Understanding Spinal Cord Injuries: Nursing Assessment and Interventions

Fares Yahya Mohammed Alqhtani [1], Abdulaziz Munahi R Alruwaili [2], Tarfah Saleh Alabalawi [3], Alkhaibari Yousef Hamed M [4], Atheah Lela Arowili [5], Ahmed Muttalib Alhazmi [6], Nouf Musabbiha Alhazmi [7], Albalawi, Ohud Khalaf M [8], Daham Hashim Alruwaili [9], Abdulaziz Awad Khamis Alsharari [10]

[1-] Nursing Specialist, Jeddah Second Health Cluster, Jeddah, Kingdom of Saudi Arabia
[2-] Nursing Specialist, Prince Abdulaziz bin Musaed Hospital - Arar, Saudi Arabia
[3-] Nursing technician, Tabuk Health Cluster, Tabuk, Saudi Arabia
[4-] Nursing technician, Madinah Health Cluster, Madinah, Saudi Arabia
[5-] Nursing technician, Al-Salhiyah Health Center, Turaif, Saudi Arabia
[6-] Nursing technician, Turaif General Hospital, Turaif, Saudi Arabia
[7-] Nursing technician, Turaif General Hospital, Turaif, Saudi Arabia
[8-] Nursing technician, Abu Rakah General Hospital, Tabuk, Saudi Arabia
[9-] Nursing, Turaif General Hospital, Turaif, Saudi Arabia
[10-] Health Assistant, Turaif General Hospital, Turaif, Saudi Arabia

Abstract:

Spinal cord injuries (SCIs) can have profound physical and psychological impacts on patients, requiring comprehensive nursing assessments to identify the extent of injury and the specific needs of the individual. Initial assessments involve obtaining a detailed medical history, conducting neurological examinations, and utilizing imaging techniques such as MRI or CT scans to evaluate the level and severity of the injury. Nurses also assess vital signs, motor function, sensory function, and reflexes, focusing on any potential complications such as respiratory distress, pressure ulcers, and bladder or bowel dysfunction. Continuous monitoring is vital, as changes in neurological status can signal potential complications and necessitate immediate intervention. Nursing interventions for patients with SCIs are multifaceted and aim to promote patient safety, mobility, and psychosocial well-being. Interventions include implementing a rehabilitation plan that incorporates physical and occupational therapies tailored to the patient's specific limitations and goals. Education is key; nurses should inform patients and their families about injury management, self-care, adaptive equipment use, and lifestyle modifications. Additionally, psychosocial support is essential, addressing the emotional and mental health aspects of recovery. Nurses must collaborate with multidisciplinary teams, including physicians, counselors, and rehabilitation specialists, to create a holistic care plan that addresses the comprehensive needs of patients with spinal cord injuries.

Keywords: Spinal Cord Injuries, Nursing Assessment, Neurological Examination, Imaging Techniques, Vital Signs, Complications, Mobility, Rehabilitation, Psychosocial Support, Multidisciplinary Team.

Introduction:

Spinal cord injuries (SCIs) represent a significant challenge within the landscape of contemporary healthcare, impacting millions of individuals globally and posing intricate challenges for patients, families, and healthcare practitioners. The spinal cord, a vital structure of the central nervous system (CNS), functions not only as a conduit for signals between the brain and the body but also plays a critical role in reflex actions. When an injury occurs to this essential structure, the repercussions are often profound and life-altering, resulting in varying degrees of sensory and motor dysfunction below the level of injury. Understanding the complexities surrounding SCIs is paramount for healthcare professionals, particularly nurses, who are at the forefront of patient care in acute settings and rehabilitation units [1].

The exact nature of spinal cord injuries can vary widely, ranging from minor, temporary dysfunction to complete paralysis, depending on the extent and location of the injury. These injuries commonly arise from traumatic incidents, such as motor vehicle accidents, falls, sports injuries, or acts of violence,

as well as from non-traumatic causes such as diseases, tumors, or infections. According to the National Spinal Cord Injury Statistical Center (NSCISC), there are approximately 17,000 new cases of spinal cord injury each year in the United States alone, with a total prevalence of about 291,000 individuals living with some form of SCI [2].

Given the serious implications of spinal cord injuries, effective nursing assessment and intervention strategies are vital components of the care continuum. Nurses not only engage in the initial assessment to determine the extent of injury and establish a baseline for care, but they also play a crucial role in the ongoing management, rehabilitation, and support of individuals with SCIs. Such responsibilities necessitate a thorough understanding of the pathophysiology of SCIs, the diverse manifestations of injury, and the approaches to monitoring and supporting recovery and rehabilitation [3].

Assessment of spinal cord injuries requires a multidimensional approach that encompasses physiological, neurological, respiratory, and psychological evaluations. The ASIA (American Spinal Injury Association) Impairment Scale is a widely used tool that aids in determining the completeness and severity of the injury, guiding therapeutic decisions, and providing prognostic information. Comprehensive evaluation not only entails meticulous physical examination techniques, including detailed neurological assessments, but also involves recognizing and addressing a patient's psychosocial needs through sensitive communication and emotional support [4].

Interventions targeted at patients with SCIs are multifaceted and must be tailored to meet the unique needs of each individual. Nursing care may include complex wound management, respiratory support, prevention of secondary complications such as pressure ulcers and deep vein thrombosis, and the implementation of mobility and rehabilitation programs. Furthermore, education of patients and their families is an essential intervention, ensuring that they understand the condition, the implications for their lives, and the required strategies for long-term adaptive care [5].

Anatomy and Physiology of the Spinal Cord:

The spinal cord is an essential component of the central nervous system (CNS), serving as the conduit for nerve signals between the brain and the body. It is a complex structure that not only facilitates communication between different regions of the body but also plays a crucial role in reflex actions and the overall coordination of bodily functions [6].

The spinal cord is a long, cylindrical structure that extends from the base of the brain, known as the medulla oblongata, down to the lower back, terminating at an anatomical structure called the conus medullaris, typically located around the first or second lumbar vertebra (L1-L2) in adults. The spinal cord is protected by the bony vertebral column, surrounded by several layers of membranes called meninges, and is bathed in cerebrospinal fluid (CSF), which cushions and nourishes the neural tissue [7].

Structural Organization

The spinal cord is divided into distinct regions, each of which corresponds to different segments of the body. These regions are categorized into four primary areas:

1. **Cervical Region (C1-C8):** This uppermost region contains eight pairs of spinal nerves and is responsible for motor and sensory innervation of the neck, shoulders, arms, and diaphragm. The cervical enlargements accommodate the increased neural traffic required for upper limb movement and sensation.
2. **Thoracic Region (T1-T12):** Comprised of twelve pairs of spinal nerves, the thoracic region is responsible for innervating the trunk and parts of the abdominal area. The nerves in this region control the trunk muscles and convey sensory information from the chest and abdominal structures.
3. **Lumbar Region (L1-L5):** This region contains five pairs of spinal nerves and innervates the lower back, hips, and legs. The lumbar enlargement supports the increased demand for neural communication with these lower extremities.

