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Management of Cervical Spine Injury: Clinical Roles of Neurology Consultants and Physiotherapists-An Updated Review

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Abstract

Background: Cervical spine injuries present critical clinical challenges due to their potential to cause permanent neurological deficits and significant morbidity. These injuries commonly result from high-energy trauma such as motor vehicle collisions, falls, and sports-related accidents. Early identification and multidisciplinary management are essential to prevent secondary complications and improve patient outcomes.
Aim: To review the clinical roles of neurology consultants and physiotherapists in the evaluation, management, and rehabilitation of cervical spine injuries.
Methods: This updated review synthesizes current literature addressing mechanisms of injury, clinical presentation, neurological assessment, imaging modalities, classification systems, management strategies, and rehabilitation practices.
Results: Findings highlight the importance of early neurological assessment, appropriate imaging guided by NEXUS and Canadian Cervical Spine Rule criteria, and accurate injury classification to guide treatment. Management ranges from conservative immobilization to surgical decompression and stabilization, depending on injury stability and neurological deficits. Physiotherapists play a crucial role in early mobilization, prevention of complications, and long-term functional recovery.
Conclusion: Timely, evidence-based, multidisciplinary management—including neurology and physiotherapy—is essential to optimize functional outcomes, minimize long-term disability, and improve prognosis following cervical spine injury.
Keywords: Cervical spine injury, neurology consultants, physiotherapy, trauma, neurological assessment, rehabilitation.

Introduction

Cervical spine injuries, though not highly prevalent, present critical clinical challenges due to their capacity to produce profound and often permanent functional deficits. The cervical spine, consisting of seven vertebrae labeled C1 through C7, serves the dual function of structural support and protection of the spinal cord, a central conduit transmitting neural signals between the brain and peripheral body systems [1][2][3]. The cervical region's complex anatomy, combined with its extensive range of motion, renders it particularly susceptible to traumatic insult. The high mobility required for head and neck movement increases the risk of vertebral displacement or spinal cord compromise following injury. Mechanisms of cervical spine injury are diverse, encompassing motor vehicle collisions, falls from height, sports-related impacts, and other forms of blunt trauma. Epidemiological studies suggest that approximately 5% to 10% of patients experiencing blunt trauma sustain cervical spine injuries, highlighting the necessity for rapid and precise diagnostic evaluation [4]. Failure to promptly recognize cervical spine injury can result in devastating neurological sequelae, including paralysis, sensory deficits, or autonomic dysfunction, emphasizing the importance of immediate clinical attention. Early identification and intervention are essential to optimize neurological preservation and functional recovery. Comprehensive assessment includes detailed history-taking, physical examination focusing on neurological deficits, and imaging studies to detect fractures, dislocations, or spinal cord compromise. Multidisciplinary involvement is critical, with neurology consultants assessing neurological integrity and physiotherapists contributing to early mobilization strategies, prevention of secondary complications, and rehabilitation planning. Timely, evidence-based management facilitates improved patient outcomes, reduces long-term morbidity, and

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enhances quality of life for individuals affected by cervical spine injuries [1][2][3][4].

Etiology

Cervical spine injuries often result from sudden and forceful biomechanical forces applied to the neck, with hyperextension being a particularly frequent mechanism. One common scenario involves abrupt forward acceleration of the body, causing the cervical region to extend posteriorly beyond its physiological limits. This type of trauma imposes significant stress on the vertebral column and spinal cord, increasing the risk of vertebral fractures, dislocations, or neural compromise. Epidemiological data indicate that the patterns of injury vary across age groups. In pediatric populations, particularly children younger than eight years, falls represent a predominant cause of cervical trauma, reflecting their developmental susceptibility and relative lack of protective reflexes [5]. In contrast, adolescents are more frequently affected by sports-related mechanisms, which include high-impact collisions, contact sports, and activities involving repetitive or forceful neck movements. Certain high-risk scenarios are associated with an elevated likelihood of cervical spinal cord injury. Falls from heights exceeding three feet or incidents involving descent from five or more stairs impose substantial axial and rotational forces on the cervical vertebrae, leading to potential spinal compromise. Diving accidents that generate axial loading of the head represent another critical mechanism, particularly when individuals enter shallow water, transmitting force directly through the cervical spine. High-speed motor vehicle collisions remain a leading cause of severe cervical injuries, with rapid deceleration forces capable of producing complex vertebral and ligamentous damage. Additionally, incidents involving motorized all-terrain vehicles present a unique risk due to high-velocity impacts and unpredictable terrain, contributing to traumatic cervical injury [6]. Understanding these etiological factors is essential for identifying at-risk populations, implementing preventive strategies, and guiding early diagnostic and therapeutic interventions in patients with suspected cervical spine trauma.

