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Prehospital Management Of Suspected Cervical Spine Injuries: A Paramedic Perspective

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Abstract

Cervical spine injuries (CSIs) pose significant risks due to their potential for catastrophic neurological consequences. Paramedics play a crucial role in the prehospital management of suspected CSIs, as their decisions and actions can significantly impact patient outcomes. This review provides a comprehensive synthesis of current evidence and practices related to the prehospital management of suspected CSIs from a paramedic perspective. The epidemiology of CSIs is discussed, highlighting the predominance of these injuries in young adult males and the increasing incidence among the elderly population. The pathophysiology of CSIs is explored, emphasizing the importance of minimizing secondary injury through early immobilization and careful patient handling. The paramedic's role and responsibilities in assessing and managing suspected CSIs are outlined, including the use of clinical decision tools and immobilization techniques. Airway management in the context of suspected CSIs is a critical challenge for paramedics, requiring a balance between maintaining airway patency and minimizing cervical spine movement. Pain and sedation management is also discussed, considering the need to provide effective analgesia while preserving neurological assessment integrity. Extrication and transport considerations are reviewed, focusing on safe patient movement techniques and the decision between air and ground transport. Finally, recommendations for practice improvement are provided, summarizing best practices supported by current evidence, identifying areas requiring further research, and emphasizing the importance of interprofessional collaboration between paramedics, nurses, and physicians in optimizing patient care.

Keywords: Cervical spine injury; spinal immobilization; prehospital care; paramedics; spinal motion restriction (SMR).

1. Introduction

Spinal injuries represent a critical concern in trauma care due to their potential for permanent neurological impairment and disability. Among spinal injuries, cervical spine injuries (CSI) pose the greatest risk because of their proximity to the brainstem and the essential neurological pathways they contain. Damage to the cervical spine can lead to catastrophic outcomes, including paralysis or death, emphasizing the importance of early and effective management from the point of injury (Yadollahi et al., 2016).

Cervical spine injuries account for a significant burden in trauma populations worldwide. The incidence rates vary but are generally estimated around 12 to 15 per 100,000 persons annually in different regions, with younger adults and males disproportionately affected, often due to high-energy mechanisms such as motor vehicle collisions and falls. Recently, demographic shifts have shown an increasing incidence among elderly populations, often due to low-energy falls, illustrating epidemiological transitions in many countries. Globally, cervical spinal cord injuries account for more than half of all traumatic spinal cord injuries, with an increasing trend in absolute cases although age-adjusted rates have plateaued or declined slightly. These injuries lead to substantial morbidity, long-term disability, and healthcare costs, requiring tailored public health and clinical strategies to reduce incidence and improve outcomes (Utheim et al., 2022).

The pathophysiology of cervical spine injury involves not just the primary mechanical insult but also secondary injury cascades that occur minutes to days afterward. Secondary injury includes ischemia, inflammation, and cellular apoptosis that worsen neurological deficits. Early immobilization prevents harmful movements that may exacerbate spinal cord damage during patient extrication and transport. Immobilization techniques such as manual in-line stabilization and the use of cervical collars aim to maintain spinal alignment and reduce motion, thereby minimizing secondary injury risk. Timely intervention in the prehospital setting is crucial to preserving neurological function and optimizing recovery potential (Waghmare & Singh, 2024a).

Paramedics are often the first healthcare providers to encounter trauma patients with suspected cervical spine injuries. Their role is pivotal in early assessment, spinal immobilization, airway management, and rapid transport to definitive care facilities. Decisions made by paramedics concerning spinal immobilization and airway techniques directly impact patient outcomes. The prehospital phase is vulnerable to secondary spinal damage due to movement during rescue and transport, highlighting why paramedics must be well-trained and equipped to manage suspected CSI safely and effectively. Advances in training, protocols, and immobilization technology have increasingly empowered paramedics to not only manage suspected CSI but also to participate in clinical decision-making about immobilization necessity, reducing unnecessary interventions without compromising safety (Vaillancourt et al., 2011).

This review aims to provide a comprehensive synthesis of current evidence and practices related to the prehospital management of suspected cervical spine injuries from a paramedic perspective. It will cover epidemiological insights, the pathophysiological rationale for early immobilization, practical assessment, decision-making algorithms, immobilization techniques, airway management considerations, and current controversies in spinal clearance and immobilization protocols. By focusing on the paramedic's role, this review underscores the critical nature of prehospital care in mitigating secondary injury, enhancing patient safety, and improving neurological outcomes for trauma patients with suspected cervical spine injuries.

