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# Stability of Cervical Spine Fractures After Gunshot Wounds to the Head and Neck

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**Study Design.** Retrospective chart review.

**Objectives.** To determine the frequency of stable and unstable cervical spine fractures after gunshot wounds to the head or neck; to identify potential risk factor(s) for an unstable *versus* stable cervical spine fracture.

**Summary of Background Data.** Cervical spine fractures after gunshot wounds to the head and neck are common. Because of the nature of their injuries, patients often present with concomitant airway obstruction and large blood vessel injury that can necessitate emergent procedures. In some cases, acute treatment of these problems can be hindered by the presence of a cervical collar or strict adherence to spinal precautions (*i.e.,* patient laying supine). In such situations, information regarding the probability of a stable *versus* unstable cervical spine fracture would be useful in emergency treatment decision making.

**Methods.** A search for patients with gunshot wounds to the head or neck potentially involving the cervical spine over a 13-year period was performed using a trauma registry. Individuals with cervical spine fractures were identified and their records reviewed in detail. Data collected included information about neurologic deficits, mental status, airway treatment, entrance wounds, fracture level/type, initial/definitive fracture treatment, and final disposition at hospital discharge.

**Results.** A total of 81 patients were identified; 19 had cervical spine fractures. There were 5 patients who were not examinable because of altered mental status (severe head trauma, hemorrhagic shock, or intoxication). All 5 patients had stable cervical spine fractures. There were 11 patients who had an acute spinal cord injury, 3 (30%) of whom underwent surgery for an unstable fracture. Of the 65 awake, alert patients without a neurologic deficit, only 3 (5%) had a fracture, none of which were unstable.

**Conclusions.** Gunshot wounds to the head and neck had a high rate of concomitant cervical spine fracture. Neurologically intact patients have a lower rate of fracture than those presenting with a spinal cord injury or altered mental status. In this small series of patients, the only unstable cervical spine injuries were detected in patients with a spinal cord injury. The data suggest that spinal precautions and/or a hard cervical collar should not be maintained at the expense of delaying or hindering emergent life-saving airway or hemodynamically stabilizing procedures, particularly in awake, neurologically intact patients. However, the cervical collar and spinal precautions should be resumed after such procedures are completed and continued until a more definitive evaluation of spinal stability can be performed.

**Key words:** stability, head trauma, neck trauma, gunshot wounds, cervical spine, spine fracture, hard collar, surgery, spine precautions, immobilization. **Spine 2005; 30:2274–2279**

Patients with gunshot wounds to the head and neck are initially presumed to have a potentially unstable cervical spine fracture until radiographic and physical examination can be performed. In following, victims of gunshot wounds to the head and neck are usually immobilized in the field with a hard cervical collar before presentation to the emergency department. Cervical radiographs are then routinely performed as a first step for excluding a cervical spine fracture.

In many patients, substantial airway and vascular injuries have occurred[1] that may present an imminent threat to a patient's survival. The priority of treatment of these injuries clearly supersedes that of a potential cervical spine injury. Methods of acute airway or hemodynamic treatment, such as a cricothyrotomy, central line placement, or open vascular exploration, necessitate full exposure of the neck that can be hindered by the presence of a cervical collar. In other patients with less severe airway obstruction, simply sitting the patient up can allow improved clearance of blood and secretions, although this maneuver is often avoided in strict adherence to spinal precautions (*i.e.*, laying flat, log rolls). Notwithstanding the worth of manual techniques of neck stabilization, it would be useful to know, based on physical examination characteristics, the likelihood of the presence of an unstable cervical spine fracture after a gunshot wound to the head or neck. This information might influence the decision to remove a cervical collar earlier to facilitate urgent interventions. It could enable a more selective application of cervical spine precautions and immobilization to those patients at a real, rather than perceived, risk of an unstable injury.[1–4]

To our knowledge, there are no previous studies that have examined the incidence of stable and unstable cervical spine fractures after gunshot wounds to the head and neck regions. Hypothesizing that an unstable injury would be exceedingly rare in a patient without a neurologic deficit, it was this study's purpose to compare the incidence of stable and unstable cervical spine fractures

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in patients with and without neurologic deficit over a 13-year period at an urban inner city, level 1 trauma center.

