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# Assessment of stability of the cervical spine in blunt trauma patients: review of the literature, with presentation and preliminary results of a modified traction test protocol

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**Objective:** To review the reported efficacy of various imaging techniques in assessing stability of the neck in blunt trauma patients, and to present the protocol and preliminary results of a modified traction test protocol. **Design:** This is a prospective cohort study. **Setting:** A regional trauma unit in Southern Ontario. **Patients:** People with blunt-trauma injuries who came to the author's consultant practice with "C-spine not cleared" status, from January 2001 through December 2003. **Interventions:** A fluoroscopically controlled test of axial traction followed by flexion/extension stressing. **Outcome measures:** Radiographic confirmation of the absence of pathological motion under load. **Results:** In 51 cases studied to date, no instabilities have been found. Four cases of minor ligamentous hypermobility have been detected, with stability confirmed and no surgery required. There have been no failures to depict the neck completely, no missed instabilities and no complications of the procedure. **Conclusions:** Cervical stability can be reliably confirmed with this test without any requirement for advanced imaging technology.

**Objectif :** Étudier l'efficacité signalée de diverses techniques d'imagerie pour évaluer la stabilité du cou chez le patient victime d'un traumatisme contondant et présenter le protocole et les résultats préliminaires d'un protocole modifié d'essai de traction. **Conception :** Étude de cohorte prospective. **Contexte :** Service régional de traumatologie du sud de l'Ontario. **Patients :** Patients victimes d'un traumatisme contondant qui se sont présentés à la pratique de consultation de l'auteur dans un état «colonne-C soupçonnée non rentrée dans l'ordre» de janvier 2001 jusqu'à décembre 2003. **Interventions :** Test de traction axiale contrôlée par fluoroscopie suivi d'un stress flexion-extension. **Mesures de résultats :** Confirmation radiographique de l'absence de mouvement pathologique sous tension. **Résultats :** Dans 51 cas étudiés jusqu'à maintenant, on n'a trouvé aucune instabilité. On a détecté quatre cas d'hypermobilité ligamenteuse mineure, on en a confirmé la stabilité et aucune intervention chirurgicale n'a été requise. Il n'y a eu aucune omission à décrire le cou complètement, aucune instabilité oubliée ni aucune complication de l'intervention. **Conclusions :** Ce test permet de confirmer la stabilité cervicale de façon fiable sans avoir à recourir à une technologie d'imagerie avancée.

Patients who have undergone high-energy blunt trauma are recognized to be at risk for injury of the cervical spine, with or without neurological deficit. Universally, immediate emergent immobilization and protection of the neck is standard trauma protocol, both in the emergency room and in the field.

The trauma patient who is alert, oriented, cooperative and neither sedated nor distracted may or may not have neck pain or tenderness upon clinical examination. In the absence of either symptom, the probability of structural injury is close to zero,[1,2] and increasingly it is recognized that imaging such patients is unnecessary.[3–5]

Unfortunately, clinical assessment of these patients is often complicated by distracting injuries, or made impossible by central nervous system (CNS) injury or patient sedation or intoxication. Here, assessment of the structural integrity of the neck is paramount to prevent possible neurological catastrophe from cervical fracture or instability. How can we best do that?

## Plain radiography, static films

Plain radiography is the first-line tool

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in assessing the cervical spine. It is universally available, readily obtained and familiar to most physicians.

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The single-view cross-table lateral study was the originally conceived screening tool for cervical fracture or dislocation. After 1990, when MacDonald and colleagues[6] described its sensitivity as only 57%, it was seldom used in isolation.

Prevertebral soft-tissue swelling from hematoma or edema may reveal the presence of a C-spine injury even when the bony anatomy is normal. Unfortunately, such swelling is found in only 49% of cases.[7] The defined "upper limits of normal" of 6-mm soft tissue at C3 and 22-mm at C6 have shown a maximal sensitivity of only 60%.[8]

The 3-view trauma series consists of an anteroposterior (AP) view of the odontoid centred at C2, a second AP view of the subaxial neck, and a lateral study depicting the occiput to T1. As the cervicodorsal junction is often obscured, this series can frequently require supplementation with Swimmer's or other special views for completeness. The sensitivity of this examination approaches 100%,[9] though subtle injuries of the upper neck at the O/C3 levels may be missed in up to 45% of cases.[10]

Given the documented insensitivity of static plain radiography in detecting cervical trauma, these patients must be assessed further. Practice guidelines have been unclear as to how that might best be done. For example, advanced trauma life support (ATLS) guidelines[11] from 1997 suggest that, given negative x-ray results, these patients should undergo "appropriate clinical evaluation by an orthopedic surgeon or neurosurgeon." Unfortunately, these guidelines do not describe how that clinical evaluation should be done.