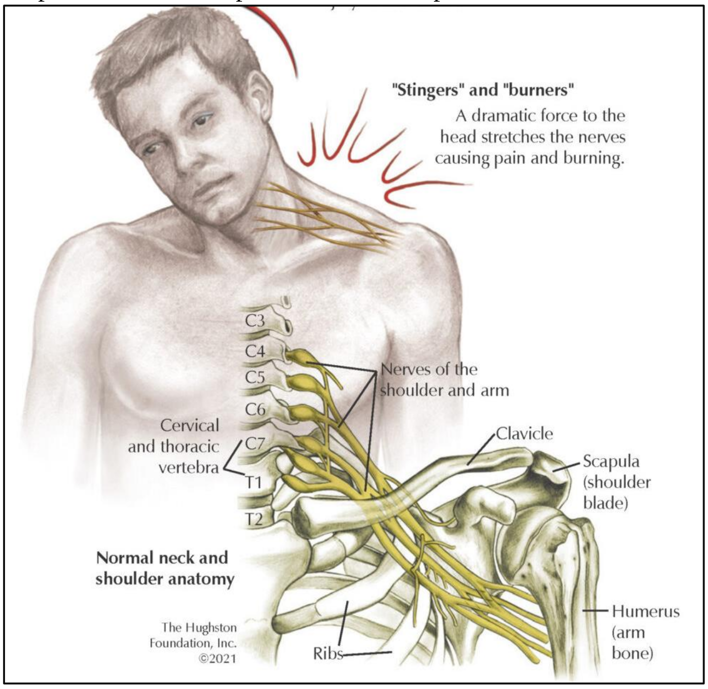

Fig. 1: Normal anatomy of cervical spine.

Pathophysiology

Cervical spine injuries arise from a spectrum of biomechanical forces applied to the cervical vertebrae, ligaments, and spinal cord, with blunt trauma representing the most prevalent etiology. Among these, motor vehicle collisions account for the majority of cases, reflecting the high-energy impact and sudden deceleration forces that the cervical region is subjected to during these events. The pattern and severity of injury are highly dependent on both the magnitude and direction of the applied force, with specific mechanisms correlating to distinct structural and neurological outcomes. A comprehensive understanding of these pathophysiological processes is critical for accurate clinical evaluation, timely intervention, and the prevention of secondary complications. Flexion injuries occur when the cervical spine bends forward, typically resulting in compression of the anterior vertebral bodies and potential disruption of posterior ligamentous structures. Extension mechanisms, conversely, involve backward bending of the neck, placing stress on the anterior longitudinal ligament and predisposing the posterior elements to tension-related injury. Rotational forces generate torsional stress on the cervical vertebrae, often resulting in fractures or dislocations, while lateral bending produces asymmetric loading that may compromise facet joints or intervertebral discs. Distraction forces stretch the spinal column longitudinally, leading to potential ligamentous disruption, vertebral separation, or spinal cord strain. Axial compression, commonly referred to as vertical loading, transmits force through the vertebral bodies, potentially resulting in burst fractures, vertebral collapse, or spinal canal compromise [5][6].

High-energy trauma, such as those sustained during high-speed motor vehicle rollovers or severe falls, frequently involves a combination of these mechanisms. In these complex injury patterns, initial clinical evaluation may underestimate the extent of structural and neurological compromise. Secondary pathophysiological processes contribute to ongoing deterioration following the primary insult. Free radical generation and oxidative stress can damage neuronal membranes, while vasogenic edema and ischemia compromise spinal cord perfusion. Altered microcirculation and local inflammatory responses exacerbate cellular injury, potentially transforming incomplete lesions into complete neurological deficits. This evolving cascade underscores the importance of early recognition, immobilization, and timely intervention to limit secondary injury and preserve neurological function. Understanding the intricate interplay between mechanical forces and biological responses provides a framework for predicting injury patterns, planning therapeutic strategies, and improving prognostic outcomes in patients with cervical spine trauma [1][2][3].