## ■ Materials and Methods

A previously established computerized registry (DBASE® 5; Borland, CO) of all trauma patients admitted to the surgical intensive care unit at an urban inner city, level 1 trauma center from 1984 to 1997 was used to identify subjects for this study. During this period, all gunshot wounds to the head, neck, and thorax were initially admitted to the surgical intensive care unit for airway, hemodynamic, and neurologic observation, regardless of the severity of the injury. This procedure ensured the capture of all potential candidates for the current study. Specific queries using the diagnosis codes E965.0 (handgun), E965.1 (shotgun), or E965.2 (rifle) were used to identify all gunshot victims. The resultant list of patients was then reviewed to select only those patients with injuries to the head and/or neck regions. From these patients, those who had a cervical spine fracture secondary to a gunshot wound were identified using the diagnosis code E805.1 (open cervical fracture) for subsequent detailed chart review. A retrospective medical record review was then subsequently performed for all identified victims with cervical spine injury. Before inception of this study, approval was obtained from the institutional review board.

The following data were then collected and recorded from the medical records: (1) neurologic deficits, including the level of spinal cord injury on initial examination; (2) mental status as measured by the Glasgow Coma Scale; (3) method and necessity of airway treatment; (4) location of entrance wounds; (5) the presence, level, and type of cervical spine fracture; (6) initial and definitive treatment of cervical spine injuries; and (7) the final disposition of the patient at discharge from the hospital. Incidences of various injury parameters were then calculated and expressed as percentages. Confidence intervals (CIs) were calculated using STATA® SE 7.0 (StataCorp, College Station, TX) and reported where appropriate. Because of the small numbers in this series, it was the authors' intent to present a range of values (with 95% confidence) for each calculated incidence that might be expected were the study to be repeated on a large population. In this manner, the data might be better extrapolated to a population-wide basis.

## ■ Results

A total of 81 patients with gunshot wounds to the head or neck potentially involving the cervical spine were identified over the 13-year period (Figure 1). There were 19 patients (23%; 95% CI 14% to 33%) who had a cervical spine fracture. Fractures were initially detected by plain radiographs in all but 1 patient (No. 9), in whom fractures of the C3 pedicle, facet, and lamina were first detected by computerized tomography. The most common entrance wound location was the neck, followed in descending order by the face, chest, and posterior shoulder (Table 1). The level, types, and treatment of each injury are listed in Table 2.

**Table 1. Distribution of Entrance Wounds**

| Wound Location | No. Injuries |
|---|---|
| Neck | |
| Zone I | 2 |
| Zone II | 5 |
| Zone III | 2 |
| Face | 8 |
| Chest | 1 |
| Shoulder (superior angle of scapula) | 1 |

Acute airway treatment was necessary in 16 (84%) of the 19 patients with fractures. This total included orotracheal intubation in 14 patients, nasotracheal intubation in 1, and an emergent cricothyrotomy in another. The remaining 3 patients did not require airway intervention. Of the 19 patients, 3 died during initial hospitalization, 11 were discharged to a spinal cord rehabilitation unit or chronic care facility, and 5 were discharged to home directly from the hospital.

### *Patients with Neurologic Deficit (examinable)*

There were 11 patients who presented with acute neurologic deficits, all of whom were men who had had a cervical spine fracture secondary to the missile injury. Spinal cord injury, evidenced by partial or complete flaccid extremity paralysis, decreased or absent sensation below the level of injury, decreased or absent rectal tone, or priapism, was documented in all 11 patients. Of the victims, 8 had quadriplegia, and 2 of them had paraplegia.

Operative stabilization and/or decompression for an unstable cervical spine injury were required in 3 patients. One patient (No. 17) underwent an anterior corpectomy, fusion, and plating for a comminuted C6 vertebral body and lateral mass fracture that occurred from a high-energy rifle injury. The second patient (No. 18) underwent C4–C7 posterior instrumented fusion without a formal decompression after having extensive comminution of both C5–C6 facet joints and transverse processes.

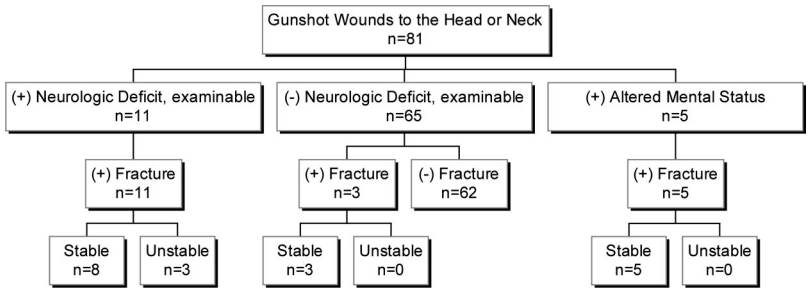


Figure 1. Flow chart of all patients with gunshot wounds to the head or neck that presented to the authors' institution over a 13-year period. The presence or absence of neurologic deficit is noted as well as the presence of a stable or unstable cervical spine fracture. n, number of patients.

