Asymptomatic cervical spine fractures: Current guidelines can fail older patients

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BACKGROUND: Older adults represent a growing proportion of trauma patients treated in the United States, and cervical spine (c-spine) fracture is an injury that is increasingly common in this population. Neck pain is a major component of current clinical clearance guidelines, but some older adults with c-spine fractures report no neck pain after injury. The objective of this study was to investigate the frequency at which c-spine fractures were unassociated with neck pain in an aging population.

METHODS: A retrospective review was performed for patients 55 years or older with a c-spine fracture during a 4-year study period. All patients had a Glasgow Coma Scale score of 15 and were considered asymptomatic if they did not complain of neck pain on initial presentation, denied tenderness to palpation of the c-spine on examination, and were without neurologic deficit. Differences between groups were assessed with Kruskal-Wallis and χ^2 tests.

RESULTS: Of 173 patients with c-spine fractures, 36 (21%) were asymptomatic and reported no neck pain on presentation or on examination. The group without neck pain had higher median injury severity scores (15 vs 10; $p < 0.001$), were more likely to have another injured body region (69% vs 42%; $p = 0.004$), and had longer hospitalization (7 vs 5 days; $p = 0.008$) than patients with neck pain. Twenty-two percent of the symptomatic group and 19% of the asymptomatic group required halo, fusion, or other surgical intervention.

DISCUSSION: Study results indicate that one fifth of patients with a c-spine fracture reported no pain on initial presentation and denied tenderness to palpation on examination. The presence or absence of pain may be an unreliable indicator of c-spine fracture in an aging population. When used in conjunction with existing clearance guidelines, denial of pain may lead to missed injury. We recommend liberal c-spine imaging for older trauma patients with significant mechanism of trauma. (*J Trauma Acute Care Surg.* 2017;83: 119–125. Copyright © 2017 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Therapeutic study, level III.

KEY WORDS: Geriatric trauma; cervical spine fracture; radiology; pain; clearance protocols.

The United States population continues to age. Based on US Census projections, 30% of the general population will be 55 years or older by 2020.[1] Unsurprisingly, this shift corresponds to an increasing number of older trauma patients. According to figures from the National Trauma Data Bank, 25% of all trauma patients in 2005 were 55 years or older; a decade later, this percentage increased to 41%.[2,3] Geriatric trauma is on the rise, and many trauma centers and trauma organizations are working diligently to improve processes of care for this population.[4–8]

An injury that is common among older adults is cervical spine (c-spine) fracture; the literature reports prevalence of this injury anywhere between 2% and 13%.[9–20] One symptom commonly associated with c-spine fracture is the presence of neck pain or tenderness to palpation of the neck. This is a component of several best practice protocols that guide clinical clearance of the c-spine, including the National Emergency X-Ray Utilization Study (NEXUS) guidelines, published in 2000, and the Canadian C-Spine Rule for Radiography in Alert and Stable Trauma Patients (CCR), published in 2001.[16,21] Despite its prominence in the clearance guidelines, however, only a handful of studies have evaluated if presence or absence of neck pain is an adequate indicator of c-spine fracture in older patients who are alert and oriented. Evans et al.[14] found that 34% of patients 65 years and older with a c-spine fracture had no tenderness on examination, and Shrag et al.[20] reported that more than half of patients 65 years and older who sustained a c-spine fracture after a fall from standing or sitting had no tenderness on examination. These numbers are alarmingly high and deserve further investigation.

The purpose of the present study was to investigate the association of neck pain and c-spine fracture in an aging population. Specifically, we examined a population of trauma patients 55 years and older with known c-spine fractures to determine if they reported pain on presentation or clinical examination.

