SPINAL CORD INJURY GUIDELINE

Guidelines for the Preservation of Upper Limb Function Following Spinal Cord Injury[1]

Drafted: February 15, 2017
Peer Reviewed:
Finalized:

I. Definition, Assessment, Diagnosis

A. Definition

1. Paralysis of the lower limbs in patients with a spinal cord injury (SCI) and paraplegia or tetraplegia shifts dependence for mobility to the upper limbs, and increases the risk of injury to the upper limb.

a. The upper limbs are designed primarily to facilitate hand placement, not for performing weight-bearing exercises needed for mobility.

b. The stress on the upper limb is magnified by the individual's repetitive use of the arms throughout life.

c. The repetitive use of the upper limbs can cause pain and injury, which can negatively impact the individual's mobility and activities of daily living (ADLs) throughout life.

2. The two most common upper limb complications in patients with SCI are carpal tunnel syndrome (CTS) and shoulder pain/injury (see table 1 in reference 1).

a. Prevalence of CTS in cross-sectional studies was 40 to 66% along with an increase in prevalence with an increase in the duration of the SCI[2 3 4].

b. Studies show median nerve damage without clinical symptoms of hand and wrist pain in 15-48% of subjects.

c. Shoulder problems are present in both paraplegia and tetraplegia and occur in 30-60% of subjects.

3. Other complications include ulnar nerve entrapment at both the wrist and elbow, tendinitis, osteoarthritis, osteophytes, lateral epicondylitis, olecranon bursitis, rotator cuff tear, shoulder impingement or adhesive capsulitis of the glenohumeral joint, recurrent shoulder dislocations, bicipital tendinitis, and myofascial pain syndrome involving the cervical and thoracic paraspinals.

4. Patients who suffer from SCI at an older age may experience functional changes more quickly than those injured at a younger age.

5. The factors that increase SCI patients' risk for upper limb injury include:

a. Changes in medical status, including pregnancy

b. New medical problems, such as heart disease

c. Significant weight gain

B. Assessment

1. Patient's function, ergonomics, equipment, and level of pain should be assessed routinely. This assessment should include evaluation of:

a. Subject with an updated history and physical exam

b. Equipment (wheelchair and transfer device)

c. Wheelchair transfer and propulsion techniques

2. Assess the patient's environment, obtain the appropriate equipment, and modify the home according to Americans with Disabilities Act (ADA) standards.

3. The following should be assessed in patients with chronic musculoskeletal pain:

a. Etiology of the pain

b. Pain intensity

c. Functional capacity or limitations

d. Psychosocial distress caused by the condition

1) Assess for changes in sleep, as lack of sleep can contribute to psychosocial distress.

2) Assess for abuse of alcohol, illicit substances, and/or prescription medications.

4. Assess psychosocial adjustment to an upper limb injury and administer treatment if necessary. Special emphasis should be given to the detection of mood and adjustment disorders.

C. Diagnosis

1. CTS and nerve entrapment can be diagnosed by signs and symptoms and/or Electromyography/nerve conduction study (EMG/NCS).

2. Shoulder pain assessment requires a thorough history and physical exam, followed by an assessment with ultrasound, EMG/NCS's and/or radiologic tests.

II. Management and Treatment Recommendations

A. Management/Treatment

1. Minimize the frequency of repetitive upper limb tasks. This can be achieved by:

a. Decreasing the frequency of propulsive stroke during wheelchair propulsion

b. Decreasing the number of transfers per day

c. Switching to a power wheelchair or power assist, if appropriate. This does not mean patients should decrease all activity, as staying active is an important component of pain management. It allows someone to be in control and more deliberate about their activity and exercise program.

2. Minimize the force required for upper limb tasks. This can be accomplished by:

a. Maintaining an ideal body weight

b. Improving wheelchair propulsion techniques and seating position in a manual wheelchair

c. Ensuring optimal biomechanics during weight bearing

d. Switching to a power wheelchair when appropriate

e. Minimizing exposure to high loads with light weight (K0004 30-35 lbs.) ultra-light weight (K0005 < 30 lbs.) manual wheelchair

1) Higher force applied to the push rim on a wheelchair increases the risk for median nerve injury.

2) Increased motion at the wrist during wheelchair propulsion is associated with healthier median and ulnar nerves as long as the increased range of motion is associated with decreased forces during propulsion.[5]

3. Minimize positions that increase the patient's risk for injury.

a. Avoid potentially injurious positions of the wrist, especially maximum extension when weight bearing during transfers.

b. Avoid positioning the hand above the shoulder. This leads to higher forces in the shoulder, impingement of rotator cuff tendons, and increases the risk of pain and injury to the shoulder.

c. Avoid positions that increase the risk for shoulder injury, especially extreme internal rotation with abduction and/or forward flexion.

