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The American Academy of Physical Medicine and Rehabilitation is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to provide continuing medical education for physicians. The 2007 Study Guide and Self-Assessment Examination for Practitioners was planned and produced in accordance with the ACCME Essentials for developing continuing medical education.

Peer Review Statement

The educational material in this Medical Education issue has been peer reviewed by special expert panels of the AAPM&R through its Medical Education Committee with editorial supervision by guest editors. It has not been peer reviewed by the Editorial Board of the Archives of Physical Medicine and Rehabilitation. Correspondence commenting on the material in this issue should be directed to the Chair of the Academy’s Study Guide Subcommittee.
Self-Directed Physiatric Education Program in Physical Medicine and Rehabilitation

Sponsored by the American Academy of Physical Medicine and Rehabilitation as a supplemental issue of the Archives of Physical Medicine and Rehabilitation.

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The Sixth Edition: Self-Directed Physiatric Education Program (SDPEP) 2007

THE SELF-DIRECTED PHYSIATRIC Education Program Study Guide and Self-Assessment Examination for Practitioners (SAE-P) contained in this supplemental issue of the Archives are part of the Self-Directed Physiatric Education Program of the American Academy of Physical Medicine and Rehabilitation (AAPM&R). On matters of physiatric practice, the opinions expressed are those of the individual authors.

THE SIXTH EDITION

This Medical Education Issue comprises the fifth and sixth installments of the Sixth Edition Study Guide. The Sixth Edition Study Guide continues the process of the previous editions of presenting information on advances in the rehabilitation sciences with particular focus on updated clinical considerations. Based on feedback from practicing physiatrists using the Study Guide, the faculty committees have expanded the useful text by formulating learning objectives that exemplify many of the dilemmas faced in clinical physiatric practice. The authors have emphasized issues such as aging with disability and functional outcome measures in recognition of the current realities facing physiatric practitioners. Moreover, it is realized the Study Guides may be used as a mechanism to fulfill the Lifelong-Learning and Self-Assessment component for the Maintenance of Certification program of the American Board of Physical Medicine and Rehabilitation. If used to fulfill this component, several competencies should be able to be met including medical knowledge, patient care, interpersonal and communication skills, practice-based learning and improvement, and systems-based practice.

Learners will find information on electrodiagnosis, therapeutic modalities, orthotics and prosthetics, and age-related issues throughout the topics presented in the Sixth Edition of the Study Guide. The Sixth Edition reflects the scope of practice of physical medicine and rehabilitation, while maintaining a publishing cycle that allows the learner to remain current. The Sixth Edition will address the following topics:

2005
- Neuromuscular Rehabilitation and Electrodiagnosis
- Rehabilitation of Orthopedic and Rheumatologic Disorders

2006
- Limb Deficiency and Prosthetic Management
- Cardiopulmonary Rehabilitation and Cancer Rehabilitation

2007
- Industrial Medicine and Acute Musculoskeletal Rehabilitation
- Spinal Cord Injury Medicine

2008
- Congenital and Acquired Brain Injury
- Interventions in Chronic Pain Management

2009
- Rehabilitation of Stroke and Neurodegenerative Disorders
- Sports and Performing Arts Medicine

Acknowledgments: The Study Guide Subcommittee wishes to acknowledge the commitment of the two faculty committees represented in this issue. Chaired by Patrick M. Foye, MD (Industrial Medicine and Acute Musculoskeletal Rehabilitation), and Steven C. Kirshblum, MD (Spinal Cord Injury Medicine), the faculty committees approached this voluntary scholarly endeavor with enthusiasm and dedication to produce the best possible product for their peers. Thanks also go to Venu Akuthota, MD, Brian M. Kelly, DO, Thomas S. Kiser, MD, MPH, Theresa J. Lie-Nemeth, MD, Virginia S. Nelson, MD, MPH, Amy H. Phelan, MD, DVM, Jeffrey Rosenbluth, MD, and Vivian C. Shih, MD, who served as Self-Assessment Examination Subcommittee liaisons and authored the SAE-P questions associated with the study guide articles.

The Study Guide Subcommittee would like to thank the members of the AAPM&R Medical Education Committee, chaired by Steve R. Geiringer, MD, for their ongoing interest in and support of this annual project. Thanks also to Cheryl L. Wilder, ELS, for her continued editorial guidance.

I would personally like to thank the four other members of the Study Guide Subcommittee, Stuart J. Glassman, MD, Robert J. Kaplan, MD, Ira G. Rashbaum, MD, and William C. Walker, MD, for their hard work and dedication to this process.

Keith M. Robinson, MD
Chair
Study Guide Subcommittee of the Medical Education Committee

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0003-9993/07/8803S-1$32.00/0
Arch Phys Med Rehabil Vol 88, Suppl 1, March 2007
Instructions for AAPM&R Self-Assessment Examinations

An examination component of the 2007 Study Guide enables you to assess your need for continuing medical education (CME) in the topics presented: the Self-Assessment Examination for Practitioners (SAE-P). An SAE-P with an accompanying answer key for each Study Guide chapter is contained in this issue. Completion of the 2 Study Guide topics earns 30 hours of Category 1 CME credit. Credit may be obtained until March 31, 2010.

The AAPM&R has designated each set of Study Guide articles and its corresponding SAE-P for a maximum of 15 Category 1 CME credits toward the AMA Physician’s Recognition Award. Each physician should claim only those hours of credit that he/she actually spent in the educational activity.

Please complete the relevant program evaluation(s) and the CME application enclosed in the back of this issue to receive credit for these activities. Your participation in the Study Guides will be documented to the American Board of Physical Medicine and Rehabilitation (ABPMR). These activities are an acceptable form of self-assessment required for Maintenance of Certification by the ABPMR. The Study Guide and the Self-Assessment Examination subcommittees welcome your evaluation of these materials. Each year members who have evaluated these materials have contributed to the ongoing improvement of the Self-Directed Physiatric Education Program.

Thank you for your cooperation and participation.

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Industrial Medicine and Acute Musculoskeletal Rehabilitation.  
1. Diagnostic Testing in Industrial and Acute Musculoskeletal Injuries

Andre Panagos, MD, Aaron W. Sable, MD, Joseph P. Zuhosky, MD, Robert W. Irwin, MD, 
William J. Sullivan, MD, Patrick M. Foye, MD


This self-directed learning module reviews the history and physical examination of common acute musculoskeletal conditions that occur in the occupational setting. It is part of the industrial medicine and acute musculoskeletal rehabilitation study guide in the Self-Directed Physiatric Education Program for practitioners and trainees in physical medicine and rehabilitation. This article presents case vignettes to review the diagnostic evaluation of heel pain, whiplash, repetitive strain injuries, and low back pain.

**Overall Article Objective:** To understand the important components of a history, physical examination, and concise diagnostic testing when evaluating acute industrial and musculoskeletal injuries.

**Key Words:** Carpal tunnel syndrome; Cumulative trauma disorders; Low back pain; Rehabilitation; Sacroiliac joint; Tenosynovitis; Whiplash injuries.

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1.1 Educational Activity: To discuss the diagnostic approach in a 40-year-old home improvement warehouse worker who develops heel pain within several weeks of starting a job that entails prolonged walking and standing on concrete floors.

**HEEL PAIN IS THE MOST common presenting symptom in the foot, and plantar fascitis is the most common etiology of that pain.**¹ The diagnosis can be challenging to clinicians without a familiarity of midfoot and hindfoot anatomy. The midfoot is made up of the navicular, cuboid, and 3 cuneiform bones, and the hindfoot, or heel, is made up of the talus and calcaneus bones. Major soft-tissue regions include the calcaneal fat pad, the plantar fascia, and the Achilles’ tendon insertion. The tendons that cross beneath the medial flexor retinaculum include the posterior tibialis, flexor digitorum longus (FDL), and flexor hallucis longus (FHL) tendons; the peroneal tendons pass beneath the lateral retinaculum.²

Any alteration of normal foot biomechanics can play a role in the development of heel pain through increased plantar fascia stress. The foot dissipates forces and adapts to a surface by increasing flexibility through pronation at initial heel strike. Associated movements include tibial internal rotation, subtalar joint eversion, ankle dorsiflexion, and foot abduction. As the foot rolls forward to toe-off, it stabilizes itself by supinating through the plantar fascia by means of a windlass mechanism.³

The longitudinal arch is then stabilized as the toe hyperextends. The plantar fascia is composed of fibrous connective tissues that are interwoven into multiple layers to form an aponeurosis. This aponeurosis attaches to the 3 main weight-bearing structures of the foot: the medial calcaneus and first and fifth metatarsal heads, which together form the longitudinal arch.² It is composed of 3 parts, of which the central portion is referred to as the plantar fascia.³ Underneath the plantar fascia is the insertion of the flexor brevis muscle, where osteophytes can occur.⁴

Plantar fascitis most commonly occurs in patients between the ages of 40 and 70 years and in military recruits and runners.³¹ It affects men and women equally, and risk factors include obesity.³³ The clinical course is generally favorable, with up to 90% of patients achieving complete resolution with a nonsurgical approach within 11 months; the remaining 5% require surgery.⁵

The pain is located in the anteromedial or central part of the heel. It has a rapid onset if there has been a rupture of the plantar fascia; otherwise, it gradually worsens. It is exacerbated with toe walking, significant changes in activity, or alterations in footwear.³ The pain tends to be worse in the morning and on standing after prolonged sitting.² The history typically includes a recent increase in the amount or intensity of walking or running. It may also include a change in footwear or an unyielding walking or running surface.¹ The cause is multifactorial and poorly understood, but conditions that increase the tension on the plantar fascia such as pes cavus, pes planus, decreased subtalar motion, and a tight Achilles’ tendon may contribute.³ The repetitive trauma associated with plantar fasciitis is thought to cause a traction injury resulting in microtears. This chronic situation can result in periositis of the plantar fascia origin on the calcaneus.³

The physical examination routinely shows limited ankle dorsiflexion with maximal tenderness at the anteromedial aspect of the inferior heel.¹ Examination should include assessment of the foot during weight bearing and non–weight bearing, with these factors considered: altered arch height, such as pes planus or cavus; passive range of motion of the ankle,
subtalar, and midfoot joints; and overall postural assessment. A gap noted with palpation of the plantar fascia may indicate a rupture. The bony prominences and tendinous insertions should also be palpated near the heel and midfoot. The windlass test is positive if there is plantar fascia pain by forced great toe dorsiflexion. Sensation should be evaluated to rule out neurogenic pathology.

Imaging studies play a limited role. They are used to rule out other causes of heel pain including a calcaneal stress fracture or other bony lesion. Plain radiographs, ideally performed in weight bearing, can detect a fracture, dislocation, degenerative joint disease, foreign bodies, tumors, and soft-tissue calcifications. A calcaneal osteophyte (heel spur) is often noted, which is often of no value in diagnosis or treatment. Wolff’s law of bone remodeling would suggest that the osteophyte is a response to plantar fascia tension rather than a primary etiology of symptoms. A flabby periostitis may suggest a spondyloarthropathy. If a calcaneal stress fracture is suspected and plain radiographs are normal, a bone scan is recommended. A linear fracture line or diffuse calcaneal uptake is consistent with a calcaneal stress fracture compared with increased activity at the calcaneal plantar fascia insertion site associated with plantar fasciitis. Avascular necrosis (AVN) is often caused by trauma. Magnetic resonance imaging (MRI) is the most sensitive and specific radiographic test for AVN, because plain radiographs are initially normal. MRI of normal plantar fascia is hypointense on all pulse sequences, because the structure is composed mainly of collagen. MRI of the foot with plantar fascitis shows increased tissue thickness and increased signal intensity on T2 and short tau inversion recovery sequences consistent with edema and structural microtears. There is also increased signal in the adjacent subcutaneous tissue and calcaneal insertion site. Diagnostic ultrasound is useful but uncommonly used. Under ultrasound, the normal plantar fascia thickness is 2.4 to 4.3mm, whereas abnormal plantar fascia thickness is 4.3 to 8.1mm. There is also a loss of definition at the interface between the plantar fascia and surrounding tissue, as well as calcaneal origin edema.

The differential diagnosis includes fracture, infection, malignancy, or rheumatologic disorders. The calcaneus is the second most common site of stress fractures in the foot after the metatarsals. It occurs with excessive or repetitive weight bearing and is associated with osteoporosis or an increase in occupational or recreational activity. It presents with vague pain that is worsened with weight bearing and relieved with rest. A mediolateral calcaneal compression or squeeze may reproduce pain. Plain radiographs may be normal initially, but, over time, show a sclerotic area directed inferiorly in an oblique angle from the superior calcaneus. A bone bruise may present with similar symptoms but is associated with direct trauma without a cortical fracture on plain radiographs or MRI. The bone bruise is believed to be caused by trabecular microfractures accompanied by hemorrhage, hyperemia, and edema.

Heel fat pad atrophy presents with symptoms similar to plantar fasciitis and is commonly found in elderly or obese patients. The pain and tenderness is located in the central heel with associated atrophy and is more diffuse than with plantar fasciitis. Unlike plantar fasciitis, pain due to heel pad atrophy does not radiate anteriorly or worsen with great toe dorsiflexion, and it is not worse in the morning. Achilles tendinitis develops with overuse or abnormal stresses including jumping or running and may result in Achilles’ insertion tenderness or swelling. The adult Achilles’ tendon is approximately 10 to 15cm in length and is formed by the union of the gastrocnemius and soleus muscle tendons. It inserts on the posterior calcaneus and develops pathology along a critical zone that is 2 to 6cm proximal to the calcaneal insertion. A chronic tendonopathy results in thickening associated with microtears that may rupture with a characteristic pop.

Retrocalcaneal bursitis, also known as a pump bump, is characterized by Achilles’ tendon insertion site pain. It is caused by abrasion and resulting inflammation of the bursa between the Achilles’ tendon insertion site and the calcaneus by shoes with a stiff posterior edge. It is also associated with a systemic inflammatory arthritis. Haglund’s disease, a bony protrubance of the calcaneal tuberosity, may also result in a retrocalcaneal bursitis. A retroachilles’ bursitis presents with similar findings but is caused by inflammation between the Achilles’ tendon and the skin.

Medial or lateral heel pain may result from a tendonopathy of the posterior tibialis, FDL, or FHL tendons in the medial compartment or a tendonopathy of the peroneus longus and brevis tendons in the lateral compartment. The peroneus brevis tendon ruptures proximally to the insertion site at the base of the fifth metatarsal near or just distal to the lateral malleolus. It is associated with swelling and tenderness after recurrent inversion ankle sprains. A pes planus foot predisposes to a posterior tibial tendon rupture.

Tarsal tunnel syndrome (TTS) is caused by posterior tibial nerve irritation and/or compression as it dives beneath the medial retinaculum behind the medial malleolus. The posterior tibial nerve separates into medial and lateral calcaneal sensory nerves and into the medial and lateral plantar nerves, which have sensory and motor components. Increased tibial nerve tension may be caused by increased forefoot abduction and hindfoot valgus deviation. Nerve compression may be caused by trauma or degenerative bony conditions. It may present with numbness, tingling, or burning pain or tenderness along the path of the nerve that may radiate along the plantar aspect of the foot to the toes. It is worsened with prolonged weight bearing and ambulation on hard surfaces. A Tinel sign may be found at the medial heel. Foot dorsiflexion and eversion stretches the nerve and can reproduce symptoms. Nerve conduction studies (NCS) for TTS should include the distal tibial motor, medial, and lateral plantar orthodromic sensory nerve studies and electromyography of the abductor hallucis longus and abductor digitii quinti. The NCS results may be compared with those of the asymptomatic side. Other causes of neurogenic heel pain include a medial calcaneal neuroma, S1 radiculopathy, or a neuropathy of the nerve to the abductor digitii quinti.

1.2 Clinical Activity: To review the etiology and diagnostics assessment in a Department of Transportation worker who presents with neck pain after a rear-end collision while stopped at the side of the road.

The cervical spine is composed of 7 vertebrae that permit greater motion compared with the lumbar spine. The term whiplash describes the transfer of energy to the neck through sagittal acceleration–deceleration leading to bony and/or soft-tissue injury. It is most commonly associated with rear-end motor vehicle collisions (MVCs). It has been associated with chronic somatic and psychologic problems.

A constellation of symptoms and signs has been named whiplash-associated disorders. These disorders are associated with disability, increased health care costs, and decreased income, social functioning, and overall well-being. In 1994, the estimated incidence of whiplash-associated disorders in the United States was 3.8 per 1000. Many people who are in-
follow-up. Leads to increased risk of whiplash-associated disorders at 1. Not surprisingly, increased severity in the acute stage increased cervical spine range of motion, neurologic deficits are up to 33% have chronic symptoms. Chronic pain does not involve in rear-end collisions do not suffer permanent injury, and symptoms usually resolve within 4 to 6 weeks. However, up to 33% have chronic symptoms. Chronic pain does not represent persistent acute pain but results from adaptations of peripheral and central pain modulation. Symptoms associated with whiplash-associated disorder include neck pain and stiffness, arm pain, paresthesias, temporal mandibular joint dysfunction, headache, dizziness, visual disturbances, and difficulty with memory and concentration.

