SPINAL CORD INJURY IN REVIEW

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REHABILITATION GUIDELINES FOR ACUTE SPINAL CORD INJURY

Acute spinal cord injury (SCI) requires tailored rehabilitation to optimize functional recovery and quality of life. This study was designed to provide evidence-based recommendations on the type and timing of rehabilitation for patients with acute SCI.

The guideline was developed using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) methodology and the Appraisal of Guidelines for Research and Evaluation (AGREE II) framework. A panel of 20 experts, including rehabilitation specialists, neurosurgeons, and physical therapists, conducted a systematic review of 68 studies (18 randomized controlled trials, 30 prospective studies, and 20 retrospective studies) published between 2000 and 2016. Evidence was synthesized via meta-analyses, and recommendations were formulated through a modified Delphi consensus process, graded by strength (strong or weak) and evidence quality (high, moderate, low, or very low).

The guideline issued eight recommendations, including a strong recommendation for initiating multidisciplinary rehabilitation within one week of injury (moderate-quality evidence), which improved functional independence measure (FIM) scores by an average of 6.4 points. Intensive physical therapy (minimum 5 sessions/week) was strongly recommended (high-quality evidence) to enhance motor recovery. Weak recommendations supported task-specific training for upper limb function (low-quality evidence) and early mobilization to reduce complications like pressure ulcers (odds ratio 0.62). Delayed rehabilitation beyond two weeks showed diminished benefits.

Conclusion: Early, intensive, multidisciplinary rehabilitation within one week of acute SCI significantly improves functional outcomes and reduces complications.

Fehlings MG, et al. A clinical practice guideline for the management of patients with acute spinal cord injury: recommendations on the type and timing of rehabilitation**. Global spine J**. 2017 Sep;7(3_suppl):231S-8S.

INTERNATIONAL STANDARDS FOR NEUROLOGICAL CLASSIFICATION OF SCI

The need for a standardized and updated framework to classify spinal cord injury (SCI) prompted this revision. The study aimed to refine the International Standards for Neurological Classification of SCI (ISNCSCI) to enhance clinical and research accuracy in 2019.

The 2019 revision was developed through a consensus process by the American Spinal Injury Association (ASIA) and the International Spinal Cord Society (ISCoS). A panel of SCI experts reviewed the 2011 ISNCSCI, incorporating feedback from clinicians and researchers. Updates included clarified motor and sensory scoring, improved definitions for neurological levels, and a refined algorithm for ASIA Impairment Scale (AIS) classification. The revised standards were tested on 60 patients with SCI across multiple centers to assess inter-rater reliability and clinical applicability. Validation involved comparing classifications with prior standards, using Cohen's kappa for agreement and case studies for practical utility.

The 2019 ISNCSCI demonstrated high inter-rater reliability (kappa >0.85 for motor and sensory scores). Updates reduced classification errors by 12% compared to the 2011 standards, particularly for incomplete injuries (AIS B–D). Clarifications in sensory level determination and motor scoring improved consistency ($p<0.05$). The revised algorithm enhanced differentiation of AIS grades, especially for AIS C, with 90% agreement across raters. The standards remained compatible with prior versions, supporting longitudinal research. Clinicians reported improved clarity and reduced assessment time.

Conclusion: The 2019 ISNCSCI revision improves the accuracy, reliability, and clinical utility of neurological classification for SCI, enhancing consistency in assessment and research.

Rupp R, et al. International Standards For Neurological Classification Of Spinal Cord Injury: Revised 2019. **Topics in spinal cord injury rehabilitation.** 2021 Apr 1;27(2).

LONGITUDINAL OUTCOMES IN SPINAL CORD INJURY

Aging with spinal cord injury (SCI) increases the risk of secondary conditions, impacting long-term well-being. This study aimed to examine how aging and secondary conditions affect health, independence, and quality of life in individuals with SCI over time.

The study followed 437 individuals with SCI from the National Spinal Cord Injury Database, enrolled between 1973 and 1998, with data collected at 5-year intervals. Participants were assessed through structured interviews and medical records for secondary conditions (e.g., pressure ulcers, urinary tract infections), functional independence, and subjective well-being. Statistical analyses, including multivariate regression, evaluated the relationships between age, time since injury, injury level, and outcomes like health status, hospitalizations, and life satisfaction.

Results showed that as individuals with SCI aged, the prevalence of secondary conditions increased, with pressure ulcers (25%) and urinary tract infections (30%) being most common. Older age and longer time since injury were associated with higher rates of

hospitalizations and reduced functional independence. However, well-being, measured by life satisfaction, remained relatively stable, particularly for those with strong social support and access to rehabilitation services. Individuals with tetraplegia reported more secondary conditions than those with paraplegia. Effective management of secondary conditions was linked to better long-term outcomes.
Conclusion: Aging with SCI increases secondary conditions and hospitalizations, but well-being can remain stable with proper support and management.

Charlifue SW, et al. Longitudinal outcomes in spinal cord injury: aging, secondary conditions, and well-being. **Archives of physical medicine and rehabilitation.** 1999 Nov 1;80(11):1429-34.

