Selective Cervical Spine Radiography in Blunt Trauma: Methodology of the National Emergency X-Radiography Utilization Study (NEXUS)

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Fear of failure to identify cervical spine injury has led to extremely liberal use of radiography in patients with blunt trauma and remotely possible neck injury. A number of previous retrospective and small prospective studies have tried to address the question of whether any clinical criteria can identify patients, from among this group, at sufficiently low risk that cervical spine radiography is unnecessary. The National Emergency X-Radiography Utilization Study (NEXUS) is a very large, federally supported, multicenter, prospective study designed to define the sensitivity, for detecting significant cervical spine injury, of criteria previously shown to have high negative predictive value. Done at 23 different emergency departments across the United States and projected to enroll more than 20 times as many patients with cervical spine injury than any previous study, NEXUS should be able to answer definitively questions about the validity and reliability of clinical criteria used as a preliminary screen for cervical spine injury.

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INTRODUCTION

Unrecognized cervical spine injury can produce catastrophic neurologic disability. Fear of failing to diagnose such injuries has led to the use of radiographic spine imaging in virtually all cases of multiple blunt trauma.[1,2] This practice exposes large numbers of patients to x-ray imaging, at considerable expense, while detecting injuries in a small minority.[1-7] It is estimated that each year in the United States approximately 800,000 people undergo cervical spine radiography, at a cost of $180 million.[8] These radiographs identify cervical spine injuries in only 10,000 cases,[9,10] leaving the remaining 790,000 individuals (almost 98%) with the expense and radiation exposure of a negative examination.[8,11,12]

Relatively small prospective studies have led to the development of criteria that appear to identify those patients with blunt trauma who have at most a minimal risk of cervical spine injury.[8,12-16] If these criteria can be validated as safe and reliable, their implementation could reduce radiographic imaging by almost one third.[8] Reduced imaging would result in a $60 million annual decrease in radiographic charges, and reduced radiation exposure would spare many patients excess morbidity and mortality from radiation-induced thyroid and other malignancies.

The NEXUS group was organized to evaluate the previously derived clinical criteria and determine whether they can reliably identify patients who have "no risk" of cervical spine fracture or dislocation and who could consequently be spared radiographic evaluation. The multicenter study is designed to test the hypothesis that blunt trauma victims have virtually no risk of cervical spine injury if they meet all of the following criteria: (1) no neurologic abnormalities, including normal level of alertness and absence of focal deficits; (2) no evidence of intoxication; (3) no posterior midline cervical spine tenderness; (4) no other distracting painful injury. The methodology for the NEXUS study is described here.

MATERIALS AND METHODS

NEXUS is a multicenter, prospective, observational study of ED patients with blunt trauma for whom cervical spine imaging is ordered. Participating centers represent a wide variety of facilities, including university hospitals, community teaching hospitals, and community hospitals without teaching programs; public hospitals and private hospitals; and hospitals with all levels of trauma categorization. In this prospective study, the presence or absence of the 4 low-risk criteria will be ascertained and documented for study patients before cervical spine imaging is done. The presence or absence of cervical spine injury, as determined from all cervical spine imaging studies, will then be documented for each patient.

Patient inclusion criteria

All patients with blunt trauma presenting to participating study centers will be eligible for inclusion in the study. Patients without blunt trauma and those undergoing neck imaging for other reasons will not be eligible. Patients will be enrolled when the examining physician orders radiographic imaging. The decision to obtain cervical spine imaging will be made by ED clinicians based on whatever criteria they ordinarily use. Study participation should not influence the decision to obtain radiographs. The study population will ultimately consist of consecutive patients with blunt trauma for whom cervical radiography has been ordered. Patients who do not undergo imaging will be excluded from participation. There are no other exclusion criteria.

In patients for whom radiographic imaging is ordered, the presence or absence of each of the 4 low-risk criteria will be documented before any images are obtained. All participating institutions have agreed to enforce a rigid protocol whereby cervical spine imaging is not performed on any trauma patient until study data have been collected. Furthermore, such data will be recorded before review of the radiographic studies.

This protocol will be accomplished at all study sites in the following manner: radiology technicians will be instructed not to perform cervical spine imaging unless they first receive a NEXUS computer-generated form authorizing the imaging. These forms will be generated by dedicated NEXUS computers, which have been distributed to each of the study sites. The forms will be generated only after data entry is complete. In some institutions, the form will be an x-ray requisition; in others, it will be a voucher. In all cases, cervical spine radiography will not be performed without the proper form, and forms will be generated only after data entry is complete.