The Quebec Task Force on Whiplash-Associated Disorders developed a classification system grading severity from 0 to IV by stratifying patients on anatomic-clinical determinants (table 1). Not surprisingly, increased severity in the acute stage leads to increased risk of whiplash-associated disorders at follow-up.

Whiplash was first identified in World War I pilots after emergency ejection, but the prevalence decreased with the development of the shoulder harness and headrest. Significant risk factors for whiplash after MVC include older age, higher acceleration and deceleration forces, seat belt use, poor headrest positioning, poor car seat energy absorption, and improper car design and construction.

Cadavers exposed to rear-end collisions show tears in the ligamentum flavum, disruption of the annulus of the intervertebral disk and anterior longitudinal ligament, capsular strains, and fractures of the zygopophyseal joints. These injuries often do not show up on imaging studies. Lord et al. used controlled diagnostic blocks to show zygopophyseal pain generators in 60% of patients with chronic whiplash-associated disorders.

Two causes hypothesized for the cognitive impairment seen with these disorders are (1) disruption of the central homeostatic regulatory system resulting in neural, hormonal, and behavioral changes in response to stress and (2) a coup–contrecoup traumatic brain injury.

The center of the automobile headrest should be at ear level to limit the amount of head and neck flexion and extension at impact. The more reclined the car seat is during a rear-end collision, the larger the arc that the head and neck travel in relation to the chest. From the 1980s to mid-1990s, the proper use of seat belts would have been expected to decrease the prevalence of whiplash injuries, yet whiplash injuries increased between 1989 and 1995 although seat belt use remained stable.

There is no specific historical or physical examination finding for the diagnosis of whiplash-associated disorders. To gauge the force of impact it is very important to review the details, including speed at the time of the collision, possible head injury with associated loss of consciousness, and condition of the vehicle. Symptoms may be initially mild after the accident but may increase over the following 2 to 3 days. Although the physical examination shows stiffness and decreased cervical spine range of motion, neurologic deficits are rare. The mechanism of injury in combination with the presenting symptoms and signs on physical examination allows the diagnosis of whiplash-associated disorders to be made. Imaging is useful to rule out bony or soft-tissue injury, including fractures and injuries to the disk and ligamentous structures. Plain radiographs often show decreased lordosis and possible widening of adjacent soft tissues.

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Work-related musculoskeletal disorders that result from repetitive motions have had various names, including cumulative trauma disorders and repetitive strain injuries. Repetitive movements in occupational and avocational settings may result in these conditions; however, debate exists concerning the actual existence of these injuries. The biomechanic risk factors associated with tissue damage include the extent of tissue damage caused by repetitive or prolonged activities, forceful exertion, awkward or static postures, vibration, localized mechanical stress, and cold temperatures. Individual risk factors include older age, obesity, diabetes, smoking, pregnancy, rheumatoid arthritis, and psychologic stress. In 2002, there were 96,500 cases of repetitive strain injury reported in the United States, resulting in a median of 23 days lost from work. Causation is often difficult to identify.

Repetitive strain injuries are often attributed to musculotendinous unit disorders. Tendons and ligaments require mechanical stress to maintain function. When the load exceeds the ability to adapt, injury occurs, with resultant inflammation. This is associated with subsequent healing, scarring, and tissue remodeling. If the injury is not allowed to heal completely, continued high–muscle-effort levels can result in further disability. Several theories exist to explain such injuries, including (1) temporary lengthening of collagenous structures in response to prolonged loading, (2) intramuscular pressure rise with resulting ischemia caused by prolonged loading, and (3) inconsistent afferent information including visual and proprioceptive resulting motor responses. Some have termed repetitive strain injuries to be tendonopathy or tendinosis, because histopathology has not shown inflammatory mediators.

The history should include questions assessing occupational and avocational activities that include high repetition rates and prolonged abnormal postures. The history may also identify obstacles to recovery such as “catastrophizing,” histrionic behavior, job monotony, high work demands, and financial reliance on disability payments. The cardinal complaint is pain at the site of muscle or tendon insertion associated with tender-
ness during palpation or resisted motion. Often there is associated swelling and warmth. Evaluation for upper-extremity complaints begins at the cervical spine and proceeds to the digits; it includes a screen of the unaffected contralateral side. The patient should be assured that there is no evidence that continued activity will increase the damage, although work activities must be modified, with minimal time off from work taken. Treatment should include physical and/or occupational therapy with work modifications.

De Quervain’s disease results in pain of the first dorsal compartment (fig 1) through which pass the tendons of the abductor pollicis longus and extensor pollicis brevis muscles. Symptoms can also include tenderness and swelling over the radial styloid at the anatomic snuffbox. The Finkelstein’s test is accomplished by having the patient place his/her thumb in the palm and closing the fingers around it, followed by ulnar deviation of the wrist. Increased pain on palpation of the site reproduces the clinical diagnosis. Other tendinous disorders at the wrist may present as pain in the region of the involved tendon reproduced with resisted motion.

Carpal tunnel syndrome (CTS) can result in short- and/or long-term work absence, so early management and treatment are essential. Classically, it causes pain, numbness, or tingling at the thumb, index, and long fingers. It can cause wasting of the thenar muscles and significant loss of oppositional function in advanced cases. It is caused by increased carpal tunnel pressure impairing neurovascular flow and causing direct median nerve compression. Repetitive or sustained flexed or extended wrist positions, as well as finger flexion, can increase carpal tunnel pressure, leading to demyelination or Wallerian degeneration over months to years. The history should assess work factors associated with repetitive wrist motions.

The Phalen test is accomplished by wrist flexion for about 1 minute to reproduce dysesthesias and numbness in the median nerve distribution. The Tinel sign involves tapping over the wrist crease to reproduce median nerve dysesthesias. However, the sensitivity of these tests is poor. Electrodiagnostic studies have been found to provide a high degree of sensitivity (>85%) and specificity (95%) for diagnosing CTS. At the least, a 14-cm median sensory NCS across the wrist should be performed and compared with a sensory NCS of an adjacent nerve in the symptomatic limb followed by an 8-cm median motor NCS to the abductor pollicis brevis (APB). Needle electromyography of the APB muscle can determine the severity of the CTS and exclude other conditions. Ultrasound of the carpal tunnel is viewed as a new and promising diagnostic method.

1.4 Clinical Activity: To formulate a diagnostic plan for a loading dock worker who has lower back pain.

Diagnosis and treatment of low back pain (LBP) in an injured worker can present formidable tasks for clinicians because of the interactive anatomic, functional, medical, and psychologic factors. The workers’ compensation system adds an additional layer of complexity, occasionally promoting additional pain behaviors and disability. An early and accurate diagnosis is essential for the patient to return to work safely and effectively. The peak prevalence of LBP is age 25 to 60 years, yet the age group that results in the highest costs is the 31- to 40-year-old subgroup. LBP is associated with lifting, carrying, material handling, and lower job performance ratings. Accidental onset has also been found to result in higher total treatment costs.

The objective of the history and physical examination is to direct the patient toward diagnostic tests of greatest yield, to formulate the most specific treatment, and to return the patient to the highest functional level. Failure to do this can lead to treatment failure and recurrence. It is important to recognize psychologic factors that may impede recovery yet be unbiased so that one does not inadvertently attribute a treatment failure to psychologic factors when diagnostic errors may possibly have occurred.

The first step in assessing an occupational injury is to determine whether it is indeed work related or is related to an underlying illness. This step consists of reviewing the mechanism of injury to clarify its association with work. Reviewing the consistency of the injury report with witnesses may also help complete the sequence of events. Occasionally, an association with a work injury remains elusive despite diligent information gathering. Possible litigation associated with the injury either in the workplace or after an MVC can alert the physician to possible counterproductive incentives. The physician should not communicate a message of disbelief; otherwise, treatment of the patient may become more difficult.

Pain localization often can be difficult for patients and physicians. Localized point tenderness that is easily identifiable and reproducible denotes localized injury. Dermatomal pain patterns caused by nerve lesions are not as easy to localize as follows established distribution patterns. Sclerotomal and myotomal referral patterns of non–nervous system tissues such as muscles and ligaments are not as well established. They can be diffuse and overlap with dermatomal patterns. To further understand a patient’s pain experience, additional information about intensity, frequency, quality, and aggravating and relieving factors also must be articulated. A family history of spondyloarthopathies and connective tissue disorders should be clarified.

Fractures, infection, and cauda equina syndrome also must be excluded. Cauda equina syndrome can be a serious condition; therefore, inquiries regarding bowel or bladder function...
must be made even in the absence of limb nerve root involvement. A patient with a cancer history must have malignancy excluded, especially if his/her pain has persisted longer than 1 month, is not relieved with bedrest, or is associated with unexplained weight loss. Intravenous drug use, persistent fevers, and/or night sweats suggest a spinal infection.

Detailed information on past treatments gives the physician a unique view of the patient’s compliance and response. A review of medications, physical modalities, and exercise regimens, as well as surgical and nonsurgical procedures, provides a clue to previous diagnoses. Detailed inquiry needs to be made about medication names and doses, what nonsurgical invasive interventions were performed, and the responses to these treatments.

The focused physical examination helps to confirm or exclude diagnoses suggested by the history. This examination involves inspection, range of motion, flexibility, palpation, neurovascular testing, and performance of provocative maneuvers. Inspection includes assessing for symmetry of the shoulders, iliac crests, and greater trochanteric areas and checking for muscle bulk symmetry and tone of the paraspinal muscles, for excessive or reduced kyphosis and lordosis, or for a fixed or functional scoliosis. A functional scoliosis is reduced with forward flexion, whereas a fixed scoliosis does not change. Lumbar range of motion is checked in the 6 cardinal planes including forward flexion, extension, and right- and left-side bending and rotation. Forward flexion involves a reversal of the normal lumbar lordosis and pelvic rotation. It can be measured with an inclinometer or the modified Schober test, in which a horizontal line is drawn between the posterior superior iliac spines at approximately the S2 level. At the midline, a perpendicular line is drawn to 5cm below and 10cm above. An increase of more than 5cm is normal.

Lower-limb joints are screened using the Quick test, in which a patient squats 2 or 3 times and returns to standing. This grossly tests the sacrum, hips, knees, and ankles to rule out pathology. This should not be performed by pregnant women and should be used cautiously in elderly patients. Palpation is used to assess side-to-side differences in tenderness and tissue quality in the muscular, osseous, and ligamentous structures. Trigger points are noted by their characteristic band-like quality and palpation-induced twitch response. Myotomal screening should include strength assessments of the hip flexors (L1-3), knee extensors (L2-4), ankle dorsiflexors (L4-5), great toe extension (L5), and ankle plantarflexors (S1). The ankle plantarflexors should provocatively be tested with toe-walking or 10 toe raises. Sensation should be tested at the knee (L3), medial malleolus (L4), dorsum of the foot (L5), and the lateral malleolus (S1). Muscle stretch reflexes are assessed at the patella (L4), medial hamstring (L5), and the Achilles’ tendon (S1). Because 98% of all lumbar disk herniations occur at the L4-5 and L5-S1 levels affecting the L5 and S1 nerve roots, it is important to screen the strength of the ankle dorsiflexors and great toe extensors as well as the ankle reflexes and sensation at the medial, dorsal, and lateral foot. Peripheral vascular disease should be assessed by checking lower-extremity pulses and looking for signs of vascular insufficiency.

Hamstring and gluteus maximus inflexibility can cause a posterior pelvic tilt, decreasing lumbar lordosis, whereas a tight rectus femoris and iliopsoas can increase anterior pelvic tilt, thereby increasing lumbar lordosis—both of which may increase forces across the lumbar spine. The Ely test, which tests for a tight rectus femoris, is accomplished by maximally flexing the knee toward the buttock while the patient is prone. Elevation of the buttocks constitutes a positive test. In the Thomas test, which assesses the iliopsoas muscle, the contralateral leg is maximally flexed toward the chest while the patient is supine. A positive sign is elevation of the nonflexed thigh off the table. The straight-leg raise (SLR) test assesses hamstring flexibility and is also a dural tension sign. A person tests positive if posterior leg pain occurs below the knee with a straight leg raise between 30° and 70° of hip flexion. Sacroiliac dysfunction is uncovered at greater than 70°. The positive crossed SLR suggests a large disk protrusion. The femoral stretch test to assess pathology at the L4 nerve root and above is accomplished with the patient in the prone position by lifting the thigh off the table while flexing the knee to 90°. Finally, it is also important to review the condition of the bone and soft-tissue structures above and below the lumbar spine. These structures include the thoracic spine, the sacroiliac joint (SIJ), and the pelvic girdle muscles.

The SIJ has been found to contribute to LBP. Several tests have been characterized, yet none are very sensitive or specific. The Patrick or FABER test is accomplished by flexing, abducting, and externally rotating the hip while applying pressure to the contralateral anterior superior iliac spine. Ipsilateral groin pain is of hip origin, whereas contralateral buttoc pain often originates from the SIJ. The Gaenslen test is performed with the patient supine by flexing the contralateral leg while dropping the ipsilateral leg off the table. A positive response is pain in the region of the SIJ of the ipsilateral leg. The Gill test is performed by palpating the posterior superior iliac spine while the patient is standing and asking the patient to flex the ipsilateral hip to 90°. A positive finding is the failure of the posterior superior iliac spine to descend. The 5 Waddell signs of nonorganic pathology include nonanatomic regional tenderness, overreaction, nonanatomic regionalization, distraction (using a seated SLR), and stimulation (with axial loading). If any 3 of the 5 findings are positive, the Waddell signs suggest the neurotic triad of hysteria, depression, and hypochondriasis on the Minnesota Multiphasic Personality Inventory.

Diagnostic testing is based on history and physical examination findings. If there are no red flags noted it is often prudent to refrain from ordering imaging studies. The dogmatic reliance on plain radiographs predates the understanding of lumbar pathology, recent surgical observations, and imaging techniques; therefore, minimal critical review has been done. The routine use of plain radiographs has been controversial, because radiographic abnormalities are not necessarily related to symptoms. Criteria have been established for the early use of plain radiographs. They include age greater than 50 years, significant trauma, neurologic deficits, unplanned weight loss for longer than 6 months, and assessing for possible ankylosing spondylitis. Plain radiographs should also be considered if there is drug or alcohol abuse, a history of carcinoma, corticosteroid use, fever, lack of improvement with conservative care, litigation, and no improvement after 7 weeks. They are optimal for checking spinal segment alignment during weight bearing in the anteroposterior and lateral views to rule out spondylolisthesis and to assess for hypermobility using flexion and extension films. Although oblique views significantly increase the radiation dose, they help assess the posterior elements for fractures or other lesions. The presence of spondylodiscitis, spondylolysis, or posterior element hypertrophy can have a significant influence on the specific exercise prescription.

Computed tomography (CT) is an excellent means of assessing bony architecture—specifically, foraminal bony narrowing and lateral recess stenosis. It is most often used to assess fractures, especially stress fractures, or disk lesions in patients who cannot have an MRI scan. CT myelography allows improved visualization of compression by soft tissues or bone.
The major limitation of CT is radiation exposure, restricted field of view, and poor delineation of intrathecal anatomy. MRI provides excellent osseous and soft-tissue detail. Disk degeneration is clearly shown through the state of hydration of the disk complex. High-intensity zones, which may represent an annular tear as well as various stages of a herniated nucleus pulposus, are clearly delineated. It is the study of choice to detect sequestered disk fragments and vertebral body endplate changes, to assess for inflammatory processes and neoplastic conditions, and to assess structures in the retroperitoneal space.

The addition of gadolinium contrast helps differentiate post-surgical granulation tissue from disk material and increases the sensitivity for bony abnormality detection and surgical granulation tissue from disk material and increases the sensitivity for bony abnormality detection and permits better lesion localization. This modality is useful for localizing posterior element fractures or degenerative changes and also helps identify neoplastic conditions and infections.

Electrodiagnostic studies are the only physiologic test of muscle and nerve function and are useful in several ways: for differentiating objective weakness from weakness resulting from pain, for ruling out a peripheral neuropathy or neuromuscular diseases, to localize the level of the lesion, to differentiate between neuropraxic and axonal injuries, and to assist in prognosis.

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Suggested Reading
Industrial Medicine and Acute Musculoskeletal Rehabilitation. 2. Medications for the Treatment of Acute Musculoskeletal Pain

William J. Sullivan, MD, Andre Panagos, MD, Patrick M. Foye, MD, Aaron W. Sable, MD, Robert W. Irwin, MD, Joseph P. Zuhosky, MD


This self-directed learning module highlights medications used in the treatment of acute musculoskeletal pain in the context of industrial rehabilitation. It is part of the study guide on industrial rehabilitation medicine and acute musculoskeletal rehabilitation in the Self-Directed Physiatric Education Program for practitioners and trainees in physical medicine and rehabilitation. This article compares various skeletal muscle relaxants, addresses issues related to nonsteroidal anti-inflammatory medications, provides an algorithm for acute pain management in an injured worker, and discusses topical medications for the treatment of pain.