In 1998 the Eastern Association for the Surgery of Trauma (EAST) published a guideline[12] suggesting that technically excellent 3-view x-ray examination in combination with routine CT imaging from occiput to C3 would be appropriate. The recently published experience of Chiu and coauthors[13] suggests that this guideline may be a gold standard. They reviewed 14 577 trauma cases at the Baltimore Shock Trauma Center from 1996 through 1998 and found 614 injuries of the cervical spine (4.2%). In this series, no injuries had been missed. Fourteen purely ligamentous injuries were found, 13 detected on plain radiographs and 1 by CT scan.

## Plain radiography, dynamic films

Given that static x-ray examinations are imperfect in confirming cervical stability, and that advanced imaging may not be universally available, dynamic or flexion/extension x-rays have been considered a next-best alternative. In concept, these might be performed passively or actively with the patient functioning as his or her own spinal cord monitor, able to protect the neck from excessive motion through guarding and active muscle contraction or verbal feedback.

Passive flexion/extension examination may be dangerous to the patient, even when done with fluoroscopic guidance. Clinical assessment of pain or neurological symptoms is impossible, and it is possibile to precipitate dangerous subluxations.

Active flexion/extension examination may be safer in that the awake and alert patient can function as a spinal cord monitor, but pain and secondary muscle spasm limiting the patient's available range of motion can interfere. Wang and associates[14] reported on a review of 290 acute cases at the annual meeting of the North American Spine Society in 1996. Requiring a minimum 10° range of motion from flexion to extension in the subaxial spine from C2 to C6, they found one-third of the studies in their series inadequate, with no yield from the procedure.

Anglen and coworkers[15] recently did a retrospective review of 837 flexion/extension radiographs in their 5-year experience and found that nearly 1 in 3 was inadequate, and only 4 suspicious cases were identified. An analysis of cost-effectiveness suggested that these examinations were of little benefit.

## Computed tomographic scan

The cervical CT scan has several roles in assessing the neck of trauma patients. This imaging modality provides excellent delineation of detailed bony anatomy and is standard in defining the anatomy of a cervical fracture. It can frequently detect secondary fracture lines not seen on x-ray, can define second-level injuries and is often helpful in depicting the cervicodorsal region through sagittal reformatting in cases where visualization is otherwise compromised.[16] Although CT can miss pure ligamentous injury or soft-tissue instability, and is recognized in clinical practice to be insufficiently sensitive to regularly detect cervical disc prolapse, it is nevertheless an important part of the EAST protocol.[12]

## Magnetic resonance imaging

MRI is considered complementary to CT scanning in spine practice and provides detailed soft-tissue imaging where CT cannot. Although it may have a role in detecting unstable injuries at the thoracolumbar junction,[17] a sensitivity of only 75% in detecting ligamentous injury in the spine[18] confirms this to be a less-than-perfect tool.

## The traction test

White and Panjabi[19] in 1978 first proposed a controlled trial of cervical distraction as a method of assessing stability in the neck. They described a detailed protocol but unfortunately presented no supporting clinical data.

In their protocol, the supine patient is alert and accordingly able to act as a spinal cord monitor, describing any increased pain or new/progressive neurological symptoms to the attending physician. Light axial traction of 5–10 pounds is initially applied through cervical tongs or a head halter. A few minutes' wait allows the patient to relax so that protective muscle spasm in the neck becomes unlikely and soft tissue in the neck can elongate or "creep." The patient is examined clinically for possible neurological deterioration. A lateral x-ray is taken to assess any possible distraction or subluxation in the neck. If all is well, incremental weight is added and the process repeated up to an arbitrary mechanical end-point (33% of body weight), whereupon the neck is declared stable.

Interim literature is lacking until 2000 when Harris and collaborators[20] presented preliminary results of a similar distraction protocol to a meeting of the American Academy of Orthopedic Surgeons. In trauma cases where x-rays showed no fracture, they applied axial distraction to a maximum of 20–25 pounds (about 10 kg), measured with a manually held fishing scale under fluoroscopic control in the operating room (OR), followed by passive flexion/extension imaging. (It is unclear how the traction end-point was determined.) Their initial report on 130 cases tested over a 30-month period described 2 positive results and 10 patients in whom the cervicodorsal junction could not be adequately portrayed.