History and Physical

A meticulous history is paramount when evaluating suspected cervical spine trauma. The clinician must identify the mechanism of injury, as high-energy forces such as motor vehicle collisions, significant falls, sports-related impacts, or direct blunt trauma markedly increase the risk of cervical vertebral or spinal cord injury. Any patient presenting with axial neck pain, neurologic deficits, or altered mental status following trauma should be presumed to have a cervical spine injury until definitive evaluation excludes it. Special caution is warranted in unconscious, sedated, or intoxicated patients, as clinical signs may be subtle or absent despite significant injury. In cases where the exact mechanism is unknown, clinical management should proceed under the assumption that a cervical spine injury is present to prevent secondary damage during assessment or mobilization [1][2][3]. Clinical presentation often varies depending on the location and severity of the injury. Patients may report midline cervical tenderness, localized pain over the spinous processes, or reduced cervical mobility. Stiffness, muscle spasm, or torticollis may also be observed. In cases involving neural compromise, patients may describe paresthesias, numbness, or weakness in the upper or lower extremities. These neurologic symptoms are critical indicators of potential spinal cord or nerve root involvement and necessitate urgent diagnostic evaluation. Associated signs, such as crepitus or deformity, may suggest vertebral fractures or dislocations and should prompt heightened vigilance during examination and handling [4][5]. Physical examination begins with stabilization of airway, breathing, and circulation, consistent with trauma protocols, before a focused cervical assessment. Once the patient is stabilized, inspection should evaluate alignment, deformity, and symmetry of the cervical region. Palpation for midline tenderness, step-offs, or subluxation is essential. When safe, assessment of cervical range of motion can provide further information regarding structural integrity. A detailed neurologic examination must include evaluation of motor strength, sensory function, reflexes, and coordination to identify deficits and localize the level of injury. Early identification of neurologic involvement is crucial for prognosis and guides emergent management, including immobilization, imaging, and potential surgical intervention. Collectively, a thorough history and structured physical examination provide the foundation for timely and accurate diagnosis, minimizing secondary injury and optimizing patient outcomes [1][2][3][4][5].

Neurological Assessment

A comprehensive neurological assessment is essential in patients with cervical spine injury, as the cervical region houses critical spinal cord segments responsible for motor, sensory, and autonomic functions. Early identification of deficits can guide acute management, predict prognosis, and determine the need for interventions such as surgical decompression or ventilatory support. Clinicians must systematically evaluate both motor and sensory pathways, correlating clinical findings with specific spinal levels to localize injury accurately. Signs of nerve root involvement may manifest as focal weakness, corresponding to the distribution of the affected myotome, diminished or absent deep tendon reflexes, and sensory alterations along a defined dermatome. Proprioceptive deficits, impaired vibration sense, or loss of fine touch generally indicate involvement of the dorsal columns, whereas disturbances in pain and temperature perception suggest anterior spinal cord compromise. Recognition of these patterns aids in distinguishing between peripheral nerve root lesions and central cord pathology. Myotomes, defined as groups of muscles innervated by a single spinal nerve root, are critical for evaluating motor integrity. In the cervical spine, each myotome corresponds to a specific spinal level. The C1–C2 myotomes govern neck flexion, C3 controls lateral neck flexion, and C4 mediates shoulder elevation via the trapezius. The C5 myotome is responsible for shoulder abduction through the deltoid, while C6 controls elbow flexion and wrist extension. C7 governs elbow extension and wrist flexion, C8 mediates finger flexion, and T1 contributes to fine motor control of the intrinsic hand muscles. Evaluating these muscle groups allows clinicians to localize the level of injury and determine the severity of motor compromise. Reflex testing provides additional localization by assessing the integrity of specific spinal nerve roots. The C5 level is evaluated through the biceps reflex, C6 via the brachioradialis reflex, and C7 through the triceps reflex. Abnormal reflexes, including hypo- or hyperreflexia, can indicate nerve root compression or upper motor neuron injury. Furthermore, motor control of the diaphragm is mediated by the phrenic nerve arising from C3–C5, highlighting the importance of assessing respiratory function in high cervical injuries, as compromise can result in diaphragmatic paralysis and respiratory failure [5][6].

Sensory examination involves assessing dermatomal distribution. The C2 dermatome encompasses the posterior head and upper neck, C3 the lateral neck and lower jaw, and C4 the shoulder region, particularly the upper trapezius. C5 corresponds to the lateral upper arm, C6 to the lateral forearm and the thumb and index finger, C7 to the middle finger and central posterior forearm, C8 to the ring and little fingers and medial forearm, and T1 to the medial upper arm near the elbow. Precise mapping of sensory deficits across these dermatomes facilitates accurate localization of nerve root injury and assists in differentiating central from peripheral involvement. Overall, a structured neurological assessment integrating myotomal motor testing, reflex evaluation, and dermatomal sensory mapping provides a detailed framework for identifying the level and extent of cervical spine injury. This evaluation is indispensable for early diagnosis, planning appropriate interventions, and monitoring recovery, particularly in injuries that may compromise respiratory function, upper extremity mobility, or fine motor coordination. Accurate and timely assessment improves patient outcomes and guides multidisciplinary management strategies, including neurosurgical consultation, physiotherapy, and rehabilitation planning [4][5][6].