**Table 2. Cervical Spine Fractures Resulting From Gunshot Wounds to the Head and/or Neck**

| Patient No. | Fracture Level, Type | Neurologic Status | Intervention | Adverse Clinical Outcome |
|---|---|---|---|---|
| 1 | C1 Lateral mass | Intact | Hard collar | |
| 2 | C1 Anterior arch | Altered MS | Hard collar | Brain death |
| 3 | C1 Anterior/posterior ring, C2 body comminuted | Altered MS | Hard collar | |
| 4 | C1 Anterior, C2 body and dens | SCI | Halo traction → C1–C2 fusion | |
| 5 | C2–C3 Subluxation, dens, C2 lamina/C2–C3 facet joint | SCI | SOMI brace | |
| 6 | C2 Spinous process/lamina | SCI | Hard collar | |
| 7 | C2–C3 Comminuted articular pillars | Intact | Hard collar | |
| 8 | C3 Body, nondisplaced | SCI | Hard collar | |
| 9 | C3 Pedicle, facet and lamina | SCI | Hard collar | |
| 10 | C3 Body and lamina | SCI | Tong traction → hard collar | |
| 11 | C3 Transverse process | Altered MS | Hard collar | Brain death |
| 12 | C3–C4 Facet | SCI | Hard collar | Death, thoracic injury |
| 13 | C4 Spinous process avulsion | Intact | Hard collar | |
| 14 | C5 Body | SCI | Tong traction → SOMI brace | |
| 15 | C5 Open | Altered MS | Hard collar | Brain death |
| 16 | C6–C7 Facet | SCI | Hard collar | |
| 17 | C6 Vertebral body, lateral mass, C6–C7 transverse process | Altered MS | C6 Corpectomy, C5–C7 anterior fusion | |
| 18 | C6 Bilateral facet and transverse process | SCI | C4–C7 Posterior fusion | |
| 19 | C7 Pedicle, T1 lateral mass | SCI | Hard collar | |

MS = mental status; SCI = spinal cord injury; SOMI = sterno-occipital-mandibular-immobilizer.

A third patient (No. 4) was treated with a posterior C1–C2 fusion after a brief period of traction failed to reduce an unstable, comminuted C2 odontoid and vertebral body fracture with a concomitant C1 ring fracture.

Weighted traction using cranial tongs was used to realign cervical fractures in 3 patients, including patient No. 4, 2 of whom were definitively treated in a sterno-occipital-mandibular-immobilizer brace (No. 14) or hard collar (No. 10). The remaining 6 patients with a spinal cord injury were treated with a hard collar or sterno-occipital-mandibular-immobilizer brace without traction for stable cervical spine fractures (patient Nos. 5, 6, 8, 9, 16, and 19).

#### *Patients with Altered Levels of Consciousness (not examinable)*

There were 5 patients who initially presented with an altered level of consciousness and a Glasgow Coma Scale of 3. Three patients (Nos. 2, 12, and 15) had severe brain injuries and progression to a persistently vegetative state. One patient (No. 11), who had had a zone 1 neck injury and underwent an emergent thoracotomy for hemorrhagic shock, eventually died of exsanguination. Despite the unfortunate outcomes, all 3 of these severely brain-injured individuals had, what was considered by the spine service, to be mechanically stable cervical spine fractures that were ultimately treated in a hard collar. The fifth patient (No. 3) presented to the emergency department extremely combative secondary to cocaine and alcohol intoxication. Despite grossly moving all 4 extremities, a detailed neurologic examination could not be reliably performed at initial presentation to exclude a spinal cord injury. This patient had a stable anterior and posterior C1 ring fracture, and odontoid fracture that was definitively treated with a hard collar. After detoxification, the patient had a normal neurologic examination.

