craig and Nielsen³</td>
<td>2</td>
<td>Laerdal Stifneck</td>
<td>Head injury</td>
<td>10.0</td>
<td>23.5</td>
<td>Rise of 13.5</td>
</tr>
</tbody>
</table>

ICP, intracranial pressure; GCS, Glasgow coma score.
Increased ICP with collar

- The reason for increased ICP with C-Collar use is unclear
- Two theories:
  - Nocireceptive stimulation – pain causes increase. However studies have not shown this correlation to be true
  - Disruption of venous flow, specifically of IJ
42 healthy volunteers underwent US examination of the internal jugular vein before and after cervical collar application.

Internal jugular vein cross-sectional areas were compared with and without the cervical collar in place at the same location (laryngeal prominence) and during the same time: maximal dimension during passive respiration.
• The mean (±SD) cross-sectional area of the right internal jugular vein was 0.70 (±0.28) cm² without the rigid cervical collar and 0.89 (±0.35) cm² after placement of the collar:

• The cross-sectional area of the internal jugular vein increased significantly (p < 0.0001) after application of the cervical collar. The mean percentage increase in cross-sectional area was 37% (95% confidence interval [CI] = 20% to 53%).
• **Limitations**
  - Measurements taken right after collar application instead of waiting for possible equilibrium
  - Did not measure ICP

• **Conclusion**
  - Internal jugular vein cross-sectional area increases after c-collar application, and this may explain the increase in ICP from c-collar application
  - More studies can be done
Summary

- There is growing evidence that pre-hospital application of c-collar:
  - may not significantly decrease cervical spine motion
  - C-collar may not significantly reduce neurologic injury secondary to cervical injury
  - May cause harm to the patient, specifically in the way of increased intracranial pressure
ILCOR recommendation

“We suggest against spinal motion restriction, defined as the reduction of or limitation of cervical spinal movement, by routine application of a cervical collar or bilateral sandbags (joined with 3-inch-wide cloth tape across the forehead) in comparison to no cervical spine restriction in adults and children with blunt suspected traumatic cervical spinal injury.”
“Because of proven adverse effects in studies with injured patients, and evidence concerning a decrease in head movement only comes from studies with cadavers or healthy volunteers, benefits do not outweigh harms, and routine application of cervical collars is not recommended.”