Spinal Column Stability and Injury Classification

The cervical spine relies on a complex interplay between its anterior and posterior structural columns to maintain stability and protect the spinal cord from injury. The anterior column is composed of the vertebral bodies and intervertebral discs, which bear the majority of axial load and provide structural support during flexion and extension movements. The posterior column consists of the facet joints, laminae, and spinous processes, which contribute to rotational stability and resist shear forces. Injuries compromising a single column may be considered stable if the other column remains intact and provides sufficient support. However, compromise of both anterior and posterior columns results in an unstable injury, significantly increasing the risk of spinal cord compression, neurological deterioration, and secondary complications. Understanding the integrity of these structural components is essential for both diagnostic evaluation and surgical planning, as unstable injuries frequently necessitate early stabilization procedures to prevent further neurologic compromise. Assessment of vital signs and mental status offers important clues regarding the extent of cervical spinal cord involvement. Injuries at or above the C5 level may compromise the phrenic nerve, leading to diaphragmatic dysfunction and subsequent hypoventilation or apnea. Sympathetic outflow disruption, particularly in higher cervical injuries, can result in hypotension due to unopposed parasympathetic activity, which further complicates perfusion of the spinal cord and other vital organs. Altered mental status in a trauma patient may reflect impaired cerebral perfusion secondary to hypotension, or concurrent traumatic brain injury, necessitating a comprehensive evaluation to address both spinal and neurological threats [4][5][6].

Neurologic and reflex findings play a critical role in the early recognition of spinal cord compromise. The presence of a positive Babinski sign, priapism, or absence of the bulbocavernosus reflex is strongly suggestive of acute spinal cord injury. Loss of the bulbocavernosus reflex in particular indicates a complete lesion and should prompt immediate intervention. Additional findings, such as flaccid paralysis, severe weakness, sensory deficits, or absent reflexes, are indicative of more severe cord injury and necessitate urgent imaging to guide management. Cervical spinal cord injuries are classified into several syndromes based on the mechanism and pattern of neurological deficit. Anterior cord syndrome typically results from flexion injuries and presents with motor paralysis and loss of pain and temperature sensation below the injury level, while vibration and position sense are preserved. Central cord syndrome, the most common incomplete injury, usually arises from hyperextension forces and is characterized by disproportionately greater weakness in the upper extremities compared to the lower extremities. Posterior cord syndrome, although rare, manifests as loss of proprioception and vibratory sense while preserving motor function and pain/temperature sensation. Brown-Séquard syndrome results from hemisection of the cord and presents with ipsilateral motor paralysis and loss of proprioception, coupled with contralateral loss of pain and temperature sensation. Recognizing these syndromes allows clinicians to localize injury, predict functional deficits, and guide treatment planning, including surgical stabilization, rehabilitation, and respiratory support when necessary. Effective assessment of cervical spinal column stability and injury classification integrates structural, hemodynamic, and neurological evaluations. Early recognition of instability, associated neurological deficits, and spinal cord syndromes ensures timely interventions, minimizing long-term morbidity and optimizing functional recovery in patients with cervical spine trauma [5][6].

Evaluation

The clinical evaluation of suspected cervical spine injury begins with strict stabilization of the cervical region, adhering to the American College of Surgeons Advanced Trauma Life Support (ATLS) algorithm. The primary objective is the identification of potentially life-threatening conditions and cervical spine compromise while simultaneously maintaining airway, breathing, and circulation. The initial assessment prioritizes the ABCs, followed by a systematic head-to-toe examination to detect associated injuries that may either contribute to or complicate cervical trauma. During this assessment, careful attention is given to midline cervical tenderness, torticollis, and neurological deficits, with inline stabilization maintained throughout to prevent secondary spinal cord injury. Once the patient is stabilized, imaging evaluation forms the cornerstone of diagnostic assessment for cervical spine trauma in clinically stable patients. Radiographic evaluation typically includes anteroposterior, lateral, oblique, and odontoid (open-mouth) views of the cervical spine. An adequate lateral view must visualize all seven cervical vertebrae and the C7–T1 disc space. In cases where visualization of the lower cervical segments is limited, the addition of a "swimmer's view" can provide imaging of C7 and T1, ensuring no injuries are overlooked [7][8][9]. Decision-making regarding imaging is often guided by validated clinical tools such as the National Emergency X-Radiography Utilization Study (NEXUS) criteria and the Canadian Cervical Spine Rule. These instruments aim to identify patients at low risk for cervical spine injury who can safely forgo radiographic evaluation, thus minimizing unnecessary radiation exposure and healthcare resource utilization [10][11][12][13]. While effective in adults, these tools have limited applicability in pediatric populations, necessitating greater clinical vigilance when evaluating children [14].