#### *Patients without Neurologic Deficit (examinable)*

The majority of patients (65 of 81, 75%) were awake, examinable, and had no signs of acute neurologic deficit. Cervical spine fractures were detected in only 3 patients (Nos. 1, 7, and 13) in this group (4.6%; 95% CI 1.0% to 12.9%). These fractures were treated in a hard collar, and no acute or late surgical interventions were performed in this group. No patients (0%; 95% CI 0% to 5.5%) were found to have unstable fractures.

## ■ Discussion

Gunshot wounds to the head and neck frequently involve the cervical spine. With 13% to 17% of all spinal cord injuries each year caused by penetrating trauma,[5–7] those of the cervical region are perhaps the most devastating.[8,9] Despite their relative frequency, there remains a paucity of evidence-based data concerning the treatment of these serious injuries. In particular, the role of routine cervical immobilization after gunshot wounds to the head and neck remains unclear.

Most practitioners agree that low-velocity gunshot wounds to the spine are usually inherently mechanically stable.[3,9–11] Despite this, routine cervical immobilization after neck and head gunshot wounds, usually in the form of a hard cervical collar and spinal precautions, is usually recommended until radiographic "clearance" of the spine. In patients in whom airway and respiration are not compromised and those who are easily hemodynamically resuscitated, it seems prudent to postpone removal

of the collar until spinal imaging has been performed. However, in many cases, concomitant injuries such as hemorrhage or laryngeal edema are present. It is in these cases that a cervical collar can impede life-saving procedures, such as cricothyrotomy or neck exploration.

To understand better this issue, one must first examine the likelihood of cervical fracture after a gunshot wound. Previous investigators have stratified the risk of fracture after gunshot wounds to the head.[3,10] In a series of 53 consecutive patients with gunshots to the cranium, Chong *et al*[12] found that none had cervical spine fractures. Similarly, Kennedy *et al*[3] reported no cervical spine fractures in 105 patients with gunshots limited to the calvaria. However, in a group of patients with wounds extending outside the calvaria, they found a 10% incidence of cervical spine fracture. Kihitir *et al*[10] examined the risk of spine injury after gunshot wounds to the face. Although injuries involving the maxillary and orbital regions had a 10% and 20% rate of cervical fracture, respectively, none was reported after gunshots to the mandible.

The rate of cervical spine fracture after gunshot neck injuries has also been previously examined. In a review of 110 gunshot wounds to the neck, Ordog *et al*[13] found cervical spine fractures in 24 patients (22%). Isiklar and Lindsey[14] reported a series of 12 cervical spine fractures resulting from civilian gunshot wounds. Although all 3 (25%) unstable fractures presented in patients with spinal cord injury, only 1 of the 12 patients was neurologically intact, limiting conclusions about the likelihood of an unstable fracture in this subgroup.

The findings from the current study are comparable to those previously reported. The overall rate of cervical spine fracture was 23% after gunshot wounds to the head or neck. Of these fractures, 16% were unstable. The overall incidence of unstable spine fractures after gunshot wounds to the head or neck was low in the current series, occurring in only 3.7% of cases. More importantly, none occurred in patients who were examinable and neurologically intact. Although these data suggest that the cervical collar can be removed and spinal precautions discontinued in most alert and awake patients without spinal cord injury, a number of additional variables must be considered. It must be acknowledged that numbers in the current study were too low to consider the actual risk of unstable fracture to be zero. In fact, the 95% CI for this incidence was 0% to 5.5%. In other words, if this study were repeated with much larger numbers, perhaps on a population-wide scale, the rate of unstable fracture in neurologically intact patients may be as high as 5.5%. Therefore, the current authors are reluctant to recommend collar removal based on this one parameter. The fracture pattern is also considered important because some fractures, such as bilateral facet joint injuries or extensively comminuted odontoid fractures, are more likely to be unstable than others fractures, such as a unilateral facet injury or a unilateral C2 pedicle fracture. In the awake, examinable, and cooperative patient, additional information, such as that gained from flexion-extension views, can be used to determine the stability of the cervical spine.

To temper further such conclusions, one must consider that an unstable spine fracture is possible in a neurologically intact patient after a gunshot wound. In a review of the literature, only 1 such case was found.[15] Considering the potentially disastrous complication of creating a neurologic deficit by displacing an unstable spine fracture, the authors advise that when it does not prevent or inhibit life-saving maneuvers, the cervical collar should remain in place and spinal precautions observed until adequate radiographic examination.