Overall Article Objective: To summarize medication options in the treatment of acute musculoskeletal pain in the setting of injured workers.

Key Words: Administration, topical; Analgesics; Anti-inflammatory agents; Muscle relaxants, central; Rehabilitation. © 2007 by the American Academy of Physical Medicine and Rehabilitation

Case Presentation: A 45-year-old Department of Transportation employee was working on a highway project when the vehicle she was driving was hit from behind. She experienced neck pain immediately after the collision but had no focal neurologic problems. Since the collision, she has had some difficulty with neck motions and is experiencing increased pain on the job. Her duties include driving a pickup truck loaded with barricades, setting up barricades and cones, and working as a flagperson. She was referred to the injured Department of Transportation worker, who must be able to drive and/or function on the job in heavy, high-speed traffic. Also, these drugs are hepatically metabolized and re-ally or kidney disease.

Three commonly prescribed agents used as SMRs include metaxalone, cyclobenzaprine, and carisoprodol. Each SMR has different mechanisms of action and side-effect profiles, although older studies have not shown any particular SMR to have superior efficacy. Medications that are approved for treatment of spasticity and are sometimes used to treat musculoskeletal pain include baclofen and tizanidine.

Metaxalone was initially introduced in 1962. Its exact mechanism of action is unknown; it is thought to act by depressing polysynaptic spinal reflexes. Studies have shown a low rate of side effects with no reports of sedation. Double-blind placebo studies from the 1960s and 1970s showed positive effects in reducing back pain with no reports in the literature of dangerous side effects or safety concerns.

Cyclobenzaprine is structurally similar to tricyclic antidepressants (TCAs) and was first studied as an antidepressant with regard to efficacy and safety. The exact mechanism of action is unknown, but it is presumed to work at the level of the brainstem or higher with a generalized sedative effect. Studies have repeatedly shown its superiority over placebo and efficacy at least comparable to diazepam. It is also more effective...
when used in combination with nonsteroidal anti-inflammatory drugs (NSAIDs) than are NSAIDs alone.4 Its chemical similarity to TCAs explains its main side effects of sedation, lethargy, and other anticholinergic effects. There are case reports of adverse reaction of cyclobenzaprine in combination with alcohol, tramadol, droperidol, and other multiple drug interactions.2

Carisoprodol has been in use for decades. Although its exact mechanism is not clear, it may be related to its sedative effects. Some studies2 suggest blockage of interneuronal activity in the descending reticular formation and spinal cord. Although carisoprodol has been shown to be more effective than placebo, comparison with other SMRs has not shown any reproducible differences. More importantly, there are serious safety concerns related to its active metabolite, meprobamate, which is a schedule IV controlled substance. There are multiple reports2 of abuse and cases of impaired driving associated with carisoprodol. Interestingly, a questionnaire probing prescribing practices showed that a low percentage of physicians recognized the abuse potential and had an understanding of the active metabolite, despite this being a heavily prescribed drug.2

Baclofen is a chemical analog of γ-aminobutyric acid that acts by inhibiting synaptic transmission in the spinal cord.1 It is mainly used in the treatment of neurogenic spasticity with efficacy similar to diazepam, dantrolene, and tizanidine. It generally causes less sedation but may lead to increased weakness. Baclofen is not generally used as therapy for acute paravertrbral muscle spasm.1

Tizanidine is approved for the treatment of spasticity and is also used to treat pain and “spasm” from musculoskeletal conditions. It is an agonist at α2-adrenergic receptor sites and presumably reduces spasticity by increased presynaptic inhibition of motoneurons.2 Several studies1 have shown its efficacy for patients with musculoskeletal back pain with side effects similar to those of other SMRs and drowsiness as the primary reason for discontinuing the medication. There is a case report1 of hypotension when used in combination with an antihypertensive medication, possibly due to its chemical similarity to clonidine.

In the case of the highway worker with presumed “muscle spasm” and pain, the choice of SMR for pain relief is important. Side effects and abuse potential should be considered before prescribing this class of medication. Shorter duration of treatment is generally recommended to limit potential of side effects and/or abuse.1,2

### 2.2 Educational Activity: To discuss the use of NSAIDs in the treatment of neck pain in this highway worker.

NSAIDs are commonly prescribed medications. Since 1991, 7 new NSAIDs have entered the U.S. market. These are listed in table 2.

Drug manufacturers are required to show analgesic efficacy for each of the agents. The models most commonly used to obtain approval from the U.S. Food and Drug Administration (FDA) are dental pain, postsurgical pain, dysmenorrhea, and postpartum cramps. Although some of these agents have FDA approval for the treatment of rheumatoid arthritis and osteoarthritis, some are also approved for the treatment of acute pain. Note that several of these medications have been pulled from the market because of the postmarketing identification of side effects. Bromfenac was withdrawn because of liver toxicity. Rofecoxib and valdecoxib were withdrawn because of cardiovascular events. The FDA also recommended stronger warnings for all NSAIDs because of gastrointestinal (GI) toxicity and increased risk of cardiovascular events. This recommendation included conventional NSAIDs, because little information existed regarding their cardiovascular risks.2,6

Although there is no evidence to suggest superior efficacy of one NSAID over another, individual patients may respond differently to different medications. Conventional NSAIDs act by inhibiting cyclooxygenase (COX)–2 and the pathologic responses to pain and inflammation. In the GI tract, they also inhibit COX-1 activity, decrease prostaglandins, and increase the risk of GI side effects such as life-threatening bleeding. Conventional NSAIDs show dose-dependent side effects, which may limit their use in elderly people or other patients at high risk. Additional side effects include renal dysfunction and platelet inhibition. The COX-2–specific agents (celecoxib) have a decreased incidence of GI toxicity,7 but increased costs and cardiovascular risks may limit their utility in the elderly and in those with cardiovascular risk factors. COX-2–selective agents (etodolac, meloxicam) have a decreased risk of clini-

### Table 1: Antispasmodic Medications

<table>
<thead>
<tr>
<th>Category</th>
<th>Medication (Product)</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antihistamines</td>
<td>Orphenadrine (Norflex)</td>
<td>3M</td>
</tr>
<tr>
<td>Central nervous system depressants</td>
<td>Chlorzoxazone (Parafon, Forte DSC; Paraflex Ortho-McNeil)</td>
<td>Metropolitan King</td>
</tr>
<tr>
<td>Central alpha2-adrenergic agonists</td>
<td>Tizanidine (Zanaflex)</td>
<td>Elan</td>
</tr>
<tr>
<td>Tricyclic antidepressant agents</td>
<td>Cyclobenzaprine (Flexeril)</td>
<td>McNeil</td>
</tr>
<tr>
<td>γ-aminobutyric acid agonists</td>
<td>Diazepam (Valium)</td>
<td>Roche</td>
</tr>
<tr>
<td>      Baclofen (Lioresal)</td>
<td>Novartis</td>
<td></td>
</tr>
<tr>
<td>      Other benzodiazepines</td>
<td>     </td>
<td></td>
</tr>
</tbody>
</table>

**NOTE.** Data from Ridgway.14

### Table 2: Recently Approved NSAIDs

<table>
<thead>
<tr>
<th>Medication (trade name)</th>
<th>Manufacturer</th>
<th>Year FDA Approved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ketorolac (Toradol)</td>
<td>Syntex</td>
<td>1991</td>
</tr>
<tr>
<td>Diclofenac potassium ( Cataflam)</td>
<td>Novartis</td>
<td>1993</td>
</tr>
<tr>
<td>Celecoxib (Celebrex)</td>
<td>Searle</td>
<td>1998</td>
</tr>
<tr>
<td>Refecoxib (Vioxx)</td>
<td>Merck</td>
<td>1999 (withdrawn 2004)</td>
</tr>
<tr>
<td>Meloxicam (Mobic)</td>
<td>Boehringer Ingleheim/Abbott</td>
<td>2000</td>
</tr>
<tr>
<td>Valdecoxib (Bextra)</td>
<td>Searle</td>
<td>2001 (withdrawn 2005)</td>
</tr>
</tbody>
</table>

NOTE. Data from Ridgway.14
cally significant GI side effects compared with other NSAIDs. Etodolac has increased COX-2 selectivity compared with celecoxib and meloxicam, but the cardiovascular risks are unknown. Whether a patient is on a COX-2–selective or –specific agent, those agents’ GI protectivity may be compromised by concomitant use of even low-dose aspirin, and renal side effects are not decreased.

A medication recently approved by the FDA for the treatment of osteoarthritis is flavocoxid (Limbrel). This product is a blend of natural ingredients from phytochemical food source materials. It is presumed to have action on COX and lipoxigenase pathways, limiting prostaglandins and leukotrienes. It is not a COX-2–specific or –selective agent, and its ingredients are generally regarded as safe according to the FDA. To our knowledge, there is no literature available at the time of this writing to suggest efficacy in the treatment of acute musculoskeletal pain.

2.3 Educational Activity: To outline a treatment algorithm for the medication management of acute pain in a 40-year-old home improvement warehouse store worker who fell off a ladder, injuring his foot and ankle.

Physicians most often recommend or prescribe oral medications for the treatment of acute musculoskeletal pain. Acute pain generally does not require long-term use of analgesics. Much of the literature on oral analgesics defines the efficacy of a specific medication as the proportion of patients who need to take that particular drug to experience a least a 50% reduction in pain when compared with placebo. The number needed to treat (NNT) is a concept that refers to the number of patients who have to use the treatment for 1 patient to have a benefit. A lower NNT is better. Other measures of pain relief include a visual analog scale, with a meaningful analgesia effect of 13mm on a 100-mm scale.

Acetaminophen is a unique medication without a clearly defined mechanism of action related to analgesia. It has little or no anti-inflammatory effects. It also has an excellent safety profile with the exception of liver toxicity at doses exceeding 4000mg daily. An increased GI ulceration risk is not supported by the current literature. Direct comparison studies between acetaminophen (1000-mg dose) and NSAIDs show equivalent analgesia in some settings (orthopedic surgery, tension headache) and NSAID superiority in others (dental and menstrual pain). Acetaminophen remains a good initial choice for most conditions where treatment with stronger opioids is not required. Its primary metabolite shows a higher affinity for opioid receptors than the parent drug. Moreover, the analgesic action of tramadol is only partially inhibited by the opioid antagonist naloxone, which suggests the existence of another mechanism of action. This hypothesis was confirmed by the discovery of monoaminergic activity that inhibits norepinephrine and serotonin reuptake, contributing to the analgesic action. Tramadol should not be administered to patients receiving monoamine oxidase inhibitors, and cotreatment with TCAs and selective serotonin reuptake inhibitors should be undertaken with caution to avoid serotonin syndrome and increased risk of seizure. Tramadol has pharmacologic properties that may make it less likely to lead to dependence. It may be of value in treating pain conditions where treatment with stronger opioids is not required. Others report side effects and a lack of efficacy, both of which limit its usefulness. Additional preparations are 325mg of acetaminophen with 37.5mg of tramadol (Ultracet) and an extended-release preparation (Ultram ER).

Options for the treatment of acute ankle pain after a fall off a ladder thus can be summarized as shown in table 3.

2.4 Educational Activity: To identify the rationale for the use of topical analgesics in the treatment of lateral epicondylitis in a 50-year-old secretary.

Alternative delivery systems such as topical preparations have been developed to try to minimize the adverse effects of

<table>
<thead>
<tr>
<th>Table 3: Treatment Options for Acute Ankle Pain</th>
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<tbody>
<tr>
<td>Treatment</td>
</tr>
<tr>
<td>Acetaminophen</td>
</tr>
<tr>
<td>Acetaminophen plus NSAID</td>
</tr>
<tr>
<td>Combination therapy</td>
</tr>
<tr>
<td>Opioid or tramadol with acetaminophen and/or Ibuprofen for anti-inflammatory effects as needed</td>
</tr>
<tr>
<td>GI protectant</td>
</tr>
<tr>
<td>COX-2 NSAID</td>
</tr>
</tbody>
</table>

Alternative delivery systems such as topical preparations have been developed to try to minimize the adverse effects of...
NSAIDs. When NSAIDs are applied topically, there is a high concentration in the dermis and muscle levels at least equivalent to systemic administration. There is penetration into synovial fluid, but it is unclear if this is facilitated by systemic circulation. Several studies have addressed the efficacy of topical analgesics, including a study on musculoskeletal and soft-tissue injuries. Each study reported efficacy of topical NSAIDs, whether it was by gel, spray, or patch. Most drug reactions were local cutaneous reactions. GI effects were less common but were found to be more likely to occur in those who had GI side effects from oral NSAIDs.

Topical opioid administration has recently been used for the local treatment of painful ulcers and skin lesions. Factors determining bioavailability after application and the potential for cutaneous side effects associated with histamine release need to be evaluated. To our knowledge, there are no studies addressing the use of topical opioids for acute musculoskeletal pain. Delivery systems that minimize systemic uptake would also be beneficial to minimize central nervous system side effects.

Capsaicin—a natural constituent in red chili peppers—may induce analgesia via desensitization from substance P and calcitonin gene–related peptide release. Capsaicin has been found to activate a family of thermosensitive vanilloid receptors. Several studies have reported benefit in postherpetic neuralgia, postmastectomy pain, trigeminal neuralgia, cluster headache, osteoarthritis, and other conditions. Whereas pain relief is widely observed, the degree is often modest, and capsaicin is usually reserved for use as an adjunct treatment. Further, side effects, such as burning pain in the initial treatment period, are often difficult for patients to tolerate; such pain has been reported in clinical studies as a common reason for patient drop-out. Compliance may also be an issue because of the delay between onset of treatment and observation of therapeutic benefit. For acute musculoskeletal pain, capsaicin likely is not a good treatment option.

Topical formulations of local anesthetics such as the 5% lidocaine patch (Lidoderm) may be an effective alternative to systemic treatment, but most studies have focused on chronic pain conditions. Studies have addressed the efficacy of treatment for pain with no systemic side effects. Although the use of the 5% lidocaine patch in professional athletes with soft-tissue pain has been reported, there is a paucity of published evidence regarding its use in the treatment of acute musculoskeletal pain.

Multiple other classes of medication have been developed, including topical doxepin, glutamate receptor antagonists, α-adrenergic agonists, adenosine, cannabinoids, neostigmine (cholinesterase inhibitor), and gabapentin. These have been studied in animal models and various chronic pain models but have not gained acceptance in the treatment of acute pain.

References


*Key reference.

This chapter focuses on the use of modalities, therapeutic exercise, and orthotic devices in the treatment of lateral epicondylitis, carpal tunnel syndrome, plantar fasciitis, neck pain, and low back pain. It is part of the study guide on industrial rehabilitation medicine and acute musculoskeletal rehabilitation in the Self-Directed Physiatric Education Program for practitioners and trainees in physical medicine and rehabilitation.

Overall Article Objective: To review the medical literature that may help clinicians make treatment decisions regarding modalities, therapeutic exercise, and orthotic devices for treating common work-related conditions in the upper and lower limbs.

Key Words: Carpal tunnel syndrome; Exercise therapy; Low back pain; Orthotic devices; Physical therapy techniques; Rehabilitation; Tennis elbow.

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3.1 Clinical Activity: To assess the efficacy of modalities and splinting to guide treatment of a 40-year-old home improvement warehouse worker with plantar heel pain.

A 2003 COCHRANE REVIEW1 examined the effectiveness of various treatments for plantar heel pain. Nineteen randomized trials involving 1626 participants met the inclusion criteria for analysis. Trial quality was generally considered poor and data from the various studies could not be pooled. All trials measured heel pain as the primary outcome. The reviewers found limited evidence that stretching exercises and heel pads are associated with better outcomes than custom made orthoses in people who stand for more than 8 hours a day. There was some evidence that orthotic devices were not as effective as corticosteroid injections. Evidence for topical corticosteroids administered by iontophoresis was limited. Based upon conflicting evidence for low energy extra corporeal shock wave therapy (ECSWT) in reducing pain in the short term (6 and 12wk), its effectiveness remains equivocal. No evidence was found supporting the effectiveness of therapeutic ultrasound, low-intensity laser therapy, or insoles with magnetic foil. In people with chronic (>6mo) plantar heel pain, there was limited evidence that dorsiflexion night splints reduce pain. Overall, the reviewers concluded that further research studies (eg, well-designed, randomized trials) are needed.