Data will be gathered by examining physicians at the study sites. These physicians will ascertain whether each of the 4 criteria is present, absent, or cannot be determined (eg, neck tenderness in a comatose patient). This information will be entered into the dedicated NEXUS computer by the physician or other ED staff member. The computer will then generate the imaging requisition (or voucher), allowing cervical spine radiography to be performed.

The entire process will involve the collection of only a small amount of the information that is normally gathered in the evaluation of all blunt trauma victims. The data collection should never interfere with patient care.

Data collection can be partially bypassed at the discretion of the treating physician in cases in which even a minimal delay is thought to be capable of producing harm. In cases in which a patient is considered physiologically unstable and any delay may be inappropriate, the clinician may designate the patient as "unstable." The computer will then immediately generate the requisition form without completion of additional data elements. In such cases (which should be extremely rare), physicians will complete the data collection at the earliest opportunity. This process will not threaten the study validity, because all unstable patients will automatically be excluded from the low-risk category by virtue of the injuries that make them

unstable (ie, distracting injuries and/or altered level of alertness). Data will be collected on all patients entered into the study.

Data collection

Data collected by the computer survey will include demographic information (date, time, age, sex, and race) and presence or absence of the 4 study criteria. Each record will also carry embedded information indicating the identity of the institution producing the data. To ensure that the validated low-risk criteria are widely applicable, rigid definitions will not be provided for any of the 4 individual data elements. Clinicians will be asked to judge whether the 4 elements are present based on their routine clinical assessment. However, for purposes of clarification, clinicians will be provided with descriptions of possible markers of non-low-risk characteristics (Figure). These will be presented as informational material to all sites and have been reviewed with clinicians in prestudy inservice sessions. These descriptions will also be listed on "Help" screens that are accessible from the computer entry screens.

Patient consent

NEXUS is an observational study with radiographic ordering at the discretion of the examining physician. The study itself will not mandate or direct any aspect of patient care. Patient confidentiality will be maintained by the assignment of a unique study number to each patient. Because these numbers are not linked to any patient information, it will be impossible to identify individual patients from study data. In addition, the study poses no risk to patients and would be virtually impossible to conduct without a waiver of informed consent. The study protocols and methodology have been reviewed by the institutional review boards at each site, and appropriate waivers have been granted by each participating institution.

Radiographic imaging

Radiographic technicians at each institution will perform cervical spine imaging only after they receive an appropriate computer-generated request. All centers obtain at least 3 standard views (cross-table lateral, anteroposterior, and open-mouth odontoid) as part of their basic cervical spine screening radiography. Cases for which these minimal views are not obtained and no positive findings are identified will be excluded from the study. These initial views may be supplemented by oblique views, flexion-extension radiographs, cervical computed tomography, or any other imaging study deemed necessary by the treating physician.

Fracture diagnosis

All radiographs will be reviewed by the clinical radiologists at the study site. The diagnosis of cervical spine injury will be based on the final radiologic interpretation of all cervical spine radiographs, including studies obtained in the inpatient setting.

Copies of final radiographic readings will be collected and abstracted to determine whether cervical spine injuries are present. Final fracture classification will be made on the basis of these reports. Study investigators will review all ambiguous reports. After examining all available radiologic studies, the investigators will determine the final fracture classification. Data abstracted from each report will be concatenated with the computer survey data to form the final study database.

Participating centers

Study sites comprise a range of acute care facilities, including academic trauma centers, community trauma centers, and community EDs. Study sites are organized

Figure.
Instructions to participating physicians

1. Altered neurologic function is present if *any* of the following is present: (a) Glasgow Coma Scale score of 14 or less; (b) disorientation to person, place, time, or events; (c) inability to remember 3 objects at 5 minutes; (d) delayed or inappropriate response to external stimuli; or (e) any focal deficit on motor or sensory examination. Patients with none of these individual findings should be classified as having normal neurologic function.

2. Patients should be considered intoxicated if they have either of the following: (a) a recent history of intoxication or intoxicating ingestion; or (b) evidence of intoxication on physical examination. Patients may also be considered to be intoxicated if tests of bodily secretions are positive for drugs that affect level of alertness, including a blood alcohol level greater than .08 mg/dL.