4. **Sacral Region (S1-S5) and Coccygeal Region (Co1):** The sacral region consists of five pairs of spinal nerves, while the coccygeal region comprises a single pair of nerves. These areas primarily innervate the pelvic organs, genitalia, and provide sensation to the skin of the buttocks and lower limbs [8].

Internal Structure

Internally, the spinal cord is characterized by a central "butterfly" or "H"-shaped configuration of gray matter surrounded by white matter. The gray matter is primarily composed of neuronal cell bodies, dendrites, and unmyelinated axons and is organized into distinct horns:

- **Dorsal Horn:** Contains sensory neurons that receive input from peripheral sensory receptors. The information is transmitted to the brain or processed locally for reflex responses.
- **Ventral Horn:** Contains motor neurons that send axons out of the spinal cord to skeletal muscles, thereby facilitating movement.
- **Lateral Horn:** Present in the thoracic and upper lumbar regions, this horn contains autonomic neurons that control involuntary functions through the sympathetic nervous system.

The white matter, formed by myelinated axons, comprises ascending (sensory) and descending (motor) pathways. These tracts facilitate communication between the spinal cord and various parts of the brain, allowing for conscious perception and voluntary movement [9].

Physiology of the Spinal Cord

The spinal cord plays multifaceted roles in the functioning of the nervous system. One of its primary functions is the conduction of nerve impulses. These impulses can be divided into two main types:

Sensory Pathways

The spinal cord contains ascending tracts that convey sensory information from peripheral receptors to the brain. Sensory pathways include:

1. **Dorsal Columns:** Carry fine touch, proprioception, and vibration sensations to the brain.
2. **Spinothalamic Tract:** Transmits pain and temperature sensations to the brain.
3. **Spinocerebellar Tracts:** Provide proprioceptive information to the cerebellum, facilitating balance and coordination.

As sensory signals travel along these pathways, they undergo synaptic relay in the spinal cord and brainstem before reaching the cerebral cortex for conscious interpretation [10].

Motor Pathways

Conversely, the spinal cord is responsible for descending pathways that transmit motor commands from the brain to the body. Major motor pathways include:

1. **Corticospinal Tract:** This pathway carries voluntary motor commands from the cerebral cortex to the spinal cord, where they synapse with lower motor neurons in the ventral horn, which then innervate skeletal muscles.
2. **Extrapyramidal Tracts:** These tracts coordinate involuntary and automatic movements, contributing to posture, balance, and reflexes [11].

Reflexes

The spinal cord also facilitates reflex actions, which are involuntary responses to stimuli that occur without conscious thought. Reflexes are mediated through reflex arcs, which consist of:

1. **Receptor:** Detects a stimulus and initiates the reflex.
2. **Sensory Neuron:** Transmits the signal to the spinal cord.
3. **Integration Center:** Typically located within the spinal cord, this center processes the sensory input and formulates a corresponding motor output.
4. **Motor Neuron:** Carries the response signal from the spinal cord to the effector.
5. **Effector:** This is the muscle or gland that produces the response (e.g., muscle

contraction to withdraw from a painful stimulus) [12].

Homeostasis

The spinal cord plays a vital role in maintaining homeostasis, especially through autonomic reflexes. For example, reflexes controlling blood pressure, heart rate, and digestion are mediated by the autonomic nervous system, which is intricately connected to spinal cord pathways. Any disruption in spinal cord function can lead to severe consequences for homeostatic regulation, including impaired temperature control, loss of bladder and bowel function, and disruptions in cardiovascular regulation [13].

Classification and Types of Spinal Cord Injuries:

Spinal cord injuries (SCIs) represent a significant concern within the medical community due to their profound impact on physical health, quality of life, and health care costs. The spinal cord serves as the primary conduit for transmitting nerve signals between the brain and the rest of the body. Therefore, any damage to this vital structure can result in severe motor and sensory deficits, as well as autonomic dysfunction. Understanding the classification and various types of spinal cord injuries is essential for effective diagnosis, treatment, and rehabilitation.

Before diving into classification, it is crucial to understand what constitutes a spinal cord injury. SCIs occur when there is an injury to the spinal cord itself, often resulting from trauma such as car accidents, falls, violence, and sports-related incidents. Furthermore, SCIs can also stem from non-traumatic causes like infections, tumors, and degenerative diseases.

The consequences of SCIs depend on several factors, including the location of the injury along the spinal column, the severity of the damage, and the extent of neurological involvement. Broadly speaking, the effects can be categorized into two main groups: complete and incomplete injuries [14].

Classification of Spinal Cord Injuries

1. **Complete Spinal Cord Injuries**
In complete injuries, there is a total loss of motor and sensory function below the level of the injury. Complete SCIs result in paraplegia (loss of sensation and movement in the legs) or quadriplegia (loss of sensation and movement in the arms and legs). The mechanisms leading to complete injuries typically involve significant trauma that severs the spinal cord or causes profound damage to it [15].

2. **Incomplete Spinal Cord Injuries**
In contrast, incomplete injuries involve partial preservation of sensation and/or motor function below the level of injury. The degree of recovery can vary widely and is influenced by many factors, including the nature and extent of the damage. The differentiation among incomplete injuries includes several specific types:

    - **Central Cord Syndrome**: This condition typically results from cervical spinal cord injury and is characterized by greater motor impairment in the upper limbs than in the lower limbs, often accompanied by varying degrees of sensory loss. The recovery patterns may lead to notable functional improvements, particularly in lower limbs as rehabilitation progresses [16].
    - **Brown-Sequard Syndrome**: This occurs when one half of the spinal cord is damaged, typically due to a stab wound or a traumatic injury. Individuals with this syndrome may exhibit motor function loss on the side of the body affected by the injury while preserving sensory functions. Conversely, the opposite side may experience altered sensations (such as loss of temperature and pain sensation).
    - **Anterior Cord Syndrome**: In this syndrome, damage to the anterior two-thirds of the spinal cord results in loss of motor function and sense of temperature and pain, while proprioceptive and vibratory senses remain intact. This syndrome is relatively

rare and often occurs due to ischemia or trauma.

- **Cauda Equina Syndrome**: This severe type of injury entails damage to the nerve roots below the level of the spinal cord. Symptoms often include severe pain, loss of bowel and bladder control, and lower limb weakness. The prognosis for recovery in cauda equina syndrome varies considerably, dependent primarily on the extent of nerve root damage and the promptness of surgical intervention.
- **Conus Medullaris Syndrome**: This syndrome occurs at the terminal end of the spinal cord and is characterized by a mix of upper and lower motor neuron symptoms, resulting in varying degrees of motor and sensory function loss. Patients often present with symptoms that resemble both cauda equina syndrome and typical upper motor neuron injuries, complicating diagnosis [16].