The type of weapon is another important consideration in judging the probability of an unstable fracture. Unfortunately, the use of high-energy weapons has become increasingly popular among the civilian criminal element,[16] accounting for 16% of homicides in New York City in 1995.[17] High-energy weapons, such as rifles and military assault weapons, impart exponentially more damage to bone and soft tissue than typical low-energy weapons, such as handguns. Accordingly, head and neck injuries secondary to high-energy weapons should be treated with caution. In a review of penetrating neck wounds during wartime, Arishita *et al*[18] found the injury to be fatal in all cases. In the current study, 1 of the 3 (33%) unstable fractures was the result of a high-energy rifle wound. Although these data are limited, it seems prudent to hold a higher index of suspicion for an unstable cervical spine fracture after high-energy gunshot wounds to the head and neck. Based on the presented data, cervical spine injury should be suspected in all patients presenting with a gunshot wound to the neck or head. It appears that 2 subgroups of patients are at particularly high risk for the presence of a cervical spine fracture: (1) those with a neurologic deficit and (2) those who have altered mental status.

Notwithstanding the limited numbers, it is noteworthy that all 5 patients who presented with an altered mental status, either from head injury, hemodynamic shock, or intoxication, had had a cervical spine fracture. These 5 were the only patients who presented with an altered mental status and, thus, were not examinable of the 81 with gunshot wounds to the head and neck. Although it has been previously suggested that the presence of a neurologic deficit may be a risk factor for cervical spine fracture,[13,14] to the authors' knowledge, this is the first report to suggest that patients presenting with an altered mental status may be also be a high-risk group. While all 5 patients were considered to have stable fractures, manipulation of the head and neck, and removal of the cervical collar in a patient who cannot be serially neurologically examined should proceed with the utmost caution.

A number of limitations of this study must be noted. Although the 81 identified cases represented all head and neck gunshot injuries during a 13-year period, the true incidence of unstable *versus* stable cervical spine injuries

after gunshot wounds may not be accurately reflected in a study of a single center's experience. Because patients were only followed until hospital discharge, long-term neurologic and treatment outcomes were not assessed; however, they were not the foci of the current analysis. An additional question that was not addressed is the frequency of concomitant thoracic or lumbar fractures after cervical spine gunshot wounds, which could influence the decision to discontinue full spine precautions and sit a patient upright.

Another important limitation of this study is that various members of the orthopedic spine service assessed spinal stability. By the nature of this study being retrospective, as well as involving a number of different practitioners, a uniform set of mechanical stability criteria were not used. This result could certainly have introduced an additional source of bias. Although there are currently no universally accepted published criteria for assessing spinal stability after gunshot wounds, the authors have developed an algorithm that might be useful to guide workup, imaging, and immobilization of patients with injuries to the neck (Figure 2). It distinguishes patients at high risk for a potentially unstable cervical fracture, which includes those who are not examinable or present with a neurologic deficit. Furthermore, based on extrapolation of biomechanical and clinical data of cervical injuries sustained by blunt trauma, lists of likely stable and unstable fracture patterns have been formulated. Currently in the authors' institution, these are the criteria on which the decision to remove the cervical collar or perform a spine stabilizing procedure are based.

## ■ Conclusions

Collar immobilization and adherence to spinal precautions are warranted in patients with gunshot wounds

