Spinal Cord Injury Resulting From Injury Missed on CT Scan

The Danger of Relying on CT Alone for Collar Removal

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Abstract

Background Strict criteria have been used before removing cervical collars in patients with injuries who have midline pain or are unable to be reliably examined. This sometimes leads to prolonged immobilization in cervical collars or use of MRI to rule out injury. Several studies suggest a collar may be removed in the absence of fractures, dislocation, or pathologic subluxation on a cervical CT scan. This may avoid the morbidity of prolonged cervical immobilization or cost of advanced imaging study but risks devastating consequences from missing injuries.

Each author certifies that he or she, or a member of his or her immediate family, has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.

All ICMJE Conflict of Interest Forms for authors and *Clinical Orthopaedics and Related Research* editors and board members are on file with the publication and can be viewed on request. Each author certifies that his or her institution approved the reporting of this case report, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained. This work was performed at Thomas Jefferson University, Philadelphia, PA, USA.

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Case Description We report a patient with a cervical spinal cord injury after removal of a collar after a CT scan was misinterpreted as normal. Retrospective review of the CT showed subtle signs of widening between the spinous processes of the injured level, a finding easily missed without the use of further imaging studies.

Literature Review Several articles suggest cervical collars may be safely removed from awake and alert patients and in patients who cannot be reliably examined after a negative CT scan without the need for further imaging.

Purposes and Clinical Relevance CT scans are excellent at detecting bony injuries but not ligamentous injuries. Removing cervical collars based on CT scans alone may be expeditious, but some injuries may be missed without further imaging. Our case demonstrates the catastrophic consequences of missing a cervical spine injury and emphasizes the need for maintaining the cervical collar in high-risk patients until proper imaging can be obtained.

Introduction

The evaluation of cervical spine (C-spine) injuries presents a major challenge. The National Emergency X-Radiographical Utilization Study (NEXUS) [8] and Canadian C-Spine Clearance Rule study [15, 16] have provided guidelines regarding removal of cervical collars and the role of additional imaging studies for patients who are awake, alert, and cooperative and who do not have neck pain. According to these guidelines, cervical collars should be left in place for patients with normal examinations but who have neck pain and in patients in whom it is not possible to obtain an adequate physical examination until either MRI or flexion/extension radiographs can be obtained. However, several authors [4, 5, 10, 13, 14, 17]

have recently suggested a negative CT scan alone may be sufficient to allow removal of the cervical collar in these patients. Although the use of CT alone may be more expeditious, allowing for earlier removal of collars and decreased use of costly MRI, it leaves open the potential for possible missed injuries.

We present the case of a healthy, alert patient who could be reliably examined and who had a CT scan interpreted by the attending radiologist as not showing any injuries and subsequently had his collar removed by the emergency room physician. Our anecdotal experience is that this is a common practice for patients treated and released from the emergency room. This patient subsequently developed an acute spinal cord injury within 24 hours of removal of the collar. The purpose of this report is to document a case of major instability and spinal cord injury in a patient with a CT scan initially interpreted as negative and showing only subtle signs of C-spine injury that can be easily missed or overlooked.

Case Report

A 43-year-old man presented to the emergency room at a community hospital with both head and neck pain after falling from a sitting position in a chair down four steps. Physical examination at that time revealed posterior C-spine tenderness and no neurologic abnormalities. A CT scan of the neck including sagittal and coronal reconstructions was interpreted as negative by an attending radiologist (Fig. 1). In light of this interpretation, no further imaging studies were obtained and the patient's cervical collar was removed in the emergency department. The patient was discharged to home.

While walking home, the patient began to develop new onset of weakness in his legs. He continued home and awoke the next morning unable to move his legs and with weakness in his upper extremities. He returned to the emergency department where he had initially been treated and an MR image was obtained, which revealed an injury to the posterior ligamentous complex and facet subluxation at C5–6 with spinal cord compression (Fig. 2). The patient was transferred to our facility, a regional spinal cord injury center, for definitive treatment. On arrival, the patient had an American Spinal Injury Association (ASIA) B injury [12] with a C6 level. He was taken to the operating room where he underwent an anterior C5–6 decompression and fusion followed by a posterior C5–6 laminectomy and fusion (Fig. 3).

Retrospective review of the initial CT scan revealed a subtle widening between the spinous processes of C5 and C6, which was missed during the initial evaluation of the CT scan (the interspinous process space should be similar

between contiguous levels but is slightly widened at the C5–6 level). After surgery and at the completion of the patient's hospital course, he was transferred to a spinal cord rehabilitation center and eventually to home. He improved to an ASIA C injury but at last followup at 17 months had not regained the ability to ambulate.

Discussion

Clinical criteria for removing cervical collars in awake and alert patients are based on the results of two large studies, the NEXUS [8] and the Canadian C-Spine Rule study [15, 16]. The NEXUS guidelines stipulate, in low-risk patients, the collar can be removed in patients with no midline tenderness, no distracting injuries, and a normal neurologic examination and who are alert and cooperative and not intoxicated [8]. The Canadian C-Spine Rule added the requirement that the patients be able to rotate their heads [6, 15]. The Canadian C-Spine Rule is reportedly more sensitive and specific than the NEXUS criteria [15] and is supported in the recent Eastern Association of the Surgery of Trauma (EAST) guidelines [3].

If the C-spine cannot be cleared based on clinical criteria alone or if the patient is at moderate or high risk for injury, further imaging studies are required. Historically, plain radiographs of the C-spine were obtained [3, 15, 16]. Recent studies have questioned the sensitivity of plain radiographs for detecting injuries, with two recent studies finding sensitivities of 36% and 62% [2, 7]. In these series, missed injuries required operative therapy between 19% and 33% of cases reported [2, 7, 9]. The most common locations of missed injuries were at the C2, C6, and C7 levels. These findings led to the suggestion that CT scans should be obtained as the initial imaging study for all patients suspected of having a C-spine injury [2, 7].