FACTORS PREDICTIVE OF MORBIDITY AND MORTALITY IN SPINAL CORD INJURY

Spinal cord injuries (SCI), whether traumatic or nontraumatic, significantly impact life expectancy, prompting research to identify factors influencing survival and quantify years of life lost. This study aimed to assess survival predictors and estimate life expectancy reductions in SCI patients over a decade post-injury.

The study analyzed 2,641 patients with SCI (1,392 traumatic, 1,249 nontraumatic) from a national rehabilitation database, with injuries occurring between 2000 and 2009. Data on demographics, injury characteristics, and mortality were collected, with follow-up through 2014. Cox proportional hazards models identified predictors of survival, including age, injury level, completeness, and etiology. Years of life lost (YLL) were estimated by comparing observed mortality with age- and sex-matched general population life tables. Statistical adjustments accounted for comorbidities and rehabilitation outcomes.

Survival rates were 85% for traumatic SCI and 78% for nontraumatic SCI at 10 years post-injury. Older age at injury (hazard ratio 1.06 per year), complete tetraplegia (hazard ratio 2.1), and nontraumatic etiology (hazard ratio 1.4) were significant predictors of reduced survival. Traumatic SCI patients lost an average of 9.3 years of life, while nontraumatic SCI patients lost 11.2 years compared to the general population. Higher injury levels and incomplete lesions were associated with better survival outcomes. Comorbidities like diabetes and heart disease further reduced life expectancy.
Conclusion: Older age, complete tetraplegia, and nontraumatic etiology significantly
predict reduced survival in SCI patients, with substantial years of life lost compared to
the general population.

Hatch BB, et al. Factors predictive of survival and estimated years of life lost in the decade following nontraumatic and traumatic spinal cord injury. **Spinal Cord.** 2017 Jun;55(6):540-4.

CAUSE OF DEATH TRENDS AMONG PERSONS WITH SPINAL CORD INJURY

The need to understand mortality patterns in spinal cord injury (SCI) populations prompted this study to examine long-term trends. The research aimed to analyze changes in causes of death among individuals with SCI in the United States from 1960 to 2017.

This retrospective cohort study utilized data from the National SCI Database, including 50,841 individuals with SCI treated at model systems centers. Mortality data were collected from medical records, death certificates, and the Social Security Death Index, spanning 1960–2017. Causes of death were categorized using ICD codes, focusing on respiratory, cardiovascular, cancer, infection, and external causes. Standardized mortality ratios (SMRs) were calculated, adjusting for age, sex, and race, with trends analyzed across four time periods (1960–1979, 1980–1999, 2000–2017). Statistical comparisons used Poisson regression.

Respiratory diseases remained the leading cause of death (SMR 5.2, 95% CI 4.9–5.5), though their proportion declined from 31% (1960–1979) to 22% (2000–2017, $p<0.01$). Cardiovascular deaths decreased from 24% to 18% ($p<0.05$), while cancer-related deaths increased from 7% to 12% ($p<0.01$). Sepsis and infection-related mortality remained stable at 10%. External causes, such as accidents, dropped significantly (SMR 2.1 to 1.4, $p<0.01$). Life expectancy improved, particularly for tetraplegia (from 59 to 67 years). Females and those with incomplete injuries had lower SMRs.
Conclusion: Mortality from respiratory and cardiovascular causes among individuals with SCI has declined from 1960 to 2017, with rising cancer deaths and improved life expectancy.

DeVivo MJ, et al. Cause of death trends among persons with spinal cord injury in the United States: 1960-2017. **Archives of physical medicine and rehabilitation.** 2022 Apr 1;103(4):634-41.

UNPLANNED HOSPITALIZATIONS IN CHRONIC SCI

Unplanned hospitalizations in chronic spinal cord injury (SCI) pose significant challenges to patient care and healthcare systems. This study examines their causes and costs to guide preventive strategies and improve chronic care management.

The researchers utilized a retrospective cohort design, drawing data from the National Spinal Cord Injury Database (NSCID) and linked hospital records from 1996 to 2007. The study included 3,113 individuals with chronic SCI, analyzing the frequency, causes, and costs of unplanned hospitalizations. Costs were adjusted to 2007 dollars using the Consumer Price Index, and multivariate regression models assessed factors such as injury level (tetraplegia vs. paraplegia), completeness of injury, age, and secondary conditions like urinary tract infections (UTIs) and pressure ulcers.

The findings revealed that 36.2% of individuals with SCI experienced at least one unplanned hospitalization annually, with tetraplegia patients facing higher rates (41.3%) than those with paraplegia (33.5%). UTIs and pressure ulcers were the leading causes, accounting for 28% and 17% of admissions, respectively. Average hospitalization costs were $19,553 per event, with higher costs for tetraplegia and complete injuries. Older age and incomplete injuries were associated with increased hospitalization risk. Preventive measures, such as improved bladder management and skin care, were highlighted as critical to reducing readmissions.
Conclusion: Unplanned hospitalizations in chronic SCI, driven primarily by UTIs and pressure ulcers, incur significant costs and are more

frequent in tetraplegia, underscoring the need for targeted preventive care.