Severity Rating: The ASIA Score

The American Spinal Injury Association (ASIA) developed a standardized method of categorizing the severity of spinal cord injuries through the ASIA Impairment Scale (AIS). This scale ranges from A (complete impairment) to D (some motor function retained), with B reflecting the preservation of sensory function and C indicating the presence of some motor function but below the threshold for strength. The AIS is widely utilized in clinical settings as it provides a structured framework for evaluating neurological recovery and guiding treatment protocols [17].

Comprehensive Nursing Assessment in Spinal Cord Injuries:

Spinal cord injuries (SCIs) represent a significant public health challenge, affecting individuals across various demographics and resulting in substantial physical, psychological, and socio-economic implications. A comprehensive nursing assessment is crucial for the effective management of SCIs, as it aids in identifying patient needs, formulating care plans, and providing ongoing support [18].

A spinal cord injury occurs when there is damage to the spinal cord, leading to a loss of function, sensation, or mobility. The severity of an SCI can vary widely, ranging from mild concussions to complete paralysis. The classification of spinal cord injuries divides them into two main categories: complete and incomplete. In a complete injury, there is a total loss of sensory and motor function below the injury site. In an incomplete injury, some function remains. The level of injury—cervical, thoracic, lumbar, or sacral—also significantly influences the degree of impairment and the specific nursing considerations that must be observed [19].

The Significance of Comprehensive Nursing Assessment

A comprehensive nursing assessment goes beyond the physical evaluation; it encompasses holistic considerations, recognizing the patient in their entirety, including physical, emotional, psychosocial, and spiritual health. The purpose of this thorough assessment is to ascertain baseline data, monitor changes over time, and develop individualized care plans that are responsive to the patient's needs [20].

1. **Physical Assessment**: Physical assessment includes evaluating the neurological status of the patient. Nurses utilize tools such as the American Spinal Injury Association (ASIA) impairment scale, which helps classify sensory and motor function, thereby determining the extent of the injury. Vital signs monitoring is also critical as SCIs can affect autonomic functions, potentially leading to conditions such as neurogenic shock, bradycardia, and hypothermia. Additionally, assessment of respiratory function is essential, particularly in cervical injuries, as they can impair diaphragm function.
2. **Skin Integrity Assessment**: Individuals with SCIs are at a heightened risk for pressure ulcers due to immobility and altered sensation. Nurses must conduct regular skin assessments, paying close attention to bony prominences. Effective prevention strategies, including patient

repositioning and proper nutrition, can be instituted based on these assessments.

3. **Functional Assessment**: Evaluating a patient's ability to perform daily activities is vital in identifying the level of assistance required. Tools like the Functional Independence Measure (FIM) can assist nurses in assessing the patient's abilities and establishing rehabilitation goals.
4. **Psychosocial Assessment**: The psychological impact of spinal cord injuries can be profound, leading to conditions such as depression, anxiety, or post-traumatic stress disorder. By utilizing screening tools and open communication, nurses can appraise the emotional and psychological health of their patients, allowing for timely referrals to mental health services.
5. **Social Assessment**: Understanding the patient's social context—including family support, financial resources, and access to community services—is essential. A social assessment can unearth specific challenges patients may face in reintegrating into their communities and can inform discharge planning and post-acute care [20].

Implementation of the Comprehensive Assessment

The process of comprehensive nursing assessment in spinal cord injuries typically involves multiple steps: interview, physical examination, and tool application. The nursing process begins with a thorough patient interview to gather subjective data regarding the patient's symptoms, history, and concerns. Following this, a systematic physical examination assesses neurological function and other physiological parameters that can directly impact patient care [21].

Assessment tools are valuable in standardizing data collection and improving the accuracy of findings. Utilizing scales for pain assessment, functional mobility, and quality of life can provide quantifiable measures for comparison and progress tracking. Documentation and communication of findings among the multidisciplinary team—encompassing physicians, physiotherapists, occupational therapists, and social workers—are crucial to ensure coordinated care [22].

Assessing patients with spinal cord injuries presents unique challenges. Variability in presentation and individual responses to injuries can complicate assessments. Additionally, cultural differences may influence how patients communicate their needs and preferences. Nurses must remain culturally competent and adaptable, ensuring that assessments are respectful, inclusive, and relevant to each patient's individual background [23].

Patients may also have cognitive impairments based on the location and type of injury. This necessitates clear communication and repeated assessments as cognitive function can fluctuate based on fatigue or medical conditions. Furthermore, the emotional state of the patient can influence their engagement with the assessment process, making it imperative for nurses to employ empathetic techniques [24].

Common Complications and Challenges in SCI Patients:

Spinal Cord Injury (SCI) is a debilitating condition characterized by damage to the spinal cord, which can result in a range of physical and psychological challenges. The severity of the complications faced by SCI patients largely depends on the extent and location of the injury, leading to varying degrees of paralysis and sensory loss. While advancements in medical technology and rehabilitation have improved the prognosis for many, SCI patients often face a multitude of complications that can complicate their recovery, affect their quality of life, and challenge their support systems [25].

Physical Complications

One of the most immediate challenges faced by SCI patients is the risk of secondary complications arising from immobility and lack of sensation. These complications can significantly impact health and require ongoing medical attention [26].

1. **Pressure Ulcers**: Due to prolonged periods of immobility and reduced sensation, individuals with SCI are highly susceptible to pressure ulcers (also known as bedsores). These painful skin injuries occur when tissue is damaged due to prolonged pressure against the skin. Preventative measures include regular repositioning, the

use of specialized mattresses and cushions, and maintaining proper hygiene.

2. **Deep Vein Thrombosis (DVT)**: SCI patients are at an elevated risk for DVT, a condition characterized by blood clots in the deep veins, usually in the legs. The loss of muscle movement and blood flow can lead to stagnation, and if a clot breaks free, it can travel to the lungs, resulting in a life-threatening pulmonary embolism. Preventative strategies may include medication, compression therapies, and encouraging movement where possible [27].
3. **Respiratory Impairments**: Injuries at higher levels of the spinal cord (e.g., cervical injuries) can lead to respiratory difficulties due to paralysis of the diaphragm and intercostal muscles. This can increase the risk of pneumonia and other respiratory infections, necessitating prompt medical interventions and, in some cases, respiratory therapy.
4. **Autonomic Dysreflexia**: This condition occurs primarily in individuals with higher-level injuries and is characterized by an exaggerated response of the autonomic nervous system to stimuli, such as a full bladder or pain. Symptoms may include high blood pressure, headaches, sweating, and flushing. It is a medical emergency that necessitates immediate attention to identify and alleviate the triggering cause.
5. **Contractures and Musculoskeletal Issues**: Lack of movement can lead to muscle shortening and joint stiffening, resulting in contractures. These can impede mobility and require physical therapy and stretching exercises to manage. Spinal deformities, such as scoliosis, may also develop over time, particularly among adolescents with SCI [28].