4. Wheelchair selection, adjustments and training:

a. Consider a power wheelchair or Power assist options to prevent repetitive injuries in high-risk patients.

1) High-risk patients include those complaining of upper limb pain, those who have already sustained an upper limb injury, are obese, are elderly, or live in a challenging environment.

2) Power wheelchair use increases the risk for weight gain and upper limb deconditioning.

b. For SCI patients who will use a manual wheelchair, provide a high-strength, fully customizable wheelchair made of the lightest material available. Lighter weight wheelchairs are recommended because they:

1) require less force to propel.[6]

2) are more customizable to the person to improve propulsion mechanics.

3) are made of better components which last longer and dampen vibration which can damage the spine and shoulder

4) cost less to operate because they last longer and have fewer catastrophic failures.[7]

c. Move the rear axle as far forward as possible without compromising user stability.

1) An axle that is farther forward decreases rolling resistance and thus increases propulsion efficiency. This results in less muscle effort, smoother joint excursions, and lower stroke frequencies.

2) The axle should be moved farther forward in increments to prevent compromising user stability.

d. Adjust the rear axle so that when the hand is placed at the top center of the pushrim, the angle between the upper arm and forearm is between 100 and 120 degrees.

e. Adjust seating and trunk support to provide a stable base for the upper extremities. Instability or falls when reaching for objects increase risk of injury and energy expenditure.

1). Stabilize the pelvis first, then the lower extremity and finally the trunk.

2) Stabilize the pelvis with a cushion that provides postural support and good pressure distribution.[8] [9]

3) If spine and/or pelvic deformities are flexible and not fixed promote a neutral, midline pelvis and normal cervical and lumbar lordosis.

4) Accommodate fixed deformities of pelvis, legs, and trunk with the goal of good balance to allow performance of ADLs.

5) Provide trunk support as high as needed to allow for functional activities at the wheelchair level.

6) Make special accommodations for individuals with tetraplegia with head forward and kyphotic position through shape and angle of back support to allow for improved reaching and stability.[10]

7) If C4 and higher SCI, provide full forearm and hand support to decrease subluxation of shoulder.

5. Appropriately position the arm in bed and in a mobility device for patients with upper limb paralysis and/or pain in order to avoid decreased range of motion and associated upper limb pain/injury using the following principles:

a. Avoid direct pressure on the shoulder.

b. Provide support to the upper limb at all points.

c. Position the upper limb in abduction and external rotation when the patient is regularly supine.

d. Avoid pulling on the arm when positioning patients by hold the patient at the lower portion of the scapula.

e. The primary goal of positioning is to prevent pain.

6. For SCI patients who use power wheelchairs and have upper limb function, provide seat elevation or a standing position. This helps prevent injury from reaching overhead[11] and the seat elevation helps increase the likelihood of a level transfers[12].

7. All patients with SCI should consider using a transfer-assist device (i.e. sliding board, patient lift, power seat elevator), especially if they have arm pain and/or upper limb weakness, are pregnant, or are obese.

8. Management of musculoskeletal upper limb injuries in SCI patients is nearly identical to management of the unimpaired population.

9. Treat acute pain as early as possible to prevent the development of chronic pain.

10. A medical and rehabilitative approach to initial treatment should be considered for non-traumatic upper limb injury in patients with SCI before surgery is considered.

11. Because it is difficult for SCI patients to achieve relative rest of an injured or postsurgical upper limb, consider the following:

a. Use of resting night splints in a neutral position in carpal tunnel syndrome

b. Modifications to the home or additional assistance

c. If pain cannot be relieved or if complete rest is indicated, admission to a medical facility may be warranted.

12. Emphasis should be placed on maintaining optimal range of motion during rehabilitation from upper limb injury.

13. When upper limb injury or pain is present, alternative techniques for activities should be considered.

14. If pain relief does not occur with treatment, further work-ups and treatments are appropriate.

15. If the patient has chronic neuro-musculoskeletal pain, has failed to regain functional capacity with medical and rehabilitative treatment, and if the likelihood of a successful surgical and functional outcome outweighs the likelihood of an unsuccessful procedure, surgery should be considered.

a. Consider surgery if the condition shows no improvement after three months of non-operative management.

b. Tendon transfer surgery involves surgical transfer of the distal tendon from an innervated muscle into the tendon of a paralyzed muscle to restore movement.

