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Undetected Hangman’s Fracture in a Patient Referred for Physical Therapy for the Treatment of Neck Pain Following Trauma

Michael D Ross, John M Cheeks

Background and Purpose
This case report describes a patient referred for physical therapy treatment of neck pain who had an underlying hangman’s fracture that precluded physical therapy intervention.

Case Description
This case involved a 61-year-old man who had a sudden onset of neck pain after a motor vehicle accident 8 weeks before his initial physical therapy visit. Conventional radiographs of his cervical spine taken on the day of the accident did not reveal any abnormalities. Based on the findings at his initial physical therapy visit, the physical therapist ordered conventional radiographs of the cervical spine to rule out the possibility of an undetected fracture.

Outcomes
The radiographs revealed bilateral C2 pars interarticularis defects consistent with a hangman’s fracture. The patient was referred to a neurosurgeon for immediate review. Based on a normal neurological examination, a relatively low level of pain, and the results of radiographic flexion and extension views of the cervical spine (which revealed no evidence of instability), the neurosurgeon recommended that the patient continue with nonsurgical management.

Discussion
In patients with neck pain caused by trauma, physical therapists should be alert for the presence of cervical spine fractures. Even if the initial radiographs are negative for a fracture, additional diagnostic imaging may be necessary for a small number of patients, because they may have undetected injuries that would necessitate medical referral and preclude physical therapy intervention.
In an outpatient physical therapy setting, neck pain is a common condition for which patients seek treatment. Although a specific pathoanatomical source cannot be routinely identified in the vast majority of patients with mechanical neck pain, a small number of patients may have a serious underlying medical condition that may be causing the neck pain, which would preclude physical therapy intervention.

Fractures of the cervical spine are one example of a serious underlying medical condition that can cause neck pain. Fractures of the cervical spine should be considered in the presence of major trauma (ie, motor vehicle accident) or in the presence of minor trauma for older individuals. In an effort to recognize cervical spine fractures in a timely and accurate manner, patients who have sustained trauma and have the possibility of a cervical spine fracture should routinely receive conventional radiographs initially.

In an effort to categorize the frequencies and types of injuries missed by conventional radiographic screening, Mower et al prospectively assessed the efficacy of conventional radiographs of the cervical spine (cross-table lateral, anterior-posterior, and odontoid views) in patients with a history of blunt trauma. They reviewed 818 cases of cervical spine injuries. Conventional radiographs failed to identify serious cervical injuries in 320 patients. The majority of missed injuries (77%) were due to inadequate conventional radiographs. The other missed injuries (23%) were not visualized despite adequate conventional radiographs. They concluded that conventional radiographs may not always detect serious cervical injuries.

In patients with neck pain caused by trauma, physical therapists should be alert for the presence of cervical spine fractures. In 2001, a clinical decision rule was developed to help clinicians determine when radiographs of the cervical spine would be needed in patients with neck pain caused by trauma (Fig. 1). This decision rule is 100% sensitive and 43% specific for cervical spine fractures. Even if initial conventional radiographs of the cervical spine are negative for a fracture, additional diagnostic imaging for a small number of patients may be necessary, because they may have undetected injuries that would necessitate medical referral and preclude physical therapy intervention.

Some cases of missed cervical spine fractures in patients with neck pain following trauma have been reported in the chiropractic literature. These cases involved patients with neck pain following trauma who were seeking chiropractic treatment and whose radiographs taken early after their injury were found to be negative for a fracture. In some of the cases, the chiropractors requested repeat radiographs after the initial examination but before implementing treatment, and the cervical spine fractures were detected. In other cases, chiropractic or physical therapy treatment was initiated without repeat radiographs, and the fractures were not detected until later in the course of care.

We were not able to locate any reported cases of missed cervical spine fractures in the physical therapy literature. If physical therapists suspect an underlying cervical spine fracture, it would be necessary to request or recommend diagnostic imaging before initiating treatment for patients with neck pain following trauma. The purpose of this case report is to describe a patient referred for physical therapy treatment of neck pain who had an underlying hangman’s fracture that precluded physical therapy intervention.

Case Description

History

The patient was a 61-year-old man who reported a sudden onset of neck pain after a motor vehicle accident 8 weeks before his initial physical therapy visit. Specifically, he reported that he accidentally drove off a 10-m cliff in reverse to avoid an oncoming vehicle. The patient was restrained by a seat belt. He denied losing consciousness, but he did report neck and head pain immediately after the accident. The patient was taken by ambulance to an emergency department at a local hospital immediately after the motor vehicle accident. Conventional radiographs of his cervical spine were performed and found to be negative for a fracture. A computed tomography scan of his head also was performed and found to be negative.