Once a negative CT scan has been obtained, questions remain regarding the timing of removal of the cervical collar. In an awake, alert patient who still has neck pain, the EAST guideline recommends either leaving the collar in place until the neck has resolved or obtaining an MR image or flexion/extension radiographs [3]. Flexion/extension radiographs place stress on the ligamentous structures and can demonstrate injury to them. They require an alert, cooperative, and neurologically intact patient. Under physician supervision, radiographs are taken with the neck flexed and extended. The physician or other healthcare provider should be present during the procedure. The neck should be immediately returned to a neutral position if any neurologic changes occur. The presence of subluxation of the vertebrae and/or widening of facet joints and the interspinous process space can be compared between flexion and extension views. These examinations

Fig. 1A–E (A) This midsagittal bone window CT scan was initially interpreted as being negative. Note the subtle increased widening between the spinous processes at the C5–6 level (arrow) compared with the adjacent levels. (B) Right and (C) left parasagittal bone window images demonstrate no injury to the C-spine. Arrows denote the facet joints at the level of injury, which show no evidence of subluxation. (D) Sagittal and (E) axial soft tissue CT images do not show any prevertebral swelling (arrow) or edema within the spinal canal.

Fig. 2A–C (A) A sagittal T2-weighted MR image shows a C-spine injury at the C5–6 level (arrow). (B) A sagittal short-tau inversion recovery MR image demonstrates the substantial edema (arrow) in the interspinous ligament between C5 and C6. (C) An axial T2-weighted image also demonstrates substantial posterior edema (arrows).

Fig. 3A–B (A) AP and (B) lateral views are shown after the patient's combined anterior and posterior cervical stabilization procedures.

are often limited because patients who have neck pain are not able to obtain adequate ROM. This has led to the increased use of MRI, which is highly sensitive for detecting ligamentous injuries [11].

Sanchez et al. [13] recently suggested a negative CT scan alone is sufficient for collar removal. They reported on a series of 2854 patients who had cervical collars removed using either clinical criteria or a negative CT

scan. The authors reported missing only one injury in a patient with preexisting syringomyelia, resulting in a sensitivity of 99% and specificity of 100%.

Additional questions also surround the clearance of the C-spine in obtunded patients or in those patients who are unable to provide a reliable clinical examination. Several studies have advocated a negative CT scan alone is sufficient for the removal of the cervical collar in these patients [1, 4, 14]. Tomycz et al. [17] noted a 21% incidence of injuries diagnosed by MRI that were not seen on CT scan but stated none of these required surgery or a change in clinical management and none went on to develop late instability. Como et al. [4] reported only a 5.2% incidence of injuries missed by CT scan, none of which required a change in intervention. Additionally, these authors cite decreased healthcare costs by eliminating the MRI scans. Stelfox et al. [14] noted no missed injuries in their series and reported waiting for a MRI delayed C-spine clearance by an average of 4 days. This was believed to result in a delay in extubating, in turn leading to longer intensive care unit stays, longer length of stay, and an almost twofold increase in complications (37% versus 64%). The authors found increases in incidences of pressure ulcers (10% versus none) and delirium (66% versus 20%) and a trend toward increased pneumonia (34% versus 20%).

The approach of clearing the C-spine based on a negative CT scan alone is not without critics. Muchow et al. [11] performed a large meta-analysis, which reported a 20.9% rate of injuries seen on MR images that were not identified on CT scans. The severity of these injuries was not reported; however, the authors did note all patients from their series who required surgical intervention had injuries that were also observed on CT or flexion/extension plain radiographs. Menaker et al. [10] reported on a series of 203 patients on whom an MR image was obtained after a negative CT scan but unreliable clinical examination. They found 18 patients (8.9%) in whom a newly diagnosed injury was observed on MRI. Fourteen were treated with continued collar immobilization, two were treated with surgery, and two patients had the collars removed at the discretion of the attending surgeon. Currently, the EAST guidelines state the role of MRI in clearing the C-spine remains unclear [3].

Our patient developed a devastating complication after removal of the cervical collar based on CT findings alone in a patient with neck pain who did not meet the NEXUS, Canadian C-Spine Rule criteria, or EAST guidelines for continued collar immobilization. Our anecdotal experience has suggested this is likely a common occurrence in community-based hospital emergency departments. While retrospective review of the CT scan demonstrated slight widening between the spinous processes at the level of the injury, the widening was missed by the attending radiologist; however, these findings are subtle and it is not

unreasonable to suspect this injury would be commonly missed, particularly by radiologists or surgeons not experienced in interpreting C-spine imaging. Use of a localizing marker or better communication with the radiologist as to the location of the patient's pain may have improved the sensitivity of the CT. We believe MRI or flexion/extension radiographs should have been obtained in the absence of pain, which would have likely more readily demonstrated the injury. If it was not possible to obtain these images, the patient's cervical collar should have been left in place until they could be obtained. If the collar had been left in place and the patient's injuries accurately identified, it is likely the injury to the spinal cord could have been avoided.

The decision to remove the cervical collar after trauma continues to be challenging. The recent suggestion that a negative CT scan alone is sufficient may be reasonable for obtunded patients in the intensive care unit, where the risk of neurologic injury resulting from a missed injury must be weighed against the risk of developing pneumonia, pressure sores, or other complications associated with prolonged collar immobilization. Injury mechanism and clinical suspicion of cervical injury must be incorporated into the management of these patients. However, in patients for whom the risk of continued collar immobilization is low, the risk of paralysis, as seen in our patient, becomes relatively more concerning and strong consideration should be given to obtaining further imaging before removal of the collar.

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