Since the 2003 Cochrane review, a more-recent, prospective, randomized study2 evaluated the effectiveness of 2 different types of stretching programs in 101 patients with chronic plantar fasciitis (at least 10mo). Researchers compared a program of non-weight-bearing stretching exercises specific to the plantar fascia versus a standard program of weight-bearing stretching exercises for the Achilles' tendon. They concluded that stretching the plantar fascia under non-weight-bearing conditions provides significantly better outcomes in terms of pain relief, activity limitations, and patient satisfaction. The authors also provided all patients with prefabricated soft insoles and 3 weeks of nonsteroidal anti-inflammatory drugs (NSAIDs), and concluded that these treatments (especially when combined with non-weight-bearing stretching of the plantar fascia) can be very helpful nonsurgical treatments for patients with chronic, disabling plantar heel pain.2

3.2 Clinical Activity: To evaluate the use of soft cervical orthoses (“collars”) and modalities for a state Department of Transportation employee with neck pain following a rear-end automobile collision.

Frequently, soft cervical orthoses are prescribed to patients with whiplash, although recent studies question this approach. Crawford et al3 prospectively studied 108 consecutive patients with soft tissue cervical injuries from automobile collisions. Patients were randomized to either early mobilization using an exercise regime or 3 weeks in a soft cervical orthosis followed by the same exercise regime. Results found no differences between the 2 groups for improvements in pain, range of movement, or activities of daily living at any of the follow up intervals (3, 12, and 52wk). Patients treated with a collar took significantly longer to return to work after injury than those treated with early mobilization (34d vs 17d, P<.05). Overall, treatment with a soft cervical orthosis had no obvious benefit and was adversely associated with prolonged time out of
work. Similarly, Gennis et al found that collars do not influence the duration or degree of persistent pain. In 2001, the Philadelphia Panel for Evidence Based Clinical Practice Guidelines on Selected Rehabilitation Interventions for Neck Pain analyzed randomized controlled trials (RCTs) and observational studies, regarding treatments for neck pain. The panel used methods defined by the Cochrane Collaboration, using a systematic approach to literature search, study selection, data extraction, and data synthesis. The panel concluded that for patients with neck pain, therapeutic exercises including both proprioceptive and traditional therapeutic exercises were the only intervention with clinically important benefits. Benefits included pain relief, functional improvement, and improved patient global assessment compared with controls. There was a lack of evidence regarding whether to include or exclude the use of thermotherapy, massage, electromyographic biofeedback, mechanical cervical traction, ultrasound, electric stimulation, and combined rehabilitation interventions for acute and chronic neck pain.

3.3 Clinical Activity: To review the use of counterforce bracing (forearm straps), modalities, and exercise in the case of a secretary with lateral epicondylitis.

Counterforce bracing is frequently prescribed for patients with lateral epicondylitis. The brace is a nonelastic strap that is curved for better fit and support of the conical shape of the forearm. The orthosis decreases intrinsic muscular forces on sensitive or vulnerable areas such as the wrist extensor origins at the lateral epicondylye. Nirschl demonstrated improvement in wrist extension and grip strength with counterforce bracing. However, some other investigators have not found benefit from it. Wuori et al compared 50 patients who used 2 commercially available braces versus a placebo strap; that investigation found no significant difference in pain-free grip.

A nationwide occupational medicine network that cares for approximately 7% of U.S. workers’ compensation patients recently retrospectively studied the efficacy of splinting for epicondylitis. Among 4000 patients, those given splints had higher rates of limited-duty work, more medical visits, higher charges, and longer treatment durations than patients treated without splints. Logistic regression was used to minimize the confounding variable of whether more severe cases were more likely to have been splinted. Other limitations of this study included no standardization of the splinted side (forearm vs wrist), type of splinting used, or site of epicondylitis (medial vs lateral).

Svernlov and Adolfsson studied 38 patients with lateral epicondylitis who were randomly allocated to 2 treatment groups: a contract-relax stretching program and an isometric eccentric exercise program. Reduced pain and increased grip strength were seen more frequently in the eccentric exercise group (71%), than in the stretching group (39%) (P=.09). The eccentric training regimen seemed more effective at reducing symptoms in a majority of the patients, regardless of symptom duration, and was superior to conventional stretching.

In a systematic review and meta-analysis Bisset et al examined 76 RCTs on physical modalities for lateral epicondylalgia. They found a lack of evidence for long-term benefit of physical interventions in general. Evidence suggested that EC-SWT is not beneficial. Meanwhile, a Cochrane review of EC-SWT included 2 trials that yielded conflicting results.

Haahr and Andersen studied a cohort of 266 consecutive new lateral epicondylitis cases and found that after 1 year, 83% of cases showed overall improvement. Poor overall improvement was associated with employment in manual jobs, high level of physical strain at work, and a high level of baseline pain. Other studies had similar findings of poor prognosis among patients who reported neuropathic symptoms, keyboarding, or highly repetitive monotonous work. These findings may imply that physiatrists should place a greater focus on workplace modifications in order to reduce physical demands during recovery from lateral epicondylitis.

3.4 Clinical Activity: To review the use of bracing, modalities, and exercise in an assembly-line worker who has carpal tunnel syndrome.

A Cochrane review of nonsurgical interventions for carpal tunnel syndrome (CTS) found moderate evidence for short-term benefit from oral steroids; limited evidence for short-term benefit from splinting, ultrasound, yoga, and carpal bone mobilization; and no clear evidence for other nonsurgical treatments. Among these, oral steroids are a simple, inexpensive treatment, but side effects may be a concern.

Werner et al found that autoworkers with symptoms consistent with CTS benefited from a 6-week nocturnal splinting trial and the benefits were still evident at the 1-year follow-up. The splinted group’s hand discomfort improved regardless of degree of median nerve impairment, whereas the controls showed improvement only among subjects with normal median nerve function. Results suggest that a short course of nocturnal splinting may reduce wrist, hand, and/or finger discomfort among active workers with CTS symptoms.

Walker et al found that CTS patients who were instructed to wear neutral splints full-time had superior motor and sensory distal latency improvements compared to subjects instructed to wear splints only at night. Function and symptom severity were also improved. Walker concluded that neutral wrist splints are efficacious for CTS, particularly when worn as much as possible.

3.5 Educational Activity: To educate a workers’ compensation nurse case manager regarding the use of lumbosacral supports and directional-based exercises for a loading dock worker with low back pain.

A recent Cochrane back review systematically examined 5 randomized and 2 nonrandomized preventative trials, and 6 randomized therapeutic trials. Only 4 of 13 studies were of high quality. There was moderate evidence that lumbosacral supports are ineffective for primary low back pain (LBP) prevention. No evidence supported the use of these supports for secondary LBP prevention. There was limited evidence that lumbosacral supports are more effective than no treatment, but was unclear whether they are more effective than other treatments for LBP. An essential issue to address in future trials is compliance with wearing the device.

Petersen et al did an RCT with an 8-month follow-up period on 260 consecutive patients with LBP for longer than 8 weeks. One subgroup was treated with the McKenzie method and another subgroup was treated with intensive dynamic strengthening training. The outpatient treatment period for both groups was 8 weeks, followed by 2 months of self training at home. Petersen found no significant differences in pain reduction at any time and no significant differences in disability. Petersen concluded that the McKenzie method and intensive dynamic strength training were equally effective treatments for subacute or chronic LBP.

In a study of patient-specific exercises for LBP, 312 patients underwent a standardized mechanical assessment classifying them by their pain responses, specifically eliciting a
A prospective study of 15 patients with chronic Achilles' tendinosis whose exercises matched their directional preference and the "nondirectional" exercises withdrew within 2 weeks of the "opposite" exercises and one third of subjects treated with the "directional" relative to their preferred direction. Outcome measures included pain intensity, location, disability, medication use, degree of recovery, depression, and work interference. Results showed that a directional preference was elicited in 74% (230) of subjects. One third of the subjects treated with "nondirectional" exercises withdrew within 2 weeks because of no improvement or worsening symptoms. No subjects whose exercises matched their directional preference withdrew. Significantly greater improvements occurred in subjects performing exercises that matched their directional preference compared with both other treatment groups in every outcome \( (P<.001) \), including a 3-fold decrease in medication use. They concluded that standardized mechanical assessment identified a large subgroup of LBP patients with a directional preference. Regardless of subjects' direction of preference, exercise that matched their directional preference significantly and rapidly decreased pain and medication use and improved all other outcomes. Results suggest that patient-specific therapeutic exercises are more effective than nonspecific exercises. This may explain the previously reported lack of efficacy of exercise and physical therapy for LBP treatment.

### 3.6 Educational Activity: To critique the literature regarding modalities and exercise as treatment for Achilles' tendinosis in a 45-year-old tree trimmer.

A Cochrane review for Achilles' tendinosis found 9 trials \( (N=697) \) that met the inclusion criteria for review. They found weak evidence of benefit from oral NSAIDs, but weak evidence of no benefit for heel pads, topical laser therapy, heparin injection, or peritendinous steroid injections. Heat, cold, and ultrasonography are anecdotally beneficial for Achilles' tendinosis, but well-designed research supporting their use is somewhat sparse.

Eccentrically loading the Achilles' tendon via calf muscle training is a well-supported treatment for Achilles' tendinosis. It is favorably associated with reduction in abnormal Achilles' tendon thickness, decreased pain, restoration of normal tendon architecture, and decreased abnormal neovascularization of the tendon. A prospective study of 15 patients with chronic Achilles' tendinosis showed that 12 weeks of this therapy, using eccentric heavy loading, resulted in full recovery to preinjury functional levels, including running, while all patients in a control group had persistent pain and underwent surgical treatment.

### References


*Key Reference.*

Suggested Reading


This self-directed learning module outlines the use of interventional techniques in the treatment of neck pain with and without referred pain into the arm. It is part of the supplement on industrial rehabilitation medicine and acute musculoskeletal rehabilitation in the Self-Directed Physiatric Education Program for practitioners and trainees in physical medicine and rehabilitation. This article specifically focuses on interventions used to diagnose or treat the conditions commonly seen in patients with neck pain or referred pain into the upper limb. Techniques reviewed include the use of botulinum toxin injections in the treatment of myofascial pain, cervical zygapophyseal joint injections and radiofrequency neuroablation in the treatment of posterior column disorders, and epidural steroid injections in the treatment of cervical radicular and referred upper-limb pain.

Overall Article Objective: To give an overview of the current state of the art regarding diagnostic and nonsurgical invasive treatment procedures for neck pain with and without referred upper-limb pain.

Key Words: Botulinum toxins; Facet joint; Disk, herniated; Injections, epidural; Rehabilitation; Trigger points, myofascial. © 2007 by the American Academy of Physical Medicine and Rehabilitation

4.1 Educational Activity: To discuss the use of zygapophyseal injections and the use of botulinum toxin to treat a 45-year-old Department of Transportation worker with upper-thoracic and neck pain related to a “whiplash” injury for whom conservative treatment has failed.

UPPER-THORACIC, PERISCAPULAR, and neck pain from myofascial and/or whiplash-like injuries present a potentially vexing challenge to the treating clinician. Prompt and specific diagnosis coupled with early treatment generally results in better clinical outcomes. Much of the literature addressing myofascial pain describes trigger points in the discussion of the pathogenesis of these disorders. Trigger-point injections are a commonly used therapeutic option for this problem. Variations of these injections include dry needling, local anesthetic injections only, and combined local anesthetics with corticosteroid injections. These variations appear to have comparable efficacy. However, anecdotal experience and the available literature on trigger-point injections suggest that the benefits achieved may not be sustained if performed in isolation. In general, pain relief lasts 1 to 3 weeks when trigger-point injections are given as stand-alone treatment. Administering trigger-point injections as 1 component of a comprehensive rehabilitation program may yield better results.

The pathogenesis of trigger points remains unknown. Electromyographic investigation1 has suggested that mini-endplate potentials found routinely in trigger points may be used to characterize this phenomenon. These mini-endplate potentials, however, are not pathognomonic and are not consistently found. Others1 have examined oxygen tension in trigger points and note consistently lower oxygen levels in these muscle fibers. The mechanism that permits creation and maintenance of this lower level of muscle fiber oxygenation remains unclear.

Another hypothesis of trigger points’ pathogenesis contends that uncontrolled acetylcholine release results in chronic muscle fiber contraction. In an attempt to address this possible pathogenesis in particular, clinicians have turned to botulinum toxin types A and B to break this cycle. A recent focused review2 has described the use of these agents in cervical dystonias, spasticity, headaches, myofascial pain, and chronic low back pain. Botulinum toxin’s mechanism of action is the reversible blockade of acetylcholine release at the neuromuscular junction, generally lasting 3 to 4 months. Several small prospective studies have yielded promising results; however, the variety of dosing schedules and the number, frequency, and pattern of injections prove somewhat problematic in evaluating this research area.

Upper-thoracic, periscapular, and neck pain may emanate from the cervical zygapophyseal joints, commonly referred to as facet joints. The patterns of pain provocation mapped out in zygapophyseal-joint injections of symptomatic and asymptomatic people have significant overlap with the patterns seen in myofascial and whiplash-associated disorders.3,4 The prevalence of cervical zygapophyseal-joint pain has been estimated at greater than 25% in neck pain patients and, after whiplash-like injuries, the prevalence is increased to greater than 50%, most often affecting the C2-3 and C5-6 joints.5,6

On physical examination, neck pain reproduction with the Spurling maneuver without referred pain into the arm and with cervical extension or rotation, with reduced, painful range of motion, may suggest a cervical zygapophyseal-joint disorder. History and physical examination alone, however, have proven...
Pulsed radiofrequency neuroablation has been investigated as a treatment of zygapophyseal-joint pain partly in an effort to increase the safety of these procedures. This procedure allows lower levels of heating (42°C vs 80°C), and the subsequent risk of deafferentation pain is theoretically decreased. Animal models show cellular changes and an increase of immunoreactive cells with the pulsed techniques when compared with a sham procedure.12 Very few trials have looked critically at pulsed radiofrequency neuroablation. One suggested a positive response with greater than 50% relief sustained for 1 to 5 months in about 60% of patients.13 Further research is needed before this procedure can be widely recommended for clinical practice.

4.2 Educational Activity: The above Department of Transportation worker has persistent pain in the neck and posterior shoulder and now has arm pain despite botulinum toxin injections and facet injections. Discuss other nonsurgical interventions that may be considered, including their potential risks and benefits.

Upper-limb pain associated with spinal pathology is considered synonymous with cervical radiculopathy in some settings; however, referred pain into the upper limb may in fact emanate from other somatic sources (eg, cervical zygapophyseal joint, myofascial) and does not always represent irritation or injury of the nerve root. Although pain related to a clear-cut radiculopathy is generally perceived along the affected dermatome, pain patterns from other causes often overlap dermatomes, sclerotomes, or myotomes, as well as peripheral nerve innervation patterns. Patients may also suffer with referred pain from an irritated nerve root without having associated neurologic deficits. Some clinicians refer to this as radiculitis, but others use the term radiculitis to denote inflammatory involvement (whether associated with neurologic deficits or not). Unfortunately, there is no consensus in differentiating the etiology of radicular pain patterns in the upper limb. Hence, the literature evaluating upper-limb referred pain remains confounded by a heterogeneous patient population with likely multiple underlying etiologies contributing to radicular pain. The distinction between truly radicular and referred upper-limb pain is important. A patient who has referred pain that is not clearly the result of radiculopathy might not benefit from an epidural steroid injection (ESI); however, treatments including zygapophyseal-joint injections and botulinum toxin injections might be more helpful. Conversely, if a physician fails to recognize a clear-cut radicular pain pattern, an inappropriate zygapophyseal-joint injection or trigger-point injection might be performed. A recent study suggests that tender points can be associated with radiculopathies and/or with myofascial pain. Various shoulder pathologies may also create periscapular, shoulder, and upper-limb pain. The importance of a detailed history, thorough physical examination, and correlation with appropriate advance imaging studies to arrive at a specific diagnosis cannot be overstated.

In patients with a clear-cut cervical radiculopathy, direct application of corticosteroids to the site of inflammation is a well-recognized treatment option. This can be achieved by means of a cervical transforaminal or interlaminar ESI. No prospective, randomized controlled trials have compared these injection techniques. A handful of prospective studies14,15 evaluating cervical transforaminal ESI have shown promising re-
sults in patients with cervical radiculopathy for whom conservative treatment protocols had failed. One theoretic advantage of this injection is the low volume of injectate yielding a high concentration of corticosteroid directly to the site of inflammation. The cervical transforaminal ESI, in particular, is technically demanding because even small deviations in needle placement may have profound deleterious effects. It is important that the physician performing this procedure know the anatomy of the cervical spine, be familiar with the use of live fluoroscopic images, and be well aware of the potential injection complications. Transforaminal ESI complications include infection, nerve root injury, vertebral artery dissection, paralysis, and stroke.\cite{5,6} It has been postulated that particulate steroid deposition into an artery or arterial watershed zone has resulted in spinal cord and brain infarction, culminating in tetraplegia and death in some patients.\cite{17-22} There is also a risk of a high spinal block with respiratory compromise with inadvertent subarachnoid injection of anesthetic.