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METHODS

Study Design and Patient Sample

A retrospective study was performed at a Level I adult trauma center in the Midwest. The hospital is located in a medium-sized city, and one third of all patients are transferred in from rural facilities within a 100-mile radius of the hospital. The trauma center serves an aging population; in 2015, nearly half of all trauma patients were 55 years or older. Ethical approval for this study was obtained from the hospital's institutional review board. Because data were collected retrospectively, the requirement of informed consent was waived by the institutional review board.

The center's trauma registry was used to identify patients 55 years and older with a c-spine fracture during the 4-year study period (March 2012 to February 2016). Age 55 was chosen as the threshold for study inclusion criteria because it compliments Centers for Disease Control and Prevention (CDC)[22] national triage guidelines and matches the study institution's demographic profile. Patients were excluded if the Glasgow Coma Scale (GCS) was less than 15 at the time of clinical examination, if there was any neurologic deficit or baseline dementia, if the patient was heavily intoxicated, or if documentation from the transferring hospital was unavailable.

Chart review of the electronic medical record was conducted for data not included in the trauma registry. A standardized data abstraction form was used for chart review. To ensure consistency, 20% of charts (n = 37) were randomly selected to test for interrater reliability. Percentage agreement (% agreement) and kappa statistic (κ) were considered moderate to strong: report of pain (% agreement, 92%; κ, 0.84; $p < 0.001$) and tenderness on examination (% agreement, 87%; κ, 0.80; $p < 0.001$). To compute sensitivity and specificity, additional abstraction was conducted to determine the presence or absence of neck pain before CT imaging for patients who met the aforementioned study inclusion criteria but did not sustain a c-spine fracture (% agreement, 91%; κ, 0.80; $p < 0.001$).

Study Variables

Variables in the analyses included sex, age, and mechanism of injury. Hospital days were calculated such that any partial day counted as a full day. Intensive care unit days and discharge disposition were coded to the National Trauma Data Standard (NTDS). Mortality included deaths in the hospital. Injury diagnoses were derived from the Abbreviated Injury Score (AIS-1998), which was used to calculate the overall injury severity score (ISS). Other injured body regions were considered if there was an AIS severity score of 2 or higher in the head, thorax or abdomen, or extremity region. Treatment of c-spine injury was derived from *International Classification of Diseases, Ninth Revision, Clinical Modification* procedure codes and neurosurgical consultation notes. Categories included fusion or surgical repair, halo, spinal orthoses, hard collar, or no treatment. If a patient was discharged in a soft collar for comfort only, this was categorized as no treatment.

C-spine fracture was defined as any acute fracture of the C1 through C7 vertebrae; this excluded fractures that were considered nonacute or age-indeterminate. Fractures were specified by level and type using official radiologic reports. Initial abstraction of degenerative joint disease (DJD) was abstracted from the radiology report; if degeneration was not mentioned in the report, the original images were reviewed by a board-certified radiologist (B.D.K.) to determine the absence or presence of DJD. The radiologist was not blinded to the presence of fracture during review.

Emergency department and trauma center documentations were reviewed for notation of c-spine pain, and patients were assigned to one of the two patient groups. A patient was considered to be symptomatic if any neck pain was documented in the Review of System, if there was any anecdotal notation of patient report of neck pain in the physician's history and physical, or if there was any documentation of pain or tenderness to palpation on clinical examination. A patient was considered asymptomatic when it was explicitly clear that the patient denied neck pain and reported no tenderness to palpation. When documentation was unclear or there was a possibility that the clinical examination was incomplete or poorly documented, the patient was considered to be symptomatic. We used only documentation from before the computed tomography (CT) scan to avoid bias. If there was no documentation from before CT imaging, the patient was excluded from analyses.

Statistical Procedures

All analyses were performed with IBM SPSS Basic Statistics for Windows, version 20.0 (IBM Corp, 2011). Descriptive statistics were examined and reported for continuous data as medians and interquartile ranges; categorical data were reported as counts and percentages. All statistical tests were two-tailed and based on a 0.05 significance level. Because data were not normally distributed and sample sizes were unequal, differences between medians were assessed using the Kruskal-Wallis one-way analysis of variance. Differences between nominal variables were assessed using the χ^2 test.