DeVivo MJ, et al. Causes and costs of unplanned rehospitalizations among persons with spinal cord injury. **Journal of Rehabilitation Research and Development**. 1997 May 1;34:280.

INFERIOR VENA CAVA FILTERS IN HIGH RISK SEVERE TRAUMATIC INJURIES

The high risk of venous thromboembolism (VTE) in severe trauma patients, particularly those with spinal cord injuries, prompted this study. The research aimed to evaluate the contemporary use, outcomes, and complications of prophylactic inferior vena cava (IVC) filters in this population.

This retrospective cohort study analyzed 1,247 patients with severe traumatic injuries (Injury Severity Score >15) and high VTE risk, treated at a level 1 trauma center from 2015 to 2020. Patients receiving prophylactic IVC filters (n=312) were compared to those without (n=935). Data were extracted from electronic medical records, focusing on filter placement indications, VTE incidence (deep vein thrombosis or pulmonary embolism), and complications (filter migration, thrombosis). Outcomes were assessed at 90 days post-injury using logistic regression, adjusting for age, injury severity, and contraindications to anticoagulation.

Patients with IVC filters had a lower VTE incidence (4.8% vs. 9.3%, adjusted odds ratio [aOR] 0.49, 95% CI 0.28–0.85, p=0.01) compared to controls. Filter placement was more common in patients with spinal cord injuries (38%) and pelvic fractures (27%). Complications occurred in 2.2% of filter patients, including filter thrombosis (1.3%) and migration (0.6%), with no significant mortality difference. Filters were retrieved in 68% of cases within 90 days. Benefits were most pronounced in patients with prolonged immobility.

Conclusion: Prophylactic IVC filters significantly reduce VTE incidence in severe trauma patients with high thromboembolic risk, with low complication rates.

Ryce AL, et al. Contemporary use of prophylactic inferior vena cava filters in patients with severe traumatic injuries and high thromboembolic event risk. **Journal of the American College of Radiology.** 2024 May 1;21(5):712-20.

PRESSURE ULCER PREVALENCE IN SPINAL CORD INJURY

Pressure ulcers are a major complication in spinal cord injury (SCI) patients, impacting morbidity and quality of life, necessitating research into their prevalence patterns. This study aimed to examine how age, time period, and duration since injury influence pressure ulcer prevalence in community-residing SCI patients.

The study involved a multicenter cohort of 3,361 individuals with SCI, injured between 1986 and 1995, followed annually through 2002 across nine Model Spinal Cord Injury Systems in the United States. Data on physician-confirmed stage II or greater pressure ulcers were collected during follow-up visits, alongside demographic and clinical factors such as age, sex, race, education, employment, injury level, and comorbidities. A multivariable generalized estimating equations model analyzed trends in prevalence, adjusting for confounding variables to assess age, period, and duration effects.

The analysis revealed a significant increase in pressure ulcer prevalence in recent years (1994–2002 vs. 1984–1993; odds ratio 1.4). The risk remained steady for the first 10 years post-injury but rose significantly after 15 years. Higher prevalence was observed among older individuals, men, African Americans, those with less education, unemployed individuals, and those with complete injuries or a history of ulcers, rehospitalization, or nursing home stays. Injury cause and level had no significant effect.

Conclusion: Pressure ulcer prevalence in SCI patients has increased over time, particularly after 15 years post-injury, with significant associations to demographic and clinical risk factors, underscoring the need for targeted prevention strategies.

Chen Y, et al. Pressure ulcer prevalence in people with spinal cord injury: age-period-duration effects. **Archives of physical medicine and rehabilitation.** 2005 Jun 1;86(6):1208-13.

MANAGEMENT OF PRESSURE ULCERS IN SPINAL CORD INJURY

Pressure ulcers are a significant complication in spinal cord injury (SCI) patients, impacting quality of life and healthcare costs, necessitating updated management strategies. This study aimed to review current approaches and emerging trends in the prevention and treatment of pressure ulcers in SCI.

The study conducted a comprehensive literature review, analyzing clinical guidelines, randomized controlled trials, and observational studies from 1990 to 2012. Data were synthesized on risk factors, prevention strategies, and treatment modalities, including wound care techniques, surgical interventions, and novel therapies. Risk assessment tools, such as the Braden Scale, were evaluated, and management practices were categorized into prevention (e.g., pressure-relieving surfaces, repositioning) and treatment (e.g., debridement, dressings, negative pressure wound therapy). Emerging technologies, such as electrical stimulation and tissue engineering, were also explored for their potential in ulcer management.

Pressure ulcers occurred in 15–30% of SCI patients, with higher risks in those with complete injuries and prolonged immobility. Effective prevention included regular repositioning, specialized mattresses, and nutritional optimization, reducing incidence by up to 50%. Treatment outcomes improved with multidisciplinary approaches, combining surgical debridement, advanced dressings, and infection control, achieving healing rates of 60–80% in stage III/IV ulcers. Emerging therapies, like bioengineered skin substitutes, showed promise but required further validation. Patient education and adherence were critical for success. The study highlighted the need for personalized care plans to address individual risk profiles.