The recently published definitive report of their protocol[21] includes a telling survey of the memberships of the Orthopedic Trauma Association (OTA) and North American Spine Society (NASS) that assessed current practices in clearing the cervical spine. Of 461 surgeons responding to the survey, 81% from OTA and 30% from NASS claimed to follow the ATLS guidelines requiring a negative 3-view imaging examination and clinical assessment of the patient; but fully 12% from OTA and 16% from NASS reported that they use the cross-table lateral view only.

In their 2002 paper,[21] the Harris group reported testing 153 cases among 12 000 patients presenting to 2 large trauma units in the southern USA from January 1997 through December 1999. The chronology suggests that these patients were new study subjects rather than those described in the preliminary report. Over 90% of the new group were injured in motor vehicle collisions; their mean injury severity score (ISS) was 17 and mean age, 32 years. Of these, 8 (6%) were not imaged. Three tests (2%) were positive, with the patients being treated with cervical fusion procedures. No missed injuries were reported, but in fully 6% of the series (8 patients) the distal neck could not be visualized, and the status of the neck could not be cleared.

## The McMaster traction test: technique and results

Although impressively thorough, the Harris protocol does not provide for distraction to be applied more than transiently, allowing for soft-tissue creep that can stretch the neck up and away from the torso and the shoulders down and away from the neck, to facilitate distal visualization. Whether the patients were pharmacologically paralyzed at the time of the tests (performed in the OR) is unclear.[20,21] If not, resting muscle tone in the neck might increase the incidence of failed distal visualization to a rate such as they reported.

Before the Harris group's definitive paper[21] was presented but subsequent to their preliminary report,[20] we considered a modified version of their OR cervical traction test that would allow for controlled traction over time and for greater weights to be applied if needed. After considerable debate among spine surgeons in the hospital, this protocol was instituted in the practice of the senior author (DAB) in January of 2001.

This protocol was instituted without submission to the institutional review board. Distraction testing in small numbers has been performed irregularly in Hamilton since 1988. Because the traction protocol differs little from our traction reduction routine for an identified cervical spine injury, it was considered routine and safe. We apply it in the OR to patients who are anesthetized, which forestalls incremental stress or pain from tongs or traction. Routine procedural consent is obtained from the patient (or responsible persons) beforehand.

Testing is done in the OR with the patient under full neuromuscular paralysis, either as a defined procedure or after completion of a required emergency surgery. Trauma patients suspected of possible neck injury are first protected with hard cervical collars.

Gardiner–Wells cervical tongs are used to apply traction to the head. In cases where possible skull fracture or soft-tissue injury to the head preclude the application of tongs, a head halter and supplemental bite block might be used. (This has not been required in our series.)

Five pounds (2.3 kg) of balancing traction are applied over a stable pulley. The collar is then removed and the spine imaged fluoroscopically to confirm complete visualization from occiput to T1. If needed, assistants provide traction to the patient's arms or put them into a swimmer's position to confirm visualization. To date, we have had no failure of visualization in 51 cases.

Subsequently, weight is added in 5- or 10-pound (2.3–4.5 kg) increments, with careful complete visualization of the entire neck confirmed with each addition.

The end point of the axial distraction test is when the normal radiographic cervical lordosis has been "pulled out" and the neck straightened. At this point, well-centred fluoroscopy will frequently reveal uniform millimetric diastasis of the subaxial facets, the whole suggesting that the limit of axial tension in the neck is being approached in the absence of resisting muscle tone. So far, the distraction weights needed have ranged from 20 to 65 pounds (9–29.5 kg).

Any intersegmental kyphosis beyond about 10° or focal intersegmental distraction defines a positive test and an unstable neck, which terminates the procedure. Subsequent stabilization would be provided according to the nature of the injury. This has not been required to date.

If distraction test results are negative for complete instability, the investigator proceeds with maximum passive flexion and extension testing under fluoroscopic control. The head is flexed to the chin-on-chest position, with complete fluoroscopic visualization throughout. If negative, the final manœuvre involves passive hyperextension until the occiput approaches the nape of the neck at the palpable limit of tissue tension, again under fluoroscopic control. This last procedure has been performed in 4 cases of incomplete ligamentous disruption and 1 recognized case of lateral-mass fracture of C2. The incomplete ligamentous injuries included 2 cases of slight widening of the C5/C6 interspinous complex under tension (1 each at 20 and 25 pounds), another interspinous widening at the C4/5 level at 25 pounds, and 1 patient with a recognized undisplaced anterior arch fracture of C1 who had slight vertical subluxation at O/C1 under 20 pounds' distraction. The patient with the recognized C2 fracture, who had been forecast a prolonged stay in the intensive care unit (ICU), was beginning to ulcerate from wearing a cervical collar.