2. Anatomy and Biomechanics of the Cervical Spine

The cervical spine is composed of seven vertebrae labeled C1 through C7. It supports the skull, protects the spinal cord, and allows a remarkable range of motion including flexion, extension, lateral bending, and rotation. The first cervical vertebra (atlas) and the second (axis) are specialized to enable rotation, with the atlanto-axial joint permitting up to 90° of rotation due to its unique biconcave articulating facets. The vertebral bodies from C2 to C7 provide both structural support and protection to the spinal cord segments traversing this region, which include crucial neurovascular elements supplying the head and upper limbs (Swartz et al., 2005).

Biomechanically, the cervical spine is highly mobile but also inherently vulnerable to injury due to its design balancing flexibility and stability. The range of motion averages about 80° to 90° of flexion, 70° of extension, 20° to 45° of lateral flexion, and up to 90° of rotation, primarily occurring at the upper cervical segments (C1-C2). The instantaneous center of rotation varies by vertebral segment and influences how forces translate through the spine during motion. Notably, cervical vertebrae can undergo complex coupled movements, such as the atlas extending when the cervical spine flexes, reflecting a sophisticated interplay of forces that impacts injury mechanisms (Swartz et al., 2005).

2.1 Mechanisms of Injury

In prehospital settings, understanding cervical spine injury mechanisms aids paramedics in assessment and management. Common forces leading to injury include:

- **Flexion:** forward bending causing ligamentous injury, subluxations, and compression fractures.
- **Extension:** backward bending often resulting in avulsion fractures and dislocations such as the Hangman's fracture.
- **Axial Loading (Vertical Compression):** forces transmitted along the spine axis causing burst fractures or Jefferson fractures, where sudden compressive forces lead to vertebral body failure.
- **Rotational Forces:** twisting motions that may produce unilateral facet dislocations and avulsions of ligaments such as the alar ligament, potentially leading to instability.
- **Lateral Flexion:** side-bending forces that can cause fractures of processes or joints.

These mechanisms rarely act in isolation; high-energy trauma often involves combinations, complicating injury patterns. For example, during axial loading, the cervical spine experiences a 'buckling' effect where compressive forces cause rapid angulations that may produce severe ligamentous and bony injuries within milliseconds, before gross movement is visible (Waseem et al., 2025).

2.2 Relationship Between Mechanism and Instability Patterns

The injury mechanism strongly influences the type and stability of cervical spine lesions. Flexion injuries may cause anterior subluxation and compromise posterior ligaments, leading to unstable injuries risking spinal cord damage. Extension injuries such as Hangman's fractures involve bilateral pars interarticularis fractures leading to instability. Axial loading may result in burst fractures that disrupt the vertebral body and posterior elements, often causing instability and neurologic compromise. Rotation combined with flexion or extension frequently leads to facet dislocations, severely destabilizing the spine. Clinically, spinal stability is defined by the spine's ability to maintain neural element protection under physiological loading without progressive deformity. Understanding the mechanism helps paramedics anticipate potential instability, guiding immobilization decisions and triage urgency (Gupta et al., 2012).

3. Epidemiology and Etiology of Cervical Spine Injuries

Cervical spine injuries (CSI) represent a significant trauma subset due to their potential for catastrophic neurological consequences. The incidence of cervical spine fractures has been reported to be around 12 per 100,000 population annually, though precise epidemiological data vary between regions and healthcare settings. Traumatic spinal cord injuries (TSCIs), of which cervical lesions predominate, make up a substantial portion of spinal trauma and contribute heavily to long-term morbidity and mortality (Yadollahi et al., 2016).

3.1 Incidence and Prevalence Across Demographics

CSIs predominantly affect young adults in the age group of 16 to 40 years, with a marked male predominance observed across numerous studies. For example, one study showed that 78% of cervical spine fracture patients were male, highlighting a consistent trend toward higher injury rates in males due to greater exposure to high-risk activities. However, there is also a notable increase in CSI incidence observed in the elderly population, often related to falls and underlying degenerative spinal conditions, such as osteoporosis and spondylosis, with increased mortality risk in patients aged 75 years and older (Barbiellini Amidei et al., 2022).

Geographically, the incidence varies; high-income countries report TSCI incidence rates ranging from 12.1 to 57.8 per million population per year, whereas low-income regions report lower but variable rates, possibly due to underreporting or limited trauma surveillance systems. Cervical lesions constitute over 50% of TSCI cases, affirming the cervical spine as the most vulnerable region in traumatic spinal injuries (Barbiellini Amidei et al., 2022).

3.2 Common Causes

The etiology of CSI is largely attributable to high-energy trauma. The leading mechanisms include:

- Motor vehicle collisions (MVC), including car rollovers and high-speed impacts, consistently the most frequent cause in adult populations (Clayton et al., 2012).
- Falls, particularly significant in older adults with falls from standing height or higher, and an increasing cause due to the aging population (Clayton et al., 2012).
- Sports-related trauma, particularly contact sports and recreational activities contributing to cervical sprains and fractures.
- Violence, including assaults leading to blunt trauma to the cervical region.