3. Midline posterior bony cervical spine tenderness is present if the patient complains of pain on palpation of the posterior midline neck from the nuchal ridge to the prominence of the first thoracic vertebra, or if the patient evinces pain with direct palpation of any cervical spinous process.

4. Patients should be considered to have a distracting painful injury if they have any of the following: (a) a long bone fracture; (b) a visceral injury requiring surgical consultation; (c) a large laceration, degloving injury, or crush injury; (d) large burns; or (e) any other injury producing acute functional impairment. Physicians may also classify any injury as distracting if it is thought to have the potential to impair the patient's ability to appreciate other injuries.

into geographic regions. Participation of a wide range of hospitals increases the external validity of the study and makes results generalizable to the majority of trauma victims.

Sample size calculations

To be clinically reliable, selective criteria must satisfy 2 requirements. First, the criteria must exhibit a 100% negative predictive value. This implies that the patients identified as risk free by the criteria will never be found to have cervical spine injuries and may safely forego radiographic evaluation. Second, the criteria must be 100% sensitive. This requirement implies that every patient with cervical spine injury will exhibit at least 1 of the risk criteria (and subsequently be identified and undergo radiographic imaging).

Verification of negative predictive value and sensitivity at an absolute level is not statistically possible with a finite sample size. However, it is possible to estimate limits for the true values of these proportions. For large sample sizes, inferences about these proportions can be made with the use of the binomial probability distribution. Following the method of Fleiss,[17] the lower confidence limit of a proportion (such as negative predictive value or sensitivity) is related to the total size of the study population. The quantitative relation is expressed by the following equation:

$$P_L = \frac{(2np + c\alpha/_2{}^2\text{-}1) - c\alpha/_2\sqrt{c\alpha/_2{}^2\text{-}(2 + 1/_n) + 4p\,(nq\text{+}1)}}{2(n + c\alpha/_2{}^2)}$$

where: P_L=lower confidence limit for the proportion being studied (ie, for the negative predictive value or sensitivity);

α=statistical confidence value (set to .05);

$c\alpha_{/2}$=value cutting off the upper $\alpha/2$ tail area of the standard normal distribution (for α=.05, $c\alpha_{/2}$=1.96);

n=size of the population being studied (to be determined by this analysis);

p=proportion of the population having the properties under study; and

q=proportion of the population not having the properties under study (q=1–p).

Validation of a given P_L to a 95% level of statistical certainty implies that α=.05 and, in turn, that $c\alpha_{/2}$=1.96. The main hypothesis of this study is that low-risk criteria will identify all patients with cervical spine injuries after blunt trauma. For purposes of sample size calculations, using a hypothesized value of 100% for either negative predictive value or sensitivity, *P*=1.0. Since q= 1–p, it then follows that q=0.0. Substituting these values yields an algebraic equation for P_L, to be satisfied by the single unknown quantity, "n":

$$P_L = \frac{(2\times n\times 1.0+(1.96)^2 -1) -1.96\sqrt{(1.96)^2-(2+1/n)+4\times 1.0\times(n\times 0.0+1)}}{2(n+(1.96)^2)}$$

or, equivalently:

$$P_L = \frac{(2n+2.84)-1.96\sqrt{5.84-1/n)}}{2(n+3.84)}$$

Practical concerns regarding radiographic charges and radiation health effects, as discussed later, suggest that selective criteria will remain cost-effective and reduce mortality and morbidity even if they miss 5 of every 1,000 injuries. Thus, to validate the use of low-risk criteria, the study must be capable of demonstrating a lower sensitivity limit of 99.5%. This implies that P_L=.995. Substituting this value in the lower confidence limit equation yields the following algebraic equation for cervical spine injury (for population size n):

$$.995 = \frac{(2n+2.84)-1.96\sqrt{5.84-1/n)}}{2(n+3.84)}$$

The numerical solution to this equation is n=854. This implies that validation of low-risk sensitivity to a 99.5% level requires a study population of 854 blunt trauma patients *with cervical spine injury*. Cervical spine fracture prevalence among blunt trauma victims is between 2% and 4%. A fracture prevalence of 2% implies that 42,700 patients with blunt trauma must be prospectively evaluated to attain the needed number of spine injury cases.

Validation of negative predictive value at the .995 level requires the study of a population of 854 patients with blunt trauma *who are risk free*. Because approximately one third of blunt trauma patients are free of the risk criteria, this validation would require a population of only 2,562 patients with blunt trauma. Consequently, the study sample size is driven by the requirements of sensitivity validation.