Compared with transforaminal ESI, the interlaminar ESI theoretically may have a disadvantage of less availability of corticosteroid anteriorly at the site of inflammation. Cervical interlaminar ESIs may present less risk of inadvertent arterial particulate steroid deposition but are not without complications.\cite{23,24} Risks of interlaminar ESI include delayed injury to the spinal cord, which may occur because of mass effect from either a hematoma or epidural abscess.\cite{53} One may also sustain direct spinal cord injury as a result of needle puncture of the spinal cord itself. High spinal block may occur with injection of local anesthetic into the subarachnoid space, and for this reason interlaminar ESIs with local anesthetic are typically performed at C6-7 or below. To minimize complications, interlaminar ESI should not be performed at stenotic levels.

There exists a relative paucity of literature to support the routine use of cervical ESI in the treatment of cervical radicular pain. To our knowledge, no study exists to date directly comparing the efficacy or safety of transforaminal ESI versus interlaminar ESI, and thus this choice rests with the injecting physician. The current debate as to which of the 2 injections may be more advantageous revolves more around the perceived safety of each injection and the potential complication of serious central nervous system (CNS) injury. Several studies have addressed the possible complications in retrospective analyses. In 1 study,\cite{23} the overall complication rate from cervical interlaminar ESI was 16.8%. Most of these complications were characterized as minor and resolved within 24 hours. However, there was 1 (0.3%) serious complication of a dural puncture.\cite{53}

A 2003 study of cervical transforaminal ESI found that 19.4% of patients had intravascular injection on installation of contrast medium under real time fluoroscopy.\cite{18} These intravascular injections did not always correlate with blood in the hub of the needle on withdrawal of the syringe.

There have been several case reports of CNS complications resulting from cervical transforaminal ESI.\cite{19,20,22,25} Magnetic resonance imaging studies after these complications have shown injury or infarction to either the spinal cord or the brainstem. Only 1 study,\cite{27} which used computed tomography guidance during the procedure, showed evidence of arterial needle placement. In this study, the needle was placed in the vertebral artery before the injection.\cite{25} The other studies did not have fluoroscopic guidance or image documentation of needle placement listed in their reports. The available literature and hypotheses of CNS injuries suggests, at a minimum, that cervical transforaminal ESI procedures should always be performed with fluoroscopic guidance with live fluoroscopic images during contrast installation to minimize the risk of inadvertent intravascular injection. Some clinicians have suggested a further safeguard of digital subtraction analysis of the fluoroscopic images to further decrease this risk.

In summary, cervical ESI remains a treatment option for cervical radicular pain; however, little literature exists to support the clinical efficacy of these injections. It is important to recognize and inform the patient of the potentially disabling and life-threatening CNS complications that may occur with these injections. Appropriate use of fluoroscopic guidance in the performance of these injections may reduce, but certainly do not eliminate, the risks associated with these injections.

References


*Key reference.
Industrial Medicine and Acute Musculoskeletal Rehabilitation. 5. Interventional Procedures for Work-Related Lumbar Spine Conditions

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This chapter emphasizes the importance of establishing a differential diagnosis for low back pain (LBP) with and without referred lower-limb pain and outlines potential interventional treatments appropriate for each diagnosis. It is part of the study guide on industrial rehabilitation and acute musculoskeletal rehabilitation in the Self-Directed Physiatric Education Program for practitioners and trainers in physical medicine and rehabilitation. The article specifically focuses on the various interventions used to diagnose or treat those conditions commonly seen in patients with work-related LBP or referred pain in the lower limb. Current criterion treatments for lumbar disk pain, including surgical options, are reviewed.

Overall Article Objective: To give an overview of the current state of diagnosis and treatment options for low back pain with or without referred leg pain focusing on interventional procedures.

Key Words: Arthroplasty; Biochemical markers; Disk, herniated; Facet joint; Injections, epidural; Low back pain; Lumbar region; Rehabilitation; Sacroiliac joint.

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5.1 Clinical Activity: To discuss the differential diagnosis and procedural management of a 40-year-old dockworker with low back pain and leg pain for whom conservative treatment has failed.

To establish an appropriate treatment plan for an injured worker with low back pain (LBP) and referred leg pain, it is imperative to develop a proper differential diagnosis. Clearly, this process is guided by the history, physical examination and laboratory and imaging studies. The clinician must evaluate and rule out systemic diseases including cancer and rheumatologic disease, which may have been exacerbated by activity at work or home. Obtaining a detailed medical history, review of systems (including constitutional symptoms), and psychosocial background are critical in determining an appropriate differential diagnosis. After systemic diseases have been ruled out, the differential diagnosis then dictates the treatment algorithm and appropriate diagnostic and therapeutic interventions.

In this patient with both LBP and referred leg symptoms, the differential diagnosis should include but not be limited to lumbar disk herniation, sacroiliac joint pain, zygapophysial joint pain, diskogenic pain, piriformis syndrome, spondylolisthesis, lumbar-sacralplexopathy, and in today’s aging workforce, exacerbation of lumbar spinal stenosis. To determine which spinal intervention is most appropriate in these cases, one must consider the goal of the intervention. Some spinal interventions can be useful diagnostically, whereas others are therapeutic. For persistent pain presumed to emanate from the zygapophysial joint or the sacroiliac joint, intra-articular injections are appropriate treatment options.

The prevalence of zygapophysial joint-mediated pain, commonly referred to as a facet syndrome, varies between 15% and 40% of chronic LBP patients. Intra-articular zygapophysialjoint injections can be used therapeutically and may also be diagnostic if pain relief is achieved. For a more purely diagnostic approach, performing anesthetic blocks of the medial branches of the dorsal rami supplying the zygapophysial joint in question may help ascertain the exact level of involvement and may also help correlate the patient’s history, physical examination, and imaging study results. In the double-block approach, injections targeting the medial branches of the dorsal rami, commonly referred to as medial branch blocks, are performed at 2 separate occasions. Different anesthetics with different durations of action are administered at the 2 occasions. Pain relief lasting at least the minimum length of effectiveness of the local anesthetic constitutes a positive response. This technique is considered superior to single anesthetic blocks in the diagnosis of zygapophysial joint-mediated pain and is the criterion standard for making the diagnosis. Based on a beneficial response to these injections, one might consider radiofrequency ablation of the appropriate medial branches.

The prevalence of sacroiliac joint pain ranges from 18% to 30% of chronic LBP patients. Intra-articular sacroiliac joint corticosteroid injections remain the only interventional option proven useful in this condition. However, these injections have been controversial. Diagnostic injections using the comparative local anesthetic block approach may also help confirm the role of the sacroiliac joint as a pain generator.

There are 3 approaches for performing epidural injections: caudal, interlaminar, and transforminal. Lumbar spinal stenosis, lumbar disk herniation, and lumbar diskogenic pain may all present as LBP with or without a radicular component and are...
common diagnoses for which an epidural steroid injection (ESI) is routinely performed. To date, prospective, blinded, and controlled scientific studies supporting the efficacy of lumbar ESIs for the treatment of these disorders have been lacking. Certain patient populations warrant specific mention. For patients with lumbar stenosis, interlaminar ESI should be performed below the level of stenosis to minimize the risk of intrathecal injection. Interlaminar ESI may not be helpful in the treatment of neuroforaminal stenosis, whereas a transforaminal ESI may be more appropriate.

5.2 Educational Activity: To discuss the biomechanical changes and treatment recommendations for this 40-year-old dockworker diagnosed with a lumbar disk herniation.

Various treatment options exist for lumbar herniated nucleus pulposus (HNP), including medications, therapies, injections, surgical discectomy, and fusion. Although there have been multiple treatments proposed for a lumbar HNP, the natural history is favorable for spontaneous improvement. In a controlled, matched cohort of patients with lumbar HNP, the group treated conservatively had similar pain improvement at the 10-year follow-up. Further evaluation showed that the surgical group had a slightly better result for complete relief of pain than did the conservatively treated patients.²⁵ No specific treatment has had a clear advantage over another. After an appropriate trial of more conservative treatments including medications, physical therapy, and activity modifications (but not bed rest), one may consider interventional procedures if pain persists. To understand the rationale behind these treatments, one should have a basic understanding of the biochemistry and pathophysiology associated with a lumbar HNP.

Radicular pain as a result of lumbar HNP has been described.⁶ Although initial studies focused on mass effect and pressure on the nerve root created by HNP, more recent research⁷-¹³ has focused on the subsequent inflammatory milieu. Studies⁷-¹⁴ showed that neural compression can cause painless weakness, and many studies¹⁵-¹⁷ have confirmed that the nucleus pulposus contains a multitude of inflammatory mediators. The combination of mechanical compression of the nerve root and presence of inflammatory mediators seems to be more than just additive.⁸ Researchers have searched for the inflammatory markers associated with a lumbar HNP. Phospholipase A₂ was found within the extravasated nucleus pulposus,⁸ validating the theory that nuclear material can cause inflammation. Other inflammatory markers have been associated with the nucleus pulposus including nitric oxide, interleukin-6, prostaglandin E₂, and matrix metalloproteinases. These markers may also be tied to increases in interleukin-1.⁹,¹⁰ The isolation of tumor necrosis factor alpha (TNF-α) has been inconsistent in the setting of disk herniation. The presence of both leukotriene B₄ and thromboxane B₂ has also been associated with the HNP.¹¹

In various animal studies of lumbar HNP, changes in nerve function and structure, cellular matrix, and inflammatory markers have been observed.⁷-¹⁷ These studies examined both experimentally induced disk disruption in vivo and exposure to nucleus pulposus materials in tissue culture. Leukotaxis and increased vascular permeability have been noted in vitro as a result of exposure to nucleus pulposus material.¹² Different researchers have noted an increase in macrophages and a possible increase in mast cells in the inflammatory milieu.¹³ Of note, in nerve tissue surrounded by nucleus pulposus, myelin changes occur in the local area of exposure. Other changes include an increase in Schwann cell cytoplasmic and intracellular edema.¹⁴ Decreases in nerve conduction velocity (NCV) and amplitude of the compound muscle action potential are also seen.⁷ The presence of TNF-α has been correlated with a decrease in NCV in nerve roots that have been exposed to nucleus pulposus. One animal study¹⁶ has shown that application of the nucleus pulposus decreases the blood flow to the dorsal root ganglion, with increased edema of the dorsal root ganglion and interneural space. This may be a result of increased vascular permeability mentioned earlier. Other researchers have found a direct relation between blood flow to the nerve and NCV. There is a time lag between the exposure and the measured decrease in NCV.¹⁷

In accordance with the described pathophysiology, corticosteroids and anesthetics have been used for injection into the epidural space in the setting of lumbar HNP. Studies have shown that corticosteroids may have more than anti-inflammatory effects. Corticosteroids may have some anesthetic affects on small unmyelinated C fibers in irritated neural tissue.¹⁸ In porcine models, high doses of methylprednisolone given early after an exposure to nucleus pulposus material showed a protective effect on NCV in the exposed nerves.¹⁹ Lidocaine has also shown a mild protective effect in nerves exposed to nucleus pulposus when evaluating the NCV. It seems to have its greatest effect when administered early. Studies have also suggested that lidocaine may exhibit anti-inflammatory properties such as decreasing phagocytosis, polymorphonuclear neutrophil lysozyme enzyme release, and superoxide anion production.¹⁸,²⁰,²¹

ESIs are used to deliver anti-inflammatory medications and local anesthetics in concentrated amounts to the epidural space surrounding areas of presumed pathology and inflammation. Caudal and interlaminar approaches were the initial routes of administration of medication in epidural injections pioneered before the advent of fluoroscopy. The advantage of these approaches is easy access to the epidural space. Without fluoroscopy, however, no approach allowed confirmation of successful deposition of medication into the epidural space. Fluoroscopic studies of interlaminar injections performed without imaging (blind) have shown that, even in experienced hands, nearly one third of blind injections do not truly access the epidural space.²² The efficacy of blind interlaminar injections has subsequently been questioned. Lack of fluoroscopic confirmation of epidural flow on injection of contrast medium also likely increases the risk of dural puncture. Fluoroscopically guided ESI with contrast confirmation improves the accuracy of—by supposition—the efficacy of these injections. Retrospective and limited prospective trials have shown generally short-term pain relief in heterogeneous patient populations with questionable long-term benefits.²³ The lack of well-controlled, prospective trials assessing the efficacy of interlaminar ESI, with or without fluoroscopic guidance, leaves the true efficacy of these injections open to debate. Further, this literature rarely includes functional outcome measures beyond pain relief.

Compared with interlaminar ESI, transforaminal ESI has a theoretic advantage of delivering medication to the anterior epidural space where the nerve root traverses. By necessity, these injections are performed with fluoroscopic guidance and, ideally, with contrast medium to confirm needle placement within the epidural space and to prevent injection inadvertently into vascular structures. Several studies²⁴-²⁶ evaluated the effectiveness of these injections for a lumbar HNP. In particular, recent prospective, controlled studies show that transforaminal ESI may help patients avoid surgery and reduce pain in the setting of lumbar HNP.²⁴,²⁵

Given these studies and the evolving evidence regarding the biomolecular effects and pathophysiology of lumbar HNP, it is
reasonable to recommend ESIs performed with fluoroscopic guidance and contrast confirmation as appropriate treatments for HNP. The literature suggests potential advantages with a transforaminal approach; however, currently no well-controlled comparative study evaluates the various epidural approaches for delivering medications.

5.3 Educational Activity: To describe, in a 35-year-old home improvement warehouse worker with predominantly LBP, the use of interventional procedures in the diagnosis and treatment of posterior element pain.

The posterior elements of the lumbar spine include the zygapophyseal joints and the sacroiliac joints. The use of interventional techniques to confirm the diagnosis of zygapophyseal joint—or sacroiliac joint—mediated pain and interventional treatment options for these conditions are outlined as follows.

Revel et al described a set of criteria increasing the likelihood of a diagnosis of zygapophyseal-joint pain in the lumbar spine, including age greater than 65 years; pain well relieved by recumbency; and no pain exacerbation with coughing, sneezing, forward flexion, lumbar extension, rising from a flexed lumbar spine, or extension combined with rotation. Other investigators have challenged these criteria, claiming that these screening tests yield a low sensitivity and a high specificity for the diagnosis of zygapophyseal-joint pain. A single physical examination maneuver or combination of maneuvers correctly identifying the zygapophyseal joints as the primary source of pain remains to be elucidated. Other methods are often used to confirm the clinical suspicion of zygapophyseal-joint pain. The zygapophyseal-joint pain referral patterns, based on provocative injections, may include the lower back and ipsilateral hip. Clinicians often use controlled comparative local anesthetic blocks. These are a more objective way to confirm the diagnosis of zygapophyseal-joint pain. The dual innervation of the lumbar zygapophyseal joints (fig 1) must be considered when contemplating medial branch blocks.

Although generally considered diagnostic, medial branch blocks may also be therapeutic, with long-term pain relief achieved in some patients. Therapeutic benefit may result from disruption of the central feedback loop that forms in chronic pain states or by inadvertent neurotomy of the medial branch by the needle tip. Adding steroid to the local anesthetic in these injections may potentiate the anesthetic blockade effects, but no literature supports its use.

The interventional treatment options commonly used to alleviate zygapophyseal-joint pain include intra-articular injections and radiofrequency ablation of the medial branches. Intra-articular zygapophyseal-joint injections with corticosteroids and local anesthetic have been validated as an effective treatment for zygapophyseal-joint pain. Drawbacks of zygapophyseal-joint intra-articular corticosteroid injections include limited long-term efficacy. Because of potential deleterious effects of steroids on the synovial lining and ligamentous supports for these joints, as well as potential local osteoporotic effects, clinicians should limit the number of injections a patient receives.

Several studies have confirmed the efficacy and long-term pain relief of radiofrequency ablation of neural structures. In this procedure, the nerve and tissues surrounding the electrode are heated to 80°C, thus causing destruction of the medial branch of the dorsal ramus itself. When it is administered after diagnostic, comparative, local-anesthetic, medial branch blocks, this therapy relieves pain in up to 85% of these patients, providing long-term (median, 263d) relief sometimes lasting longer than 1 year. Workers’ compensation patient outcomes for this therapy rival those of the general population. The nerve typically regenerates in 90 days. If the pain returns, a repeat of the radiofrequency ablation generally affords the same long-term relief obtained by the initial treatment. Although the medial branch also innervates a small portion of the lumbar multifidus muscle, no functional weakness has been associated with this procedure. One study validated good relief of pain with radiofrequency neuroablation after a single anesthetic block; however, the efficacy is diminished compared with the use of diagnostic, controlled, comparative, local anesthetic medical branch blocks.

The sacroiliac joint is a true diarthrodial joint containing approximately 2 to 3mL of synovial fluid. Joint pain may result from trauma, cumulative shear forces (eg, lifting, running, altered gait mechanics), a rheumatologic process such as ankylosing spondylitis or pregnancy, or it may be idiopathic. Physical examination maneuvers, particularly in isolation, have limited diagnostic utility. Use of combination maneuvers may increase diagnostic yield. Pain maps of the sacroiliac joint show significant overlap with those generated for the lower-lumbar zygapophyseal joints and pain patterns from radiculopathies or diskogenic pain but do not typically include pain above the L5 level. One study suggests pain may refer distally to the feet. The double-block procedure has become the diagnostic standard.

