Clinical Examination and its Reliability in Identifying Cervical Spine Fractures


Background: The Eastern Association for the Surgery of Trauma (EAST) guidelines recommend that cervical spine (c-spine) radiographic evaluation is unnecessary in the awake, alert blunt trauma patient who is not intoxicated, has no distracting injuries, and demonstrates no tenderness over the c-spine or neurologic deficits. The purpose of this study was to compare the reliability of the clinical examination (CE) with that of computed tomography in identifying the presence of c-spine fractures.

Methods: We prospectively evaluated 534 blunt trauma patients between February 2004 and January 2005. Positive CE was defined as complaints of neck pain, external trauma of the c-spine or neurologic deficit, tenderness or abnormalities to palpation over the cervical spine. Computed tomography was used to define the accuracy of CE.

Results: There were 52 patients with, and 482 patients without, c-spine fractures. Forty of the 52 patients with fractures were accurately identified by CE for a sensitivity of 76.9% and a negative predictive value (NPV) of 95.7%. In the group with an initial Glasgow Coma Score of 15, 16 of 24 patients with fractures were accurately identified for a sensitivity of 66.7% and an NPV of 96.5%. In the subset of patients who by EAST guidelines would not require any radiographic evaluation, there were 17 fractures and 10 were accurately identified by clinical examination. The sensitivity in this group was 58.8% with an NPV of 96.4%. Four of the seven missed injuries required intervention.

Conclusions: This trial suggests that with a normal Glasgow Coma Score, CE cannot be relied upon to rule out c-spine fracture. CE is unreliable to diagnose or exclude a cervical spine fracture.

Key Words: Cervical spine fractures, Computed tomography, Clinical examination radiographs.


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It can be devastating both for the patient and the physician for a cervical spine fracture to be missed. Hence, a great deal of time and effort has gone into identifying the optimal strategy to identify such injuries. Presently, the Eastern Association for the Surgery of Trauma (EAST) practice guidelines suggest that trauma patients who have no complaints of neck pain, no distracting injuries, no neurologic deficits, and are awake and alert without mental status changes may be considered to have a stable cervical spine that does not require radiographic evaluation. This recommendation is based in part on the study by Ersoy et al. who prospectively reviewed the clinical examination findings of 267 patients. No patient in this study without neck pain or neurologic deficit was found to have a cervical spine fracture.

Velmahos et al. confirmed the above findings with a prospective study in which they looked at 549 consecutive alert patients who were clinically not intoxicated, had no neck symptoms, and had no fractures by radiographic evaluation. The majority of these patients underwent plain films to evaluate their cervical spines with 78 also undergoing a computed tomography (CT) and one magnetic resonance imaging (MRI). Because none of their patients were found to have a cervical spine fracture, they concluded that this subset of patients could have their cervical spines cleared clinically, thereby saving the time and resources of an extensive work-up.

Despite these studies, the accuracy of the clinical examination for cervical spine injury is not well defined. Of note, these trials used plain films to rule out a cervical spine fracture. Because plain radiographs can be inaccurate and CT is a more appropriate tool to determine the presence of these injuries, this prospective trial was undertaken to compare the reliability of the clinical examination with that of CT in identifying the presence of cervical spine fractures.

PATIENTS AND METHODS

A prospective study was performed at our Level I trauma center from February 2004 until June 2005. Blunt trauma patients over the age of 16 years were included. Information regarding mechanism of injury, patient demographics, initial hemodynamics, and laboratory values was collected. Subjective complaints of neck pain or neurologic deficits, or both, were documented, as were physical examination findings of tenderness to palpation over the cervical spine, abnormalities to palpation, and neurologic deficits.
CT was used to determine the accuracy of the clinical examination. A Siemens Sensation 16 multidetector CT (Siemens AG, Munich, Germany) was used for all patients. The standard protocol included 2-mm thick axial cuts performed at 2-mm increments with sagittal multiplanar reformatted images. The scan extended from the base of the skull to the level of the third thoracic vertebra.