Psychological Challenges

The psychological impact of SCI can be profound and multifaceted. Patients often experience a range of emotional responses, including grief, depression, anxiety, and post-traumatic stress disorder (PTSD) [29].

1. **Adjustment Disorders**: Adapting to new physical limitations can create a significant emotional burden. Many individuals go through a grieving process for their previous functional abilities and face challenges in redefining their self-identity and purpose in life. Behavioral therapies may be beneficial in addressing these adjustment issues.
2. **Depression and Anxiety**: The risk of depression in SCI populations is significantly higher than in the general population. Factors contributing to depression include loss of autonomy, changes in body image, and social isolation. Anxiety may arise from fears about the future, such as concerns about health, financial stability, and social acceptance. Comprehensive mental health support, including medication and counseling, can help manage these conditions.
3. **Social Isolation**: Many individuals with SCI find themselves becoming socially isolated due to physical limitations and accessibility issues. The emotional toll of diminished social interaction can exacerbate feelings of loneliness and depression. Rehabilitation programs that encourage social engagement, as well as assistive technology that facilitates communication, can help combat isolation [30].

Social and Economic Challenges

The transition from hospital to home and the adjustment to everyday life can be particularly daunting for SCI patients, highlighting various social and economic challenges that may arise.

1. **Accessibility Issues**: Many environments are not equipped for individuals with mobility challenges. Barriers such as stairs, narrow doorways, and inadequate bathroom facilities can prevent SCI patients from navigating their own homes or community spaces independently. Advocacy for universal design principles in buildings and public spaces is essential for fostering an inclusive society [31].

2. **Employment Barriers**: Individuals with SCI often encounter difficulties in maintaining or finding employment. This can stem from physical limitations, employer biases, and a lack of vocational training tailored to their capacities. The importance of job accommodations and supportive employment programs cannot be overstated in promoting the integration of these individuals into the workforce.
3. **Financial Strain**: The financial implications of sustaining an SCI can be substantial. Medical costs, rehabilitation services, adaptive equipment, and ongoing care needs often place a significant financial burden on patients and their families. Navigating health insurance policies to cover these expenses can also be a complex task, necessitating reliable financial planning and legal advocacy.
4. **Family Dynamics**: The impact of SCI extends beyond the individual to their families and caregivers. The role of caregivers can be physically and emotionally taxing, leading to caregiver burnout. Support groups and respite care services can play a vital role in providing necessary support and resources to family members [32].

Implementing Evidence-Based Nursing Interventions:

Spinal cord injury (SCI) is a life-altering event that can lead to significant physical, psychological, and social challenges. The spinal cord, a critical component of the central nervous system, transmits signals between the brain and the body, facilitating movement and sensation. Injuries to the spinal cord can result from trauma, diseases, or congenital conditions, culminating in varying degrees of paralysis, loss of sensation, and other systemic complications. As the prevalence of spinal cord injuries continues to rise—primarily due to motor vehicle accidents, falls, and gunshot wounds—there is a pressing need for the nursing profession to implement evidence-based interventions that can enhance patient outcomes, minimize complications, and promote rehabilitation [33].

Patients with spinal cord injuries face a multitude of challenges. The physical consequences, depending on the location and severity of the injury—classified as complete or incomplete—can directly affect motor function, sensory perception, and autonomic regulation. Such impairments can lead to secondary health complications, including pressure ulcers, pneumonia, urinary tract infections, deep vein thrombosis (DVT), and issues related to thermoregulation. Furthermore, individuals with SCI also contend with profound emotional and psychological impacts. Depression, anxiety, and adjustment disorders are common, resulting from the sudden changes in their physical abilities and general lifestyle [34].

Given the complex nature of care required for patients with SCI, it is crucial for nursing interventions to be grounded in scientific evidence. Evidence-based practice (EBP) integrates clinical expertise with the best available research and patient values to make informed decisions about care. This approach not only enhances patient outcomes but also encourages a culture of continuous improvement within healthcare settings [35].

Core Evidence-Based Nursing Interventions

1. **Multidisciplinary Assessment and Collaborative Care Planning:** The first step in caring for a patient with SCI is thorough assessment. This entails not only assessing the level and completeness of the injury but also the patient's overall physical and psychological health. Utilizing standardized assessment tools, such as the ASIA Impairment Scale, helps categorize the level of injury, which informs intervention strategies. A multidisciplinary approach, involving physical therapists, occupational therapists, psychologists, and social workers, enhances care by addressing the multifaceted needs of the patient. Collaborative care planning empowers the patient and their family, fostering active participation in their rehabilitation journey [36].
2. **Pressure Ulcer Prevention:** Patients with spinal cord injury are at an elevated risk of developing pressure ulcers due to reduced mobility and sensation. Evidence suggests that implementing a regular turning schedule—typically every

two hours for those in bed and every 15-30 minutes for wheelchair users—can significantly mitigate the risk. Utilizing pressure-relieving devices such as specialized mattresses and cushions is recommended, alongside regular skin assessments to identify early signs of pressure damage. Educating patients and caregivers on proper skin care routines, nutrition, and hydration plays a critical role in prevention [37].

3. **Autonomic Dysreflexia Management:** Individuals with high-level spinal cord injuries (typically above T6) are at risk for autonomic dysreflexia, a potentially life-threatening condition characterized by an exaggerated autonomic response to stimuli. Nursing interventions should encompass continuous monitoring of vital signs, recognizing symptoms (e.g., severe headache, flushing, sweating), and addressing potential triggers such as bladder distension or bowel impaction. Prompt intervention is critical, including sitting the patient up and identifying and alleviating the cause of the dysreflexia.
4. **Urinary Management:** Urinary complications, particularly urinary tract infections (UTIs), are prevalent among patients with SCI. Evidence suggests that intermittent catheterization is a preferred method for bladder management as it reduces the risk of infection compared to indwelling catheters. Teaching patients sterile catheterization technique and promoting hydration allows for better management of urinary function. Regular bladder training can also empower patients, enabling them to gain greater autonomy over their care [38].
5. **Physical Rehabilitation:** Early engagement in physical rehabilitation is pivotal in optimizing functional recovery following spinal cord injury. Research indicates that initiating rehabilitation within 24 to 48 hours post-injury can yield better long-term outcomes. Nursing interventions should facilitate a tailored rehabilitation program that includes physical and occupational therapy focused on maximizing mobility, enhancing activities of daily living (ADLs), and addressing muscle spasticity through appropriate techniques. Integrating assistive technologies, such as mobility aids, can further empower patients to regain independence [39].
6. **Psychosocial Support and Education:** Depression and anxiety are common among patients with spinal cord injuries. Nurses must provide empathetic support, educate patients on coping strategies, and encourage participation in support groups. Evidence suggests that psychological interventions, including cognitive-behavioral therapy, can significantly enhance mental well-being. Regular screening for mental health issues, along with referrals to mental health professionals when necessary, is essential to providing holistic care.
7. **Patient and Family Education:** Education is a vital component of care for patients with SCI, and nursing interventions should include comprehensive education for both patients and their families. Understanding the nature of the injury, potential complications, self-care strategies, and community resources equips patients and families with the knowledge needed to manage their lives post-injury. Providing educational materials, facilitating discussions, and creating opportunities for hands-on practice can significantly enhance patient confidence and autonomy [39].