The forces involved in injury are typically flexion, extension, axial loading (compression), rotation, lateral bending, or distraction, with combined force vectors seen in high-energy trauma. Low-velocity trauma can also cause injury, especially in those with preexisting cervical spine degeneration (Waseem et al., 2025).

3.3 Risk Factors and Coexisting Trauma Patterns

Risk factors for cervical spine injury have been elucidated in trauma registries and clinical studies. Motor vehicle collisions and falls are independent predictors of CSI, with an odds ratio of 1.6 to 2.1 for these mechanisms. Younger age (<40 years) is a risk factor in some cohorts, while older age increases mortality risk (Clayton et al., 2012).

Coexisting trauma commonly involves head injuries and pelvic fractures. The combination of pelvic fracture with either falls or head injuries greatly amplifies the risk of concurrent cervical injury, indicating a need for heightened suspicion and careful evaluation in these patients. Thoracic injuries are frequently associated, particularly in high-energy impacts (Clayton et al., 2012).

3.4 Prehospital Detection and Outcomes

Prehospital identification of cervical spine injury is critical in minimizing secondary injury. Clinical suspicion is based heavily on injury mechanism and presentation, yet missed diagnoses can occur. Studies report that around 17% of blunt trauma patients with confirmed cervical spine injuries did not receive prehospital cervical spinal motion restriction (C-SMR), attributed to factors such as patient age, injury mechanism (e.g., low falls), and clinical severity (Jao et al., 2023).

Early immobilization protocols are vital; however, not all patients with cervical fractures exhibit obvious neurological deficits initially, emphasizing the challenge for paramedics and emergency medical providers to accurately detect potential injuries in the field. Outcomes are significantly influenced by the timeliness and appropriateness of immobilization and transport, with cervical lesions associated with higher mortality than injuries to other spinal segments, especially in elderly patients (Shaharudin et al., 2025).

4. Pathophysiology and Mechanisms of Secondary Injury

Understanding the pathophysiology behind cervical spine injuries is crucial for paramedics, as early prehospital decisions can significantly affect patient outcomes. Spinal Cord Injury (SCI) involves two stages: primary injury and secondary injury, each with different mechanisms and implications (Zhang et al., 2021).

4.1 Primary vs. Secondary Spinal Cord Injury

The primary injury is the initial mechanical trauma that physically damages the spinal cord tissue. This can involve direct impact, compression, contusion, laceration, or vascular disruption from forces such as dislocation, fracture fragments, or penetrating injuries. The primary insult occurs at the moment of trauma and sets the stage for subsequent damage (Alizadeh et al., 2019).

The secondary injury develops minutes to days after the initial insult and involves a cascade of biological processes that exacerbate tissue damage beyond the primary site. This includes ischemia (lack of blood flow), inflammation, oxidative stress, excitotoxicity (neuronal damage caused by excessive neurotransmitters), edema (swelling), and apoptosis (programmed cell death) among others. These reinforce and expand the injury, often worsening neurological outcomes (Anjum et al., 2020).

4.2 Role of Ischemia, Inflammation, and Spinal Shock

- **Ischemia:** Primary mechanical disruption often impairs spinal cord blood flow via vascular injury and vasospasm, causing local hypoxia (oxygen deficiency). This ischemia rapidly leads to cellular energy failure, ionic imbalances, and neuronal death. Ischemic injury is central to secondary damage and produces cytotoxic, ionic, and vasogenic edema in spinal tissues (Anjum et al., 2020).
- **Inflammation:** Following ischemia and cellular injury, inflammatory cells infiltrate the spinal cord releasing cytokines and free radicals. While aiming to clear debris, this immune response paradoxically damages the microenvironment further through oxidative stress and disruption of the blood-spinal cord barrier (Anwar et al., 2016).
- **Spinal Shock:** This is the transient loss or depression of spinal cord functions below the injury level, characterized acutely by flaccid paralysis, loss of reflexes, and autonomic dysfunction such as hypotension and bradycardia. Neurogenic shock, a related phenomenon especially in high cervical injuries, results from the interruption of sympathetic tone and complicates perfusion, exacerbating ischemic insult (Oyinbo, 2011).

4.3 Importance of Minimizing Movement-induced Exacerbation Prehospital

Preventing additional mechanical trauma from patient movement is critical in the prehospital phase to avoid exacerbating the injury. The unstable cervical spine can be further damaged by inappropriate handling, causing secondary injury amplification. Immobilization techniques aim to restrict cervical motion, thereby reducing risks of dislocation or spinal cord compression progression. However, recent evidence also emphasizes balancing immobilization benefits against complications such as discomfort or respiratory compromise.