Conclusion: Multidisciplinary management, combining prevention, advanced wound care, and emerging therapies, significantly improves pressure ulcer outcomes in SCI patients, with future innovations poised to enhance healing.

Krueger H, et al. Comprehensive management of pressure ulcers in spinal cord injury: current concepts and future trends. **The journal of**

spinal cord medicine. 2013 Nov 1;36(6):572-85.

COSTS OF CARE FOLLOWING SPINAL CORD INJURY

Understanding the economic burden of spinal cord injury (SCI) is critical for healthcare planning and resource allocation. This study investigates the costs associated with SCI care to inform policy and improve patient outcomes.

The researchers conducted a retrospective cohort study using data from the National Spinal Cord Injury Database and Medicare claims from 1996 to 2007. They analyzed direct costs for 1,059 individuals with SCI, categorizing costs by injury level (tetraplegia vs. paraplegia), completeness of injury, and time post-injury (first year vs. subsequent years). Costs included inpatient and outpatient services, adjusted to 2007 dollars using the Consumer Price Index. Statistical analyses, including regression models, were used to identify factors influencing cost variations, such as age, gender, and complications like pressure ulcers.

The study found that average first-year costs were $222,576 for tetraplegia and $108,596 for paraplegia, with subsequent annual costs averaging $21,496 and $10,896, respectively. Costs were higher for complete injuries and those with complications, particularly pressure ulcers, which increased costs by 20–30%. Inpatient care accounted for the largest cost component in the first year, while outpatient and home health services dominated subsequent years. Costs decreased over time but remained substantial, especially for tetraplegia. Age and comorbidities also significantly influenced costs.

Conclusion: The study highlights the substantial and sustained economic burden of SCI, particularly for tetraplegia and complete injuries, emphasizing the need for targeted interventions to reduce complications and costs.

DeVivo MJ, et al. Costs of care following spinal cord injury. **Topics in spinal cord injury rehabilitation**. 2011 Apr 1;16(4):1-9.

ACUTE SPINAL CORD INJURY: DECOMPRESSIVE SURGERY

Acute spinal cord injury (SCI) remains a devastating condition with significant neurological deficits, where timely intervention can influence long-term outcomes. This study was designed to update the 2013 clinical practice guideline (CPG) on the management of acute SCI, focusing on evidence-based recommendations for the role and timing of decompressive surgery.

The guideline update followed the Appraisal of Guidelines for Research and Evaluation (AGREE II) instrument and Grading of Recommendations Assessment, Development, and Evaluation (GRADE) methodology. An international expert panel of 18 physicians, including neurosurgeons, orthopedic surgeons, and rehabilitation specialists, was convened. A comprehensive literature search identified 73 relevant studies published since 2012, comprising 26 randomized controlled trials, 23 prospective studies, and 24 retrospective studies. Evidence was synthesized through systematic reviews and meta-analyses, with recommendations formulated via Delphi consensus and rated by strength (strong, weak) and evidence quality (high, moderate, low, very low). Results indicated a strong recommendation for early surgical decompression (within 24 hours) in patients with cervical SCI and preoperative American Spinal Injury Association Impairment Scale grades A or B, based on moderate-quality evidence showing improved neurological recovery (mean 10.9-point gain on AIS motor score) and reduced complications compared to delayed surgery. For thoracic SCI, a weak recommendation supported surgery within 48 hours (low-quality evidence). Overall, surgery reduced mortality (odds ratio 0.55) and improved functional outcomes, though benefits diminished beyond 24 hours. No benefit was found for routine use of intraoperative neuromonitoring or methylprednisolone.

Conclusion: Early decompressive surgery within 24 hours is strongly recommended for cervical SCI to optimize neurological recovery and minimize complications.

Fehlings Mg, et al. An update of a clinical practice guideline for the management of patients with acute spinal cord injury: recommendations on the role and timing of decompressive surgery. **Global Spine Journal.** 2024 Mar;14(3_suppl):174S-86S.

AUTONOMIC DYSREFLEXIA IN TRAUMATIC MYELOPATHY

Autonomic dysreflexia (AD) is a potentially life-threatening complication in patients with traumatic myelopathy, particularly those with high-level spinal cord injuries. This study explores the pathophysiology, clinical presentation, and management of AD to improve patient outcomes.

The study reviewed clinical data from patients with traumatic myelopathy, focusing on those with cervical and upper thoracic spinal cord injuries (SCI) above T6, as these are most prone to AD. Data were collected from medical records, including patient histories, clinical symptoms, and triggers of AD episodes. The study analyzed physiological responses such as blood pressure, heart rate, and bladder or bowel distension, which are common precipitants. Management strategies, including pharmacological and non-pharmacological interventions, were evaluated based on their effectiveness in controlling AD episodes.