RESULTS

During the study period, 2,390 patients 55 years and older presented to the study hospital with a Glasgow Coma Scale score of 15, and 1,071 (45%) received a c-spine CT scan (Fig. 1). Of those who received c-spine CT imaging, 183 patients (17%) were found to have a c-spine fracture and 173 (16%) met study inclusion criteria. Overall, 36 (21%) of the 173 patients with a c-spine fracture were asymptomatic and reported no neck pain on presentation or on examination. Presence of neck pain was associated with 79.2% sensitivity (confidence interval [CI], 72.4–85.0%) and 59.6% specificity (CI, 56.3–62.8%) for cervical spine fracture. Neck pain had a positive predictive value of 27.6% (CI, 25.5–29.9%).

Demographic and injury characteristics of the sample are found in Table 1. The groups did not differ statistically by sex, age, mechanism of injury, presence of DJD, or mortality. More than half of all patients were transferred to the trauma center from a nontertiary hospital; 93% of symptomatic patients received cervical spine CT imaging at the nontertiary hospital before arrival at the transfer center, compared to 75% of asymptomatic patients ($p = 0.01$).

Patients without neck pain had a higher median ISS (15 vs 10; $p = 0.001$) and longer hospitalization (7 vs 5 days; $p = 0.008$)

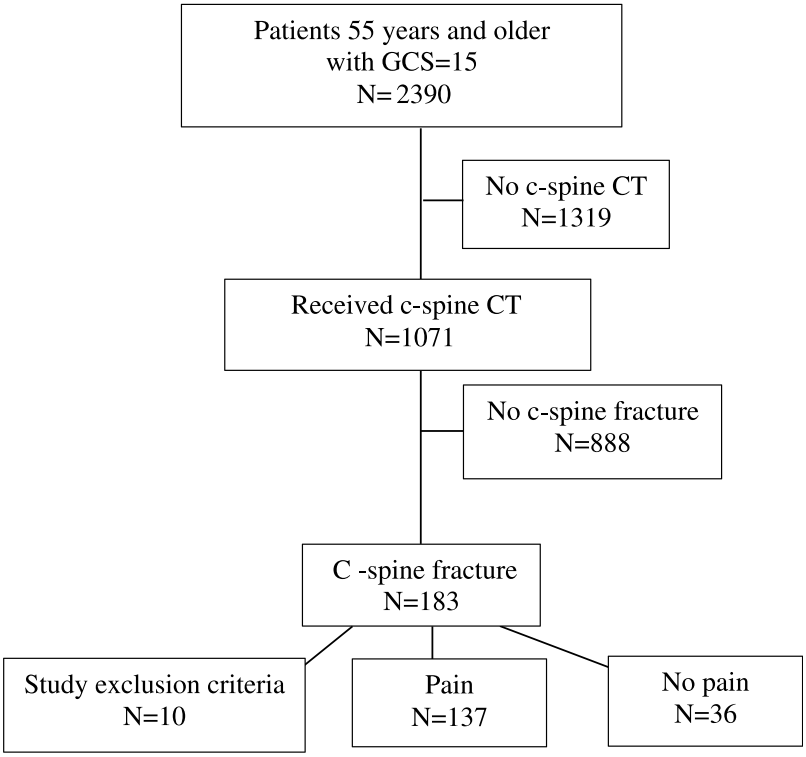

Figure 1. Study sample.

than patients who reported pain. In addition, more than two thirds of asymptomatic patients had an injury in another body region. While the groups did not differ significantly in the prevalence of head or extremity injuries, significantly more asymptomatic patients had a thoracic or abdominal injury.