Paramedics must carefully evaluate and apply cervical spine motion restriction tailored to patient condition, using techniques like manual in-line stabilization (MILS) during airway management to minimize spinal movement while maintaining airway patency. Early awareness of secondary injury mechanisms underscores the urgency in maintaining spinal cord perfusion, preventing hypotension, and avoiding movement-induced worsening.

5. Paramedic Role and Responsibilities in Suspected Cervical Spine Injury

Paramedics play an essential frontline role in the management of suspected cervical spine injuries (CSI) in prehospital settings. Their responsibilities encompass rapid assessment, stabilization, and coordination to minimize secondary spinal cord injury, which can have devastating consequences. Understanding variations in EMS scope, decision-making hierarchy, initial assessment priorities, and collaboration with multidisciplinary teams is vital for optimal patient outcomes (McDonald et al., 2022).

5.1 Scope of Practice Across Different EMS Systems

Paramedic scope regarding cervical spine injury management varies internationally and by EMS system protocols. While some paramedics are authorized to perform selective cervical spine clearance using clinical decision rules such as the Canadian C-Spine Rule (CCR), others follow more conservative protocols mandating immobilization for any suspected CSI. A study across seven Canadian EMS systems validated paramedic utilization of CCR after targeted training, supporting increased autonomy in managing low-risk trauma patients and enhancing resource efficiency without compromising safety. Furthermore, paramedic scope may differ in extrication techniques and immobilization devices permitted by local policies. Such variability necessitates that paramedics be well-versed in their local guidelines and the evidence underpinning them (Vaillancourt et al., 2011).

5.2 Decision-Making Hierarchy and Scene Safety

In the dynamic and often uncontrolled prehospital environment, paramedics exercise critical judgment under time pressure. They prioritize scene safety, assessing environmental hazards before patient contact, and rapidly evaluate patients to determine the need for spinal precautions. Cognitive frameworks employed by paramedics include rapid initial impressions to detect major abnormalities, followed by systematic assessments and hypothesis testing to refine clinical decisions. They integrate mechanism of injury, clinical signs, and patient factors while adhering to protocols that emphasize minimizing movement and protecting the spine. Scene safety also means coordinating with other responders and managing extrication to prevent exacerbation of spinal injuries (Phillips et al., 2025).

5.3 Initial Approach: Assessment Priorities

The initial approach includes a comprehensive scene survey, accounting for mechanism of injury and environmental risks. Paramedics then conduct primary surveys focusing on airway, breathing, and circulation while maintaining manual cervical spine stabilization to prevent neurological compromise. Following stabilization, a secondary survey seeks neurological deficits, spinal tenderness, and other trauma indicators. The accurate application of cervical collars, spinal immobilization techniques, and extrication methods are critical, with emphasis on minimizing unnecessary immobilization to prevent additional patient discomfort or complications. Field use of validated decision tools (e.g., NEXUS, CCR) supports safe triage, though clinical judgment remains paramount (Shaharudin et al., 2025).

5.4 Coordination with Emergency Physicians, Nurses, and Trauma Teams

Paramedic responsibilities extend to effective communication and coordination with hospital trauma teams. Early notification and structured handovers enhance continuity of care and preparedness of emergency department (ED) resources. Paramedics provide key injury mechanism details, vital signs, neurological assessment findings, and immobilization status to physicians, nurses, and trauma surgeons. Collaborative models, including physician-paramedic teams especially in rural and remote settings, have shown improved patient outcomes by enabling advanced interventions on-scene and during transport. The multidisciplinary approach ensures rapid diagnostic imaging and definitive care, minimizing risks of secondary injury (Cowan et al., 2023).

6. Prehospital Assessment and Recognition of Suspected Cervical Spine Injuries

This section covers the critical steps paramedics must take in the field to safely assess and recognize potential cervical spine (C-spine) injuries. Efficient assessment relies on trauma principles, clinical indicators, neurological examinations, and decision support tools tailored for prehospital conditions.

6.1 Primary Survey and Trauma Principles

Paramedics initiate assessment following the ABCDE trauma approach with integration of spinal precautions throughout. This includes:

- **Airway with cervical spine control:** Establish and maintain airway patency while manually stabilizing the cervical spine to prevent further injury.
- **Breathing:** Assess adequacy and symmetry, continuing spinal precautions.
- **Circulation:** Monitor pulse, hemorrhage control while maintaining spinal alignment.
- **Disability:** Rapid neurological status check using Glasgow Coma Scale (GCS).
- **Exposure:** Complete examination to detect other injuries while preserving spine immobilization.

