Background: The National Emergency X-Radiography Utilization Study defined five criteria for obtaining cervical spine radiographic investigations in blunt trauma patients. Distracting injury was given as the indication for more than 30% of all x-ray studies ordered. The hypothesis of this study was that upper and lower torso injuries would have different effects on clinical cervical spine assessment.

Methods: This was a single-center, prospective, observational study of admitted, alert, adult blunt-trauma patients. All patients underwent cervical spine plain-film radiography. Data were collected on all injuries, physical examination findings, narcotic administration, and radiograph results. Patients with upper and lower torso injuries were compared in their ability to distract from painful spine fracture.

Results: In all, 406 patients participated. All patients received narcotic administration. Forty patients (9.9%) had cervical spine fractures, of whom seven had a nontender neck examination. All seven patients with a nontender cervical spine and a neck fracture had at least one upper torso injury. None of the 99 patients with injuries isolated to the lower torso had a cervical spine fracture (p < 0.05). The frequency of cervical spine fracture among patients with cervical spine tenderness was 19.8% (n = 33).

Conclusions: The National Emergency X-Radiography Utilization Study definition of a distracting injury may be narrowed. Upper torso injuries may be sufficiently painful to distract from a reliable cervical spine examination. Patients may detect spine tenderness in the presence of isolated painful lower torso injuries. Patients with spine tenderness warrant imaging.

Key Words: Cervical spine clearance, Blunt trauma, Cervical spine injury, Distracting injuries.

cervical spine. Patients were then asked to grade any neck pain or tenderness on a scale of 0 to 10, with 0 being no pain or tenderness and 10 being maximum imaginable pain. After the neck examination, the head, chest, abdomen, pelvis, upper and lower extremities, thoracic and lumbar spine were all examined in a similar fashion, with the patient grading any pain or tenderness on the same 0 to 10 scale. Following the body pain examination, a complete neurologic examination was performed.

After the physical examination was complete, the medical record was reviewed. Abstracted data included the time from injury to examination in hours, the admission blood alcohol level, and the cumulative dose of narcotic analgesics for the 4 hours preceding patient enrollment and examination. Only after the completion of the physical examination and record review were all c-spine radiographic studies reviewed. All c-spine radiographic evaluation was performed at the discretion of the primary team without knowledge of research assistant findings.

To distinguish proximity injuries from more distal injuries that could distract from the c-spine examination, we operationally divided the body into upper and lower torso. Lower torso injuries were defined as an injury with an abbreviated injury score (AIS) of two or higher for the abdomen, pelvis, lower extremities or lumbar spine. Upper torso injuries were defined as any injury with an AIS score of 2 or greater for the head, neck, face, upper extremity, chest, diaphragm, or thoracic spine. Patients were grouped into either having lower or upper torso injuries. Patients with both upper and lower torso injuries were included in the upper torso injury group. Patients in the upper torso injury group were compared with those in the lower torso injury group by Student's t-test where appropriate. Post-hoc analysis of upper torso group was also done by comparing patients with isolated upper body injuries to those patients with combined upper and lower torso injuries. This was performed to determine whether the lower torso component additionally contributed to the severity of injury and hence to the distraction from a reliable examination. All data analysis was performed in SPSS version 10.

RESULTS

Over a period of 10 months, 1,037 patients were admitted with injury to the trauma service, 423 were eligible for enrollment, and 406 participated. Table 1 shows the demographic information of the 406 enrolled patients. Exclusion criteria are listed in Table 2. Two patients declined participation and 15 patients were missed due to time constraints. The average time from injury to examination by the research assistant was 12 hours (range 0.5 to 30 hours). All 406 patients received narcotic analgesics before examination with an average dose of 2.25 mg within the preceding 4 hours. No patient with a cervical spine fracture subsequently suffered from neurologic deterioration.