1) Common procedures and muscles used:[13]

a) to achieve active elbow extension - either a biceps brachii to triceps brachii or a deltoid to triceps brachii;

b) to achieve wrist extension or finger flexion - the brachioradialis can be used for a transfer into either wrist or finger extensors or thumb or finger flexor.

2) Other muscles available for transfer, depending on the level of SCI, include extensor carpi radialis longus, pronator teres, flexor carpi radialis, and palmaris longus.

c. Nerve transfer surgery uses expendable donors (e.g., teres minor, deltoid, supinator, and brachialis) innervated above the level of the spinal cord injury to restore volitional control of missing function such as elbow extension, wrist extension, and/or hand function (posterior interosseous nerve or anterior interosseous nerve/finger flexors reinnervated). Early results of these procedures are encouraging.[14]

1) Distal nerve transfer might have a better result than a proximal transfer because of the reduced time needed for the growing axons to reach the muscle, ensuring prompt reinnervation before permanent muscle damage occurs from chronic denervation.

2) This technique for SCI is still in its infancy but it offers several advantages over the traditionally used tendon transfers:[15]

a) nerve transfers do not require prolonged immobilization;

b) they provide greater functional gain for a given transfer;

c) reconstruction of several facets of upper limb function can potentially be performed in a single stage.

16. Operate on upper limb fractures to stabilize the fracture if indicated to allow for early mobilization of the patient and to facilitate rehabilitation.

17. Treat chronic pain in an interdisciplinary fashion, incorporating multiple modalities based on symptoms.

a. Pharmacotherapy

1) Non-opioid analgesics (acetaminophen and NSAID's) are effective for mild to moderate musculoskeletal pain.

2) Opioid analgesics

a) These medications should only be tried when other pharmacological options have failed to reduce pain.

b) Assess for history of substance abuse.

c) Monitor closely for side effects.

d) Discontinue on a tapering dose.

3) Adjuvant medications (antidepressants, anticonvulsants, muscle relaxants and corticosteroid injections)

b. Physical interventions

1) Corticosteroids can facilitate physical activity for cases in which inflammation and/or moderate to severe pain impedes implementation of an exercise program.

2) Prolotherapy has been shown to improve pain, disability, isometric strength, and shoulder AROM in patients with refractory chronic rotator cuff disease in patients without SCI in a one year follow up study[16].

3) Platelet rich plasma (PRP) has been shown to be a promising alternative treatment option in the nonoperative management of shoulder tendinopathy in individuals with spinal cord injury.[17]

c. Psychological interventions. The use of Cognitive-Behavioral Therapy can produce changes in the pain experience and help with pain management.

18. Manual wheelchair users with chronic upper limb pain should be encouraged to consider using a power wheelchair.

B. Restrictions

1. Beware of possible negative interactions if the patient uses complementary and/or alternative medicine techniques.

2. Use narcotic medication sparingly and only to address acute pain issues.

3. Avoid strengthening and stretching activity if painful or if range of motion is severely restricted.

4. Avoid maneuvers and activity which cause shoulder impingement.

III. Prevention and Education

A. Educate patients and healthcare providers about the risk of upper limb pain and injury post-SCI, available treatment options, the importance of maintaining fitness, and means of prevention.

B. Wheelchair push mechanics need to be taught. Educate wheelchair users to:

1. Use long, smooth strokes to limit the frequency and high impact force on the push rim as rapid and more frequent loading of the upper extremity are associated with impaired function of the median nerve.[18 19]

2. Allow the hand to drift down naturally, keeping it below the pushrim when not in actual contact with the pushrim of the wheelchair.

C. Advise SCI patients who perform independent transfers to:

1. Perform level transfers when possible. Transfer surfaces should be either at equal height or downhill, as uphill transfers increase forces in the upper limbs.[20]

2. Avoid positions that increase the likelihood of nerve impingement, especially avoid positions where the arm is internally rotated, abducted and flexed forward.[21]

3. Avoid placing hands on a flat surface during transfers when a handgrip is available.

a. This helps mitigate wrist pressure and the development of CTS. [22]

b. Allow the fingers to drape over the edge of the surface or use a closed fist maneuver.

c. To preserve tenodesis in individuals with C7 and above SCI if wrist extended, then keep fingers flexed.