Spinal precautions are integrated systematically during all phases to minimize neck movement, often involving manual in-line stabilization and appropriate immobilization devices (collars, head blocks, spinal boards). The standard practice is to proceed with full immobilization in patients with risk factors until cleared.

6.2 Clinical Indicators of Cervical Injury

Paramedics should consider both mechanism-based and symptom-based factors to suspect C-spine injury:

- **Mechanism-based suspicion:** High-risk mechanisms such as high-speed motor vehicle collisions, falls from height, or direct trauma to the head/neck warrant careful assessment for cervical injury.
- **Symptom-based suspicion:** Signs including neck pain, paresthesia (tingling/numbness), weakness in limbs, and altered level of consciousness increase the likelihood of spinal injury.

Neurological screening involves:

- **Glasgow Coma Scale (GCS):** Assess consciousness level to guide further management and immobilization decisions.
- **Motor and sensory checks:** Evaluate limb movement and sensation to detect deficits indicative of spinal cord compromise.

6.3 Use of Decision Tools

Two widely studied clinical decision rules assist paramedics in safely identifying patients at low risk who may not require immobilization:

- **Canadian C-Spine Rule (CCR):** Incorporates mechanism of injury, patient age, presence of neurological symptoms, and the ability to actively rotate the neck. Studies indicate paramedics can apply this rule accurately with high sensitivity, reducing unnecessary immobilizations without adverse outcomes (Vaillancourt et al., 2023).
- **NEXUS Criteria:** Based on five clinical factors: no posterior midline cervical tenderness, no focal neurological deficit, normal alertness, no intoxication, and no painful distracting injury. Although simpler, this rule has limitations especially in older patients and certain trauma mechanisms (Paykin et al., 2017).

7. Prehospital Immobilization Techniques

7.1 Traditional Immobilization Approaches

In managing suspected cervical spine injuries prehospital, paramedics rely on several traditional immobilization methods aimed at minimizing spinal movement to prevent secondary injury .

Manual Inline Stabilization (MILS)

MILS is a critical initial technique to protect the cervical spine during patient assessment and transport. It involves manually holding the patient's head to maintain it in a neutral position, thereby restricting movement without relying on equipment. Proper technique includes supporting the head from behind, using forearms to clamp the head gently but firmly, ensuring the patient's airway remains accessible. It acts not only to reduce motion but also serves as a visual cue to others to handle the patient cautiously (Waghmare & Singh, 2024b).

Cervical Collars

Cervical collars are supportive devices designed to limit neck motion. Various types exist, including rigid and semi-rigid collars. Proper sizing is essential and generally measured as the distance from the patient's chin to the trapezius using finger widths, with adjustments made according to manufacturer guidelines. Application involves sliding the collar up the chest to fit snugly around the neck so the chin rests on the chin piece without allowing retraction that could jeopardize airway patency. Mis-sizing can lead to ineffective immobilization or airway compromise (Feller et al., 2022).

Long Spine Boards and Vacuum Mattresses

Long spine boards have traditionally been used for immobilization and extrication. They provide a rigid surface to restrict motion during transport. Vacuum mattresses are an alternative designed to mold to patient contours, potentially offering better pressure distribution and comfort. However, stabilizing patients on vacuum mattresses takes significantly longer than on long spine boards, which may impact on-scene time critically in life-threatening trauma cases (Ms et al., 2021).

Head Blocks, Straps, and Securing Methods

Head blocks placed on each side of the patient's head, secured with tape or straps to the spine board, serve as adjuncts to immobilization, preventing lateral and rotational movement. Strapping techniques vary, with methods like Grady straps using crisscross configurations for optimal torso stabilization. Proper application sequence prioritizes body immobilization before securing the head to optimize spinal alignment and safety during movement (Feller et al., 2022).

7.2 Modern Modifications and Evidence-Based Practice

Recent evidence has questioned the routine use of full spinal immobilization in all trauma patients suspected of cervical spine injury. Multiple studies suggest limited clear benefit in neurological outcome prevention versus risks (Pandor et al., 2024).

Current Controversies

Routine immobilization may cause complications including increased pain, airway obstruction, respiratory difficulty, and pressure injuries from prolonged immobilization or ill-fitted devices. For example, cervical collars can increase intracranial pressure and cause discomfort or dysphagia (Pandor et al., 2024).

Evolving Evidence

Selective immobilization protocols based on patient reliability, mechanism of injury, and clinical examination have gained traction. Such protocols advocate immobilizing only those at higher risk, thereby reducing unnecessary restraint exposure and associated harms. The emphasis is shifting toward patient-centered and mechanism-based decisions rather than default full immobilization (Kreinest et al., 2016).