Patients with and without a cervical spine fracture were compared for initial presentation findings. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for the following groups: all patients, those with a Glasgow Coma Score (GCS) of 15, and those with a GCS of 15 who were not intoxicated and had no distracting injury. Continuous variables were evaluated using the Wilcoxon rank test and the nominal variables were evaluated using the Fisher's exact test. Logistic regression was used to determine independent predictors of cervical spine fractures. The Virginia Commonwealth University Institutional Review Board approved this study.

RESULTS

There were 534 adult, blunt trauma patients evaluated as part of the study. Fifty-two patients had a cervical spine fracture identified by CT, whereas 482 patients did not have a cervical spine fracture. The majority of both groups sustained injuries after a motor vehicle crash (75% fracture group vs. 78.4% no fracture group, \( p = 0.28 \)). Most patients were white (62% fracture group vs. 59.7% no fracture group, \( p = 0.93 \)) and male (67.3% fracture group vs. 63.4% no fracture group, \( p = 0.65 \)). They were also similar in age (40.8 ± 21.7 years, fracture group vs. 38.8 ± 17.1 years, no fracture group, \( p = 1.0 \)).

Table 1 shows the initial hemodynamics of the two groups. Both groups had similar blood alcohol levels at admission (0.068 ± 0.1 g/dL, fracture group vs. 0.05 ± 0.1 g/dL, no fracture group; \( p = 0.45 \)). They were different for the following: lactate (3.7 ± 2.6 mmol/L, fracture group vs. 2.7 ± 2.0 mmol/L, no fracture group; \( p = 0.007 \)), blood sugar (141.4 ± 58.3 mg/dL, fracture group vs. 127.6 ± 56.4 mg/dL, no fracture group; \( p = 0.025 \)), and base deficit (−0.9 ± 5.4 fracture group vs. 1.8 ± 4.5 no fracture group; \( p = 0.0006 \)). Of the 52 patients who had a cervical spine fracture on CT, only 40 patients were identified by history or physical examination. These patients had complaints of neck pain or neurologic deficits, or both, with or without findings of tenderness to palpation over the cervical spine, abnormalities to palpation or neurologic deficits, as shown in Table 2. The sensitivity of the clinical examination was 76.9% (40 of 52), the specificity was 54.7% (264 of 482), the positive predictive value was 15.5% (40 of 258), and the negative predictive value was 95.7% (264 of 276). Logistic regression identified the initial GCS (\( p = 0.03 \)) and initial base deficit (\( p = 0.003 \)) as independent predictors of cervical spine fractures.

Subset analysis evaluated the reliability of the clinical examination in those patients who came into the trauma bay with a GCS of 15 and those patients who not only had a GCS of 15 but also had documentation that they were not intoxicated and did not have a distracting injury. The findings are shown in Tables 3 and 4. For all patients with a GCS of 15, the clinical examination resulted in a sensitivity of 66.7% (16 of 24), specificity of 62% (220 of 355), PPV of 10.6% (16 of 151), and an NPV of 96.5% (220 of 228). For those with a GCS of 15 who were not intoxicated and did not have a distracting injury, the clinical examination resulted in a sensitivity of 58.8% (10 of 17), specificity of 62.7% (190 of 303), PPV of 8.1% (10 of 121), and an NPV of 96.4% (190 of 197).

In the awake and alert group with a GCS of 15 who were not intoxicated and who had no distracting injuries, 17 had cervical spine fractures, seven of which had no positive clinical examination findings. Three of these were transverse process fractures requiring no further intervention. One was a

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**Table 1 Initial Hemodynamics**

<table>
<thead>
<tr>
<th></th>
<th>Fracture Group</th>
<th>No Fracture Group</th>
<th>( p ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic blood pressure (mm Hg)</td>
<td>135.7 ± 31.0</td>
<td>139.5 ± 24.0</td>
<td>0.49</td>
</tr>
<tr>
<td>Heart rate (beats/min)</td>
<td>98.1 ± 19.9</td>
<td>91.8 ± 18.0</td>
<td>0.05</td>
</tr>
<tr>
<td>Respiratory rate/min</td>
<td>18.7 ± 5.0</td>
<td>19.7 ± 5.4</td>
<td>0.27</td>
</tr>
<tr>
<td>Glasgow Coma Score</td>
<td>11.3 ± 4.7</td>
<td>13.7 ± 3.4</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