4. Vary the transfer technique and the arm that leads.

a. The trailing arm performs more work and experiences greater force than the leading arm. [23 24]

b. Repetitive transfers in the same position can lead to upper limb injury by putting increased pressure on the vasculature of the rotator cuff, leading to tendon degeneration.

c. Flexing the trunk forward over the weight-bearing arms while protracting and depressing the scapula reduces the vertical distance between shoulders and buttocks and more weight is borne through the glenoid with reduced risk of impingement.[25]

5. When performing weight-shifting or pressure relief maneuvers, use a variety of methods: forward leaning, side-to-side shifting and depression style maneuvers.

D. Strongly encourage individuals with arm pain and/or upper limb weakness to use a transfer-assist device.

1. These devices are effective in reducing forces on the joints and tendons of the upper extremity with transfers in individuals with SCI who have shoulder pain, excessive body mass/fat, pregnancy, muscle weakness, and poor exercise capacity.

2. In individuals with higher level SCI a sliding board will reduce the force needed for lateral movement and is even better in friction reducing surfaces.[26]

3. Sliding board transfers allow the transfer motion to be broken into smaller movements which can reduce injurious forces.[27]

4. Use of mechanical or powered patient lifts should be considered to avoid injury to caregivers and if providing help avoid pulling on a weak or unstable upper limb when helping.

E. Educate patients on appropriate exercises to protect and maintain shoulder function.

1. Flexibility exercises to maintain normal glenohumeral motion and pectoral muscle mobility.

a. Stretching exercises at least 2-3 times a week with focus on external rotation of humerus and retraction and upward rotation of scapula.

b. Gentle prolonged stretch in direction of tightness and avoid impingement by providing distraction force along long axis of humerus and avoid internal rotation with overhead activity.

2. Resistance training to improve strength and endurance of all shoulder muscle groups to pain-free fatigue.

a. Goal of 8-10 exercises with onset of 8-12 repetitions 2-3 days a week

b. Start at low resistance and work up to target levels by achieving pain-free fatigue with each exercise.

c. Pay particular attention to shoulder depressors (infraspinatus, subscapularis, pectoralis major, and latissimus dorsi) and to shoulder stabilizers (trapezius and rhomboids)

d. Limit impingement by avoiding internal rotation of shoulder with exercises above the shoulder.

F. Educate patients that recovery from injury or surgery must be a gradual process and inform them of the estimated recovery time (defined as the time until weight bearing is unrestricted).

1. Recovery times are as follows:

a. Endoscopic carpal tunnel release, 3 weeks.

b. Open carpal tunnel release, 8 weeks.

c. Rotator cuff decompression or repair, 6 months.

d. Nerve graft, 2-4 weeks.

e. Tendon transfers, 8 weeks after surgery before any functional rehabilitation can commence.

This guideline was developed to improve health care access in Arkansas and to aid health care providers in making decisions about appropriate patient care. The needs of the individual patient, resources available, and limitations unique to the institution or type of practice may warrant variations.

Guideline Developers
Developed by Drake Hardy, M3 in collaboration with the TRIUMPH Team led by Medical Directors Thomas S. Kiser, M.D. and Rani Haley Lindberg, M.D.

Selected References

[1] Consortium for Spinal Cord Medicine. (2005). Preservation of upper limb function following spinal cord injury: A clinical practice guideline for health-care professionals. *Journal of Spinal Cord Medicine.*

[2] Sie IH, Waters RL, Adkins RH, Gellman H. Upper extremity pain in the postrehabilitation spinal cord injured patient. Archives of Physical Medicine & Rehabilitation 73 (1992):44-8.
[3] Aljure J, Eltori I, Bradley WE, Lin JE, Johnson B. Carpal tunnel syndrome in paraplegic patients. Paraplegia 23 (1985): 182-6.
[4] Gellman H, Chandler DR, Petrasek J, Sie I, Adkins R, Waters RL. Carpal tunnel syndrome in paraplegic patients. Journal of Bone & Joint Surgery (American Volume) 70 (1988): 517-9.
[5] Boninger ML, Impink BG, Cooper RA, Koontz A. Relationship between median and ulnar nerve function and wrist kinematics during wheelchair propulsion. Archives of Physical Medicine & Rehabilitation 85 (7) (2004):1141-5.
[6] Beckman CE, Miller-Porter L, Schoneberger M. Energy cost of propulsion in standard and ultralight wheelchairs in people with spinal cord injuries. Phys Ther 79 (1999): 146-58.