The NEXUS Low-Risk Criteria identify patients for whom imaging is indicated if any of the following features are present: midline cervical tenderness, focal neurologic deficits, altered level of consciousness, intoxication, or the presence of a distracting injury. Conversely, cervical spine imaging may not be required in patients who demonstrate absence of midline tenderness, a normal level of alertness, no neurologic deficits, no evidence of intoxication, and absence of painful or distracting injuries. These criteria streamline the initial evaluation while maintaining safety by limiting missed injuries. Radiographic interpretation begins with a three-view series, sufficient for screening patients with normal mental status and no focal neurologic findings. Among these views, the lateral projection is the most critical, identifying up to 80% of cervical injuries [15]. The anteroposterior view provides a comprehensive assessment of vertebral alignment, evaluates spinous process continuity, examines the lateral masses, and identifies subtle fractures or subluxations. The open-mouth odontoid view specifically visualizes the dens and assesses alignment of the C1–C2 lateral masses, which is essential for detecting upper cervical injuries. Together, these imaging modalities provide an integrated framework for the accurate diagnosis of cervical spine trauma, guiding subsequent management decisions and ensuring early detection of potentially unstable injuries [15].

PECARN Prediction Rule

The Pediatric Emergency Care Applied Research Network (PECARN) developed a validated clinical prediction rule to guide cervical spine imaging in children presenting with trauma to the emergency department [16]. The rule aims to minimize unnecessary radiation exposure, particularly from computed tomography (CT), while ensuring that high-risk injuries are identified promptly. CT scans are reserved for patients at elevated risk, such as those with altered mental status, neurological deficits, or evidence of significant trauma. When plain radiographs are adequate and show no abnormalities, flexion and extension radiographs may be performed to assess cervical spine stability. CT imaging is indicated in situations where cervical radiographs are insufficient, demonstrate concerning findings, show fractures or bone displacement, or when a high-risk mechanism of injury has occurred. Magnetic resonance imaging (MRI) is particularly valuable when patients present with neurological signs or symptoms and plain radiographs or CT scans are normal. MRI offers superior visualization of soft tissue structures, enabling detailed assessment of ligamentous injuries, intervertebral disk herniation, spinal cord edema, hemorrhage, compression, or transection [17]. This modality is critical for evaluating nerve root compression and identifying injuries that may not be apparent on radiographs or CT, thereby guiding appropriate management and intervention. Cervical spine injuries are classified according to anatomical location. Injuries involving the occiput to C2 are termed occipital-cervical spine injuries, whereas injuries between C3 and C7 are referred to as sub-axial cervical spine injuries. Specific fracture patterns correlate with the mechanism of injury. Wedge fractures result from flexion forces, while burst fractures occur due to axial compression. Laminar fractures may be vertical or horizontal and are often associated with other fracture types. Atlanto-occipital dislocation represents an extension injury of C1–C2, while atlantoaxial dislocation is a flexion-rotation injury at the same level. Jefferson fractures are unstable C1 fractures caused by axial compression.

A Jefferson fracture occurs when severe axial forces are transmitted through the occipital condyles to the lateral masses of C1, often during diving accidents. The lateral masses are displaced outward, disrupting the transverse ligament and fracturing the anterior and posterior arches of the atlas. Imaging reveals widening of the predental space on lateral radiographs and lateral mass displacement on open-mouth odontoid views; displacement exceeding 7 mm suggests a fracture. The hangman fracture involves bilateral fractures of the C2 pedicles or pars interarticularis, typically resulting from hyperextension forces. High-energy mechanisms, such as diving or head-on motor vehicle collisions, cause extreme hyperextension, moving the skull, C1, and C2 as a unit. Although unstable, the spinal cord is often spared due to the wide spinal canal at C2. Fracture classification is based on displacement and angulation: Type I exhibits minimal displacement (<3 mm) without angulation; Type II shows displacement >3 mm with angulation; Type III involves significant displacement and high neurological risk. Odontoid fractures are complex and often result from flexion, extension, or rotational forces. Type I fractures involve the tip of the dens and are typically stable but require exclusion of atlanto-occipital dislocation before conservative management. Type II fractures occur at the base of the dens, are unstable, and carry a high risk of nonunion due to limited vascular supply. Type III fractures extend into the C2 vertebral body and are unstable, as they permit movement of the atlas and occiput as a unit, necessitating careful management to prevent neurological compromise [14][15][16].