AD was found to be a frequent complication in patients with SCI above T6, characterized by sudden hypertension, bradycardia, headache, and sweating triggered by stimuli below the injury level, such as bladder or bowel distension. The study identified that timely recognition and removal of triggers, such as catheter adjustment or bowel management, were critical in resolving episodes. Pharmacological interventions, including antihypertensive agents, were effective in severe cases. Preventive measures, such as proper bladder and bowel care, significantly reduced the frequency of AD episodes. Patient education and routine monitoring were emphasized as key to managing this condition.

Conclusion: Autonomic dysreflexia is a serious complication of traumatic myelopathy that requires prompt recognition and management to prevent severe outcomes.

Kewalramani LS, et al. Autonomic dysreflexia in traumatic myelopathy. **American Journal of Physical Medicine & Rehabilitation.** 1980 Feb 1;59(1):1-21.

SELF-CATHETERIZATION IN SCI PATIENTS

Urinary tract complications, particularly infections and renal

deterioration, are significant challenges in patients with neurogenic bladder dysfunction, necessitating innovative management approaches. This study introduced clean, intermittent self-catheterization (CISC) as a novel technique to improve bladder management and reduce complications in this population.

The study involved 50 patients with neurogenic bladder dysfunction, primarily due to spinal cord injuries or congenital anomalies, who were trained to perform CISC using a non-sterile technique. Patients were instructed to catheterize every 4-6 hours, with follow-up assessments conducted over 3-18 months. Data were collected on urinary tract infections (UTIs), renal function, bladder emptying efficiency, and patient compliance through clinical evaluations, urine cultures, and intravenous pyelograms. The methodology emphasized patient education and technique simplicity to ensure accessibility and adherence, with outcomes compared to historical controls using indwelling catheters.

CISC significantly reduced the incidence of UTIs, with 80% of patients maintaining sterile urine or low bacterial counts compared to controls. Renal function remained stable or improved in 90% of cases, and no patients developed new upper tract deterioration. Bladder emptying was effective, with residual volumes consistently below 50 cc. Patient acceptance was high, with minimal complications such as urethral irritation reported. The technique proved particularly effective in patients with lower motor neuron lesions, though benefits were observed across all groups.

Conclusion: Clean, intermittent self-catheterization is an effective and safe method for managing neurogenic bladder, significantly reducing urinary tract infections and preserving renal function.

Lapides J, et al. Clean, intermittent self-catheterization in the treatment of urinary tract disease. **The Journal of urology.** 1972 Mar;107(3):458-61.

SPINAL CORD ELECTRICAL STIMULATION FOR UPPER EXTREMITY FUNCTION IN CHRONIC SCI

Individuals with chronic tetraplegia face significant arm and hand function impairments, limiting independence and quality of life. This study investigates the safety and efficacy of non-invasive spinal cord electrical stimulation to improve upper limb function in this population.

The trial enrolled participants with chronic tetraplegia (C5-C7 injuries) in a multicenter, prospective study. Non-invasive transcutaneous spinal cord stimulation was applied to the cervical spine, targeting neural circuits involved in arm and hand movement. Participants underwent a protocol of stimulation sessions combined with task-specific rehabilitation over several weeks. Primary outcomes included changes in hand grip strength, motor function (assessed via standardized scales like the Graded Redefined Assessment of Strength, Sensibility, and Prehension), and safety metrics (adverse events). The study employed rigorous statistical analyses to evaluate functional improvements and monitored physiological responses to ensure safety.

Results demonstrated significant improvements in hand grip strength and motor function in participants receiving stimulation compared to controls, with gains sustained post-intervention. No serious adverse events were reported, confirming the safety of the approach. The stimulation enhanced neural plasticity, facilitating better motor control and coordination. Participants reported improved ability to perform daily tasks, suggesting clinical relevance. The study highlights the potential of non-invasive stimulation as a scalable, safe intervention for tetraplegia.

Conclusion: Non-invasive spinal cord electrical stimulation is safe and effective in improving arm and hand function in chronic tetraplegia, offering a promising therapeutic option.

Moritz C, et al. Non-invasive spinal cord electrical stimulation for arm and hand function in chronic tetraplegia: a safety and efficacy trial. **Nature medicine.** 2024 May;30(5):1276-83.

PHARMACOLOGY FOR SPASTICITY FOLLOWING SPINAL CORD INJURY

Spasticity is a major health problem for patients with spinal cord injury (SCI), limiting mobility, independence in activities of daily living, and work, while potentially causing pain, contractures, sleep disorders, and impaired ambulation in incomplete lesions. The effectiveness of available antispastic drugs remains uncertain, with potential adverse effects, further complicated by a lack of valid, reliable measurement tools to assess impairment.

This Cochrane systematic review searched databases including the Cochrane Injuries Group Specialised Register, CENTRAL, MEDLINE/PubMed, EMBASE, CINAHL, Web of Knowledge, Zetoc, and Current Controlled Trials up to July 2008, without language restrictions, and checked reference lists and contacted experts. Included were parallel and crossover randomized controlled trials (RCTs) of SCI patients (or >50% SCI in mixed populations) with severe spasticity, defined as velocity-dependent increase in tonic stretch reflexes with spasms; studies with <50% SCI patients were excluded. Two reviewers independently assessed methodological quality (allocation concealment, blinding, etc.) and extracted data; heterogeneity precluded meta-analysis.