Level and Type of C-Spine Fracture

Overall, more than one third of all patients had a c-spine fracture at more than one level. This differed by group, with 65% of patients with neck pain and 35% of patients without neck pain having more than one c-spine fracture, but the difference was not statistically significant ($p = 0.43$). As shown in Figure 2, the most common level for a fracture was at the C2 (n = 95), and half (n = 48) of patients with a C2 fracture had a Type II odontoid fracture. More than one quarter of patients with a C3, C6, or C7 reported no pain or tenderness on clinical exam.

Type of fracture is presented in Table 2. The most frequent type across both groups was odontoid; more than one third of patients with neck pain and one fifth of patients without neck pain had this type of fracture ($p = 0.08$). Other common fractures included vertebral body, arch, and facet, but there were no statistically significant differences across study groups for these fractures.

Patients' Age

Report of neck pain did not differ statistically by age of patient. As shown in Figure 3, the age group most likely to report pain was 75 to 84 years, with 83% of patients reporting pain on examination. Conversely, 26% of patients 65 to 74 years reported no neck pain. Even at the youngest age category, 21% of patients aged 55 to 64 years had no neck pain on report or examination, which mirrored the overall incidence of asymptomatic fractures in this study sample.

Fractures Requiring Intervention

As shown in Table 1, one quarter of patients without neck pain received no treatment for their fracture. However, a sizable percentage of patients in both categories required major intervention for fracture stabilization. Twenty-two percent of symptomatic patients and 19% of asymptomatic patients required surgical intervention or halo; this did not differ statistically by group. Sixty-one percent of patients with neck pain and 47% of patients without neck pain were discharged with a hard cervical collar.

DISCUSSION

Current guidelines state that radiological imaging is unnecessary for safe clearance of the cervical spine in awake and alert blunt trauma patients who deny neck pain on examination. While these protocols may work well with minimally injured or younger patients, they can fail older adults. Study results indicate that one fifth of patients 55 years and older with a c-spine fracture reported no pain on initial presentation and denied tenderness to palpation on examination. All patients had normal mental status and were without neurological deficit. Findings should give pause to clinicians and warrant an abundance of caution when evaluating older trauma patients.

The CCR recommends radiologic studies for clearing the c-spine of patients 65 years and older, but this age threshold may

TABLE 1. Demographic and Injury Characteristics (N = 173)

	Pain (N = 137)	No Pain (n = 36)	*p*
Male, n (%)	63 (46)	19 (53)	0.57
Age, median (IQR)	78 (65, 85)	78 (63, 86)	0.76
Mechanism of injury, n (%)			0.53
Fall from height	25 (18)	8 (22)	
Fall from same level	68 (50)	13 (36)	
Motor vehicle crash	40 (29)	14 (39)	
Other	4 (3)	1 (3)	
Degenerative joint disease (DJD), n (%)	129 (94)	33 (92)	0.59
Transferred from nontertiary hospital, n (%)	84 (61)	20 (56)	0.57
CT at nontertiary hospital before arrival	78 (93)	15 (75)	0.01
Neurosurgical consultation, n (%)	131 (96)	34 (94)	0.67
Treatment of injury, n (%)			
Fusion or other surgical repair	12 (9)	4 (11)	0.75
Halo	18 (13)	3 (8)	0.57
Spinal orthoses	11 (8)	4 (11)	0.52
Hard cervical collar	84 (61)	17 (47)	0.13
No treatment	12 (9)	9 (25)	0.02
Injury severity score (ISS), median (IQR)	10 (9, 13)	15 (10, 20)	0.001
Other injured body region, not mutually exclusive, n (%)	57 (42)	25 (69)	0.004
Head body region	22 (16)	8 (22)	0.46
Thorax/abdomen body region	28 (20)	14 (39)	0.03
Extremity body region	27 (20)	12 (33)	0.12
ICU days, median (IQR)	0 (0, 2)	1 (0, 4)	0.07
Hospital days, median (IQR)	5 (3, 8)	7 (5, 15)	0.008
Mortality, n (%)	4 (3%)	0 (0%)	0.58