Treatment / Management

The management of cervical spine injuries begins with immediate stabilization and resuscitation, adhering to the American College of Surgeons' Advanced Trauma Life Support protocol [18][19]. In the setting of blunt trauma, early cervical spine immobilization is critical to prevent secondary injury. Standard practice involves placing the patient in a rigid cervical collar and securing them on a rigid backboard, with head blocks and straps to maintain neutral alignment. Prolonged backboard use should be avoided, as extended immobilization can result in pressure ulcers, respiratory compromise, and increased patient discomfort. Analgesic therapy should be initiated promptly to control pain; however, agents that may depress mental status must be used cautiously to preserve the patient's ability to participate in neurological assessments. Clinical clearance of the cervical spine can be considered in alert, cooperative patients without midline tenderness, focal neurological deficits, or distracting injuries [20][21]. In these cases, radiographic imaging may not be necessary, although a thorough physical examination remains mandatory [22]. Airway management, particularly intubation, must be performed with caution to avoid exacerbating cervical injury. The recommended technique involves the "sniffing position," which combines atlanto-occipital and atlantoaxial extension with lower cervical flexion, allowing optimal airway visualization while minimizing cervical movement [23]. Definitive management is guided by injury severity and stability. Stable fractures without neurological compromise can often be treated conservatively with external immobilization, such as cervical collars or halo vests, alongside analgesia and close outpatient monitoring. Serial imaging may be employed to ensure fracture alignment remains stable and to monitor healing. In contrast, unstable injuries or fractures associated with neurological deficits frequently require surgical intervention to prevent permanent spinal cord damage and to restore mechanical stability [24][25].

Surgical management encompasses decompression and stabilization procedures tailored to the injury type. Spinal cord or nerve root compression may necessitate laminectomy, laminoplasty, foraminotomy, or discectomy to relieve pressure and preserve neurological function. Cervical fusion, often supplemented with metal hardware such as plates and screws, is employed to achieve long-term stabilization. Surgical approaches vary according to the fracture location and morphology; subaxial cervical fractures may require anterior, posterior, or combined fixation strategies. The primary goals of surgical intervention are twofold: decompress neural structures to prevent or mitigate neurological deficits, and provide durable spinal stability to facilitate rehabilitation and prevent deformity. Postoperative and conservative care also emphasizes early mobilization, physical therapy, and multidisciplinary involvement to optimize functional recovery. Pain control, prevention of complications such as deep vein thrombosis or pulmonary issues, and monitoring for neurological deterioration are essential components of comprehensive management. Coordination among neurosurgeons, orthopedic spine specialists, physiotherapists, and critical care teams is crucial to ensure safe, effective, and patient-centered care throughout the acute and recovery phases [25].

Differential Diagnosis

When evaluating cervical spine injuries, it is essential to consider other conditions that can mimic or coexist with cervical trauma, as accurate identification guides appropriate management. Acute torticollis, for example, presents as involuntary contraction of neck muscles leading to lateral flexion and rotation. Although trauma can precipitate torticollis, many cases arise without a clearly identifiable cause. Patients typically exhibit neck stiffness and pain, but neurological deficits are usually absent, distinguishing it from more serious cervical injuries. Cauda equina syndrome, although primarily a lumbar pathology, must be considered when assessing spinal injuries with neurological involvement. Central disc herniation compresses the cauda equina, producing symptoms such as lower back pain radiating bilaterally to the legs, saddle anesthesia, and significant bladder or bowel dysfunction, including incontinence or urinary retention. Additional features may include impotence, diminished rectal tone, and lower extremity motor deficits. Prompt recognition is critical, as delayed intervention can result in permanent neurological impairment. Cervical strain is another common differential, often arising from hyperextension mechanisms, such as those encountered in rear-end motor vehicle collisions. This injury primarily affects the paracervical musculature, causing pain and limited range of motion. In some instances, intervertebral disc herniation may accompany the strain, potentially irritating the cervical sympathetic chain. Such involvement can manifest as Horner syndrome, characterized by ptosis, miosis, and anhidrosis, which may be misattributed to other cervical pathologies. Hanging injuries constitute a more severe differential, representing a form of strangulation trauma. Compression of the cervical airway, vasculature, and neural structures can lead to both local tissue damage and systemic consequences. Hypoxia and brainstem compression may induce arrhythmias, respiratory compromise, and cardiac arrest. Neurological deficits may be evident depending on the duration and severity of compression, necessitating rapid assessment and intervention. Careful differentiation between these conditions and true cervical spine injury relies on a combination of detailed history, mechanism of injury, physical examination, and targeted imaging. Accurate identification of the underlying pathology ensures timely and appropriate management, minimizes complications, and supports optimal functional recovery [24][25].