The upper torso injury group had 278 patients and the lower torso injury group had 128 patients. Slightly more than half of patients (n = 239, 58.9%) had a nontender c-spine and 167 (41.1%) had a tender c-spine. Overall, 40 of the 406 patients (9.9%) sustained a cervical spine fracture. Table 3 details the distribution of the fractures, fracture types, and the presence of c-spine tenderness. Although the majority (n = 33, 82.5%) of patients with c-spine fractures had pain on
Table 4 Upper versus Lower Torso Injury by Spine Tenderness and Fracture Status

<table>
<thead>
<tr>
<th></th>
<th>Nontender Fracture</th>
<th>Nontender No fracture</th>
<th>Tender Fracture</th>
<th>Tender No fracture</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>7</td>
<td>232</td>
<td>33</td>
<td>134</td>
</tr>
<tr>
<td>Upper torso injury</td>
<td>7</td>
<td>133</td>
<td>24</td>
<td>114</td>
</tr>
<tr>
<td>Lower torso injury only</td>
<td>0</td>
<td>99</td>
<td>9</td>
<td>20</td>
</tr>
</tbody>
</table>

*p = 0.04, upper torso versus lower torso for patients with a nontender c-spine; *p = 0.12, upper torso versus lower torso for patients with a tender c-spine.

examination of the c-spine, seven patients with a c-spine fracture did not complain of c-spine pain or tenderness. There was no obvious difference in c-spine fracture distribution or type with respect to tenderness on cervical spine examination; however, no formal statistical evaluation was performed due to small numbers.

Of the 167 patients who had pain upon examination of the c-spine, 138 (82.5%) had at least one upper torso injury of AIS ≥2 and 29 (17.5%) had injuries isolated to the lower torso. The frequency of c-spine fracture among patients with c-spine pain was 19.8% (n = 33). Table 4 shows the associations of upper and lower torso injuries, presence of c-spine fracture, and neck tenderness. For patients with a tender c-spine, the proportion of patients with upper torso injury did not significantly differ from those with isolated lower torso injuries (17.5% versus 31%, *p = 0.12). Post-hoc analysis showed no significant differences in tender versus nontender fractures when patients with isolated upper torso injuries were compared with those with combined upper and lower torso injuries (*p = 0.19). This suggests that proximity of injury to the c-spine was the main determinant of inability to detect spine tenderness. In addition, the mean Injury Severity Scale (ISS) score did not differ between patients with isolated upper torso injuries and those with combined upper and lower torso injuries (12.0 versus 13.6, *p = 0.28).

Seven (2.9%) of the 239 patients with a nontender c-spine had a c-spine fracture. All seven patients with nontender c-spine fractures were in the upper torso injury group (n = 140). No cervical spine fractures were found among the 99 patients who had an isolated lower torso injury and a nontender cervical spine (5.0% versus 0%, *p = 0.04). Table 5 shows the associated injuries in the seven patients with nontender cervical spine fractures.

Patients with tender versus nontender c-spine fractures did not differ in the either the percentage of patients presenting with positive blood alcohol levels (9 of 33 versus 2 of 7, *p = NS), or in the mean blood alcohol level (103 mg/dL versus 113 mg/dL, *p = NS). They also did not differ in distribution of the fractures (injuries in the C5 to C7 range in 27 of 33 tender patients versus 4 of 7 nontender patients, *p = NS) or in the narcotic dose administered (3 mg morphine sulfate in tender patients versus 4 mg morphine sulfate in nontender patients) before examination. The mean ISS was higher in the group of patients with nontender cervical spine fractures (30 versus 13, *p < 0.05).

DISCUSSION

The two most often cited indications in the NEXUS study that mandated c-spine imaging were midline cervical tenderness and the presence of a painful distracting injury. As an isolated finding, a distracting injury, in the absence of any other indication, accounted for approximately 30% of all x-ray studies ordered.4 The original definition of a distracting injury in the NEXUS guidelines included any or all of the following: 1) a long bone fracture; 2) a visceral injury requiring surgical consultation; 3) a large laceration, degloving injury, or crush injury; 4) large burns; or 5) any other injury producing acute functional impairment. Physicians were also able to classify any injury as distracting if it is thought to have the potential to impair the patient’s ability to appreciate other injuries.5 Any number of these injuries may be found in every admitted trauma victim. Therefore, by the NEXUS criteria one may state that every admitted blunt trauma victim is mandated to undergo cervical spine imaging irrespective of the nature of the associated injuries. Practice management guidelines with respect to cervical spine trauma acknowledge a lack of Level I data supporting specific recommendations.6

The concept that certain injuries may “distract” patients from other injuries is based on the gate theory of pain. In this theory, an injury such as a long bone fracture may induce enough signal through the spinal pain pathways that other smaller injuries, such as abrasions, may not cause enough stimulus and thus may go unappreciated. This phenomenon was described in 1956 as counterirritation.5 Some reports suggest that the analgesic effect of heterotopic noxious stimulation in

Table 5 Associated Injuries and Pain Scores for the Seven Subjects with Nontender Cervical Spine Fractures