[7] Fitzgerald SG, Cooper RA Boninger ML, Rentschler AJ. Comparison of fatigue life for 3 types of manual wheelchairs. Arcives of Physical Medicine &Rehabilitation 82 (10) (2001): 1484-8.
[8] Curtis KA, Kindlin CM, Riech KM, White DE. Functional reach in wheelchair users: the effects of trunk and lower extremity stabilization. Archives of Physical Medicine & Rehabilitation 76(1995): 360-7.
[9] Klefbeck G, Mattsson E, WinberJ. The effect of trunk support on performance during arm ergometry in patients with cervical cord injuries. Paraplegia 34 (1996): 167-72.
[10] Lynch SM, Leahy P, Barker SP. Reliability of measurements obtained with a modified functional reach test in subjects with spinal cord injury. Physical Therapy 78 (1998): 128-33.
[11] Herberts P, Kadefors R, Hogfors C, Sigholm G. Shoulder pain and heavy manual labor. Clinical Orthopaedics & related research (1984): 166-78.
[12] Wang YT, Kim CK, Fod III HT, Ford Jr HT. Reaction force and EMG analysis of wheelchair transfers. Perceptual & motor Skills 79 (1994): 763-6.
[13] Dunn JA, Sinnott KA, Rothwell AG, Mohammed KD, Simcock JW. Tendon Transfer Surgery for People with Tetraplegia: An Overview. Archives of Physical Medicine and Rehabilitation 97 (2016) (6 Suppl 2):S75-80.
[14] Fox IK, Davidge KM, Novak CB, Hoben G, Kahn LC, Juknis N, Ruvinskaya K, Mackinnon SE. Nerve Transfers to Restore Upper Extremity Function in Cervical Spinal Cord Injury: Update and Preliminary Outcomes. Plast Reconstr Surg 136 (2015): 780-92.
[15] Senjaya R, Midha R. Nerve Transfer Strategies for Spinal Cord Injury. World Neurosurg. (2013) 80, 6:e319-e326. http://dx.doi.org/10.1016/j.wneu.2012.10.001
[16] Lee D, Kwack K, Rah UW, Yoon S. Prolotherapy for Refractory Rotator Cuff Disease: Retrospective Case-Control Study of 1-Year Follow-Up. Archives of Physical Medicine & Rehabilitation 96 (2015): 2027-32.
[17] Ibrahim VM, Groah SL, Libin A, Ljungberg IH. Use of Platelet Rich Plasma for the Treatment of Bicipital Tendinopathy in Spinal Cord Injury: A Pilot Study. Topics in Spinal Cord Injury Rehabilitation 18(1) (2012):77–78.
[18] Boninger ML, Cooper RA, Baldwin MA, Shimada SD, Koontz A. Wheelchair pushrim kinetics: body weight and median nerve function. Archives of Physical Medicine & Rehabilitation 80 (1999): 910-5.
[19] Fronczak KJ, Boninger ML, Souza AL, Cooper RA. Wheelchair propulsion biomechanics, weight, and median nerve damage: a longitudinal study. In Proceedings of the 26rh annual RESNA conference, Atlanta, GA (2003), CD-Rom.
[20] Harvey LA, Crosbie J. Weight bearing through flexed upper limbs in quadriplegics with paralyzed triceps brachii muscles. Spinal Cord 37 (1999): 780-5.
[21] Harvey LA, Crosbie J. Biomechanical analysis of a weight relief maneuvers in C5 and C6 quadriplegia. Archives of Physical Medicine & Rehabilitation 81 (2000): 500-5.
[22] Gellman H, Sie I, Waters RL. Late complications of weight-bearing upper extremity in the paraplegic patient. Clinical Orthopaedics & related research 233 (1988): 132-5.
[23] Perry J, Gonle JK, Newsam CJ, Reyes ML, Mulroy SJ. Electromyographic analysis of the shoulder muscles during depression transfers in subjects with low-level paraplegia. Archives of Physical Medicine & Rehabilitation 77 (1996): 350-5.
[24] Papuga MO, Member WE, Crago PE. Biomedics of sliding transfer: feasibility of FES assistance. (2002): 2382-3.
[25] Gagnon D, Nadeau S, Gravel D, Noreau L, Lariviere C , Gagnon D. Biomechanical analysis of a posterior transfer maneuver on a level surface in individuals with high- and low-level spinal cord injuries. Clinical Biomechanics 18 (2003): 319-31.
[26] Grevaldign P, Bohannon RW. Reduced push forces accompany device use during sliding transfers of seated subjects. Journal of Rehabilitation Research & Development 38 (2001): 135-9.
[27] Butler EE, Sabelman EE, Kiratli BJ. Accelerometric analysis of wheelchair/car transfer strategies for individuals with spinal cord injuries. In Proceedings for the Second national Department of VA Rehabilitation R&D Conference (2000).