**Table 2 Clinical Exam for All Patients**

<table>
<thead>
<tr>
<th></th>
<th>Fracture by CT</th>
<th>No fracture by CT</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Exam</td>
<td>40</td>
<td>12</td>
<td>52</td>
</tr>
<tr>
<td>Negative Exam</td>
<td>218</td>
<td>264</td>
<td>482</td>
</tr>
<tr>
<td>Total</td>
<td>258</td>
<td>276</td>
<td>534</td>
</tr>
</tbody>
</table>

**Table 3 Clinical Exam for Patients With an Initial GCS of 15**

<table>
<thead>
<tr>
<th></th>
<th>Fracture by CT</th>
<th>No fracture by CT</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Exam</td>
<td>16</td>
<td>8</td>
<td>24</td>
</tr>
<tr>
<td>Negative Exam</td>
<td>135</td>
<td>220</td>
<td>355</td>
</tr>
<tr>
<td>Total</td>
<td>151</td>
<td>228</td>
<td>379</td>
</tr>
</tbody>
</table>

**Table 4 Clinical Exam for Patients With an Initial GCS of 15 and Who Were Nonintoxicated With No Distracting Injuries**

<table>
<thead>
<tr>
<th></th>
<th>Fracture</th>
<th>No fracture</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Exam</td>
<td>10</td>
<td>7</td>
<td>17</td>
</tr>
<tr>
<td>Negative Exam</td>
<td>113</td>
<td>190</td>
<td>303</td>
</tr>
<tr>
<td>Total</td>
<td>123</td>
<td>197</td>
<td>320</td>
</tr>
</tbody>
</table>
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Hangman’s fracture requiring an extended aspen collar for therapy. The fifth patient had a lateral mass fracture of the first cervical spine treated with a collar for 6 weeks. The sixth patient had an occipital condyle fracture treated for 6 weeks in a collar. The last patient had a fracture through the entire third cervical spine transverse foramen requiring evaluation of the vertebral artery and a collar for 6 weeks.

**DISCUSSION**

In an era of increasing health care costs, there is a great deal of motivation to minimize health care costs and maximize efficiency, but this should be weighed against optimal patient care. Although a large number of negative radiographs results in what seems to be unnecessary resource utilization, one missed injury such as a cervical spine fracture can have devastating consequences. Up to 29% of patients develop partial or full paralysis with a delay in diagnosis of cervical injury with settlement costs that can exceed several million dollars. The cost can quickly outpace that of the negative films. In a recent cost-minimization study by Grogan et al., they found that settlement costs would average over $58,000 for an institution, whereas screening plain films would be $2,142 and CTs would cost $554, even if the fracture rate was only 0.9% with a paralyzation rate of 1.7%.

Consequently, many studies have tried to determine which patients benefit from radiographic evaluation and which patients can be safely evaluated clinically. The most recent EAST guidelines suggest three-view plain films complemented by CT for the upper cervical spine in the patient with a significantly altered mental status. This recommendation is based on the findings of Widder et al. and Borock et al. who noted no missed injuries when CT was added to plain films in this population. Our study confirms this association between cervical spine fractures and closed head injury. Logistic regression in our study demonstrated initial GCS as an independent predictor of fracture. Because this is a consistent finding in the literature, radiographic evaluation is clearly necessary in the nonawake and nonalert patient.

More controversy, however, revolves around the awake and alert trauma patient. Evidence seems to be mounting to support clinical examination as adequate to rule out cervical spine fractures in this group. In 2000, The National Emergency X-Radiography Utilization Study Group published a prospective, observational study evaluating a decision instrument at 21 centers in the United States. The decision instrument included documentation of the following five findings: nontender posterior midline cervical spine, no focal neurologic deficit, normal level of alertness, no evidence of intoxication, and no obvious distracting injury. If the patient had none of the five criteria, they were considered to have a low probability of injury to the cervical spine. More than 34,000 patients were included, of whom 818 patients had cervical spine fractures and all but eight were identified with the decision instrument. Because only two of those eight patients were considered clinically significant, this study concluded that use of these criteria can safely reduce the majority of films performed in blunt trauma patients.