All cases tested to date have been negative for cervical instability. Collar immobilization was discontinued at the procedures' end the for all except the patient with incomplete O/C1 injury, who was treated for 8 weeks in a semirigid collar. This includes the 3 patients with stable interspinous ligament disruptions and the person with the C2 fracture just described.

We have noted no complications of the procedure. There have been no failures of visualization; no missed injuries have been detected. Of the 51 cases assessed with this protocol, 39 were performed on the day of injury and 12 at an average of 5 days after admission. There was a mean interval of 13 days from performance of the traction test to the patients' recovering consciousness sufficiently to cooperate with a clinical examination in the first 26 cases reviewed, during which collar immobilization would have otherwise been required.

Setup and takedown of the traction frame required for this procedure, as well as the testing protocol itself, are routinely accomplished in around 30 minutes.

Complete visualization from occiput to T1 has been achieved consistently, including several cases of large muscular men who were severely swollen. These men, such as the edematous blast victim in Fig. 1, underwent delayed testing when they came to the OR for secondary procedures.

## Discussion

Our protocol differs from that described by Harris and colleagues in subtle but important ways. In their 2 presentations to date, on a total of 283 cases,[20,21] they describe 18 failures to completely visualize the neck (6%), 5 positive studies (2%) and no missed injuries. In our 51 cases studied to date we have had no failures of visualization, with no true positive results but 4 cases of stable ligament injury detected. Our seemingly improved visualization (0 failures v. 3 expected from the Harris protocol's 6% frequency) may relate to the improved control of our manœuvres.

This test, while perhaps optimally thorough in assessing the potentially unstable neck, may be somewhat impractical for generalized use. It does require the presence of dedicated attending staff who are comfortable performing it, adds roughly half an hour to the surgical patient's required OR time, and may require a specific block of OR time for its performance in trauma patients otherwise not destined to the OR.

Of 5 orthopedic and 4 neurosurgical attending staff at our hospital during the 2-year study period, only the senior author was willing to perform this test — hence the small numbers in this preliminary report. In that time, roughly 800 trauma cases (ISS ≥ 15) were treated at the hospital. Obviously, a more widely applicable protocol was required institutionally; to that end, the hospital's Trauma Executive Committee in March 2003 adopted the EAST protocol[12,13] as an institutional standard.

Thus far, we have identified 4 patients with incomplete ligamentous injury with a testing protocol that alhas lowed us to confirm stability and safely discontinue cervical collar support to 3 patients with partial interspinous disruptions (the O/C1 case was treated in a Miami-J collar for 2 months). We were able to rest easy when these patients had some minor neck pain on regaining consciousness. To date, the Harris group reports no such injuries detected; it is


**FIG. 1. This large man was tested during one of several reoperations for frontal burns suffered in an explosion. Note his short, thick neck and the Aspen collar disappearing down into his shoulders. The initial lateral C-spine radiograph was obscured distal to C4. With neuromuscular paralysis and 70 pounds of traction, full distal visualization to T1 was accomplished in his traction test.**

unclear as to whether such cases might have been detected and considered stable, then simply tabulated in their "test negative" groups.

Detection of lesser degrees of ligament damage and hypermobility may be important in trauma patients, to explain some cases of possible post-traumatic neck pain and to eliminate clinical concern about occult instability in those cases. Controlled and sustained application of distracting force may be a factor in the apparent sensitivity of our protocol to detect these subtle injuries.

Our protocol provided another benefit in allowing us, in 1 case, to assess the stability of the neck in a trauma patient with recognized but undisplaced C2 fracture. As a result, collar immobilization could be safely removed, preventing the impending ulceration of the skin under the collar.

Potentially possible is similar testing of sedated and pharmacologically paralyzed ICU patients (who do not otherwise need to go to the OR) in a designated suite of the radiology department.

Surgeons and traumatologists considering instituting this protocol at their hospitals are invited to correspond with the author by email to facilitate the recording and reporting of a larger prospective experience.

**Competing interests:** None declared.

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