Intra-articular injection of local anesthetic and corticosteroid under fluoroscopic guidance is a common interventional treat-
ment for sacroiliac joint pain. Given the technical difficulty of the injection even under fluoroscopic guidance, successful injection of the sacroiliac joint occurs rarely when performed blindly. Injections for sacroiliitis due to anklyosing spondylitis generally last 6 months or less. Patients who had a single anesthetic block that provided pain relief responded well to intra-articular corticosteroid injections. These injections afforded long-term relief of up to 12 months, with patients frequently requiring multiple injections (average, 2.1) to achieve results. Intra-articular injections of the sacroiliac joint are best used as part of an integrated rehabilitation program. Newer studies have applied the zygapophyseal-joint double block procedure to select patients for radiofrequency neuroablation to denervate the sacroiliac joint. This treatment may only address the extra-articular pain sensations and not the intra-articular pain associated with sacroiliac joint disorders. A complex and variable innervation of the sacroiliac joint exists compared with that of the zygopophysseal joints. Given this variability and the limited anatomic landmarks for the nerves innervating the sacroiliac joint, consistent denervation of the joint is difficult to achieve. Although radiofrequency neuroablation to treat sacroiliac joint pain had favorable results in a recent, small cohort study, further research is needed.

5.4 Educational Activity: To discuss further diagnostic investigation and treatment for the above 40-year-old dockworker with disk degeneration, LBP, and referred leg pain for whom conservative management has failed.

The diagnosis of true diskogenic pain emanating from the intervertebral disk is difficult to definitively establish. In patients with chronic LBP, the prevalence of diskogenic pain is estimated at 40%. In an attempt to establish the diagnosis of diskogenic pain, researchers have evaluated several tests. A high-intensity zone on magnetic resonance imaging within the intervertebral disk is presumed to reflect a potentially painful annular tear. These tears may be partial-thickness or complete tears without frank herniation. Because of morphologic changes, increased nociception may occur in a disk with an annular tear. Also, leakage of inflammatory mediators present in the nucleus pulposus may increase nociception. This phenomenon may result from an ingrowth of sinuvertebral nerve fibers as the body attempts to heal the tear. However, the high-intensity zone exists in both symptomatic and asymptomatic subjects, thus clouding its role in the diagnosis of diskogenic pain.

Diskography has been promoted as the de facto criterion standard in the evaluation of diskogenic pain in the absence of a true standard. Diskography is typically performed at 3 levels in the lumbar spine to provide at least 1 theoretic control, or nonpainful, disk level. The procedure is painful, and risks include nerve injury, diskitis, and epidural abscess. Its routine use should be avoided. However, it may have a role in patients with chronic back and/or referred leg pain to spare nonpainful adjacent disks from an intervention, to narrow or establish treatment options, and to serve as yet another correlate to imaging studies. Diskography has limited value for predicting success with surgical fusion. Several researchers have noted abnormal results with diskography in asymptomatic patients. Other chronic pain states such as fibromyalgia may affect diskography interpretation.

New interventions, including intradiskal electrothermal annuloplasty, nucleoplasty, percutaneous disk decompression, intradiskal restorative injections, and disk replacement have fueled the diskography debate. Because the validity of diskography in diagnosing true diskogenic pain has been called into question, researchers have focused on isolating variables that may create false positive studies. A recent study with manometric pressure measurements suggests that asymptomatic patients with painful diskograms report only a lower intensity of pain occurring only at very high pressures. More recent studies suggest that painful disks at low pressures and with smaller injectate volumes on diskography more likely identify “true diskogenic” pain generators. Pressure manometry may also improve interexaminer reliability.

Intradiskal electrothermal annuloplasty was developed based on the theory that annular tear is a cause for diskogenic pain. It has potential advantages over fusion in that it is less invasive, less costly, and it preserves motion of the lumbar segment.

There are 3 proposed mechanisms by which this electrothermal approach may reduce pain and treat the annular tear. Thermal injury applied to the annulus via the heating element catheter may produce collagen remodeling with potential fibrous contraction of the tear. Some researchers question whether the target temperature of 90°C would result in collagen remodeling. A second proposed mechanism is thermal ablation of nerve endings in the outer third of the annulus fibrosus. The disk receives its innervation from the sinuvertebral nerves, which contain A-delta and C fibers. These nerve fibers have been shown to penetrate into the annulus of degenerative disks. This suggests that thermal ablation of these nerves should achieve immediate relief of pain emanating from the disk itself. Although some patients experience immediate relief after intradiskal electrothermal annuloplasty, it may take up to several weeks or longer for the full effects to be realized. The third mechanism is the proposed shrinkage of the nucleus pulposus by the thermal energy.

The indications for intradiskal electrothermal annuloplasty include axial pain with sitting intolerance, lasting longer than 6 months with or without referred lower-limb pain, 50% preservation of the height of the disk when compared with normal disks, and an absence of significant spinal stenosis. Provocation diskography with follow-up computed tomography before treatment may further define the anatomy and may confirm the presence of an annular tear without significant disk protrusion. The symptomatic disk, when provoked, should produce concordant pain at low pressures with control disks exhibiting discordant or no pain.

Contraindications for intradiskal electrothermal annuloplasty may include bleeding diatheses, previous surgery at the potential site of intervention, disk protrusion beyond the posterior longitudinal ligament in proximity to the nerve root origins, and stenosis at the level of interest. Smoking and obesity represent risk factors for a poor outcome after this therapy.

Complication rates are estimated at between 0.7% and 16% and are generally self-limited. There have been several reports of avascular necrosis of the vertebral body after intradiskal electrothermal annuloplasty. The mechanism of this injury is unknown. A report of a frank disk herniation also exists, as does a report of cauda equina syndrome after it. The cauda equina syndrome was attributed to inadvertent catheter placement and heating in the spinal canal. Although infection and thermal injury of the nerve root origins are theoretic risks, there have been no cases reported to date.

In prospective case series of intradiskal electrothermal annuloplasty for chronic LBP, 50% to 81% of patients had good or excellent results. The variable outcomes may result from the use of different outcome scales and inconsistent definitions of “good” or “excellent” results. Versus a sham treatment, the electrothermally treated patients in a randomized placebo controlled trial had a statistically significant decrease in pain,
although 50% of the annuloplasty group had no relief. Based on the Oswestry Disability Index, only 13.5% of the treatment group received more than 75% pain relief. Further analysis suggests greater benefit from intradiskal electrothermal annuloplasty for patients with either very high pain scores or lower levels of function before treatment. Patients with more moderate or mild symptoms benefit less. Results in all favorable studies suggest better outcomes with single as opposed to multiple disk levels of treatment. A subsequent study reported no benefit from intradiskal electrothermal annuloplasty when compared with placebo.

Percutaneous nucleoplasty uses radiofrequency energy to break down molecular structures in a nucleus pulposus. Cadaver studies suggest that nucleoplasty may decrease disk pressures and allow the disk to shrink, thus relieving intradiskal and intraspinal pressure.

Indications for nucleoplasty may include axial back pain with or without referred leg pain, 50% preservation of disk height, and imaging confirmation of disk protrusion. Contraindications include infection and bleeding diathesis. This procedure is approved for no more than 2 disk levels per treatment. Only a few prospective cohort studies have investigated nucleoplasty. These studies have shown that up to 80% of the patients undergoing nucleoplasty have good to excellent relief of their symptoms. Another prospective study evaluated patients who underwent nucleoplasty with or without concurrent intradiskal electrothermal annuloplasty. The patients were included if they had referred leg pain with or without back pain. Only 1 in 16 patients had greater than 50% relief. Some patients who had not been using opioid pain medications began such treatment after nucleoplasty. The researchers suggested that different patient selection criteria might have explained the poor outcome in this study. There is a paucity of literature to support nucleoplasty, with numerous critics questioning whether denaturation of central nucleus pulposus material affects in vivo disk pressure or the inflammatory milieu in the outer annulus and spinal canal.

Intradiskal injections of steroids were performed previously and recently reexamined, but no studies to date have shown a positive treatment effect. Intradiskal injection of a mixture of glucosamine, chondroitin sulfate, hypertonic dextrose, and dimethylsulfoxide resulted in improved pain based on the Roland-Morris Disability Questionnaire and visual analog pain rating scales.

Limited study of percutaneous lumbar disk decompression suggests that patients for whom conservative management has failed, have 50% disk height preserved, and experience radicular pain associated with a contained herniation less than or equal to 6mm may benefit. Disk material is removed through the introducer needle after a drill-like bit is threaded through the needle, removing up to 1 to 2mL of nuclear material. The best study to date showed a 65% decrease in pain. However, this procedure is relatively new and needs further investigation.

Based on research that suggested a role for TNF-α in the pathogenesis of pain from an HNP, intravenous infliximab (a monoclonal antibody inhibiting TNF-α) has been used to treat HNP. An initial open label study of a small number of patients with sciatica from HNP had promising results; however, the results of a randomized controlled study did not corroborate the initial study findings.

Disk arthroplasty (complete replacement of the disk) was first approved in the United States in 2004. The first-ever disk replacement was performed in Europe in 1984. Disk arthroplasty theoretically preserves physiologic and functional motion of the spinal segment. Since its inception, over 100 prosthetic disk types have been designed and manufactured; however, only 10 have been implanted into human subjects to date. In general, disk replacements are composed of a sliding polyethylene core affixed to the vertebra bodies by 2 metal implants. Some designs have a metallic core. Outcomes of initial studies suggest that lumbar disk arthroplasty was at least as efficacious as lumbar fusion. Approximately 80% of the patients reported excellent results in these studies. Some have correlated this favorable clinical outcome with preservation of motion of the spinal segment.

The clinical indications for lumbar disk arthroplasty are fairly broad and include back pain, with or without leg pain, isolated to no more than 2 symptomatic disks. Provocation diskography may help determine the appropriate disk levels for treatment but has the aforementioned diagnostic limitations. Several factors predict possible failure of this treatment, including osteoporosis, structural deformities, and pain localized to the zygapophysial joints. Reported complications are uncommon, with rates ranging from 1.5% to 4%. Most complications are device related, including improper sizing, seating, and location of the prosthesis. Long-term clinical data are currently lacking, with important questions remaining regarding patient selection, in vivo durability, and revision options.

References

This self-directed study module focuses on the use of corticosteroids and other injections in the treatment of lateral epicondylitis, de Quervain’s tenosynovitis, carpal tunnel syndrome, Achilles’ tendinitis, and plantar fasciitis. It is part of the study guide on industrial rehabilitation medicine and acute musculoskeletal rehabilitation in the Self-Directed Physiatric Education Program for practitioners and trainees in physical medicine and rehabilitation.

Overall Article Objective: To review the medical literature to help clinicians make treatment decisions regarding corticosteroid and other injections in the upper and lower limbs in injured workers.

Key Words: Achilles tendon; Carpal tunnel syndrome; Corticosteroids; Injections; Fasciitis; Rehabilitation; Tendinitis; Tennis elbow; Tenosynovitis; Tendon injuries.

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6.1 Clinical Activity: To analyze the risks and benefits of corticosteroid injections for a 40-year-old right-handed carpenter with lateral epicondylitis.

A RECENT LITERATURE REVIEW1 of complications of corticosteroid injections for musculoskeletal conditions including lateral epicondylitis concluded that, among dozens of randomized controlled trials (RCTs), only minor complications were reported. Overall, approximately 15% of patients reported side effects, with 10% reporting postinjection pain (the most common side effect), about 2% reporting skin atrophy, and less than 1% reporting either skin depigmentation, localized erythema with warmth, or facial flushing.

Postinjection exacerbations seem to be of short duration. A recent RCT2 of patients with lateral epicondylitis compared 3 treatments: corticosteroid injection, naproxen, and oral placebo. The study showed that although 62% of patients may initially have increased pain after the injection, by day 4 their pain scores were significantly lower and they were less likely to be taking acetaminophen than patients who received either naproxen or oral placebo. The researchers concluded that patients would perceive the “modest” increased pain postinjection “to be acceptable, given the clear benefits of localized corticosteroid injection treatment over the following few weeks.”

Although serious complications were not reported within the recently reviewed RCTs, published case reports have described concerning side effects such as tendon rupture, including rupture at the lateral epicondyle tendon origin.3 However, the literature review1 concluded that the case reports could not prove that corticosteroid injections actually cause tendon rupture, because the underlying tendon pathology that prompts injection may also be the underlying cause (or at least a contributing factor) to subsequent tendon rupture. Even the case reports of tendon rupture after multiple injections at a particular site could possibly reflect cases with more severe preinjection pathology (and thus the failure to respond adequately to a single injection). It still may be prudent, however, to consider multiple injections as a source of increased risk for rupture. Overall, the literature does not provide clear evidence to confirm what constitutes a safe maximal number of corticosteroid injections, although various investigators have opined on this.

Different corticosteroid agents have had varying impacts on posttreatment tendon strength. Mechanical structural defects and tendon rupture occurred more commonly in tendons treated with triamcinolone acetonide than in those treated with methylprednisolone, betamethasone, or hydrocortisone.4

A recent literature review5 concluded that these injections were associated with statistically significant and clinically relevant improvements in pain, global improvement, and grip strength compared with placebo, local anesthetic injections (without steroid), and noninjection treatments. In fact, among the published studies that met the criteria for that review, almost all studies concluded that corticosteroid injections provided more favorable outcomes for all measured parameters (eg, pain, grip strength) in the short term (<6wk). Longer-term benefit (>6wk) was more difficult to assess because of variable study designs and the lack of high-quality studies. Thus, the researchers concluded that the current literature does not provide a basis for firm conclusions regarding benefit beyond 6 weeks.

In the context of workers’ compensation injuries, the initial faster onset of improvement clearly provided by the injections may presumably translate into quicker return to work and/or better tolerance for work-related activities during those initial weeks.
Thus, the literature indicates that corticosteroid injections are very effective in the treatment of lateral epicondylitis (particularly during the initial months after injection) and that serious complications of injections are uncommon.

Substances other than corticosteroids have also been injected to treat lateral epicondylitis. There are a few published studies on the potential role of botulinum toxin in treating chronic lateral epicondylitis, with mixed results. There is a single, modest-sized study with impressive outcomes after autologous blood injection at the lateral epicondylic region. Of 28 patients with refractory lateral epicondylitis despite various nonsurgical treatments who were injected with 2mL of autologous blood at the lateral elbow, 22 (79%) had complete pain relief even with strenuous activity. The researchers speculated that the local injection of blood may induce inflammatory changes that improve recovery, although overall the mechanism remains unclear. Further research is needed before any definitive consensus can be reached on these treatment approaches.

6.2 Clinical Activity: To assess the advantages and disadvantages of administering focal corticosteroid injections in a right-handed male secretary with de Quervain’s tenosynovitis at the right wrist. His symptoms failed to resolve after ergonomic modifications of his computer workstation, use of nonsteroidal anti-inflammatory drugs, and use of a thumb spica splint.

A recently published, pooled, quantitative evaluation assessed the medical literature for treatment outcomes for de Quervain’s tenosynovitis. The researchers excluded from review any articles that did not meet their diagnostic criteria (documentation of pain at the radial wrist, tenderness at the first dorsal wrist extensor compartment, a positive Finkelstein test) and also excluded articles that did not re-evaluate these same 3 findings after treatment. Only 7 studies met the criteria to be included in this review. These 7 studies included 459 wrists subjected to 1 or several therapeutic modalities. The results were pooled for analysis. The most common intervention was corticosteroid injection alone. Analysis showed that a symptomatic cure was achieved in 83% of the 226 wrists that received injection alone, 61% of the 101 wrists that received injection and splint immobilization, and 14% of the 76 wrists that received splinting alone. Conversely, no such symptomatic cure was achieved in any of the 17 wrists treated with rest alone or in any of the 39 wrists treated with nonsteroidal anti-inflammatory drugs (NSAIDs) alone. Thus, the pooled results seem to indicate that corticosteroid injection alone (without splinting or other treatment) is by far the most effective. The investigators concluded that such injections are a simple, cost-effective, and definitive treatment.

The complication rate of corticosteroid injection to treat de Quervain’s tenosynovitis is very low. A literature review by Richie and Briner of 327 wrists that received 1 or multiple injections (either alone or in combination with splinting) reported no cases of tendon rupture. The reported side effects of injections were 18 cases of skin color changes (eg, hypopigmentation), 16 cases of subcutaneous fat atrophy (all of which were among those same 18 cases of skin color changes), 5 cases of flare, 2 nontender nodules, and a single case of superficial thrombophlebitis. Because that article was not explicit on the total number of injections given among the subset of patients receiving multiple injections, it is unfortunately not possible to calculate the exact complication rate per injection. However, there were at least 357 injections, and thus the calculated complication rate would be, at most, 5% for skin color changes, 1.4% for flare, 0.6% for nontender nodules, and 0.3% for superficial thrombophlebitis. The literature contains only 1 case report of corticosteroid injection into a first dorsal compartment causing persistent cheiralgia paresthetica (painful dysesthesias in the distribution of the superficial radial nerve).