Transition Toward Patient-Centered Practice

This trend involves balancing the need for protection with the risk of adverse events, considering factors such as airway management priorities and trauma severity. EMS protocols increasingly integrate assessment tools to guide immobilization extent with flexibility for clinical judgment (Kreinest et al., 2016).

7.3 Pediatric and Geriatric Considerations

Special attention is required when immobilizing pediatric and geriatric patients due to anatomical and physiological differences.

Pediatric Challenges

Children have a proportionally larger head-to-body ratio, leading to relative neck flexion if immobilized on flat boards without additional padding. This makes neutral alignment challenging and necessitates careful positioning, often achieved by adding towel rolls under the torso to maintain cervical neutrality and avoid airway compromise (Rao et al., 2016).

Geriatric Considerations

Elderly patients commonly present with thoracic kyphosis, fragile skin prone to pressure injuries, and multiple comorbidities. Traditional immobilization on flat boards may cause excessive neck extension, respiratory difficulties, and skin breakdown. Careful assessment and adaptation, such as using pressure-relief padding and modified positioning, are essential to minimize harm while immobilizing (Rao et al., 2016).

8. Airway Management with Suspected Cervical Spine Injury: A Paramedic Perspective

Managing the airway in patients with suspected cervical spine (C-spine) injury presents a critical challenge for paramedics. The key goal is maintaining airway patency and adequate ventilation while minimizing cervical spine movement to prevent secondary spinal cord injury. This balance requires selection of appropriate airway techniques and tools, combined with spinal immobilization methods.

8.1 Techniques for Airway Maintenance While Protecting the Spine

Manual in-line stabilization (MILS) is the cornerstone during airway management in suspected C-spine injury. MILS involves a provider stabilizing the head and neck in a neutral position to reduce spinal motion when facilitating airway interventions. Hard cervical collars, though useful for immobilization, can limit mouth opening and worsen airway visualization, therefore MILS is preferred during intubation or airway maneuvers to balance immobilization with access (Wiles et al., 2024).

The jaw-thrust maneuver is preferred for opening the airway without neck extension, moving the mandible forward to relieve tongue obstruction. It induces less cervical movement compared to the head-tilt-chin-lift, making it safer in C-spine injury suspicion. Bag-valve-mask (BVM) ventilation is frequently used for oxygenation prior to securing a definitive airway. However, BVM ventilation itself can cause more cervical spine displacement than intubation, emphasizing the need for careful technique with MILS applied. Adjuncts like oropharyngeal or nasopharyngeal airways may facilitate ventilation during BVM use (Austin et al., 2014).

8.2 Bag-Valve-Mask, Jaw-Thrust, and Intubation Methods

BVM ventilation requires a tight mask seal to deliver adequate tidal volumes. Paramedics should position the patient supine, apply MILS, and use adjunctive airways to maintain patency. Successful BVM ventilation depends on proper mask fit, adequate head positioning (without neck extension), and effective bag squeezes (Bucher et al., 2025).

Intubation techniques must aim to minimize cervical spine movement. Direct laryngoscopy remains common but requires neck manipulation, which may be mitigated by MILS. Video laryngoscopy reduces cervical motion compared to direct laryngoscopy and improves glottic visualization. Supraglottic airway (SGA) devices like the Ambu AuraGain allow airway maintenance with minimal neck movement, despite possible challenges posed by cervical collars (Jo et al., 2025).

8.3 Video Laryngoscopy and Supraglottic Airway Devices in the Field

Video laryngoscopy offers several advantages in suspected C-spine injury by requiring less lifting force than conventional methods, thereby reducing spinal motion. Studies show video laryngoscopes provide better intubation success rates, shorter intubation times, and less cervical spine displacement (Mostafa et al., 2022).

Supraglottic airway devices serve as valuable rescue airways or alternatives for patients where intubation is difficult or contraindicated. Devices like the Ambu AuraGain have demonstrated maintained oropharyngeal sealing pressure and glottic views even with cervical collars immobilizing the spine, though insertion may be technically more challenging and time-consuming (Uthaman et al., 2019).

8.4 Pharmacologic Support and Rapid Sequence Intubation Protocols

Rapid sequence intubation (RSI) is often utilized in prehospital settings to facilitate controlled intubation while protecting airway reflexes. RSI includes pretreatment with sedatives and neuromuscular blocking agents to enable timely, effective intubation with minimal cervical spine movement (Hampton et al., 2023).

Paramedics must prepare by pre-oxygenating patients using 90–100% oxygen, applying MILS, and having all necessary airway adjuncts ready. Adequate sedation is essential to avoid awareness during paralysis. RSI protocols emphasize monitoring oxygen saturation, capnography, and neurologic status throughout (Hendrix & Regunath, 2025).

