Computed tomography reconstruction artifact suggesting cervical spine subluxation

Case report

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Use of computed tomography (CT) imaging for evaluation of the cervical spine following blunt trauma is both an efficient and reliable method for detecting injury. As a result, many trauma centers and emergency departments rely exclusively on CT scans to acutely clear the cervical spine of injury. Although quite sensitive for detecting bone injury, CT may be associated with a low sensitivity for detecting herniated discs, injured soft tissue or ligaments, and dynamic instability. In addition, CT-generated artifact may obscure pathological findings. In this case report, we describe the course of a patient whose CT scan harbored CT-generated artifact that suggested traumatic subluxation of the cervical spine. Clinicians should be aware of such artifact and how to recognize it when basing clinical management on such studies. (DOI: 10.3171/SPI-08/01/084)

KEY WORDS • cervical spine • computed tomography reconstruction • imaging artifact • subluxation

The diagnostic performance of helical CT scanners for detecting cervical spine injury following blunt trauma has been shown to be excellent, with reported sensitivity as high as 99% and specificity as high as 93%.4,5,14 Missed injuries are rare, usually ligamentous, and may only be detected with MR imaging or dynamic plain radiographs. In light of such diagnostic reliability and with improvements in the accessibility of helical CT within trauma centers and emergency departments, some authors propose using CT alone to assess for osseous and ligamentous injury.12,14 However, due to the presence of CT-generated artifact that may distort the true anatomy within the cervical spine, clinicians should exercise caution when basing management decisions solely on a lone CT study.

Two main categories of CT-generated artifact exist—motion artifact and beam-hardening or scatter artifact. The former occurs as a result of errors with CT data acquisition, when the patient moves, and the images obtained are blurred or altered. In the latter, high density of neighboring bone or metal may lead to decreased penetration or scatter of radiation energy through the area imaged, leading to obscuration of the osseous anatomy near such dense materials.17 In both situations, the ability to evaluate the anatomy in question is usually limited and immediately recognized, leading to repeated or alternative imaging studies. It is possible, however, that the presence of minor artifact may lead to subtle changes within the images. In these cases, artifact may not be recognized as such, and patients may be diagnosed with a pathological condition when in truth, there is none.

In this article, we present the case of a patient who was diagnosed with an unstable cervical spine injury at another hospital following blunt trauma. The patient was scheduled to undergo urgent operative reduction and stabilization. Following transfer, further clinical and radiographic evaluation revealed that the abnormality noted on CT was a CT-generated artifact, and clinical management of the case was accordingly revised. In light of increased reliance on CT imaging in the management of spinal trauma, clinicians should be aware of such pitfalls and how to quickly evaluate for the presence of potentially misleading artifacts.

Case Report

History and Examination. This 15-year-old boy experienced transient paresthesias and weakness of the upper extremities immediately after a collision in a lacrosse game. He was placed in a rigid cervical orthosis and brought to a local emergency room. Computed tomography of the cervical spine suggested subluxation of C-5 on C-6, with perched facets on all images (Fig. 1A–C). The patient was transferred to our institution for surgical intervention.
Examination. On presentation, the patient complained of neck pain, but motor and sensory function were intact in all 4 extremities. Review of the transported CT studies revealed that only sagittal reconstructed images were available, no axial images. A repeated cervical spine CT demonstrated normal spinal alignment (Fig. 2). An MR imaging study of the cervical spine did not demonstrate any evidence of disc herniation, ligamentous, or soft-tissue injury (Fig. 3). Further review of the initial CT revealed a motion artifact at the level of presumed subluxation.

Surgery was cancelled and the patient was discharged home in a rigid cervical orthosis.

Follow-Up. Cervical spine flexion-extension radiographs, obtained 2 weeks later, demonstrated normal alignment without evidence of instability.

Discussion

It is well accepted that patients who are awake, alert, neurologically intact and without pain or other distracting factors (for example, drug intoxication) may be cleared clinically without the need for imaging. For the remainder of patients, cervical spine imaging is required. Traditionally, plain radiographs in 3 views (anteroposterior, lateral, and open mouth/odontoid) constitute the initial imaging study. Plain radiographs are readily available, cost-effective, and require a lower dose of radiation than CT. Furthermore, adequate radiographs of the cervical spine (from the base of the occiput to the top of T-1) have a sensitivity of 85–90% for detecting fractures and subluxation. The ability to adequately image the cervical spine with plain films is often limited by body habitus; however, and repeated imaging, swimmer’s views, or CT may be required.