Prognosis

Cervical spine and spinal cord injuries are associated with a guarded prognosis, frequently resulting in substantial morbidity, long-term disability, and, in severe cases, mortality.[26][27] The extent of neurological impairment correlates closely with the level and severity of injury, emphasizing the necessity for early recognition, accurate assessment, and prompt intervention. Pediatric patients are particularly vulnerable, with studies indicating that neurological injury occurs in up to one-third of children sustaining cervical trauma, highlighting the critical importance of early stabilization and careful monitoring.[5] Injuries involving the upper cervical vertebrae, particularly C1 through C4, carry significantly higher mortality rates due to their anatomical proximity to vital neurovascular structures, including the brainstem and respiratory centers. Consequently, high cervical injuries often require immediate intervention and intensive supportive care. Neurological recovery after cervical spine trauma typically follows a predictable but gradual trajectory. Functional improvement often begins with the lower extremities, progressing to the restoration of bladder control, and subsequently involving upper limb function. Recovery of fine motor control, particularly hand and finger dexterity, is often the slowest and may remain incomplete despite optimal management.[28] These patterns reflect the sequential recovery of neural pathways and the variable regenerative potential of different spinal cord regions. Compounding these challenges, missed or initially undiagnosed cervical spine injuries remain a significant concern. Epidemiological data estimate that 4% to 8% of cervical injuries are not identified during initial evaluation, potentially delaying definitive treatment and contributing to poorer outcomes.[29] The prognostic implications underscore the importance of rigorous clinical assessment, high-quality imaging, and careful neurological monitoring in all patients with suspected cervical trauma, regardless of apparent injury severity.

Complications

Cervical spine injuries are a principal cause of long-term disability, producing extensive neurological and systemic complications that profoundly impact quality of life. Quadriplegia or tetraplegia represents one of the most severe sequelae, characterized by partial or complete paralysis of all four extremities. Patients with high cervical injuries may lose voluntary motor function and sensory perception below the level of injury, resulting in permanent dependency for activities of daily living, including mobility, self-care, and feeding. The degree of functional limitation correlates with the level of spinal cord compromise, with higher injuries generally producing more extensive deficits. Respiratory compromise constitutes a major complication, particularly in injuries at or above the C5 level due to involvement of the phrenic nerve (C3–C5), which innervates the diaphragm. Impairment of diaphragmatic function can necessitate prolonged mechanical ventilation or tracheostomy support. Even injuries below this level may weaken accessory respiratory muscles, increasing susceptibility to hypoventilation, infections, and respiratory failure. Autonomic disruption also contributes to hypotension and impaired cardiovascular regulation, complicating the acute management of these patients. Bowel and bladder dysfunction is another significant consequence of cervical spinal cord injury. Damage to autonomic pathways often results in urinary retention, incontinence, and constipation, requiring interventions such as intermittent catheterization, bowel regimens, or surgical diversion procedures. The cumulative effect of these functional impairments imposes substantial emotional, physical, and financial burdens on patients, families, and healthcare systems. Early recognition, stabilization, and initiation of comprehensive multidisciplinary rehabilitation are essential to minimize morbidity, optimize functional recovery, and improve long-term outcomes [26].

Postoperative and Rehabilitation Care

Rehabilitation following cervical spine injury is central to functional restoration, pain reduction, and complication prevention. Physical therapy is foundational, commencing with early mobilization and progressing through structured strength training, balance exercises, and functional mobility activities. Therapists provide neuromuscular re-education and teach compensatory strategies to maximize independence in daily activities. Rehabilitation plans must be individualized and adaptive, with ongoing assessment ensuring the therapy remains responsive to patient progress. Occupational therapy complements these efforts by focusing on upper limb function, fine motor skills, and environmental modifications to promote autonomy. Respiratory therapy may also be necessary in patients with high-level injuries to optimize ventilation and reduce the risk of pulmonary complications.

Patient Education

Patient education and injury prevention represent critical components of long-term care and community health initiatives. Clinicians should counsel families regarding strategies to minimize the risk of cervical spine trauma, emphasizing safe practices such as the appropriate use of child safety restraints, adherence to vehicle safety guidelines, and environmental modifications to prevent falls or sports-related injuries.[30] Adolescent drivers should receive structured guidance addressing speed limits, nighttime driving restrictions, and behavioral safety agreements. Effective education also involves transparent communication regarding prognosis, highlighting the variable trajectory of neurological recovery. Clinicians must emphasize that recovery typically progresses from lower extremities to upper limbs, with hand and finger function often recovering last. Early recognition of ligamentous injury or spinal cord injury without radiographic abnormality is essential in cases with focal neurologic deficits despite normal imaging, and timely intervention can prevent further deterioration.