His emergency department physician prescribed Vicodin† for pain and recommended follow-up in the emergency department or with his primary care physician if his symptoms worsened. He returned to the emergency department 3 days later due to continued neck pain. His emergency department physician prescribed Ambien† to be taken at bedtime to help him sleep. No further diagnostic imaging was completed, and the emergency department physician recommended that he follow up with his physician.

He was seen by his primary care physician 1 week after his motor vehicle accident as his emergency department physician recommended. No additional treatment was recommended, and no further imaging was performed. He received no other medical care until 7 weeks after his motor vehicle accident, when he...
Does the patient have any high-risk factors that mandate radiography?

- Age $\geq 65$ years
- Paresthesias in the extremities
- Dangerous mechanism of injury
  - Fall from height $\geq 1$ m or 5 stairs
  - Axial load to head
  - High speed motor vehicle accident (>100 km/h), rollover, or ejection
  - Bicycle collision
  - Motorized recreational vehicle accident

Does the patient have low-risk factors present that permit safe assessment of active range of motion?

- Able to assume a normal sitting posture in the emergency department
- Ambulatory at any time since time of injury
- Onset of neck pain not immediate
- Absence of midline tenderness in the cervical spine
- Motor vehicle accident that does not include any of the following:
  - Pushed into oncoming traffic
  - Hit by bus/large truck
  - Rollover
  - Hit by high-speed vehicle

Can the patient actively rotate the neck $45^\circ$ in both directions?

Radiographs not required

Radiographs required

Figure 1.
was seen by his primary care physician because of continued neck pain. This most recent physician visit was at a different facility than his previous medical visits. His physician prescribed Flexeril® and Naprosyn® and referred him for physical therapy treatment of his neck pain.

The patient was a retired military and commercial airline pilot. His recreational activities included skiing and golfing; however, he could not participate in these activities currently because of his neck pain and an inability to turn his neck. He complained of a constant, dull ache through his cervical spine, with an intermittent sharp pain in the upper portion of his cervical spine just below the base of his skull that was most noticeable with rotational movements. His cervical spine pain, especially the intermittent sharp pain, was aggravated by turning his head to look over either shoulder. The patient’s symptoms were decreased with the application of heat to his neck. Since his motor vehicle accident, the patient stated that he had some difficulty falling asleep but generally was able to sleep through the night once he found a comfortable sleeping position. His symptoms were the best about 15 to 30 minutes after getting out of bed in the morning and the worst as the day went on and into the evening.

The patient reported that his neck pain had improved slightly since the motor vehicle accident 8 weeks ago, but his improvement had reached a plateau over the past 2 to 3 weeks. He reported no prior history of cervical spine pain before his motor vehicle accident. The patient denied numbness or tingling in his upper or lower extremities, dizziness or light-headedness, or difficulty maintaining his balance while walking. He also denied any weight changes, bowel or bladder problems, chest pain, or shortness of breath. His past medical history was significant for hypertension, which was being treated with Norvasc® and Avalide.†

Examination

The patient completed the Neck Disability Index as part of his initial examination. The Neck Disability Index is graded from 0% to 100%, with higher values indicating greater disability. The patient’s initial Neck Disability Index score was 26. The patient stated that his current resting level of pain was 1 to 2 on a scale of 0 to 10, with 0 being “no pain” and 10 being “the worst imaginable pain.” Using the same scale of 0 to 10, the patient reported that his pain had reached 4 to 5 at its worst and 1 at its best over the course of the past 24 hours.14

The patient had no apparent abnormality in his gait. Active cervical range of motion, measured with an inclinometer, was as follows: forward flexion to 42 degrees, extension to 25 degrees, left rotation to 28 degrees, right rotation to 40 degrees. All cervical movements were limited by pain and caused an increase in the constant ache in the patient’s cervical spine; left cervical rotation and extension were most painful and caused sharp pain in the upper cervical region. Active shoulder flexion and “hand behind back” movement testing were within normal limits and pain-free bilaterally. There were no signs of neurological deficits as assessed through manual muscle testing of the C4 to T1 myotomes, deep tendon reflexes, Hoffman reflex, and pinprick sensory testing for the C2 to T1 dermatomes.16 Palpation of the cervical spine was performed with the patient in the prone position. Central posterior-to-anterior pressures revealed limited mobility and significant pain at the C2 and C3 levels; significant muscle guarding and sharp local pain at these levels were noted with mobility testing.