In the setting of serious blunt trauma, CT scans of the head, spine, and body cavities performed in the emergency department may provide efficient and reliable screening for serious injury. With regard to CT imaging of the cervical spine, fractures and dislocations can be detected with a sensitivity of 98–100%, the latter rate being achieved when CT is combined with 3-view plain radiography. As a result, a number of authors have suggested that CT be used as the primary screening modality for people with moderate to high suspected risk of cervical injury, and imaging for cervical spine injury within emergency departments currently is often performed solely with CT. Nevertheless, CT has some important limitations, including low sensitivity for detecting herniated discs, injury to soft tissue or ligaments, and dynamic instability. In addition, CT imaging-specific artifacts may lead to missed injuries.

Fig. 1. Sagittal reconstruction CT images of the cervical spine showing subluxation at C5–6 in the midsagittal plane (A) and at the left and right facets (B and C, respectively). Note artifact at the level of the soft tissues (A, arrow).

Fig. 2. Sagittal reconstruction of the repeated CT of the cervical spine showing normal alignment.
Computed Tomography–Associated Artifact

Effectiveness of conventional CT can be limited by severe beam-hardening artifacts that are generated following image acquisition near metal or dense bone. In studies of the cervical spine, such artifacts can lead to obscuration of osseous anatomy in the high cervical segments due to the juxtaposed mandible and dentition, with the associated dense bone of the former and metal fillings or appliances of the latter. For instance, in a series of 5172 patients admitted to a trauma service over a 2-year period, Daffner and colleagues noted 308 distinct individual injuries in 245 patients. Although CT detected 99.2% of injuries, the 2 fractures missed by CT were at C-2, 1 fracture obscured by dental artifacts and 1 fracture in the horizontal plane of the scan. As a result, the authors recommend that CT be used as the primary screening modality for patients with suspected cervical injury together with a single lateral view of the cervical spine to include the C-2 region.

The presence of beam-hardening artifacts has also traditionally been challenging in evaluation of spines of patients with metal orthopedic hardware, classically referred to as metal or streak artifact. Fortunately, at least 2 advancements have improved this dilemma. First, stainless steel implants are no longer exclusively used for spinal fixation due to the rapid application of titanium alloy implants to the majority of pathological conditions of the spine. This change is beneficial from an imaging perspective because stainless steel traditionally creates a larger artifact than titanium alloys. Second, the evolution of CT hardware and software has made available new techniques that can help minimize beam-hardening artifacts. Specifically, multi-channel CT scanners generate higher x-ray tube currents, which may result in better penetration of metal hardware and reduction of beam-hardening artifacts. Such devices also allow faster scanning times, resulting in a reduction of motion artifacts. In addition, numerous mathematical manipulations of image data have continued to improve metal artifact reduction through such techniques as separate reconstruction of local anatomical regions, merging of metal artifact reduced images, and other algorithms.

Due to the presence of CT-generated artifact in our patient, this case illustrates a limitation of using CT as the sole modality for cervical spine imaging following blunt trauma. Although clinicians rely significantly on CT reconstructions to provide rapid and accurate renderings of the cervical spine in the sagittal and coronal planes, CT-generated artifact may lead to false conclusions about the presence or extent of spinal injury if the studies are not thoroughly reviewed. In this case, such artifact probably resulted from motion of the patient during image acquisition leading to errors in integration of the axial image data into sagittal reconstructions. Notably however, this artifact is present in both the osseous spine and the surrounding soft tissues, thus revealing itself to the trained clinician (Fig. 1). It is likely that the false positive finding on CT would have been detected sooner had plain radiographs been obtained along with the CT images at the time of presentation. For this reason, the benefits of obtaining a standard 3-view set of cervical radiographs in any trauma patient with ambiguous findings on CT imaging probably outweigh the risks of this fast and inexpensive study.

On a more basic level, this case suggests that improvements must be made in the presentation of images to non-radiologists. Specifically, for those clinicians who consistently evaluate imaging studies of their patients prior to an official review by a radiologist (for example, surgeons, emergency room physicians), it would seem beneficial for the imaging industry to institute an internal quality measure that would “flag” images that include motion or streak artifact. Such flagging could be performed automatically by means of a software or hardware interface. In this way, clinicians would still be able to evaluate such images using their own standard practice, but would be reminded that such scans may possess subtle artifacts, thus being provided with further means to avoid misreading imaging studies.

Conclusions

This case serves as a reminder to spine surgeons and radiologists that evaluation of cervical spine CT images in the setting of blunt trauma should involve thorough review of the surrounding soft tissues in order to more easily identify artifact around the suspected injury, and in cases of ambiguity, repeated studies or alternative forms of imaging should be conducted.

References

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