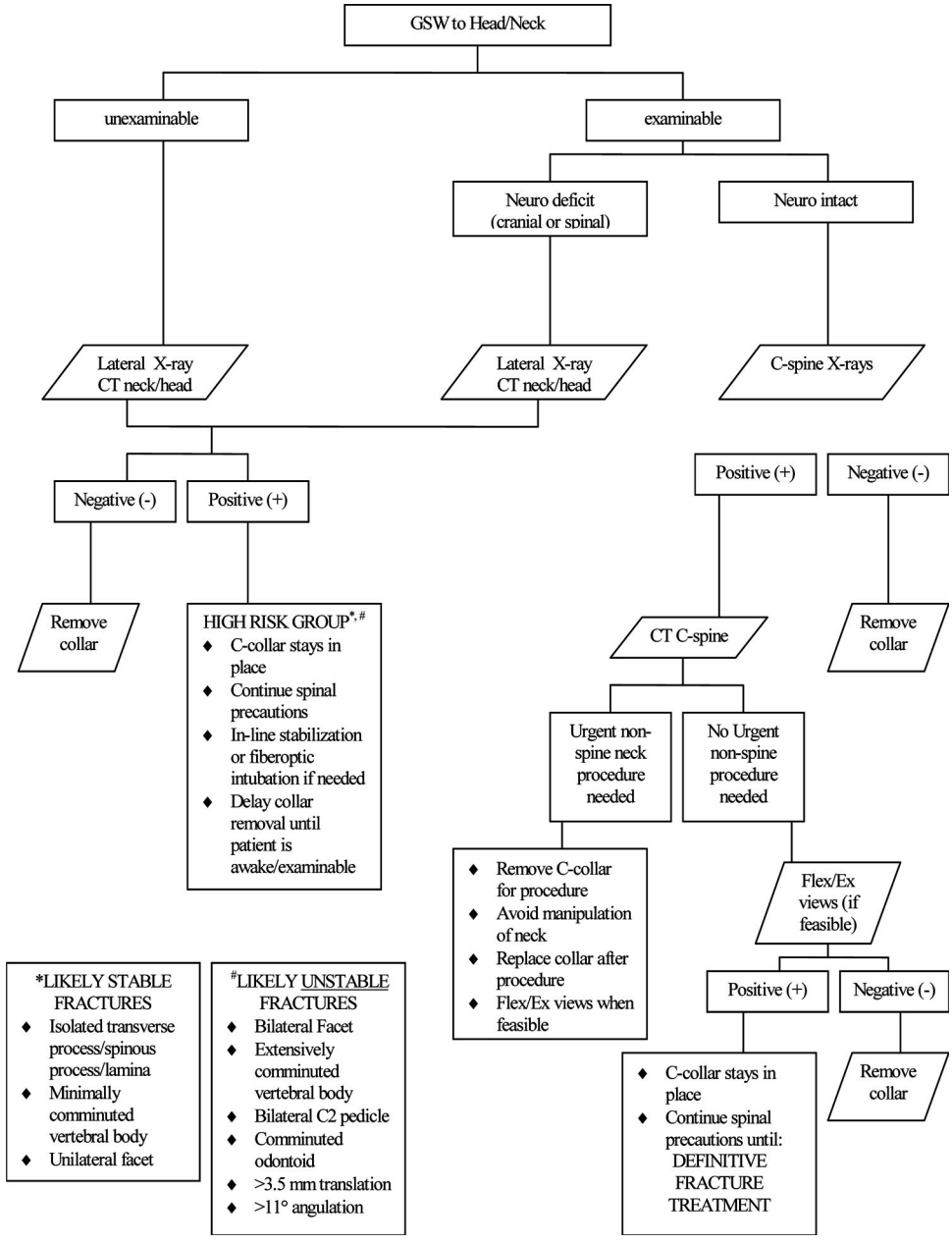


Figure 2. Algorithmic approach to evaluation and cervical immobilization of patients with gunshot wounds to the head or neck who present to the emergency department or trauma bay.

that potentially involve the cervical spine. From the presented data, the incidence of cervical spine fractures in patients with gunshot wounds to the head or neck is sufficiently high to warrant routine cervical spine imaging. It appears that the overall rate of cervical spine fracture is lower in awake, examinable patients without a neurologic deficit compared to those who have a spinal cord injury or altered mental status. In this series, the only unstable fractures occurred in those patients who had a neurologic deficit associated with a spinal cord injury. These data suggest that the presence of an unstable cervical spine fracture in a patient who is awake, alert, and examinable, and who demonstrates no neurologic deficit is low. Although the suggested algorithm may be helpful, the decision to remove the hard collar and/or discontinue spinal precautions should always be made on an individual basis. However, in select neurologically intact patients in whom emergent airway control or neck exploration is necessary, it would be reasonable to remove any obstructive devices to allow more expedient treatment.

### ■ Key Points

- Gunshot wounds to the head and neck have a high rate of concomitant cervical spine fracture.
- Neurologically intact patients have a lower rate of fracture than those presenting with a spinal cord injury or altered mental status.
- In this series, the only unstable cervical spine injuries were detected in patients with a spinal cord injury.
- These data suggest that spinal precautions and/or a hard cervical collar should not be maintained at the expense of delaying or hindering emergent life-saving airway or hemodynamically stabilizing procedures, particularly in awake, neurologically intact patients.
- However, the cervical collar and spinal precautions should be resumed after such procedures are completed and continued until a more definitive evaluation of spinal stability can be performed.

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