Interpretation of History and Physical Examination

The patient’s main complaint was a constant dull ache through his cervical spine, with an intermittent sharp pain just below the base of his skull in the upper portion of his cervical spine that was most noticeable with rotational movements. Based on the patient’s history and the findings of the physical examination, the physical therapist (MDR) thought that the patient’s symptoms were most likely caused by mechanical dysfunction in the cervical spine. The initial plan was to treat the patient with manual therapy and therapeutic exercise to address the patient’s range of motion limitations and pain.2

Because the patient had a history of significant neck trauma, constant low level neck pain that improved only slightly in the 8 weeks since the motor vehicle accident, and significant cervical spine motion limitations, however, the physical therapist ordered conventional radiographs of the cervical spine to rule out the possibility of an undetected fracture prior to manual treatment. The physical therapist could not review initial conventional radiographs taken on the day of the motor vehicle accident because they were completed at another facility and found to be negative for a fracture. The physical therapist, who was credentialed to order diagnostic imaging by the US Air Force, ordered a standard 3-view conventional radiographic series of the cervical spine to include anterior-posterior, lateral, and open-mouth views.

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2 Roche Pharmaceuticals, Roche Laboratories Inc, 340 Kingsland St, Nutley, NY 07110-1199.
4 Roche Pharmaceuticals, Roche Laboratories Inc, 340 Kingsland St, Nutley, NY 07110-1199.
5 Plizer Inc, 235 E 42nd St, New York, NY 10017-5755.
6 Palpation of the cervical spine
Course of Intervention and Outcome
The radiographs were significant for a grade 2 anterolisthesis of C2 on C3, with bilateral C2 pars interarticularis defects, consistent with a hangman’s fracture (Fig. 2).17 A computed tomography scan of the cervical spine was completed immediately after the results of the conventional radiographs were known, and the patient was referred to a neurosurgeon for immediate review. Bilateral pars interarticularis defects involving C2 with a grade 2 spondylolisthesis of C2 on C3 were reported on the computed tomography scan, and an irregular osseous density along the ventral C2-C3 intervertebral space was noted, which likely represented a combination of small avulsions or healing osteophytes. The radiologist’s report also stated that the spinal cord was visualized and no definite cord compression was seen within the limits of the examination.

The neurosurgeon examined the patient shortly after the computed tomography scan was completed. The neurosurgeon ordered conventional radiographic flexion and extension views of the cervical spine, and the radiologist reported a grade 2 anterolisthesis of C2 on C3, with bilateral C2 pars interarticularis fractures without evidence of instability. Based on a normal neurological examination, a relatively low level of pain, and the results of the radiographic flexion and extension views of the cervical spine, the neurosurgeon recommended that the patient follow up with his primary care physician and that the physical therapist continue with nonsurgical management.

Although the patient declined further medical care or physical therapy intervention, he did agree to a follow-up visit with the physical therapist 8 months after his motor vehicle accident. He did not seek medical care for his neck pain between the time of the visit to the neurosurgeon 8 weeks after his motor vehicle accident and the 8-month follow-up visit. At the follow-up visit, the patient’s Neck Disability Index score was 0, and he did not report any neck pain. Cervical active range of motion was within normal limits and was pain-free. There were no signs of neurological deficits. Cervical radiographs were ordered and revealed a grade 2 anterolisthesis of C2 on C3, with bilateral pars interarticularis fractures of C2, that appeared unchanged on flexion and extension radiographic views. The results of this examination were discussed with the neurosurgeon, who recommended no additional medical care at that time.

Discussion
The purpose of this case report is to describe a patient referred for physical therapy treatment of neck pain following a motor vehicle accident. Initial radiographs taken on the day of the motor vehicle accident were negative for a fracture. Eight weeks later, after seeking further medical care, the patient was referred for physical therapy intervention. Based on the patient’s history and the findings of the physical examination at his initial physical therapy visit, the physical therapist thought that the patient’s symptoms were most likely caused by mechanical dysfunction in the cervical spine. The initial plan...
was to treat the patient with manual therapy and therapeutic exercise to address the patient’s range-of-motion limitations and pain after conventional radiographs of the cervical spine were repeated. An underlying hangman’s fracture was detected on the repeat radiographs, which precluded physical therapy intervention, and the patient was referred to a neurosurgeon for definitive management.