Data analysis

The final concatenated database will be reviewed at the close of the study. Cases lacking radiographic reports will be deleted from the final data analysis.

A case will be considered a true positive if the patient had at least 1 of the selective criteria and was diagnosed as having a cervical spine injury. Cases in which the patient was diagnosed as having a cervical injury but none of the criteria was present will be classified as false negatives.

Cases having none of the criteria and no cervical spine injury will be classified as true negatives. The remaining cases will be classified as false positives. These values will be used to calculate the negative predictive value and sensitivity of the selective criteria. Confidence intervals will be calculated using the method of Fleiss.[17]

DISCUSSION

Sporadic case reports have described rare patients with occult or even asymptomatic cervical spine injuries after blunt trauma.[3-5,18-27] Careful review of these cases indicates that most of them involved patients who were inadequately evaluated or who actually met at least 1 of the low-risk criteria considered in the NEXUS study. Nevertheless, fear of missing cervical spine injuries, with their potential to produce severe neurologic disability, has led to the use of radiographic spine imaging in virtually all patients with blunt trauma.[1,2] The consequent human and economic losses, as well as associated medicolegal considerations, make validation of selective low-risk criteria for cervical spine radiography in blunt trauma patients an important undertaking.[28,29]

A number of clinical studies have attempted to derive low-risk spine injury criteria.[11,30-35] Because many of these studies are based on chart reviews, their credibility is threatened by the possibility of missing or unreliable data. In our own review, we found that important data elements frequently were missing, and we found it impossible to determine whether undocumented findings were not evaluated or were truly absent.[11] Furthermore, we found it difficult to determine whether positive findings were recorded before injury detection or only after radiographic review. Finally, the presence or absence of some low-risk criteria simply cannot be assessed by a review methodology. Based on chart review alone, it is impossible to determine whether associated injury, either clearly minor (eg, lacerations, abrasions) or clearly major (eg, long bone fractures), produced enough pain to qualify as a "distracting injury" that could have obscured the patient's awareness of a cervical spine injury. We believe that these same problems apply to the other review studies as well. Therefore, only a concurrent, prospective methodology, with data gathered at the bedside before radiographic results are obtained, can be used to adequately evaluate the performance of low-risk criteria.

Several small prospective studies, each of which used somewhat different criteria and data collection methods, suggest that low-risk criteria can safely exclude cervical spine injury in most patients.[8,12-16,35] Taken together, these studies comprise only 4064 patients in total, and only 92 patients with cervical spine injury. Although they suggest that the lower sensitivity and negative predictive value limits of low-risk criteria are high, they cannot provide the statistical confidence needed to validate the use of low-risk criteria.

The NEXUS study has been designed to evaluate the use of a specific set of low-risk criteria. The study has adequate power to gauge the criteria's ability to exclude cervical spine injury with a sensitivity greater than 99.5%. The precise criteria were derived from literature review in combination with findings from our own review study. They have been prospectively evaluated in a pilot study of more than 1,000 patients with blunt trauma, 27 of whom had cervical spine injuries.[8] Both the individual elements and the criteria as a whole have been shown to be reliable when used by different observers.[36]

This multicenter study requires clinicians to document, before radiographic imaging is performed, the presence or absence of neurologic impairment (including altered level of alertness), midline spinous process tenderness, evidence of intoxication, and distracting painful injuries. This study will determine whether clinical judgment alone can reliably identify all cervical spine injuries while simultaneously reducing the number of radiographic spine evaluations.

To validate the use of selective criteria at the 99.5% level with 95% probability, a sensitivity quotient of roughly 854/854 must be obtained. Because fracture prevalence among patients with blunt trauma is between 2% and 4%,[8,11-13] a sample size of almost 50,000 patients is needed to provide the necessary statistical significance.

We estimate the annual nationwide reduction in charges resulting from practice guidelines for radiographs in patients with blunt trauma to be at least $60 million. We base this estimate on the fact that the UCLA annual ED census of 40,000 visits represents approximately .05% of the more than 80 million yearly ED visits in the United States. Our facility evaluates more than 800 cervical spine series on patients with blunt trauma each year. Assuming that, as a trauma center receiving a high proportion of patients with blunt trauma and with defined protocols that include cervical spine radiograph for all patients with major trauma, we order more than twice as many films per patient visit as the national average, then approximately 800,000 cervical spine radiographs are performed each year across the country. (This number would be even greater if our rate of ordering of cervical spine films more closely approximated the national average.) Total charges for a limited cervical spine series at our institution are $225. Assuming that most

hospitals assess similar fees, the annual charges for radiographic screening for cervical spine injury in blunt trauma victims exceeds $180 million a year. Small prospective studies have shown that selective criteria can reduce the need for radiographic evaluation by one third.[8] This suggests that a reduction of nearly $60 million in radiographic charges could be realized annually if selective criteria were used to limit the use of radiography.