8.5 Evidence on Spinal Motion During Airway Interventions

Cervical spine motion varies by airway maneuver: bag-mask ventilation causes the greatest displacement (~2.9 mm), followed by oral intubation (~1.5 mm). Nasal intubation produces the least movement (~1.2 mm). Video laryngoscopy and fiberoptic techniques cause less cervical displacement than direct laryngoscopy (Jo et al., 2025).

9. Pain and Sedation Management

Managing pain and sedation in patients with suspected cervical spine injuries (CSI) during prehospital care presents unique challenges. Paramedics must provide effective analgesia while preserving neurological assessment integrity and ensuring patient safety during immobilization and extrication (Sandberg et al., 2020).

9.1 Prehospital Analgesia Options

Common analgesics used include opioids (e.g., morphine, fentanyl), ketamine, and nitrous oxide. Opioids are traditional choices with effective pain relief but carry risks such as respiratory depression and altered neurological status. Ketamine, increasingly used for prehospital analgesia, offers strong analgesic effects at sub-dissociative doses, with less respiratory depression and opioid-sparing properties. Nitrous oxide provides inhaled analgesia with rapid onset but is limited by patient cooperation and contraindications (Ahn et al., 2011).

9.2 Balancing Pain Control with Neurological Assessment

A critical consideration is maintaining a clear neurological exam while providing analgesia. Over-sedation can mask or mimic neurological deficits, complicating triage and treatment decisions. Therefore, analgesics are preferably titrated to achieve pain control without impairing consciousness or neurological function.

Ketamine at low doses may be advantageous given preserved airway reflexes and minimal alteration of mental status compared to opioids (Andolfatto et al., 2019).

9.3 Sedation During Immobilization and Extrication

Procedural sedation may be necessary for extrication or repositioning to reduce patient movement and distress. Sedatives must be chosen carefully to avoid hypotension and respiratory compromise that can exacerbate spinal cord injury. Manual in-line stabilization during airway management, including intubation, reduces cervical spine movement. Advanced airway devices such as video laryngoscopes can facilitate safer intubation with minimal cervical manipulation (Waghmare & Singh, 2024b).

10. Extrication and Transport Considerations in Prehospital Cervical Spine Injury Management

The prehospital management of suspected cervical spine injuries (CSIs) by paramedics is critical to minimize secondary neurological damage. This section focuses on key aspects of extrication and transport, emphasizing scene safety, patient handling techniques, transport mode decisions, and continuous monitoring.

10.1 Scene Assessment and Safe Patient Movement

Paramedics must first perform a thorough scene assessment to understand the mechanism of injury and environmental hazards. Careful evaluation informs the safest methods for patient extrication to avoid exacerbating spinal injuries. Manual in-line stabilization of the cervical spine is essential during all movements to reduce spinal motion (Waghmare & Singh, 2024).

10.2 Techniques for Patient Movement: Log-roll, Scoop Stretcher, Vacuum Splint

- **Log-roll maneuver:** Used to turn the patient while maintaining spinal alignment, particularly during assessment and transfer to a spinal board. However, studies indicate the log-roll may cause more spinal motion compared to other methods and should be used cautiously (Waghmare & Singh, 2024).
- **Scoop stretcher:** Allows en bloc lifting and transfer of the patient with minimal spinal movement, making it effective for spinal immobilization (Waghmare & Singh, 2024).
- **Vacuum splints:** These provide form-fitting immobilization, contouring to patient anatomy, and can be advantageous during transport to enhance comfort and immobilization (Waghmare & Singh, 2024).

10.3 Vehicle Extrication in Confined Spaces

Extrication in vehicles poses significant risks of spinal movement. Paramedics must employ controlled extrication techniques, including use of cervical collars, manual stabilization, and extrication devices like the Kendrick Extrication Device (KED). Evidence suggests that self-extrication with careful paramedic guidance may reduce cervical spine motion compared to traditional equipment-aided extrications in some stable patients. Nonetheless, rigid cervical collars and manual stabilization remain standard during extrication to protect the C-spine (Sundstrøm et al., 2014).

10.4 Air vs. Ground Transport Decisions

The choice between air and ground transport depends on factors such as distance to definitive care, patient stability, availability of resources, and environmental conditions. Early transfer to a specialized spinal injury center is paramount to improving neurological outcomes. Air transport may be faster over long distances, but it requires that the patients be stable and adequately immobilized (Theodore et al., 2013).