TABLE 2. Type of Fracture (Not Mutually Exclusive); n (%)

	Pain (N = 137)	No Pain (n = 36)	*p*
Odontoid	54 (39%)	8 (22%)	0.08
Arch	29 (21%)	4 (11%)	0.24
Vertebral body	28 (20%)	11 (31%)	0.26
Facet	20 (15%)	3 (8%)	0.42
Spinous process	14 (10%)	6 (17%)	0.38
Transverse process	11 (8%)	4 (11%)	0.52
Laminar	8 (6%)	2 (6%)	0.99
Lateral mass	7 (5%)	1 (3%)	0.99
Other	4 (3%)	3 (8%)	0.16

be too high to adequately capture a population requiring special attention. A distinct contribution of the current study is that age 55 years and older was used as the lower bound of study inclusion criterion, which complements the CDC[22] national triage recommendations as the age threshold at which special consideration is warranted. Overall, study findings were equivalent across age groups and were replicated in the youngest age category, with 21% of patients aged 55 to 64 years reporting no pain on examination. While these patients would not be considered "elderly" by conventional standards, results suggest that there is something unique about older trauma patients. They appreciate pain differently than their younger counterparts and must therefore be cared for differently owing to their unique comorbidities and age-related processes that affect perception of pain.

More than half of all patients who received a c-spine CT scan had no pain on examination. It is unclear why asymptomatic patients received a cervical CT scan, but we speculate that the reasons are multifaceted. First, more than half of all patients were transferred to the trauma center from a nontertiary hospital; imaging may have been used to determine whether the patient required transfer to a higher level of care. Second, the literature confirms that radiologic imaging is on the rise, especially in older populations.[23] With increased availability of CT technology and rapid turnaround for results, CT scans are used frequently if providers have any reason to exercise caution.

Third, CT imaging is considered the criterion standard in clearing the c-spine,[24] and we suspect that providers may already be exercising caution in this population to avoid missing significant injuries. In a study at a large trauma center, Morrison and Jeanmonod[25] found that nearly one third of NEXUS-negative patients underwent c-spine imaging. Survey data indicated that imaging was obtained because of advanced patient age, mechanism of injury, or because providers were already obtaining a head CT. The authors suggest that clinicians have a general

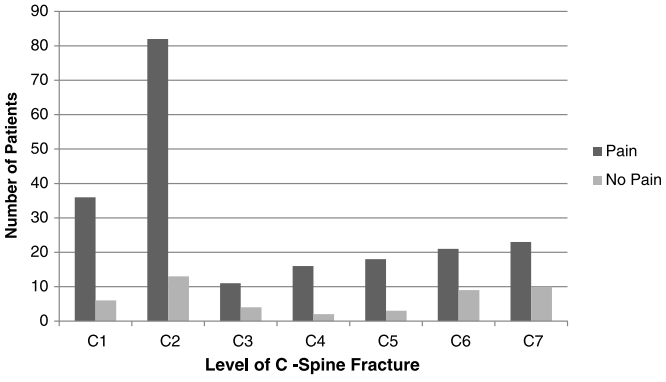

Figure 2. Level of c-spine fracture by report of neck pain, not mutually exclusive (N = 173).