Rehabilitation Strategies for Enhanced Patient Outcomes:

Spinal cord injury (SCI) represents a significant medical and social challenge, affecting hundreds of thousands of individuals globally. The impact of SCI is profound, leading to varying degrees of functional impairment and disability, largely defined by the specific nature and level of the injury. Given the complexity of physical, psychological, and social repercussions following SCI, rehabilitation emerges as a critical element in fostering recovery and improving life quality [40].

Before delving into rehabilitation, it is essential to understand the nature of spinal cord injuries. SCI can be classified as either complete or incomplete based on the degree of function preserved below the level of injury. A complete SCI results in a total loss of motor and sensory function, while an incomplete SCI may retain some sensations or movements. The effects of SCI can vary widely from patient to patient, affecting mobility, bladder and bowel control, sexual function, and respiratory health, among other areas [41].

Physical Rehabilitation Strategies

Physical rehabilitation plays a cornerstone role in improving mobility and independence for individuals with SCI. The primary goal is to maximize the potential for recovery through tailored exercise programs, which can be initiated as early as possible post-injury. While traditional physical therapy focuses on strength and endurance, modern approaches emphasize functional mobility. Strategies include:

1. **Functional Electrical Stimulation (FES)**: This technique involves using electrical currents to stimulate muscles, activating them in a way that mimics voluntary movement. For instance, FES can help patients enhance muscle activation in the legs, promoting standing or walking abilities [42].
2. **Task-Oriented Training**: This method emphasizes specific activities relevant to daily living. Task-oriented training not only improves physical function but also instills a sense of accomplishment and motivation in patients.
3. **Aquatic Therapy**: The buoyancy of water reduces the impact on joints, allowing individuals with limited mobility to engage in exercises that build strength and flexibility without the strain experienced on land.
4. **Stretching and Range of Motion Exercises**: These exercises are crucial for maintaining flexibility, preventing contractures, and ultimately enhancing overall function [42].

Occupational Therapy Interventions

Occupational therapy (OT) is pivotal in facilitating daily living skills and enhancing life quality for SCI patients. OTs work collaboratively with individuals to identify their needs and adapt their environments accordingly. Key strategies include:

1. **Adaptive Equipment and Technology**: The use of assistive devices such as wheelchairs, modified utensils, or communication tools can significantly enhance the independence of SCI patients. OTs assess patients' specific requirements and recommend appropriate equipment to aid in daily tasks.
2. **Environmental Modifications**: OTs often work with patients' families to make necessary modifications in their living spaces, such as installing ramps, widening doorways, or arranging furniture to enable easier mobility.
3. **Skill Development**: Occupational therapy interventions often focus on retraining patients in essential skills, from basic self-care activities to complex work-related tasks. This may include strategies for managing bowel and bladder care, dressing, and meal preparation [43].

Psychosocial Support

The psychological dimensions of living with a spinal cord injury cannot be overstated. Patients often grapple with feelings of loss, depression, and anxiety, making psychological support an integral part of rehabilitation. Effective strategies include:

1. **Counseling and Support Groups**: Professional counseling and peer support groups allow individuals to express their emotions and share experiences. Connection with others who have faced similar challenges can foster resilience and reduce feelings of isolation.
2. **Cognitive Behavioral Therapy (CBT)**: CBT has been successful in addressing maladaptive thought patterns and coping strategies, equipping patients with tools to navigate their new realities positively.
3. **Family Involvement**: Engaging family members in the rehabilitation process

ensures that patients receive holistic support. Family education on SCI can also alleviate misconceptions and enhance understanding of the patient's experience and needs [44].

Technological Advancements

The advent of technology has revolutionized the rehabilitation landscape for SCI patients. Innovations provide novel ways to enhance mobility and independence, improve therapeutic outcomes, and support patients throughout their recovery. Notable advancements include:

1. **Robotics and Exoskeletons**: Robotic rehabilitation devices and exoskeletons enable patients to walk and move in ways that mimic natural walking patterns. These systems not only improve physical mobility but also boost morale and motivation, providing a sense of normalcy.
2. **Telehealth**: The integration of telehealth services allows patients to access therapy sessions remotely, increasing convenience and reducing barriers to care. Particularly beneficial in rural or underserved areas, telehealth serves as a continuity strategy for maintaining engagement in rehabilitation.
3. **Virtual Reality (VR) Therapy**: VR offers immersive environments for exercising movement and coordination. Through gamified exercises, patients are often more motivated and engaged than traditional rehabilitation methods might incur [45].

Community Resources and Support

Successful rehabilitation is not limited to clinical settings; community resources play a vital role in sustaining independence and quality of life for patients with SCI. Various organizations, support groups, and services exist to enhance the well-being of SCI survivors:

1. **Recreational Activities**: Adaptive sports programs facilitate social engagement and physical activity, allowing patients to connect with others while rebuilding confidence and fitness levels.
2. **Resource Centers**: Information about local resources, advocacy, and education can empower patients and their families, ensuring they have a robust support network.
3. **Employment Services**: Vocational rehabilitation programs help patients transition back into the workforce, providing job training, placement services, and workplace accommodations [46].

Psychosocial Considerations and Support for Patients and Families:

Spinal cord injury (SCI) is a significant medical condition that results in varying degrees of physical, emotional, and social dysfunction. The impact of such an injury is profound, not only affecting the individual, but also having a ripple effect on families and caregivers. As the medical field increasingly recognizes the importance of a holistic approach to healthcare, psychosocial support has emerged as a critical aspect of care for patients with SCI and their families [47].