A clinical decision rule was developed to help clinicians determine when initial radiographs of the cervical spine may be indicated in patients with neck pain caused by trauma (Fig. 1). Given its purpose of minimizing the chance of missing a fracture, sensitivity of the rule was maximized (sensitivity = 100%; 95% confidence interval [CI] = 98%, 100%). Based on this level of sensitivity and the very narrow CI, a negative finding on this rule essentially rules out the presence of a cervical spine fracture, and radiographs are not indicated. Using this clinical decision rule for the patient described in this case report, radiographs would have been indicated immediately after his motor vehicle accident based on a positive response to the first question of the clinical decision rule (ie, dangerous mechanism of injury) (Fig. 1).

Based on the specificity of this rule (specificity = 43%; 95% CI = 40%, 44%), it would not have been surprising if the radiographs were indeed negative for a fracture, even though this patient was positive according to the rule. According to Mower et al, however, conventional radiographs may not always detect serious cervical injuries in patients with a history of blunt trauma. Therefore, if the patient’s history and physical examination findings suggest serious underlying bony pathology (even if initial screening radiographs were negative for a fracture), the radiographs should be repeated, or, if warranted, more advanced diagnostic imaging should be performed.

Although Mower et al did not define the clinical characteristics of the patients who had important bony cervical spine injuries missed on initial screening radiographs, Blackmore et al defined the clinical predictors of cervical spine fractures and quantified the degree to which each of these clinical predictors influenced the probability of a fracture. Blackmore et al studied 472 patients seen in an emergency department following trauma, including 168 patients with cervical spine fractures. They determined that the important predictors of cervical spine fractures are:

1. high-energy cause of injury (ie, high-speed motor vehicle accident > 48 km/h or pedestrian struck by motor vehicle: odds ratio [OR] = 11.6; 95% CI = 5.4, 25),
2. the patient’s age (ie, age > 50 years: OR = 4.0; 95% CI = 2.1, 7.8),
3. the presence of a severe head injury (ie, intracranial hematoma, brain parenchymal contusion, skull fracture, or loss of consciousness: OR = 8.5; 95% CI = 4.0, 17.0), or
4. focal neurological deficit (ie, focal neurological deficit that could be in a spinal cord or spinal nerve distribution: OR = 58; 95% CI = 12.0, 283.0).

Before implementing physical therapy interventions, we recommend that physical therapists consider the clinical predictors described by Blackmore et al with patients who have a history of cervical spine trauma and no fractures evident on adequate initial screening radiographs to help guide the use of repeat radiographs, advanced cervical spine diagnostic imaging, or medical referral.

In a recent systematic review, Li et al concluded that treatment options for patients with a hangman’s fracture should be recommended according to the stability of the fracture. For patients with stable cervical spine injuries without neurological deficits or signs of later instability, external immobilization of the cervical spine was recommended. Surgical stabilization was recommended for patients with cervical instability or the possibility of later instability. For the patient described in this case report, the neurosurgeon recommended that he continue with nonsurgical management after his fracture was detected 8 weeks following his motor vehicle accident. This decision, which is consistent with the recommendations of Li et al, was based on a normal neurological examination, a relatively low level of pain, and the results of radiographic flexion and extension views of the cervical spine, which revealed no evidence of instability.

**Conclusion**

In patients with neck pain caused by trauma, physical therapists should be alert for the presence of cervical spine fractures. Even if initial radiographs are negative for a fracture, additional diagnostic imaging may be necessary for a small number of patients, because they may have undetected injuries that would necessitate medical referral and preclude physical therapy intervention. Although the short-term outcome from this case was favorable (despite the presence of a fracture that went undetected for 8 weeks), this case report demonstrates the importance of screening for underlying cervical spine fractures in patients with neck pain following trauma.
Undetected Hangman’s Fracture

Both authors provided concept/idea/research design, writing, data collection and analysis, project management, subject, facilities/equipment, and consultation (including review of manuscript before submission). Dr Ross provided institutional liaisons and clerical/secretarial support.

The opinions expressed herein are those of the authors and do not necessarily reflect the opinions of the Department of Defense, the United States Air Force, or other federal agencies.

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