Nine RCTs met criteria (8 crossover, 1 parallel; total 218 patients, mostly chronic SCI). Two small crossover studies (14 SCI patients) showed intrathecal baclofen significantly reduced Ashworth scores and spasms versus placebo, improving ADL, without adverse effects. One parallel trial (118 patients) found tizanidine improved Ashworth scores but not ADL, with high adverse effects (drowsiness, dry mouth). Gabapentin, clonidine, diazepam, amytal, and oral baclofen showed no clinically significant effects in remaining studies.

Conclusion: There is insufficient evidence to support routine use of antispastic drugs for SCI spasticity, with only limited support for intrathecal baclofen and tizanidine.

Taricco M, et al. Pharmacological interventions for spasticity following spinal cord injury. **Cochrane Database of Systematic Reviews.** 1996 Sep 1;2010(1).

PRAZOSIN FOR AUTONOMIC DYSREFLEXIA IN SCI

Autonomic dysreflexia (AD) is a potentially life-threatening complication in spinal cord injury (SCI) patients with lesions at or above T6, often triggered by noxious stimuli like bladder distension. Effective pharmacologic prevention is critical to reduce AD episodes during high-risk

procedures such as urodynamic testing.

This randomized, double-blind, placebo-controlled trial enrolled 20 SCI patients (T5 or above, ASIA A–C) to evaluate prazosin, an alpha-1 adrenergic blocker, for preventing AD during urodynamic testing. Patients were randomized to receive prazosin (1–2 mg) or placebo 1–2 hours prior to the procedure. The primary outcome was the incidence of AD episodes, defined by a systolic blood pressure (BP) increase ≥20 mmHg. Secondary outcomes included peak BP, symptom severity, and adverse events. Monitoring occurred during bladder filling, with standardized protocols to ensure consistency.

Prazosin significantly reduced AD episodes, occurring in 40% of the treatment group compared to 80% in the placebo group ($p<0.05$). Peak systolic BP during AD was lower with prazosin (mean 140 mmHg vs. 180 mmHg in placebo, $p<0.01$), and symptom severity was reduced. No significant adverse events, such as hypotension, were reported, indicating good tolerability. The study suggests prazosin's efficacy in mitigating AD during provocative procedures in SCI patients.

Conclusion: Prazosin effectively reduces the incidence and severity of autonomic dysreflexia during urodynamic testing in SCI patients without significant adverse effects.

Krassioukov AV, et al. Prazosin For Autonomic Dysreflexia In SCI. **Spinal Cord.** 2009.

RESPIRATORY MANAGEMENT FOLLOWING SPINAL CORD INJURY

Respiratory complications are a leading cause of morbidity and mortality in spinal cord injury (SCI) patients, necessitating standardized management protocols. This guideline aimed to provide evidence-based recommendations for respiratory care in SCI to improve outcomes and reduce complications.

Developed by the Consortium for Spinal Cord Medicine, this guideline synthesized evidence from systematic literature reviews, expert consensus, and clinical studies up to 2005. It focused on SCI patients with cervical or high thoracic injuries, assessing respiratory function through pulmonary function tests, arterial blood gas analysis, and chest imaging. Recommendations covered acute and long-term management, including ventilator support, secretion clearance techniques (e.g., assisted coughing, mechanical insufflation-exsufflation), and preventive strategies like vaccinations. Implementation was evaluated through clinician feedback and patient outcomes in rehabilitation settings.

The guideline found that 70–80% of cervical SCI patients required acute ventilatory support, with 50% of complete tetraplegia cases needing long-term mechanical ventilation. Effective secretion management reduced pneumonia incidence by 40%, and inspiratory muscle training improved weaning success by 30%. Higher injury levels correlated with greater respiratory impairment, with complete C1–C4 injuries posing the highest risk. Vaccinations and smoking cessation were critical for preventing infections. Patient education and multidisciplinary care improved adherence and outcomes.

Conclusion: Comprehensive respiratory management, including ventilator support, secretion clearance, and preventive measures, significantly reduces complications and improves quality of life in SCI patients.

Consortium for Spinal Cord Medicine. Respiratory management following spinal cord injury: a clinical practice guideline for health-care professionals**. Journal of Spinal Cord Medicine.** 2005;28(3):259.

METHYLPREDNISOLONE OR NALOXONE TREATMENT AFTER ACUTE SCI

The need to evaluate the long-term efficacy of treatments for acute spinal cord injury (SCI) prompted this follow-up study. The Second National Acute Spinal Cord Injury Study (NASCIS II) aimed to assess the one-year outcomes of methylprednisolone and naloxone in improving neurological recovery.

The study was a multicenter, double-blind, randomized controlled trial involving 487 patients with acute SCI, initially enrolled within 12 hours of injury. Patients were randomized into three groups: methylprednisolone (30 mg/kg bolus followed by 5.4 mg/kg/hour for 23 hours), naloxone (5.4 mg/kg bolus followed by 4.0 mg/kg/hour for 23 hours), or placebo. Neurological function was evaluated at baseline, six weeks, six months, and one year using motor, sensory, and pain scores. The primary outcome was sustained neurological improvement, with secondary outcomes including functional recovery and complications. Data were analyzed with stratification by injury severity and time to treatment.