Spinal cord injury encompasses damage to the spinal cord that results in a loss of motor, sensory, or autonomic function below the level of injury. The causes of SCI range from traumatic incidents, such as motor vehicle accidents or falls, to non-traumatic factors like tumors or infections. The implications of SCI can be extensive, leading to paralysis, changes in body function, and significant lifestyle alterations. The paralysis or loss of function can be classified as either tetraplegia, involving all four limbs and torso, or paraplegia, where only the lower limbs are affected. In addition to these physical challenges, psychological and social ramifications are equally significant. [48]

The initial response to a spinal cord injury often includes acute emotional reactions, such as shock, denial, anxiety, and depression. The unpredictability of recovery, the immediate loss of physical abilities, and the new dependence on others can create a landscape of confusion and distress. Research has shown that individuals with SCI are at heightened risk for mental health disorders, including depression and anxiety. The prevalence of these conditions may be related to factors such as the severity of the injury, personal coping styles, past psychiatric history, and the level of pre-injury support systems [49].

Moreover, the psychosocial impact of SCI extends beyond immediate mental health issues. The long-term realities of living with a significant injury—including chronic pain, changes in self-image, social isolation, and the challenges of reintegration into community life—can lead to ongoing psychological distress. As individuals grapple with these profound changes, many may experience a crisis of identity, questioning who they are beyond their disabilities [50].

The implications of SCI do not solely affect the injured individual; they reverberate through families and caregivers as well. Family members often bear the weight of caregiving responsibilities while simultaneously dealing with their emotional responses to the devastating impact of the injury. They may experience feelings of helplessness, grief for the perceived loss of the patient's previous self, and frustration stemming from restructuring family dynamics. The expectations placed on family members can lead to burnout unless they are adequately supported [51].

Additionally, family systems often need to adjust in response to the changes incurred by SCI. Communication patterns may shift, and relational roles may need to be redefined. For instance, a previously independent individual may now rely on family for daily care tasks—an adjustment that can be challenging for both the individual and their family members. Developing and maintaining healthy communication within the family, promoting the expression of feelings, and encouraging adaptability are essential components of a family's ability to cope with these changes [52].

Given the complexities surrounding SCI, psychosocial support plays an indispensable role in the overall well-being of patients and their families. Support can take many forms, including psychological counseling, peer support groups, and family therapy. Each of these facets serves a critical purpose in addressing emotional and relational challenges [53].

Professional psychological support can help individuals navigate the emotional landscape of living with SCI. Therapeutic approaches such as cognitive behavioral therapy (CBT) can be beneficial in addressing issues such as depression and anxiety. A qualified therapist can assist patients in developing coping strategies, understanding their emotions, and fostering a sense of autonomy and empowerment despite their limitations. Additionally, psychological counseling can facilitate better communication skills, enabling patients to articulate their emotions and needs more effectively to their families [54].

The value of peer support is particularly significant in the context of SCI. Connections with other individuals who have experienced similar injuries provide a powerful opportunity for individuals to share experiences, challenges, and successes. Peer support groups can foster a sense of community, reduce feelings of isolation, and promote resilience. When individuals hear from peers who have successfully adapted to life after SCI, they can gain hope and insight into their own journey, helping to mitigate some of the mental health struggles they may face [55].

Families are critical players in the rehabilitation process. Family therapy can provide a safe space for family members to express their feelings, discuss tensions, and learn how best to support one another. This can be especially valuable in transforming a potentially negative atmosphere into one characterized by mutual support and understanding. Effective family therapy can enrich communication, highlight the shared experience of trauma, and facilitate collaborative problem-solving, ultimately enhancing the well-being of both patients and their families [56].

Conclusion:

Understanding spinal cord injuries (SCIs) is crucial for nursing professionals, as these injuries significantly impact patients' physical capabilities and overall quality of life. Through thorough assessments and timely interventions, nurses play a vital role in detecting complications, providing appropriate care, and facilitating rehabilitation efforts. This study highlights the importance of a comprehensive assessment that addresses not only the medical and physical needs of patients but also their emotional and psychological well-being.

Moreover, effective nursing interventions based on evidence-based practices can greatly enhance healing and recovery, helping patients adapt to their new circumstances and regain independence. Collaborative efforts with multidisciplinary teams are essential to create holistic care plans tailored to individual patient needs. Ultimately, by focusing on

both the clinical and supportive aspects of care, nursing professionals can significantly improve outcomes for individuals living with spinal cord injuries, ensuring a more comprehensive and compassionate approach to their recovery journey.

Referemce:

1. Rupp R., Biering-Sørensen F., Burns S.P., Graves D.E., Guest J., Jones L., Read M.S., Rodriguez G.M., Schuld C., Tansey-MD K.E., et al. International Standards for Neurological Classification of Spinal Cord Injury. Top. Spinal Cord Inj. Rehabil. 2021;27:1–22. doi: 10.46292/sci2702-1.
2. Khazaeipour Z., Taheri-Otaghsara S.-M., Naghdi M. Depression Following Spinal Cord Injury: Its Relationship to Demographic and Socioeconomic Indicators. Top. Spinal Cord Inj. Rehabil. 2015;21:149–155. doi: 10.1310/sci2102-149.
3. Hachem L.D., Ahuja C.S., Fehlings M.G. Assessment and Management of Acute Spinal Cord Injury: From Point of Injury to Rehabilitation. J. Spinal Cord. Med. 2017;40:665–675. doi: 10.1080/10790268.2017.1329076.
4. Yokota K., Wang S., Singh J.M., Fehlings M.G. Youmans and Winn Neurological Surgery. Volume 336. Elsevier; Amsterdam, The Netherlands: 2016. Medical Management of Spinal Cord Injury; pp. 2618–2630.e4.
5. Liu Y., Yang X., He Z., Li J., Li Y., Wu Y., Manyande A., Feng M., Xiang H. Spinal Cord Injury: Global Burden from 1990 to 2019 and Projections up to 2030 Using Bayesian Age-Period-Cohort Analysis. Front. Neurol. 2023;14:1304153. doi: 10.3389/fneur.2023.1304153.
6. Karlsson A.K. Autonomic Dysreflexia. Spinal Cord. 1999;37:383–391. doi: 10.1038/sj.sc.3100867.
7. Hall E.D., Braughler J.M. Effects of Intravenous Methylprednisolone on Spinal Cord Lipid Peroxidation and (Na+ + K+)-ATPase Activity. J. Neurosurg. 1982;57:247–253. doi: 10.3171/jns.1982.57.2.0247.
8. Davis J.F., Cao Y., Krause J.S. Changes in Alcohol Use after the Onset of Spinal Cord Injury. J. Spinal Cord. Med. 2018;41:230–237. doi: 10.1080/10790268.2017.1319996.
9. Hogg F.R.A., Gallagher M.J., Chen S., Zoumprouli A., Papadopoulos M.C., Saadoun S. Predictors of Intraspinal Pressure and Optimal Cord Perfusion Pressure After Traumatic Spinal Cord Injury. Neurocrit. Care. 2019;30:421–428. doi: 10.1007/s12028-018-0616-7.
10. Bracken M.B., Shepard M.J., Holford T.R., Leo-Summers L., Aldrich E.F., Fazl M., Fehlings M., Herr D.L., Hitchon P.W., Marshall L.F., et al. Administration of Methylprednisolone for 24 or 48 Hours or Tirilazad Mesylate for 48 Hours in the Treatment of Acute Spinal Cord Injury. Results of the Third National Acute Spinal Cord Injury Randomized Controlled Trial. National Acute Spinal Cord Injury Study. JAMA. 1997;277:1597–1604.
11. Levi L., Wolf A., Belzberg H. Hemodynamic Parameters in Patients with Acute Cervical Cord Trauma: Description, Intervention, and Prediction of Outcome. Neurosurgery. 1993;33:1007–1016; discussion 1016–1017. doi: 10.1227/00006123-199312000-00008.
12. White Iv C.C., Domeier R.M., Millin M.G., the Standards and Clinical Practice Committee, National Association of EMS Physicians EMS Spinal Precautions and the Use of the Long Backboard—Resource Document to the Position Statement of the National Association of EMS Physicians and the American College of Surgeons Committee on Trauma. Prehospital Emerg. Care. 2014;18:306–314. doi: 10.3109/10903127.2014.884197.
13. Vale F.L., Burns J., Jackson A.B., Hadley M.N. Combined Medical and Surgical Treatment after Acute Spinal Cord Injury: Results of a Prospective Pilot Study to Assess the Merits of Aggressive Medical