Other Issues

Maintaining a high index of suspicion for cervical spine injury is crucial, particularly in polytrauma patients, as distracting injuries may mask cervical pathology. Immobilization with a rigid cervical collar remains standard until radiographic clearance, particularly in intubated or obtunded patients. Pediatric patients are at higher risk for ligamentous injuries due to incomplete spinal maturation, and noncontiguous spinal injuries may coexist in up to 30% of cases.[28][32] MRI is invaluable for detecting occult ligamentous or spinal cord injuries, particularly at C3–C5 levels where phrenic nerve compromise can threaten respiratory function. Multidisciplinary management involving emergency medicine, trauma, neurosurgery, anesthesiology, and orthopedic teams is essential to optimize outcomes, with individualized care plans addressing injury severity, associated trauma, and patient-specific factors such as age, neurological deficits, and comorbidities.[33][34]

Enhancing Healthcare Team Outcomes

Effective management of cervical spine injuries necessitates a highly coordinated, multidisciplinary approach, integrating the expertise of emergency medicine physicians, trauma specialists, anesthesiologists, orthopedic surgeons, and neurosurgeons. The primary objective of such collaboration is to ensure rapid and accurate assessment, stabilization, and treatment while minimizing the risk of secondary neurological injury. Adherence to the Advanced Trauma Life Support (ATLS) protocol remains the gold standard for initial evaluation and resuscitation, providing a structured framework that prioritizes airway management, hemodynamic stability, and timely identification of life-threatening conditions. In addition, these guidelines emphasize the importance of early immobilization of the cervical spine to prevent further injury, particularly in patients with suspected fractures or neurological compromise. For patients presenting with minor, stable cervical fractures without neurological deficits, conservative management may suffice. This typically includes adequate analgesia, immobilization using a cervical collar or brace, and routine follow-up examinations to monitor healing and prevent complications. Such cases require ongoing assessment by the multidisciplinary team to ensure adherence to immobilization protocols and to identify any evolving signs of neurological compromise. In contrast, patients with unstable fractures, evidence of spinal cord compression, or progressive neurological deficits often require surgical intervention. Surgical strategies may involve decompression of neural structures, internal fixation with instrumentation, and spinal fusion to restore stability. The decision to proceed with operative management must be informed by the type, location, and severity of the injury, as well as the patient's overall physiological status and comorbidities.

Several patient-specific factors influence outcomes following cervical spine injury, including the presence of concomitant head trauma, the severity and distribution of neurological deficits, the Glasgow Coma Scale (GCS) score, and chronological age. A comprehensive evaluation that accounts for these variables is essential for the development of an individualized management plan. Such planning should integrate the patient's overall health, the precise characterization of the cervical injury, and any associated injuries that may complicate care. Even with optimal treatment, a significant proportion of patients may experience residual disability, manifesting as chronic pain, restricted cervical range of motion, or persistent neurological deficits. The coordination of care across multiple specialties facilitates timely decision-making, reduces the risk of complications, and optimizes long-term functional recovery. Regular interdisciplinary communication, including formal case discussions and real-time updates during acute care, ensures that treatment strategies are aligned with the evolving clinical status of the patient. Engaging rehabilitation specialists early in the care continuum also promotes functional recovery and mitigates the impact of long-term disability. Ultimately, the integration of expertise across emergency, surgical, and rehabilitative domains enhances patient-centered outcomes, demonstrating the critical value of a structured, team-based approach in the management of cervical spine trauma.[33][34]

Conclusion:

Cervical spine injuries represent a major cause of morbidity, disability, and mortality, particularly when associated with high-energy trauma or upper cervical involvement. Early recognition, stabilization, and accurate assessment are essential to prevent secondary neurological deterioration and ensure optimal recovery. Neurology consultants contribute significantly through detailed neurological evaluation, localization of deficits, and guidance on the urgency of intervention. Physiotherapists are equally vital, providing early mobilization strategies, preventing respiratory and musculoskeletal complications, and facilitating long-term functional rehabilitation. A multidisciplinary approach—integrating emergency medicine, trauma specialists, neurosurgeons, physiotherapists, and rehabilitation teams—remains the cornerstone of effective management. Surgical intervention is reserved for unstable fractures or progressive neurological deficits, while stable injuries benefit from conservative immobilization and structured rehabilitation. Ultimately, coordinated, evidence-based care improves patient outcomes, reduces long-term disability, and enhances quality of life for individuals recovering from cervical spine injuries.

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