Unfortunately, the study includes all blunt trauma victims who come through the emergency department including the small subset that require trauma team activation. Therefore, it might not be appropriate to extrapolate their findings to the more severely injured trauma team activation patients regardless of the absence of the five criteria. In our study, the subset that would have been considered low probability for cervical fracture (n = 320), as suggested by the above study, had seven missed injuries and four of them required intervention. In a trauma team activation population of 320 patients, this is a significant rate of missed injury.

Another issue that arises with this topic is the ideal diagnostic tool to determine a cervical spine fracture. A majority of studies used multiple plain films to make the diagnosis. Many of these found CT necessary when plain films were inadequate. Recently, McCulloch et al. evaluated the role of helical CT to diagnose these injuries. They prospectively identified 407 patients of whom 58 had cervical spine fractures. The patients all had CT and three-view plain films and both were read by radiologists blinded to the findings on either study. Plain films were inadequate in 52% of the patients with a sensitivity of 45% and a negative predictive value of 91%. CT had a sensitivity of 98% and a negative predictive value of over 99%. Given the inaccuracy of the plain film and the time-consuming resources involved, trials using them as the gold standard need to be reevaluated. There might be more missed injuries than identified on plain films alone. Another consideration for the use of CT is that the majority of these patients are having CTs performed for other reasons. Including a cervical spine CT adds minimally to the time involved in the work-up of the patient. Given that the Grogan article found that a CT actually cost less because it is more sensitive, resulting in less missed injury and, therefore, lower settlement costs, it makes good practical and economic sense to replace multiple plain film views with CT.

We are unaware of other prospective trials that include a clinical examination comparison to CT in all patients. Recently Sanchez et al. published on the value of CT to identify these injuries, but patients without suspicious findings on examination did not receive a CT, raising the question of missed injuries. We think that using CT as the gold standard of diagnosis of fractures will avoid missed injury and the false sense of security when negative plain films accompany a negative clinical examination. Diaz et al. recently confirmed the sensitivity and specificity of CT to identify fractures. Moreover, Schuster et al. found that additional tests, such as MRI, were superfluous for patients who did not have any abnormal CT findings or motor deficits.

Our findings are in direct contrast to previously published articles regarding the role of clinical examination, even for the patients with a GCS of 15 with no distracting injury who are not intoxicated. We think there are two main reasons for our contrary results. First, CT is more likely to
demonstrate injuries that would otherwise have been missed with plain films alone. Second, because the physicians were not instructed to focus specifically on the cervical spine evaluation, we think these results more accurately reflect the routine evaluation performed during a trauma resuscitation. Therefore, there was no performance bias by doctors who knew that their clinical skills were being critiqued against the results of the CT. Their behavior was not altered, and their examination was not made more accurate. As shown in the last two tables, our “blinded” physicians inaccurately evaluated patients who were evaluable based on GCS and mental status. We think these findings truly reflect our poor clinical skills at identifying these fractures.

In conclusion, this study suggests that more effort needs to be placed on improving clinical examination skills, by performing a better assessment of the neurologically intact, nonintoxicated patient with no distracting injuries. This effort should improve the sensitivity and specificity of examination. However, because our study calls into question the clinical examination, more trials comparing clinical examination with CT and not three-view plain films as the gold standard of diagnosis should be performed. Given that the majority of these patients undergo CT for other purposes, we think that it is an appropriate screening tool for cervical spine injury in all patients who qualify for trauma team activation.

REFERENCES

DISCUSSION
Dr. Peter B. Letarte (Chicago, Illinois): Dr. Duane et al. have shown us that, in spite of all the profundity usually issued from podiums about protocols for clearing the cervical spine, in actual applications these protocols, in this case the EAST protocol, miss a significant percentage of fractures.

In this study, when checked against state-of-the-art CT imaging, the EAST protocol had a sensitivity of only 76%. The authors conclude that clinical examination is unreliable to diagnose or exclude cervical spine fracture.

In an article by Pech from 1987, CT scans were compared with cryomicrotomy. In this study, cadavers were dropped on their heads to induce cervical fractures, were CT scanned, and then frozen and sectioned.

The study is of interest because it provided a rare chance to evaluate the actual sensitivity of CT. It turned out that the sensitivity of CT for certain types of fractures was not very good at all. But it also turned out that the fractures being missed were probably not of any clinical significance.