Resuscitation and Blood Pressure Management. J. Neurosurg. 1997;87:239–246. doi: 10.3171/jns.1997.87.2.0239.

14. Dumont R.J., Okonkwo D.O., Verma S., Hurlbert R.J., Boulos P.T., Ellegala D.B., Dumont A.S. Acute Spinal Cord Injury, Part I: Pathophysiologic Mechanisms. Clin. Neuropharmacol. 2001;24:254–264. doi: 10.1097/00002826-200109000-00002.

15. Tator CH, Fehlings MG. Review of the secondary injury theory of acute spinal cord trauma with emphasis on vascular mechanisms. J Neurosurg 1991;75(1):15–26. doi: 10.3171/jns.1991.75.1.0015.

16. Theodore N, Hadley MN, Aarabi B, Dhall SS, Gelb DE, Hurlbert RJ, et al. Prehospital cervical spinal immobilization after trauma. Neurosurgery 2013;72 Suppl 2:22–34.

17. Ulndreaj A, Chio JC, Ahuja CS, Fehlings MG. Modulating the immune response in spinal cord injury. Expert Rev Neurother 2016;16(10):1127–9. doi: 10.1080/14737175.2016.1207532.

18. Wilson JR, Grossman RG, Frankowski RF, Kiss A, Davis AM, Kulkarni AV, et al. A clinical prediction model for long-term functional outcome after traumatic spinal cord injury based on acute clinical and imaging factors. J Neurotrauma 2012;29(13):2263–71. doi: 10.1089/neu.2012.2417.

19. Resnick DK. Updated guidelines for the management of acute cervical spine and spinal cord injury. Neurosurgery 2013;72 Suppl 2:1. doi: 10.1227/NEU.0b013e318276ee7e.

20. Ahuja CS, Fehlings M. Concise review: bridging the gap: novel neuroregenerative and neuroprotective strategies in spinal cord injury. Stem Cells Transl Med 2016;5(7):914–24. doi: 10.5966/sctm.2015-0381.

21. Wilson JR, Voth J, Singh A, Middleton J, Jaglal SB, Singh JM, et al. Defining the pathway to definitive care and surgical decompression after traumatic spinal cord injury: results of a Canadian population-based cohort study. J Neurotrauma 2016;33(10):963–71. doi: 10.1089/neu.2015.4258.

22. Battlefield advanced trauma life support. J R Army Med Corps 2003;149(2):133–7.

23. Ahuja CS, Martin AR, Fehlings M. Recent advances in managing a spinal cord injury secondary to trauma. F1000Res 2016;5 pii.

24. Burney RE, Waggoner R, Maynard FM. Stabilization of spinal injury for early transfer. J Trauma 1989;29(11):1497–9. doi: 10.1097/00005373-198911000-00008.

25. Ditunno JF, Little JW, Tessler A, Burns AS. Spinal shock revisited: a four-phase model. Spinal Cord 2004;42(7):383–95. doi: 10.1038/sj.sc.3101603.

26. Szuflita NS, Neal CJ, Rosner MK, Frankowski RF, Grossman RG. Spine injuries sustained by U.S. military personnel in combat are different from non-combat spine injuries. Mil Med 2016;181(10):1314–23. doi: 10.7205/MILMED-D-15-00332.

27. Blair JA, Patzkowski JC, Schoenfeld AJ, Cross Rivera JD, Grenier ES, Lehman RA, et al. Are spine injuries sustained in battle truly different? Spine J 2012;12(9):824–29. doi: 10.1016/j.spinee.2011.09.012.

28. Hadley MN, Walters BC, Aarabi B, Dhall SS, Gelb DE, Hurlbert RJ, et al. Clinical assessment following acute cervical spinal cord injury. Neurosurgery 2013;72 Suppl 2:40–53.

29. Bernstock JD, Caples CM, Wagner SC, Kang DG, Lehman RA Jr. Characteristics of combat-related spine injuries: a review of recent literature. Mil Med 2015;180(5):503–12. doi: 10.7205/MILMED-D-14-00215.

30. Fehling MG, Vaccaro A, Wilson JR, Singh A D WC, Harrop JS, et al. Early versus delayed decompression for traumatic cervical spinal cord injury: results of the Surgical Timing in Acute Spinal Cord

Injury Study (STASCIS). PLoS One 2012;7(2):e32037. doi: 10.1371/journal.pone.0032037.

31. The Consortium for Spinal Cord Medicine. Early acute management in adults with spinal cord injury: a clinical practice guideline for health-care professionals. J Spinal Cord Med 2008;31(4):403–79. doi: 10.1080/10790268.2008.11760744.

32. Schoenfeld AJ, Laughlin MD, McCriskin BJ, Bader JO, Waterman BR, Belmont PJ Jr. Spinal injuries in United States military personnel deployed to Iraq and Afghanistan: an epidemiological investigation involving 7877 combat casualties from 2005 to 2009. Spine (Phila Pa 1976) 2013;38(20):1770–8. doi: 10.1097/BRS.0b013e31829ef226.

33. Ahn H, Singh J, Nathens A, MacDonald RD, Travers A, Tallon J, et al. Pre-hospital care management of a potential spinal cord injured patient: a systematic review of the literature and evidence-based guidelines. J Neurotrauma 2011;28(8):1341–61. doi: 10.1089/neu.2009.1168.