<table>
<thead>
<tr>
<th>Patient</th>
<th>Maximum Upper Torso Pain</th>
<th>Maximum Lower Torso Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1st and 2nd rib fx, scalp lac 8/10</td>
<td>Liver lac, hip dislocation 7/10</td>
</tr>
<tr>
<td>2</td>
<td>Clavicle fx, 3 rib fx, humerus fx 10/10</td>
<td>Liver laceration 6/10</td>
</tr>
<tr>
<td>3</td>
<td>Scapular fx, bilateral 1st rib fx 9/10</td>
<td>Femur fx 9/10</td>
</tr>
<tr>
<td>4</td>
<td>3 rib fx, scalp lac, radius/ulna fx 8/10</td>
<td>Large soft-tissue injury leg 5/10</td>
</tr>
<tr>
<td>5</td>
<td>Scapular fx, pneumothorax, 2 rib fx 10/10</td>
<td>Pelvic fx 7/10</td>
</tr>
<tr>
<td>6</td>
<td>3 rib fx, pneumothorax 9/10</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>2 rib fx, scalp degloving 7/10</td>
<td></td>
</tr>
</tbody>
</table>

Fx, fracture; lac, laceration.
humans is based on the activation of a specific inhibitory pain control system.\textsuperscript{6,7} It has been shown that counterirritation is not based on the systemic release of endogenous opioids\textsuperscript{8} but that heterotopic noxious stimuli inhibit the spinal nociceptive flexion reflex, which reflects the spinal transmission of nociceptive signals.\textsuperscript{8,9} Thus a greater the amount of heterotopic noxious stimuli should have a greater effect in inhibiting the spinal nociceptive flexion reflex. The patients with nontender fractures in this study appeared to have more noxious stimuli as demonstrated by higher ISS scores, and hence may have been distracted from a reliable clinical examination, supporting the concept of counterirritation.

Furthermore, it has been shown that the proximity of the two painful stimuli to each other plays a major role in whether one stimulus may inhibit the other.\textsuperscript{10} In contradistinction to the NEXUS definition that any injury may be considered distracting, clinical and animal studies have demonstrated that the proximity of the two injuries plays a large role in whether one injury may distract from another.\textsuperscript{10} Thus, our findings that upper torso and not lower torso injuries may distract from the pain of a cervical spine injury are consistent with the other human and animal model observations.

To evaluate current practice, Grossman et al.\textsuperscript{11} conducted a survey of 615 trauma centers specifically addressing which patients should undergo imaging and what imaging should one undertake. For nonintoxicated patients, 95% of respondents believed that chest trauma would constitute a distracting injury, 60% believed a femur fracture to be potentially distracting, but only 18% of Level I trauma centers would consider a tibia fracture as a distracting injury. For admitted patients, cervical spine fractures are not the “rare” entity seen in the NEXUS study. The fracture rate of 9.9% found in this study is substantially higher than the 2.8% reported in NEXUS\textsuperscript{2} but is in keeping with the rates of 5 to 11% cervical spine fractures seen in admitted patients.\textsuperscript{11–13} The demographics and the mechanisms of injury in this patient population are also in keeping with previously reported findings, with motor vehicle collisions accounting for the majority cervical spine injuries.\textsuperscript{14}

All 406 patients enrolled received opioid analgesia before examination. There was no difference between patients with nontender versus tender c-spine fractures with respect to the mean dose of morphine or the level of intoxication on initial presentation. Thus small-dose opioid administration did not appear to influence the patients’ ability to give a reliable examination. No patients were unable to understand the informed consent document because of intoxication due to narcotics or alcohol. Although no patient with isolated lower torso injury and a nontender cervical spine had a cervical spine fracture, approximately 20% of patients in the present study who had cervical midline tenderness had a cervical spine fracture, making imaging of patients with cervical tenderness mandatory.

**CONCLUSIONS**

The data from the present study suggest three important concepts. The first and most important concept is that all patients with c-spine tenderness should undergo radiographic imaging due to the high frequency of injury. The second concept is that counterirritation or distraction clearly does occur with proximity injuries, and the third is that the definition of a distracting injury used in the NEXUS study may be able to be narrowed. Upper torso injuries appear to be sufficiently painful to preclude a reliable clinical examination of the cervical spine. However, patients with injuries isolated to the lower torso appear to be able to detect spine tenderness in the presence of painful lower torso injuries and c-spine imaging may not be required for this group of patients.

**REFERENCES**