Thus, overall, the literature strongly supports the use of first dorsal compartment corticosteroid injection for de Quervain’s tenosynovitis, with very favorable outcomes (ie, most patients achieved a symptomatic cure) and very low rates of complications.

6.3 Clinical Activity: To discuss the use of corticosteroid injection into the carpal tunnel for an assembly worker with carpal tunnel syndrome in whom the use of a wrist splint has given inadequate relief.

Injecting corticosteroids into the carpal tunnel can be done by injecting just ulnar to the palmaris longus tendon at the wrist into the ulnar bursa (tenosynovium surrounding the deep and superficial flexors of digits 2–5).

There are some discrepancies in the medical literature about the effectiveness of corticosteroid injection to treat carpal tunnel syndrome (CTS). A recent meta-analysis of RCTs concluded that compared with placebo injection, local injection of corticosteroids provided symptomatic improvement of CTS 1 month after injection. Further, the same meta-analysis concluded that compared with oral steroids, local injection of corticosteroids provides significantly greater clinical improvement up to 3 months after treatment.

Even more recently, a 1-year, prospective RCT in 163 wrists with CTS compared surgical decompression versus local injection of corticosteroids into the carpal tunnel. All clinical diagnoses of CTS were electrodiagnostically confirmed. Subjects with clinically visible thenar atrophy were excluded. The study concluded that over the short term (3mo), local injection of corticosteroids is better than surgical decompression for the symptomatic relief of CTS. At 1 year, local injection is as effective as surgical decompression for the symptomatic relief of CTS.

Thus, the literature suggests that corticosteroid injection provides at least short-term (1–3mo) symptomatic relief for CTS patients, and may rival surgical treatment even at 1 year. These studies may suggest that, at least for patients with just mild or moderate CTS, corticosteroid injection may be the most appropriate initial treatment (eg, combined with wrist splinting), with surgery reserved for patients with severe or nonresponsive CTS. The caveat may be to provide close medical monitoring to make sure that patients being treated nonsurgically do not progress to the point of irreversible nerve damage and muscle atrophy.

The literature has also indicated that injecting corticosteroids into the carpal tunnel can improve median nerve function, as measured by motor and sensory nerve conduction studies. A recent study of CTS treatments showed that corticosteroid injection is superior to iontophoresis and phonophoresis and found that the most sensitive neurophysiologic parameters in follow-up were the difference between the median and ulnar distal sensory latencies to the fourth digit and also the difference between median distal sensory latency to second digit and ulnar distal sensory latency to the fifth digit.

Other studies have also shown electrodiagnostic improvements in objective median nerve conduction parameters after injection into the carpal tunnel. For example, 1 prospective study evaluated clinically mild CTS (defined as intermittent symptoms without thenar atrophy, thenar weakness, or absence of sensations). These 48 clinically mild CTS cases included electrodiagnostically mild, moderate, and severe CTS but excluded the electrically most severe cases (needle electromyography showing abnormal spon-
taneous activity in the thenar muscles and/or a median nerve distal motor latency greater than 7.5 ms). The study showed that at 3 months after the injection, 93.7% of the patients reported marked improvement in their symptoms, with significant improvement in distal motor latencies, distal sensory latencies, symptom severity, and functional scores. Improvements were seen among patients with electrically mild, moderate, and severe CTS. Significant improvement was still present for median distal motor latency at 12 months. Almost 50% of patients achieved normalization in the electrophysiologic study. At an average follow-up of 16 months, 79% of patients continued to have improvement in symptoms. Of patients studied, 16.6% relapsed clinically after an initial response that lasted 7 to 15 months. The researchers concluded that local injection of corticosteroid results in long-term improvement in nerve conduction parameters, symptom severity, and functional scores in patients whose CTS is clinically mild and electrodagnostically mild, moderate, or somewhat severe.12

One RCT13 examined intracarpal insulin injection to treat CTS. In patients with non–insulin-dependent diabetes mellitus and mild to moderate CTS, 20 mg of methylprednisolone was injected into the carpal tunnel. A week after receiving a corticosteroid injection, patients were randomized to receive additional injections into the carpal tunnel, with placebo or isophane insulin (12U), weekly for 7 weeks. Those patients who received insulin injections showed a more significant improvement in mean median nerve distal motor latency, median nerve sensory velocity, and global symptom score. The insulin injections did not appreciably change the overall glucose control, and the mechanism of CTS improvement was unclear. Further research is needed to establish what role insulin injections into the carpal tunnel may have in the nonsurgical treatment of CTS.

6.4 Clinical Activity: To critique the risks and benefits of focal corticosteroid injections in the treatment of Achilles’ tendinitis in a heavy laborer.

The medical literature currently provides no definitive consensus regarding the benefits and risks of focal corticosteroid injections for Achilles’ tendinitis. Regarding risks, a 1% overall incidence of side effects (including subcutaneous atrophy and depigmentation) was reported by a systematic review14 of 145 published articles related to Achilles’ tendinitis and corticosteroid injections. The reviewers noted that animal studies of intratendinous injections showed decreased tendon strength, thus suggesting increased risk of tendon rupture. Although they found multiple published instances of Achilles’ tendon rupture after injection, most of these were isolated case reports or small case series. One inherent problem with case reports of complications is that they generally fail to have any control group for comparison, thus making it impossible statistically to conclude that the risk of that complication was increased. The reviewers concluded that no published rigorous studies existed evaluating the risk of Achilles’ tendon rupture. Finally, they concluded that insufficient published data exist to determine the comparative risks and benefits of corticosteroid injections for Achilles’ tendinitis.14

Another study15 looked retrospectively at 64 consecutive patients with Achilles’ tendon pain (excluding, eg, ruptures and excluding patients with concomitant peroneal tendinitis) who specifically had Achilles’ pain at rest that improved with activity. Of these 64 patients, 35 chose to undergo corticosteroid injection and 29 chose not to have it not randomized. Subsequently, 2 patients in each group developed tendon rupture, representing 6% of patients who had undergone injection and 8% of those who had not undergone injection. The researchers concluded that injections did not increase the rupture rate.

A recent review article analyzed 9 randomized or quasi-randomized trials involving 697 patients with Achilles’ tendinitis.16 There was weak evidence of a modest benefit of NSAIDs for alleviation of acute symptoms. There was weak evidence of no difference (compared with no treatment) of low-dose heparin, heel pads, topical laser therapy, and peritendinous injection of corticosteroids. The reviewers concluded that evidence from RCTs was insufficient to determine the most appropriate treatment of acute or chronic Achilles’ tendinitis.

A number of recent studies have examined the potential role of ultrasound (eg, Doppler) or fluoroscopy for image guidance during injections for Achilles’ tendon pathology. Theoretically, better outcomes (improved benefits and/or decreased side effects) could be obtained by more precise peritendinous placement of the corticosteroid along the tendon sheath, rather than inadvertent injection into the substance of the tendon itself. A recent retrospective cohort study17 examined fluoroscopically guided injections along the anterior aspect of the Achilles’ tendon for Achilles’ tendinopathy: 43 patients had undergone injections, with a collective total of more than 80 injections (including 1 patient having 14), and all subjects had at least 2 years of follow-up after injection. There was 1 minor complication (persistent purplish skin discoloration after 2 injections), but no tendon ruptures or other major complications were reported. Of the patients, 17 (40%) reported improvement after the procedure(s), 23 (53%) thought that their condition was unchanged, and 3 (7%) thought that their condition was worse than it had been before the injection.

Although the literature is increasingly reporting the use of such image guidance for Achilles’-related injections, the literature currently lacks any substantial studies comparing the outcomes with and without it, thus leaving it to each individual clinician to decide whether to use such imaging techniques.

Other published articles have examined treating Achilles’ tendinitis with injections of agents other than corticosteroids. These potential alternatives include injection of sclerosing agents into newly proliferated blood vessels (neovessels),18 injection of viscosupplementation agents (eg, Hylan G-F 20),19 and a variety of other biologic substances. Further research is needed to determine what role these agents have in the management of Achilles’ tendinitis.

6.5 Clinical Activity: To evaluate the role of corticosteroid injections in the management of persistent plantar fasciitis in a salesperson working at a home improvement warehouse. The proximal plantar pain has progressed to the point where it is painful not only with the first steps in the morning but also throughout the workday, which involves prolonged standing and walking on concrete floors.

Overuse and microtears of the plantar fascia may contribute to plantar fasciitis, because histologic studies show collagen degeneration and necrosis.20 Because the histologic findings do not universally show inflammatory changes, some clinicians prefer the term plantar fasciopathy or fasciosis rather than plantar fasciitis.20 The possible lack of inflammation is germane to the discussion of injecting anti-inflammatory agents such as corticosteroids. Still, corticosteroid injections are commonly used as part of the nonsurgical treatment for plantar fasciitis. More than 80% to 90% of patients respond to nonsurgical care, including corticosteroid injections.20
suggested that corticosteroids may be beneficial because of their antinociceptive and membrane-stabilizing properties rather than just their anti-inflammatory properties.21

A recent RCT of plantar fasciopathy treatment compared extracorporeal shockwave therapy (ECSWT) with corticosteroid injection, with 3- and 12-month follow-ups. The investigators concluded that the injections were more efficacious (significantly lower pain scores, per visual analog scale) and were much more cost effective than ECSWT.22

One potential drawback to corticosteroid injection for plantar fasciitis is the pain of the injection. A recent RCT of fluoroscopically guided corticosteroid injection for plantar fasciitis compared performing the injection with versus without an antecedent posterior tibial nerve block with 5mL of 1% lidocaine.23 Except for a mild burning sensation, pain during posterior tibial block was negligible in all cases. Among patients who had undergone the posterior tibial nerve block, the plantar injection was considered painless in 90% (9/10) and just mildly painful in 10% (1/10). Among patients who had not received the nerve block, the plantar injection was considered severely painful in 70% (7/10) and moderately painful in 30% (3/10). Among those who received the nerve block, no patients had complications (despite an increased number of injections per patient, because patients receiving nerve blocks were more likely to allow the injection to be repeated). Among those who did not receive the nerve block, 10% (1/10) of patients developed fat necrosis and 10% (1/10) developed pressure periositis.

Plantar fascia rupture has been reported as a possible complication of corticosteroid injections. In a retrospective, nonrandomized study of 122 patients who received 1 or more injections, 12 (10%) patients developed plantar fascia ruptures.20 An overlapping patient population in that study showed that of 51 patients with plantar fascia rupture, 43 (84%) had received 1 or more injections into the calcaneal origin of the fascia.20 The retrospective, nonrandomized nature of this and similar studies makes it impossible to conclude that the corticosteroid injection actually causes plantar fascia rupture, because perhaps patients with more severe pathology (and hence a higher likelihood for rupture) were more likely to receive injections in the first place. Still, based on the number of case reports of plantar fascia rupture after injection, it seems prudent during informed consent to advise patients of this possible risk.

Plantar fat pad necrosis has been reported as another possible serious complication of corticosteroid injection for plantar fasciitis.22

Until further research clarifies the role of image guidance (eg, via fluoroscopy or ultrasound) in the performance of plantar fascia injections, clinicians must use their own discretion in deciding whether to use such guidance in a given injection.

References


Suggested Reading

Industrial Medicine and Acute Musculoskeletal Rehabilitation.

7. Acute Industrial Musculoskeletal Injuries in the Aging Workforce

Joseph P. Zuhosky, MD, Robert W. Irwin, MD, Aaron W. Sable, MD, William J. Sullivan, MD, Andre Panagos, MD, Patrick M. Foye, MD


This learning module highlights the unique challenges faced by physicians treating the aging workforce. It is part of the industrial medicine and acute musculoskeletal rehabilitation study guide in the Self-Directed Physiatric Education Program for practitioners and trainees in physical medicine and rehabilitation. Factors intrinsic and extrinsic to the patient that increase the risk of injury with aging are outlined. Low Back injuries are the most common musculoskeletal complaint in the aging workforce. A conceptual framework for low back pain with aging, a differential diagnosis, and appropriate laboratory and radiographic investigations are also presented. Determination of causation in the setting of comorbid medical conditions and rehabilitation strategies are reviewed.

Overall Article Objective: To recognize diagnosis and treatment issues that are unique to the aging worker.

Key Words: Aging; Cumulative trauma disorders; Industrial medicine; Low back pain; Rehabilitation.

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7.1 Educational Activity: To explain the current and future demographic trends in the aging population of workers in the United States.

The aging of the “baby boomer” generation, those born between 1946 and 1964. This generation remains quite active, and when polled, the American Association of Retired Persons reported that up to 79% of seniors (age ≥50y) plan to work part time or full time after “retirement.” With an “older worker” defined arbitrarily in the literature as age 40 years and older, this group will soon become a majority of the workforce in the very near future. Injuries in this “graying workforce” will present new challenges to the medical community, employers, and workers’ compensation insurance carriers.

7.2 Clinical Activity: To identify the factors intrinsic and extrinsic to a 65-year-old industrial worker that may predispose her to a workplace injury.

Many factors increase the risk of occupational injuries in older workers. Those commonly cited in the literature include a general decline in vision and hearing with increasing age. Findings from the Health and Retirement Study, validated by the National Health Interview Survey, and other studies affirm that diminished vision and hearing are independent risk factors for occupational injury. Diminished sensory input places older workers at risk for falls and is 1 of the leading causes of injury among all older adults, regardless of work status. Much of the literature, however, focuses on extrinsic, environmental sources of falls such as surface traction, contaminant control, and footwear. Among those workers presenting to an emergency department with an industrial musculoskeletal injury, workers over age 65 years are most likely to present with a fracture or dislocation, an injury resulting from a fall to the ground from the same level, and to require hospitalization. Besides diminished vision and hearing, older adults also experience depressed autonomic reflexes, which predisposes them to postural hypotension, syncopal episodes, and, hence, to falls. Concomitant medication usage, particularly antihypertensive medications, may compound this risk. Older workers also may have aging-related decreases in sensory and motor nerve conduction. Although the prevalence of these decreases in nerve function in older workers has not been established, affected workers may have clinically impaired vibratory sensation, reduced cutaneous pressure sensation, and prolonged sensory and motor latencies. Although the most common diagnosable cause of peripheral neuropathy in the United States remains diabetes mellitus, other etiologies occurring with increasing frequencies in older adults include peripheral neuropathies associated with herpes zoster, vitamin B₁₂ deficiency, and carcinoma. Identifying these impairments and providing modifications in work requirements and work environment are crucial for successful rehabilitation and re-entry to the workforce.

Less commonly considered factors in older workers may also contribute to work-related injuries. The prevalence of depression tends to increase with age. Somatic manifestations may mimic acute musculoskeletal injury and should be sought...
out, especially in those patients not responding to treatment. In patients on cholesterol-lowering medications, side effects of muscle pains and myopathy\(^1\) may also mimic acute musculoskeletal injury and confound the etiology of these symptoms.

Older workers have long been considered predisposed to musculoskeletal injuries. The vicious cycle of musculotendinous overload presents a schematic and conceptual framework for this inherent risk (fig 1).\(^10\)

The biomechanic deficits enumerated in figure 1 all occur, to varying degrees, with aging and cumulative trauma.\(^11\) Muscular weakness occurs after age 30 years in association with generalized muscle fiber atrophy, decreased muscle density, and increased intramuscular fat.\(^12,13\) The resultant diminished muscle mass and strength may be further compounded by inactivity and aerobic deconditioning. This reduction in muscle mass, strength, and endurance appears to accelerate after age 70 years. The observed reductions in strength are 15% per decade between ages 50 to 70 years and 30% per decade thereafter.\(^11,12\)

Inflexibility results from shortening of muscle fiber length and diminished extensibility of tendons and connective tissues surrounding joints. With age, the tensile strength of tendons decreases.\(^14\) Coupled with the loss of strength is a decrease in both insoluble and total collagen.\(^15\) This combination results in decreased flexibility, which increases the likelihood of tissue trauma. Cumulative microtrauma from repetitive activities produces inflammation, or even “scarring,” and thickening of the tendinous sheath.\(^16\) In conjunction with the weakening musculature associated with aging, the resultant inflexibility and microtrauma further exacerbate muscle imbalances resulting from improper or compensatory strategies, improper body mechanics, and poor posture accumulating over years.\(^15\) Over-stressing of these soft tissues leads to muscle strain, ligament sprain, tendon strain, or rupture as described by in the vicious cycle of musculotendinous overload.

7.3 Clinical Activity: To identify specific occupations and work-related activities that predispose an older worker to potential work-related injury.