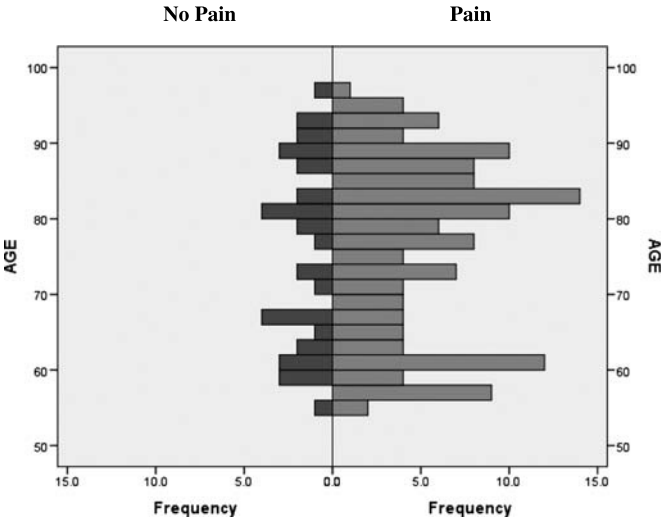

Figure 3. Report of pain by age of patient (N = 173).

discomfort in applying c-spine clearance criteria to elderly patients. We believe these concerns are consistent with providers' perspectives and practices at our trauma center.

A substantial proportion of all patients in the study had another injured body region, but this was higher in the asymptomatic group. Patients without neck pain also had a higher ISS and longer hospital stays. We suspect that other injuries may have distracted from or masked neck pain, but this was not explicitly tested as a hypothesis. While distracting injury is a component of the NEXUS criteria, no clear-cut definition of distracting injury is available. Rose et al.[18] reported that the notion of distracting injury originated without scientific basis and should not be considered when clearing the c-spine, and other authors have noted that identification of distracting injury does not increase accuracy in identifying c-spine fractures.[14,26] More work is warranted, however, to determine the role of distracting injury in this patient population.

Results should trigger concern and hesitation for using denial of neck pain to clear the cervical spine of older patients. So this begs the question: should all older patients receive a cervical CT scan? On the one hand, it would not be out of line to propose such an extreme response. Recently, the American College of Surgeons' Trauma Quality Improvement Program issued best practice guidelines for geriatric trauma and specified liberal use of CT scanning for geriatric patients after injury due to high risk of occult injury.[27] If our findings suggested that 5% to 10% of older patients with c-spine fractures were without neck pain, one could argue that results were simply an artifact of retrospective study design or inadequate physician documentation. However, 21% of patients were without pain and 19% of those patients required a major intervention to correct an unstable fracture. The percentage of patients requiring major intervention would be even larger if we focused solely on patients with unstable fractures who were appropriate surgical candidates. These are significant numbers that signal a real problem. Given the high prevalence of c-spine fracture in the elderly and the potential danger of missing a clinically significant fracture, practitioners should be vigilant for these injuries regardless of patients' report of neck pain.

The counterpoint, however, is that that not every patient older than 55 years needs a CT scan. While it is not well understood, some older adults sustain low-energy mechanism of trauma and remain uninjured. A more realistic solution, as suggested by Duane et al.,[11] may be to add c-spine CT imaging to the radiologic panel if the physician is concurrently ordering a head or chest CT. Alternatively, Duane et al.[13] more recently suggest that while NEXUS and CCR may be used to clear less severely injured patients, a noncontrast c-spine CT should be required for all patients who meet CDC trauma activation criteria. While their recent study included all adults 18 and older, patients meeting CDC triage criteria had a sixfold increase in risk of c-spine injury. Computed tomographic imaging is justified for patients with a mechanism of trauma significant enough to warrant a trauma activation.

In closing, we note that current clearance guidelines may fail older patients. The original NEXUS and CCR guidelines were published in 2000 and 2001, respectively, and were validated in populations with minor injury.[12] The Eastern Association for the Surgery of Trauma (EAST), which has a strong reputation for producing high-quality evidence-based protocols, also falls short on this issue: the EAST guideline for c-spine clearance (2009) is silent on the topic of age;[28] the EAST geriatric guideline (2012) does not make recommendations for imaging in the geriatric population;[4] and the EAST cervical spine collar clearance guideline (2015) is for obtunded patients.[29] At the time of writing, there is nothing under development or revision with EAST that specifically addresses imaging of the c-spine in nonobtuned elderly trauma patients. While our retrospective study may not provide the definitive answer, additional work is warranted. Next steps include significant revisions to the clearance protocols at our trauma center and a subsequent study to prospectively evaluate asymptomatic c-spine fractures in our elderly trauma population.