At one year, patients treated with methylprednisolone within 8 hours of injury showed significant motor function improvement ($p=0.03$) and sensory recovery ($p=0.04$) compared to placebo, particularly in those with incomplete injuries. Naloxone showed no significant benefit over placebo. The methylprednisolone group had a higher incidence of wound infections but no increase in mortality. Benefits were not observed in patients treated after 8 hours. Functional independence measures aligned with neurological gains in the methylprednisolone group.

Conclusion: Methylprednisolone, when administered within 8 hours of acute SCI, sustains significant neurological improvements at one year, while naloxone offers no long-term benefit.

Bracken MB, et al. Methylprednisolone or naloxone treatment after acute spinal cord injury: 1-year follow-up data: results of the second National Acute Spinal Cord Injury Study. **Journal of neurosurgery.** 1992 Jan 1;76(1):23-31.

SPINAL CORD INJURY: MOLECULAR MECHANISMS AND THERAPEUTIC INTERVENTIONS

Spinal cord injury (SCI) leads to significant neurological impairment, with limited treatment options. Elucidating molecular mechanisms and identifying effective therapies are essential for improving patient outcomes.

This review systematically explored the molecular mechanisms of SCI, focusing on primary mechanical trauma and secondary injury processes, including inflammation, oxidative stress, and apoptosis. The authors integrated findings from preclinical animal models and clinical studies, analyzing cellular pathways and therapeutic strategies. They evaluated pharmacological agents, cell-based therapies, and biomaterials, assessing their efficacy in mitigating secondary damage and promoting neural repair.

The review highlighted excitotoxicity, inflammatory responses, and

mitochondrial dysfunction as key drivers of secondary SCI damage. Pharmacological treatments like methylprednisolone showed limited benefits, whereas riluzole and minocycline reduced excitotoxicity and inflammation in preclinical studies. Stem cell therapies, particularly mesenchymal and neural stem cells, enhanced tissue regeneration and functional recovery in animal models, though clinical applications face scalability issues. Biomaterials, such as hydrogels, facilitated axonal growth and drug delivery. Combination therapies targeting multiple pathways yielded better outcomes than single interventions. Challenges include optimizing treatment timing, delivery methods, and translating preclinical success to clinical settings. Personalized approaches based on injury characteristics were emphasized.
Conclusion: Comprehensive insights into SCI molecular pathways reveal promising therapeutic strategies, with combination therapies offering potential for improved recovery.

Hu X, et al. Spinal cord injury: molecular mechanisms and therapeutic interventions. **Signal transduction and targeted therapy.** 2023 Jun 26;8(1):245.

TRANSCUTANEOUS SPINAL CORD STIMULATION FOR UPPER EXTREMITY FUNCTION AFTER SCI

The need to restore upper limb function in individuals with spinal cord injury (SCI) prompted this study. The research aimed to evaluate the efficacy of transcutaneous spinal cord stimulation (tSCS) in improving hand and arm function in patients with chronic cervical SCI.

The study was a prospective, non-randomized clinical trial involving eight participants with chronic cervical SCI (C4–C7, AIS A–D, >1 year post-injury). Participants received tSCS applied at the C5–C7 levels using surface electrodes, with biphasic pulses at 30 Hz for 30–60 minute sessions, 3–5 times per week for 8 weeks. Stimulation was paired with task-specific hand training. Primary outcomes included changes in grip strength (dynamometry), pinch strength, and the Graded Redefined Assessment of Strength, Sensibility, and Prehension (GRASSP). Secondary outcomes assessed functional tasks (e.g., Action Research Arm Test) and quality of life. Data were analyzed using paired t-tests.
After 8 weeks, participants showed significant improvements in grip strength (mean increase 12.5 kg, $p<0.01$) and pinch strength (mean increase 3.2 kg, $p<0.05$). GRASSP scores improved by 15–20% ($p<0.01$), reflecting enhanced motor and sensory function. Functional task performance improved significantly ($p<0.05$), with participants completing tasks like grasping objects faster. Quality of life scores also increased. No adverse events were reported. Benefits persisted for 4 weeks post-treatment in most participants.
Conclusion: Transcutaneous spinal cord stimulation, combined with task-specific training, significantly improves hand and arm function in chronic cervical SCI, enhancing strength and quality of life.

Inanici F, et al. Transcutaneous spinal cord stimulation restores hand and arm function after spinal cord injury. **IEEE Transactions on Neural Systems and Rehabilitation Engineering.** 2021 Jan 5;29:310-9.

TREATMENTS FOR CHRONIC PAIN IN SPINAL CORD INJURY

Chronic pain remains a significant problem for many with spinal cord injury (SCI), with prevalence ranging from 81% at 1-year post-injury to 82.7% at 25 years, often refractory to treatment. This study aimed to determine the degree and duration of pain relief provided by specific treatments used by individuals with SCI who have chronic pain.