10.5 Monitoring During Transport

Continuous monitoring of vital signs and neurological status during transport is vital. This includes:

- Regular assessment of airway, breathing, and circulation.
- Neurological checks focusing on motor and sensory function to detect deterioration.
- Monitoring for signs of spinal shock or respiratory compromise.
- Comfort measures to minimize patient movement and agitation.

Maintaining adequate mean arterial pressure (MAP) above 85-90 mm Hg is recommended to optimize spinal cord perfusion during transport. The paramedic team must be prepared to manage airway compromise, respiratory dysfunction, and hemodynamic instability, common in cervical SCI patients (Katipoğlu et al., 2020).

11. Recommendations for Practice Improvement

Summary of Best Practices Supported by Current Evidence; Prehospital care for suspected cervical spine injuries (CSIs) prioritizes minimizing spinal movement to prevent secondary injury. The current best practices recommend spinal motion restriction (SMR) using devices such as backboards, scoop stretchers, or vacuum splints, applied to the entire spine due to risk of noncontiguous injuries. Immobilization in a neutral axial alignment is advised to facilitate airway management and reduce further spinal damage. Clinical decision tools like the Canadian C-Spine Rule (CCR) and the National Emergency X-Radiography Utilization Study (NEXUS) criteria help identify low-risk trauma patients who may not require full immobilization, thus improving patient comfort and operational efficiency. Manual in-line stabilization (MILS) is recommended during airway management and intubation to reduce cervical spine movement, with video laryngoscopes improving intubation conditions compared to direct laryngoscopy. Pharmacological treatments such as methylprednisolone have fallen out of favor in the prehospital context due to lack of demonstrated benefit. Patients should be removed from backboards within two hours to prevent pressure sores. These practices are supported by evidence-based guidelines aiming to prevent deterioration and facilitate early neurological outcomes (Courson et al., 2020).

Areas Requiring Protocol Revision or Additional Research; Despite advances, several areas require further clinical investigation and protocol refinement. The use of cervical collars remains debated, with concerns about unnecessary immobilization and patient discomfort. Research into alternatives such as selective spinal motion restriction guided by refined clinical decision rules is ongoing. Further evaluation is warranted on the safety and efficacy of paramedic-led cervical spine clearance protocols, including broader implementation of CCR and modified CCR to safely reduce spinal immobilization use in low-risk patients. The optimal timing and methods for immobilization device removal need clearer guidelines to balance safety and complication risks. Additionally, exploration of new airway management tools like advanced video laryngoscopes in the prehospital environment warrants more operational research. The roles and protocols for pharmacological interventions, including therapeutic hypothermia, remain inconclusive, requiring high-quality trials. Emerging trauma classification systems also need validation in the paramedic context to guide treatment decisions effectively. These areas highlight the need for research to ensure that evidence-based updates translate into practical protocols improving patient outcomes and paramedic workflow (Sundstrøm et al., 2014).

Role of Interprofessional Collaboration Between Paramedics, Nurses, and Physicians Effective management of suspected cervical spine injuries in the prehospital and emergency department settings depends heavily on interprofessional collaboration. Paramedics, nurses, and physicians must engage in coordinated communication and trust to optimize patient care. Paramedics' expanding roles in trauma assessment and early spinal clearance benefit from physician-guided medical direction, especially in complex airway management and triage decisions. Nurses participate in ongoing patient monitoring and care continuity upon hospital arrival, contributing to neurological assessment and spinal clearance documentation. Shared use of electronic medical records (EMRs) and streamlined communication channels promote timely transfer of care and informed decision-making. Building trustful relationships among these professionals enhances role clarity, reduces duplication, and improves outcomes. Collaborative training, cross-disciplinary education, and removing professional silos encourage team cohesion crucial for delivering safe, efficient spinal injury management. Interprofessional collaboration fosters a comprehensive approach where paramedic autonomy is supported by nursing and physician expertise to achieve best practices in prehospital trauma care (Reeves et al., 2017).

Conclusion

The prehospital management of suspected cervical spine injuries remains a critical responsibility for paramedics, as early interventions significantly influence patient outcomes. Evidence underscores the importance of minimizing spinal motion, applying immobilization judiciously, and tailoring interventions to patient-specific factors, including age, injury mechanism, and comorbidities. Advances in clinical decision tools such as the Canadian C-Spine Rule (CCR) and NEXUS criteria support selective immobilization, reducing unnecessary procedures while maintaining patient safety. Airway management, analgesia, and safe extrication techniques require paramedics to balance spinal protection with life-saving priorities. Ongoing challenges, including controversies surrounding cervical collar use and evolving evidence on immobilization strategies, highlight the need for continued research and protocol refinement. Ultimately, interprofessional collaboration and evidence-based practice are central to optimizing prehospital care, minimizing secondary spinal cord injury, and improving neurological and functional outcomes for trauma patients.

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