In the current study more fractures are being identified by CT. The authors have a 9.7% incidence of cervical spine fractures for all comers, as compared with the 7% incidence
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I believe the authors speak for many of us when they state in their text that, “We think these findings truly reflect our poor clinical skills at identifying these fractures”.

I have several other questions for the authors. First, do you agree that this is a study of efficacy, or do you think it is a statement on the effectiveness of the clinical examination?

Do you have any thoughts on what could be done to make clinical spine clearance more practical in the busy trauma bay, or is CT scanning for everyone our only solution?

There are several articles proposing various protocols for clinically clearing the cervical spine. Do you think that a different protocol would yield better results in the real world?

You talk about patients with a GCS of 15, and that the sensitivity of the clinical examination actually got worse in this patient group. Do you think that GCS is the best criteria to evaluate the patient’s capacity to cooperate with clinical clearance of the cervical spine or should other objective criteria be used?

I also think that substituting technology for clinical acumen is hardly ever effective and is always expensive.

Dr. Therèse M. Duane (Richmond, Virginia): First of all, I can’t drop my patients on their heads on purpose so I won’t be able to redo that study, but we’ll do the best that we can.

As far as I think that it is important to identify just the clinically significant ones, yes, absolutely, which is why we separated out the four that were identified as clinically significant based on the fact that they required more intervention with prolonged collars.

I don’t think we need to pick up every single fracture because we’ve already studied this in the pelvic X-ray arena, where we’ve clearly identified all clinically relevant fractures and that’s all we care about. My concern is that, in the realm of the c-spine, a missed injury has much more untoward consequences.

I agree with you. I think this is an efficacious study as far as we might have a .22 in our hands that might be very valuable at killing somebody but if we can’t aim it, it doesn’t do us any good. I think we’re just not that good at it despite what we would like to believe.

Do I think a protocol somehow would improve our efficacy and our effectiveness? Yes, absolutely. I just don’t think we have it yet. Despite our best efforts, we’re still missing them; therefore, I do think, at this point in time, it’s not plain films and it’s not clinical exams that are going to answer the question, it’s the CT scan.

I agree that there is probably a better study than GCS to determine how awake and alert and appropriate a patient is to answer the questions. I just don’t think we have it yet, and this is our best guess.

Dr. Lawrence H. Pitts (San Francisco, California): One of the slides that you presented indicated a cost of missed fractures and indicated that if the missed fracture rate was about 1.5% and the paralysis rate was about 0.9% or whatever the number was. It sort of implies a very high neurologic
deficit rate per fracture, and clearly that’s not the case. I think your own data shows that.

I think the missing data that needs to be addressed would be a combination of a clinical exam, including mechanism as part of that information, coupled with plain films and then, finally, CT in a much smaller subgroup.

If what we’re looking for is some reasonable bridge between cost-effectiveness and patient safety—the question is—how do plain films fit into your study or the other studies that you quoted? How would that improve the performance of the clinical exam?

**Dr. Therèse M. Duane**: As far as I am concerned and from what I’ve seen in the literature, the plain films in almost all the other studies that I quoted were part of their ability or their use of ruling out a fracture.

We did not do that because we found that they are fraught with inaccuracies, and I agree and think that they continue to be problematic. So if you’re talking about cost-effectiveness, I think you have to consider time and resource utilization and multiple plain films take a lot of time and a lot of resources. And if they’re 50% inaccurate, I don’t think it’s worth bothering about, which is why I think CT scans are definitely the way to go. Even though they cost more, they’re much more time and resource effective.

**Dr. David P. Blake** (Japan): I, too, have a little bit of a concern, particularly for those of us who practice in a more austere environment, perhaps some warm and sandy places as well.

What is the cost of this transfer to get a patient to CT? And do you think that’s absolutely necessary in most of these patients, when your nearest CT scanner might be miles and miles away?

**Dr. Therèse M. Duane**: I’m not suggesting that we extrapolate it necessarily into the military arena or into a more austere area.

However, that’s not what we’re dealing with in our trauma bays in the United States. And because of that, that’s what this study is based on. And because people are going for CTs anyway, and I don’t like to use that as just an excuse, it is much quicker and much more time effective and you’re getting your answer.