The monetary benefits derived from such a policy must be weighed against any excess morbidity incurred by patients who suffer neurologic consequences because of a failure to diagnose occult unstable cervical fractures. There would be no cost if the negative predictive value of the low-yield criteria was 100% for fractures capable of producing neurologic injury. However, the utility of these guidelines would decrease with any decrease in the negative predictive value. With an estimated 10,000 new cases of spinal cord injury in the United States each year,[9,10] if the true sensitivity were 99.5%, selective criteria could miss up to 50 potentially preventable cervical spine injuries annually. Assuming a lifetime cost of $750,000 to care for each patient with cervical spine injury,[9] $38 million would be needed to provide lifetime care for 50 such patients. Therefore even with a 99.5% negative predictive value, there would be annual dollar savings of at least $20 million.

The monetary benefits of implementation of the criteria could also be lessened by potential litigation costs resulting from failure of the criteria to identify patients with significant injury. On the other hand, these (or other unproven) criteria are already in use, to at least some extent, in general clinical practice, and validation of their accuracy should if anything help protect physicians who applied them correctly, even in the event of a rare false-negative case. Furthermore, if the criteria prove to be overwhelmingly accurate, not only will the number of such patients be small, but widespread recognition of the criteria might help avoid unidentified injury (and subsequent medicolegal costs) in some patients currently being evaluated without adequate radiographic studies. Finally, if the criteria are unexpectedly found to be inadequately sensitive and should not be used, this would also help avoid litigation (as well as bad patient outcomes) based on their premature adoption.

Further potential benefits would accrue from application of the validated criteria as a result of reduced x-ray exposure. A standard 3-view cervical spine x-ray study exposes thyroid tissues to an effective radiation dose of .1 Gy.[37] The estimated number of excess thyroid cancer cases among exposed persons older than 5 years of age is 10 per 10,000 person-year-Gy (for younger persons, this rate is more than 30 per 10,000 person-year-Gy).[38] The average trauma patient who undergoes radiation is 25 years of age and can be expected to live for an additional 47 years.[11,39] Therefore, in total, these figures predict 3760 excess thyroid cancers over the lifetime of the 800,000 trauma patients irradiated each year. Thyroid cancer infrequently causes death (the mortality-to-incidence ratio is .1), but, even so, this means that 376 patients can be expected to die of thyroid malignancies incurred from cervical spine x-ray studies. Other neck tissues are less likely to develop malignant change when exposed to radiation but still contribute to the overall cancer risk.[38] Reducing radiographs by one third would directly reduce the excess cancer morbidity and mortality by one third. This would spare at least 125 patients death by thyroid malignancy and would in large part offset the morbidity of the 50 spine injuries that might, in the worst-case scenario, fail to be identified by selective criteria.

Difficulties and potential limitations

Sensitivity and negative predictive value Errors in estimating the criteria's sensitivity and negative predictive value could bias the study's internal validity. Bias could occur from failure to perform cervical spine radiography on all patients with blunt trauma (workup bias), from misclassification of patient injury status, or from doctors' changing their answers after x-ray review and diagnosis.

It is conceivable that some patients with blunt trauma could present with occult spinal injuries, lacking not only the criteria examined in this study but any indication of cervical spine injury. Failure to obtain radiographic imaging in such patients could result in underestimation of the false-negative rate for the selective criteria. This in turn could produce biased estimates of the sensitivity and negative predictive values. The magnitude of this error would depend on the incidence of occult cervical spine injuries. To date, there are no published cases of truly occult cervical spine injuries.[1,8,41] Furthermore, prospective studies examining low-risk patients have uniformly failed to identify fractures among such individuals.[8,31,40] Therefore it is extremely unlikely that workup bias will significantly affect the study results.