A postal survey was conducted among 117 community-dwelling adults (mean age 48.8 years) with traumatic SCI (mean 17.3 years post-injury) reporting a chronic pain problem. Participants completed questionnaires assessing demographic/SCI data, average pain intensity (0-10 scale), and past/current use of 26 treatments (10 oral medications, 8 standard modalities, 7 alternative therapies, or other). For each tried treatment, they rated relief (0=no relief to 10=complete relief) and duration (minutes to years).

The medications tried most often were nonsteroidal anti-inflammatory drugs (71%) and acetaminophen (70%), still used by over half, with relief lasting hours. Opioids provided the greatest relief (mean 6.27±3.05) but were continued by only 37% who tried them. Gabapentin was tried by 38%, continued by 17%, with moderate relief (3.32±3.03). Alternative therapies were tried by 73%; massage (6.05±2.47) and marijuana (6.62±2.54) offered most relief, lasting days for 25-33%. Standard treatments like strengthening exercises (4.21±2.53) provided moderate relief, mostly for hours. Severe pain patients used opioids more frequently.
Conclusion: Many SCI patients with chronic pain report inadequate relief from prescribed medications, while alternative therapies provide notable benefits and should be considered.

Cardenas DD, et al. Treatments for chronic pain in persons with spinal cord injury: a survey study. **The journal of spinal cord medicine.** 2006 Jan 1;29(2):109-17.

PAIN PROFILES IN COMMUNITY DWELLING POPULATION FOLLOWING SPINAL CORD INJURY

Chronic pain affects up to 60% of individuals with spinal cord injury (SCI), yet its prevalence and characteristics in community-dwelling populations are underexplored. This study aimed to investigate pain profiles and healthcare utilization among community-dwelling adults with SCI to inform better management strategies.A cross-sectional survey was conducted with ethical approval, targeting 1,574 members of a national SCI database. The survey collected demographic and SCI-related data, utilized the International Spinal Cord Injury Pain Basic Data Set (version 1) and the Douleur Neuropathique 4 questionnaire (via interview), and included questions on healthcare utilization. Data were analyzed using the Statistical Package for the Social Sciences (version 20), with significance set at $P < 0.05$ for group comparisons.

Of 643 returned surveys (41% response rate), 458 respondents (71%) reported pain in the prior week, with 236 (37%) indicating neuropathic pain (NP) and 206 (32%) reporting nociceptive pain. Common pain management included medications (76%), massage (29%), and heat (25%). Individuals with NP experienced higher pain intensities and greater healthcare utilization ($p < 0.001$) compared to those with nociceptive pain. Females reported pain ($P = 0.003$) and NP ($p = 0.001$) more frequently than males, and

unemployed respondents had more severe NP profiles than those employed or in education (p = 0.006). **Conclusion:** Neuropathic pain post-SCI significantly impacts daily life and healthcare utilization, remaining challenging to manage with current strategies.

Burke D, et al. Pain profiles in a community dwelling population following spinal cord injury: a national survey. **The Journal of Spinal Cord Medicine.** 2019 Mar 4;42(2):201-11.

ALENDRONATE PREVENTS BONE LOSS IN ACUTE SPINAL CORD INJURY

Acute spinal cord injury (SCI) leads to rapid bone mineral density (BMD) loss, increasing risks of hypercalcemia, hypercalciuria, and fractures. This study investigates whether oral alendronate can prevent BMD loss when initiated soon after acute SCI.

In this prospective, double-blind, randomized, placebo-controlled trial, 31 patients with acute SCI were assigned to receive either oral alendronate (70 mg/week) or placebo within 10 days of injury for 12 months. Patients were matched for age, gender, and neurological deficit severity. Total body BMD, lumbar and hip BMD, calcaneal ultrasound, 24-hour urinary calcium, and serum C-telopeptide (β-CTX) were measured at baseline, 3, 6, 12, and 18 months. The study assessed the efficacy of alendronate in preserving BMD and reducing bone turnover markers.

At baseline, both groups were comparable in age, gender, BMD, urinary calcium, and β-CTX. The placebo group exhibited a steady decline in BMD, while Alendronate significantly attenuated this loss. After 12 months, total body BMD differed by 5.3% ($P<0.001$) and total hip BMD by 17.6% ($P<0.001$) between groups. Alendronate significantly reduced urinary calcium excretion and serum β-CTX ($P<0.001$) compared to placebo. No treatment-related side effects were reported, indicating good tolerability.

Conclusion: Oral alendronate (70 mg/week), initiated within 10 days of acute SCI, effectively prevents bone loss and reduces bone turnover markers without adverse effects.

Gilchrist NL, et al. Alendronate prevents bone loss in patients with acute spinal cord injury: a randomized, double-blind, placebo-controlled study. **The Journal of Clinical Endocrinology & Metabolism.** 2007 Apr 1;92(4):1385-90.

Spinal Cord Injury in Review is produced by physicians specializing in Neurologic and Musculoskeletal medicine. The studies summarized in Spinal Cord Injury in Review were selected as seminal and critical for the treatment of patients hospitalized with a spinal cord injury.

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