34. Wilson JR, Singh A, Craven C, Verrier MC, Drew B, Ahn H, et al. Early versus late surgery for traumatic spinal cord injury: the results of a prospective Canadian cohort study. Spinal Cord 2012;50(11):840–3. doi: 10.1038/sc.2012.59.

35. Vaccaro A.R., Lehman R.A.J., Hurlbert R.J., Anderson P.A., Harris M., Hedlund R., Harrop J., Dvorak M., Wood K., Fehlings M.G., et al. A New Classification of Thoracolumbar Injuries: The Importance of Injury Morphology, the Integrity of the Posterior Ligamentous Complex, and Neurologic Status. Spine. 2005;30:2325. doi: 10.1097/01.brs.0000182986.43345.cb.

36. Strauss D.J., DeVivo M.J., Paculdo D.R., Shavelle R.M. Trends in Life Expectancy After Spinal Cord Injury. Arch. Phys. Med. Rehabil. 2006;87:1079–1085. doi: 10.1016/j.apmr.2006.04.022.

37. Hachem L.D., Schneider L., Gregory H.W.J., Fehlings M.G. Pathophysiology and Treatment of Spinal Cord Injury. Youmans Winn Neurol. Surg. 2023;308:2415–2426.e5.

38. Cardenas D.D., Hoffman J.M., Kirshblum S., McKinley W. Etiology and Incidence of Rehospitalization after Traumatic Spinal Cord Injury: A Multicenter Analysis. Arch. Phys. Med. Rehabil. 2004;85:1757–1763. doi: 10.1016/j.apmr.2004.03.016.

39. Samuel A., Bohl D.D., Basques B., Diaz-Collado P., Lukasiewicz A.M., Webb M.L., Grauer J.N. Analysis of Delays to Surgery for Cervical Spinal Cord Injuries. Spine J. 2015;15:S266. doi: 10.1016/j.spinee.2015.07.417.

40. Fehlings M.G., Wilson J.R., Tetreault L.A., Aarabi B., Anderson P., Arnold P.M., Brodke D.S., Burns A.S., Chiba K., Dettori J.R., et al. A Clinical Practice Guideline for the Management of Patients With Acute Spinal Cord Injury: Recommendations on the Use of Methylprednisolone Sodium Succinate. Glob. Spine J. 2017;7:203S–211S. doi: 10.1177/2192568217703085.

41. Rath N., Balain B. Spinal Cord Injury—The Role of Surgical Treatment for Neurological Improvement. J. Clin. Orthop. Trauma. 2017;8:99–102. doi: 10.1016/j.jcot.2017.06.016.

42. Dorsett P., Geraghty T. Health-Related Outcomes of People with Spinal Cord Injury--a 10 Year Longitudinal Study. Spinal Cord. 2008;46:386–391. doi: 10.1038/sj.sc.3102159.

43. Picetti E., Demetriades A.K., Catena F., Aarabi B., Abu-Zidan F.M., Alves O.L., Ansaloni L., Armonda R.A., Badenes R., Bala M., et al. Early Management of Adult Traumatic Spinal Cord Injury in Patients with Polytrauma: A Consensus and Clinical Recommendations Jointly Developed by the World Society of Emergency Surgery (WSES) & the European Association of Neurosurgical Societies (EANS). World J. Emerg. Surg.

2024;19:4. doi: 10.1186/s13017-023-00525-4.

44. Du J.Y., Shafi K., Blackburn C.W., Chapman J.R., Ahn N.U., Marcus R.E., Albert T.J. Resource Utilization Following Anterior Versus Posterior Cervical Decompression and Fusion for Acute Central Cord Syndrome. Clin. Spine Surg. 2024;37:E309–E316. doi: 10.1097/BSD.0000000000001598.
45. Panjabi M.M., White A.A.I. Basic Biomechanics of the Spine. Neurosurgery. 1980;7:76. doi: 10.1227/00006123-198007000-00014.
46. Battistuzzo C.R., Armstrong A., Clark J., Worley L., Sharwood L., Lin P., Rooke G., Skeers P., Nolan S., Geraghty T., et al. Early Decompression Following Cervical Spinal Cord Injury: Examining the Process of Care from Accident Scene to Surgery. J.
47. Zhao J, Wecht JM, Zhang Y, Wen X, Zeman R, Bauman WA, et al. iNOS expression in rat aorta is increased after spinal cord transection: a possible cause of orthostatic hypotension in man. Neurosci Lett 2007;415(3):210–4. doi: 10.1016/j.neulet.2007.01.025.
48. Galeiras Vazquez R, Rascado Sedes P, Mourelo Farina M, Montoto Marques A, Ferreiro Velasco ME. Respiratory management in the patient with spinal cord injury. Biomed Res Int 2013;2013:168757. doi: 10.1155/2013/168757.
49. Wilson JR, Tetreault L, Kwon BK, Arnold PM, Mroz T, Shaffrey C, et al. Timing of decompression in patients with acute spinal cord injury: a systematic review. Global Spine J 2017;6(1_suppl):s-0036-1583155.
50. Bracken MB, Collins WF, Freeman DF, Shepard MJ, Wagner FW, Silten RM, et al. Efficacy of methylprednisolone in acute spinal cord injury. JAMA 1984;251(1):45–52. doi: 10.1001/jama.1984.03340250025015.
51. Dhall SS, Hadley MN, Aarabi B, Gelb DE, Hurlbert RJ, Rozzelle CJ, et al. Deep venous thrombosis and thromboembolism in patients with cervical spinal cord injuries. Neurosurgery 2013;72 Suppl 2:244–54.
52. Ahuja C, Fehlings M. Spinal cord injury. Handbook of Neurocritical Care. New York, NY: Springer, 2016.
53. Hurlbert RJ, Hadley MN, Walters BC, Aarabi B, Dhall SS, Gelb DE, et al. Pharmacological therapy for acute spinal cord injury. Neurosurgery 2013;72(Suppl 2):93–105. doi: 10.1227/NEU.0b013e31827765c6.
54. Sheel AW, Reid WD, Townson AF, Ayas NT, Konnyu KJ. Effects of exercise training and inspiratory muscle training in spinal cord injury: a systematic review. J Spinal Cord Med 2008;31(5):500–8. doi: 10.1080/10790268.2008.11753645.
55. Wilson JR, Forgione N, Fehlings MG. Emerging therapies for acute traumatic spinal cord injury. CMAJ 2013;185(6):485–92. doi: 10.1503/cmaj.121206.
56. Bracken MB, Shepard MJ, Holford TR, Leo-Summers L, Aldrich EF, Fazl M, et al. Administration of methylprednisolone for 24 or 48 hours or tirilazad mesylate for 48 hours in the treatment of acute spinal cord injury. Results of the Third National Acute Spinal Cord Injury Randomized Controlled Trial. JAMA 1997;277(20):1597–604. doi: 10.1001/jama.1997.03540440031029.