In addition, the study has several mechanisms to identify such patients. Any patient who returns to any of the study institutions after an initial visit that ended without ordering of films, and is then found to have a fracture on subsequent radiographic studies, would be included and identified at that time, since information will be gathered on all patients who undergo cervical radiography at every

study site. Similarly, follow-up with risk-management coordinators at study centers should be able to identify patients for whom radiography was not done but who ultimately developed any complications related to cervical spine injury.

Finally, there is a great deal of variation in ED use of cervical spine radiography.[41] Many clinicians frequently order radiographs on patients who have none of the low-risk criteria. Therefore we expect that a substantial minority of the patients enrolled in NEXUS will have radiographs taken even though they meet the low-risk criteria, ostensibly because of clinicians' concerns about mechanism of injury, neck pain without tenderness, lateral neck tenderness, or some other clinical factor. If none of this group proves to have a significant cervical spine injury, the likelihood that other patients with a *less* concerning clinical presentation have occult fracture should be extremely low.

Spine injury status is based on final radiographic interpretations, and in most patients the absence of spine injury will be determined by the standard 3-view cervical spine series. The true sensitivity of the low-risk criteria depends not only on the innate test characteristics but on the negative predictive value of standard cervical spine imaging. It is not the purpose of this study, however, to determine the optimal method of radiographic evaluation. If a fracture is missed on standard radiographic evaluation, the method of patient selection is irrelevant, because such cases would be misidentified even if radiographs were performed on all patients. Therefore the measured sensitivity is the parameter of interest.

Bias resulting from alteration of data forms will be eliminated by requiring data to be entered into the computer before requests for radiography are generated. This leaves the potential for misrepresentation of data for patients who are critically ill, but such patients would in general already satisfy 1 of the selective criteria (other severe injuries and/or altered neurologic function) by virtue of their critical illness. Therefore bias in sensitivity due to data alterations should be insignificant.

Specificity Although determination of specificity of the low-risk criteria is not a primary goal of the NEXUS study, miscalculation of specificity would distort the estimates of potential cost savings to be achieved with application of the criteria. Bias in the specificity measurements could result from misclassification of subjects (as discussed previously) or from workup bias due to nonrandom exclusion of patients from the study. Such exclusions could produce a study population that does not represent trauma patients in general. If an inordinately high number of patients who meet the criteria are omitted from the study (compared with more general community practice), the measured of specificity and estimated savings would be falsely low; the converse is also possible. The inclusion of all types of hospital EDs (eg, urban and rural, community and university, with and without training programs, high- and low-volume) should allow for generalizability of the results with regard to validity of the criteria as well as reliability of their application (see the discussion of external validity). However, although it is impossible to determine with certainty the impact of possible bias on specificity measurements, the estimates, even if biased, would be very unlikely to change enough to substantially alter our conclusions. For example, if clinicians ordered radiography only for seriously injured patients, most of whom have at least 1 of the risk criteria, then the number of uninjured patients labeled negative by the criteria would be small and the specificity would be low. On the other hand, if clinicians frequently ordered x-ray studies on patients with no complaints, then the number of uninjured patients labeled negative by the criteria would be large and the specificity would be high. The first scenario would result in an erroneously low estimate of cost savings to be obtained from use of the criteria, and the second scenario would overestimate savings. However, neither scenario would alter the number of patients who have injury and are identified as such by the criteria. In addition, and most importantly, although errors in calculation of specificity could affect estimates of cost savings, they would not affect estimates of the safety of the selective criteria.

External validity The study's external validity could be compromised through ambiguities arising from study population selection. Because individual physicians decide whether patients need x-ray studies, the final study population could differ from the population that would have been selected by a different group of physicians. Examining physicians may choose to "clinically clear" patients without documenting findings or obtaining radiographic imaging. Such patients are unlikely to harbor significant cervical injuries, and elimination of this potential bias would if anything strengthen our results, by narrowing the confidence interval of the specificity of the low-yield criteria. Although the predictive values of the screening strategy may change when they are applied to different patient populations, the broad range of hospitals and clinicians used in the study should make the results generalizable to most patients with blunt trauma.

In summary, development of criteria that reliably identify blunt trauma patients at risk of cervical spine injury is a priority in emergency medicine. The NEXUS project is a cooperative, multicenter study that seeks to validate the use of selective low-risk criteria among a broad range of

patients and trauma facilities across the country. Using prospective methodology, the study has sufficient statistical power to determine whether a limited set of clinical criteria has near-perfect (or perfect) sensitivity to detect clinically significant cervical spine injury in ED patients with blunt trauma.

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