Limitations

First, results are from a single trauma center and may not be generalizable to other trauma centers. Specifically, the age distribution at our trauma center is different from some parts of the United States. In 2015, nearly half of the total trauma population at this center was 55 years or older and 18% was aged 81 years or older. Clearly, the study center is treating an elder population and results may be specific to our institution because of those trends.

Second, the data were collected retrospectively and were hindered by imperfections in documentation. It is also possible that patients were inadequately evaluated, both in their baseline status (which affects study inclusion criteria) and evaluation of pain (which affects study outcomes). We were as cautious as possible in our review of charts and assignment of patient groups; a patient was considered asymptomatic only if there was very clear documentation of the patient denying pain. It is likely that our results are underreporting the true prevalence of pain-free neck fractures in this population due to our conservative methodology.

Finally, it is impossible to know the true incidence of missed injury in this population using a retrospective design. It is plausible that some patients who initially denied neck pain and were cleared clinically developed pain after they returned home, but that cannot be ascertained with these study data.

CONCLUSION

Best practice guidelines specify the conditions by which c-spine can be cleared without imaging after trauma, and patient report of neck pain is a major component of these guidelines. Study findings indicate that report of neck pain is an unreliable indicator of c-spine fracture in alert trauma patients older than 55 years. Based on our findings, we support American College of Surgeons' Trauma Quality Improvement Program recommendations for liberal use of CT imaging in older populations and call for enhanced efforts in the trauma community to develop dedicated geriatric guidelines to improve care for older adults.

AUTHORSHIP

C.D.H. and C.A.P. were involved in study design, data acquisition, interpretation of data, and drafting and critical revision of the manuscript. S.K.S. was involved in study design, data acquisition, analysis and interpretation of data, and drafting and critical revision of the manuscript. B.D.K. was involved in data acquisition, interpretation of data, and critical revision of

the manuscript. J.E.S. was involved in interpretation of data and critical revision of the manuscript.

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DISCLOSURE

The authors declare no conflicts of interest.

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EDITORIAL CRITIQUE

Dr. Healey and colleagues have published a retrospective review investigating the prevalence of asymptomatic cervical spine (CS) fractures in an aging population. In this study, conducted over a four-year period, all patients aged 55 and older with a GCS of 15 and a CS fracture were included. Patients were considered asymptomatic if, on review of the electronic medical record (EMR), they did not complain of neck pain, have CS tenderness on examination, or have neurologic deficit. The authors report that of 173 patients with CS fractures, 36 (21%) were asymptomatic. They thus recommend liberal CS imaging for older trauma patients with a significant mechanism of injury. I congratulate the authors for their work, but I have several concerns about this study.

I do not believe that the EMR can reliably determine retrospectively if a patient has a complaint of neck pain or a finding of CS tenderness on examination. The patient's chart is meant

for clinical care and may not contain the information needed to answer a research question such as this. Those who enter data into the EMR often carelessly copy and paste from a template. In this study, a patient may have had CS pain or tenderness, but this may not have been accurately documented in the EMR.

The authors note that the asymptomatic group had a higher mean Injury Severity Score than the symptomatic patients. Because they were more severely injured, it seems likely that they may have had distracting injuries. In fact, it is stated that two-thirds of asymptomatic patients had an injury in another body region. Perhaps, in these patients, there was no complaint of neck pain or CS tenderness because of distracting injuries.

Finally, this study does not show that asymptomatic CS fractures are truly occurrences that affect only older patients. The authors did not assess asymptomatic CS injuries in patients younger than 55. Perhaps they would have found the same phenomenon in the younger patient, had this been investigated. To accurately state that "current guidelines can fail *older* patients," the miss rate is in the younger patient would also have to be known.

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