The literature exploring this observation of an increased risk of musculoskeletal injury in older workers varies depending on the industry. In certain populations, such as workers in the coal mining\(^1\) and construction industries,\(^16\) age is clearly a risk factor for industrial musculoskeletal injury. Types of injuries within these groups may also differ when stratified for age. Older union carpenters are more likely to sustain fractures of the foot but less likely to sustain contusions of the hand or foot.\(^19\) Older workers in the service industries, agriculture, forestry, and fishing industries’ mechanics, repairers, and those performing heavy lifting\(^3\) have been observed by some investigators to be particularly at risk for musculoskeletal injury. However, another investigation\(^20\) suggested a lower injury rate among older workers than younger (age <25y) workers. In a study of poultry workers and data-entry personnel (groups known to have high rates of cumulative trauma disorders [CTDs]), there was no statistical increased susceptibility to CTDs such as nerve compression syndromes, tenosynovitis, epicondylitis, or tendinitis in older workers when compared with their younger counterparts.\(^3\) In a study\(^21\) of material handlers in a home improvement retail chain, musculoskeletal injury rates in workers over age 55 years were similar to those in younger workers, even when length of employment and lifting intensity were taken into consideration.

7.4 Educational Activity: To discuss the available literature addressing the impact of older age on functional outcomes in work-related injuries.

When observing outcome studies of injured workers, there is a clearer trend of longer periods of disability resulting from occupational injuries in older workers. In the study of material handlers cited earlier,\(^21\) although the prevalence of injury was no greater in the older cohort (age >55y), the amount of lost work time because of injury was significantly greater in this group. Among construction workers, a retrospective assessment determined that the risk of development of chronic symptoms after a musculoskeletal soft-tissue injury was significantly greater in older workers.\(^22\) Prospective trials affirm the significant correlation among lost work time in older workers, their decreased likelihood of return to work, and a higher probability of future disability.\(^23\) Considering the subset of workers with spine injuries, age was linearly associated with both pretreatment duration of disability and frequency of surgeries.\(^24\) Further, older workers have a higher level of post-treatment disability, and they have a higher likelihood of recurrent injury.\(^24\) A review\(^25\) of the international literature suggests that older workers “sustain more serious injuries, take longer to recover, and are less likely to return to work than younger workers.” The risk of fatality associated with injury in the workplace clearly increases with age as well,\(^20,26\) with death resulting from falls of lesser heights and lower energies of impact.\(^25\)

7.5 Clinical Activity: To summarize how increasing age affects the differential diagnosis of low back pain.

Medical comorbidities in older workers present further confounding variables in their diagnosis and treatment. For example, low back injuries are the most common musculoskeletal injuries in the aging workforce and present unique diagnostic challenges. The maximal frequency of low back pain (LBP) occurs between the ages of 35 and 55 years, and the duration of symptoms increases with increasing age.\(^28\) The differential diagnosis for these symptoms should extend well beyond the colloquial lumbosacral sprain or strain. Spinal etiologies may include a lumbar annular tear or disk protrusion, a lumbar or lower-thoracic compression fracture, zygapophyseal joint mediated pain, or segmental injury and dysfunction with myofascial pain, that is, the strain alluded to earlier. The degenerative cascade model of Kirkaldy-Willis provides a framework in which to conceptualize the dynamic changes that occur during aging of the lumbar spine.\(^29\) In this model, the 3-joint complex of the intervertebral disk and paired zygapophyseal joints undergo characteristic and somewhat predictable changes with aging. Initially, in stage 1 (dysfunction), the cumulative trauma of aging is manifest at the zygapophyseal

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joints by cartilage degeneration, joint synovitis, and subluxation. The intervertebral disk experiences tears within the annulus with breakdown of the nucleus pulposus matrix and, potentially, even disk herniation. This may explain the peak incidence of lumbar disk herniations that occurs in the third and fourth decades of life. Stage II (instability) is characterized by further collagen degradation within the zygapophysial joint, associated with capsular laxity and increased rotational movement. Within the intervertebral disk, further annular tears with or without herniation and coalescence also increase annular laxity, with further increased translational forces. Stage III (stabilization) is marked by typical changes of osteoarthritis within the zygapophysial joints. There is loss of joint surface cartilage and joint space narrowing, with fibrosis and osteophyte formation. The intervertebral disk undergoes further deterioration of the nucleus pulposus, with changes in collagen type, disk resorption, fibrosis, and loss of disk height. These advanced changes may account for the peak in lumbar spinal stenosis in the sixth and seventh decades of life. In older patients presenting with back and referred leg pain, the associated findings also include both central and foraminal stenosis.

7.6 Clinical Activity: To explain the various nonspine diagnoses that may present with back pain in the aging worker and delineate their specific diagnostic considerations.

Vascular etiologies for LBP are a potentially fatal cause that may be overlooked. Abdominal aortic aneurysms may occur in up to 4% of the population over the age of 50. Smoking is the risk factor most strongly associated with abdominal aortic aneurysms, followed by age, hypertension, hyperlipidemia, and atherosclerosis. Men are 10 times more likely than women to have a clinically significant abdominal aortic aneurysm (ie, 4cm or larger). There is also a genetic predilection, with a 30% increased risk in patients with a family history. On physical examination in slender people, a pulsatile mass may be appreciated. Plain film radiographs may show a widened aortic silhouette with a curvilinear calcification if there is significant atherosclerosis. Contrast-enhanced computed tomography (CT) and magnetic resonance angiography are the preferred studies to define aortic aneurysms in both the thoracic and abdominal regions.

Genitourinary causes of LBP also may occur with increasing frequency after the age of 40 years. Prostatitis can cause LBP, sacral pain, and pelvic pain. It generally is characterized as acute or chronic, bacterial, or abacterial. An acute bacterial prostatitis may be easily confirmed on prostate examination (tenderness, bogginess) and with a positive urine culture and sensitivity, indicating the need for an appropriate course of antibiotics. It may otherwise present as a chronic, ill-defined pelvic pain known as chronic pelvic pain syndrome. Because of the extensive overlap of symptoms among benign prostate hypertrophy, chronic bacterial, and abacterial prostatitis, consultation with a urologist is recommended. Nephrolithiasis typically presents acutely with severe flank, low back, and, at times, pelvic pain. In a study of machinists exposed to high temperatures, there was a significantly increased prevalence of uric acid stones compared with the control group of machinists working in normal temperatures. Older employees working in occupations exposed to high heat appear particularly at risk for uric acid stones. Counseling regarding adequate fluid intake and avoidance of beverages that contain oxalate acid such as cola (black tea) are critical components to minimize this risk.

Gastrointestinal disorders can also present with low back and musculoskeletal-type symptoms. Gastric and duodenal ulcers typically present with boring abdominal pain associated with referred pain in the lumbar spine or sometimes with midback pain only. Risk factors include cigarette smoking, intake of aspirin and nonsteroidal anti-inflammatory medications, increased dietary salt, and excessive alcohol use. The risk of gastric and duodenal ulcer increases with age, fairly precipitously after age 60 years. This risk should be considered especially when prescribing nonsteroidal anti-inflammatory medications in the older worker. Workers performing rotating shift and night work and immigrant workers appear to be at significantly increased risk for the development of gastric and duodenal ulcers, which are presumed to be related to sleep disturbance and disruption of circadian rhythm in these workers. Pancreatitis is also a potentially overlooked cause of back pain in older workers. Pancreatitis should be especially considered in workers with significant alcohol and tobacco use. In the Health and Retirement Study, older male workers were more likely to answer 3 out of 4 CAGE alcoholism screening questions positively and consume 4+ drinks per day. The CAGE acronym stands for trying to cut down alcohol use (C), angry when discussing alcohol use (A), feeling guilty about alcohol use (G), and taking an eye opener (E).

Rheumatologic disorders may also present with acute musculoskeletal pain including LBP. Polymyalgia rheumatica typically presents with shoulder girdle pain and stiffness, but a subset of these patients present with hip girdle symptoms. Age at onset is invariably greater than 50 years, with most over the age of 60 years. It affects women twice as often as men. Erythrocyte sedimentation rates (ESR) of 80 to 100mm per hour (or greater) are highly suggestive of this diagnosis, although elevated C-reactive protein levels may be a more sensitive indicator of disease presence. Dramatic response to low-dose prednisone (10–20mg/d) provides both confirmation and treatment. The potential development of temporal arteritis and its inherent risk of blindness must be given careful consideration in this population. Diffuse idiopathic skeletal hyperostosis (DISH) presents generally after the age of 50 years. Flowing syndesmophytes in the thoracic and potentially the lumbar spine give the appearance of a “bamboo spine” in these patients. In addition to causing a gradual decrease in spine flexibility and range of motion, even trivial trauma may result in fractures in DISH patients. Whenever there is a history of DISH in the setting of trauma, the clinician must maintain a high index of suspicion for underlying fracture and thus pursue early and aggressive radiologic investigation.

Osteoporosis is 1 of the more common underlying comorbidities increasing the risk of injury in older workers. Risk factors for osteoporosis include being postmenopausal, particularly in a woman of eastern European descent, hyperthyroidism, previous steroid treatments, excessive alcohol intake, calcium deficiency, eating disorders, and smoking. The single greatest risk factor for injury from fall in older patients is osteoporosis, with vertebral compression fracture a likely result. Despite this, there is a paucity of research on the effects of osteoporosis on work-related injuries and their prevention. For working women in Canada older than 60 years, there is a significantly increased risk of hand fractures in the workplace compared with younger cohorts and men, likely associated with the increased prevalence of osteoporosis in this population. In addition, research shows predictable fracture patterns in older women compared with men, with women more likely than older men to sustain forearm and wrist fractures, presumably from osteoporosis. Recognition of these injury patterns and identification of osteoporosis in this patient population is critical. Within the workers’ compensation system, instructions on weight-bearing exercise and fall prevention in
the workplace are appropriate and important for the prevention of future injury. Involvement of the primary care physician outside the workers’ compensation system for medical investigation and treatment of the osteoporosis is vital as well.

A higher index of suspicion for malignancy in older workers must also be maintained, especially in workers over the age of 50 years. Malignancies creating back and spine pain may represent a primary malignancy, most commonly multiple myeloma, or metastatic disease. The most common malignancies that metastasize to the spine are those of the prostate, lung, thyroid, breast, and renal cell. Red flags that signal the possibility of malignancy in the history and presentation of these patients are outlined in appendix 1.

The presence of weight loss greater than 4.5kg (10lb) in 6 months and ESR higher than 50mm per hour, especially in combination, are reasonably sensitive and specific indicators of malignancy in the setting of LBP. Serologic studies should include a complete blood count with differential, because the presence of anemia rivals elevated ESR in sensitivity for malignancy. Serum calcium and alkaline phosphatase levels may indicate states of rapid bone turnover seen with some malignancies. Serum and urine immunoelectrophoresis studies to exclude a monoclonal protein spike, as seen in multiple myeloma, may also be helpful. Anteroposterior (AP) and lateral lumbosacral plain film radiographs are the initial radiologic screen and may show compression fracture or more subtle osteolytic or osteoblastic lesions. Because of the predilection of metastatic tumor to be harbored in more highly vascular sites, particular attention should be paid to the pedicle region when reviewing these images. A triple-phase bone scan can be a sensitive indicator of metastatic disease in the spine but may appear normal in the setting of multiple myeloma. CT of the spine has proven both sensitive and specific in differentiating benign and malignant lesions and in detecting metastatic lesions in the spine. Magnetic resonance imaging (MRI) with gadolinium remains the criterion standard for identification of spinal malignancies because of its superior soft-tissue resolution and staging of malignant spinal cord compression.

7.7 Clinical Activity: To discuss appropriate historical and diagnostic considerations in a 62-year-old dock worker presenting with LBP after a fall.

Given the complexities noted above, the investigation for older workers must be tailored to their symptoms. For instance, younger workers with back and leg pain most likely have a diskogenic source for their radicular symptoms. In older workers, spinal stenosis, whether central or foraminal, can cause neurogenic claudication, with bilateral leg pain that mimics vascular claudication. Differentiating these conditions is important. Walking uphill tends to improve the symptoms of neurogenic claudication but worsen those of vascular claudication. After symptom onset, standing still tends to improve the symptoms of vascular claudication, whereas the prolonged erect posture would typically cause persistence or worsening of the leg symptoms of neurogenic claudication. Neurogenic claudication symptoms may improve with walking behind and leaning forward on a shopping cart (the “shopping cart sign”), which generally results in no benefit for patients with vascular claudication. Noninvasive arterial studies including arterial ultrasound and ankle-brachial indices may further help differentiate neurogenic versus vascular claudication. The radiographic investigation has special considerations as well. It is generally accepted that AP and lateral films of the lumbar spine represent an adequate screening study, with the possible exception of clinical suspicion of a pars interarticularis fracture (spondylolysis), which may be missed with these studies alone. Additional oblique radiographs may increase the diagnostic yield in this clinical setting. Indications for plain film radiographs in the setting of acute LBP are outlined in appendix 2.

When a bone scan is ordered to evaluate for spinal fracture or malignancy, requesting single-photon emission computed tomography (SPECT) significantly increases the diagnostic yield, sensitivity, and specificity of this diagnostic modality. When malignancy or fracture is suspected, routine inclusion of SPECT imaging is recommended. When ordering CT or MRI, clinicians should be mindful that these yield increasing rates of false-positive results with advancing age. The history, physical examination, and imaging studies should all be correlated to arrive at an appropriate working diagnosis.

7.8 Clinical Activity: To analyze the effect of advancing age on the determination of causation in the workers’ compensation system.

The establishment of causation of injury in older workers presents yet another challenge to clinicians. The American Medical Association Guides to the Evaluation of Permanent Impairment, 5th Edition, define causation as “an identifiable factor (eg, accident or exposure to hazards or disease) that results in a medically identifiable condition.” Inherent in this definition is the general concept of a sentinel event or set of conditions—that is, environmental exposure or cumulative trauma—that either results in clear injury or exacerbates an underlying condition. For an older worker, underlying conditions such as spondylolysis can significantly affect this determination. By age 60 years, 100% of the population will have histologic changes of osteoarthritis. Employers and workers’ compensation insurance carriers have an economic interest in relating symptoms to preexisting conditions. Thus, sentinel events that bring an otherwise quiescent condition to a symptomatic state become crucial to document. Ultimate compensability of an injury or symptom complex relies on the particular policy of each individual state’s workers’ compensation system.

7.9 Educational Activity: To summarize factors specific to the employee or employer that affect the functional outcomes of older workers.

In the rehabilitation of older workers, goals should include resolution of symptoms, reduction of the risk of further injury, and successful return to the workplace. An injury at work precipitates an earlier-than-planned retirement in up to 11% of workers and correlates with preinjury dissatisfaction with their job or medical care and poor physical and mental health status. Successful return to work is enhanced by rehabilitation that emphasizes improved flexibility, increased aerobic fitness, strengthening, education on fall prevention and lifting techniques, and early return to the worksite. Old workers in general may be more likely to return to their previous employment because of their longer workplace attachment. Meanwhile, various return-to-work factors are under the control of employers. Employers who are deemed rigid, inflexible, and nonsupportive are less likely to see their older workers return. Employer policies that promote shared, governance between unions and management with emphasis on joint safety programs and appropriate workplace modifications will provide more accommodating environments for worker return. Employers who value experience and transition workers to more supervisory roles may also realize greater retention of older workers.
APPENDIX 1: “RED FLAGS” SIGNALING POSSIBLE SPINAL MALIGNANCY

Night pain
Pain at rest
No position of relief
Fever
Weight loss
Prior history of malignancy

APPENDIX 2: INDICATIONS FOR PLAIN FILM RADIOGRAPHS TO INVESTIGATE ACUTE LBP

Age greater than 50 years
Even trivial trauma in older patients
Neurologic deficit
Unexplained weight loss of more than 4.5kg (10lb) in 6 months
Drug or alcohol abuse history predisposing to infection
Suspicion of ankylosing spondylitis
History of malignancy
Use of corticosteroids
Recent visit within the month for same symptoms without improvement
Patient seeking compensation for back pain
Fever

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Educational Activity 1.1
1. Which is a risk factor for plantar fasciitis?
   (a) Obesity
   (b) Female gender
   (c) Age younger than 40 years
   (d) Increased subtalar motion


Clinical Activity 1.2
2. The best position for the center of the automobile headrest to limit the amount of head and neck flexion and extension during rear-end collisions is at
   (a) eye level.
   (b) ear level.
   (c) chin level.
   (d) comfortable resting level.


Clinical Activity 1.3
3. De Quervain’s disease includes the tendons of which 2 muscles?
   (a) Extensor pollicis longus and extensor pollicis brevis
   (b) Abductor pollicis brevis and extensor indicis
   (c) Abductor pollicis longus and extensor pollicis brevis
   (d) Extensor digitorum and extensor carpi radialis brevis


Clinical Activity 1.4
4. Which factor is NOT a criterion for early use of plain radiographs in the assessment of low-back pain?
   (a) Age less than 50 years
   (b) Unplanned weight loss for more than 6 months
   (c) Evaluation for ankylosing spondylitis
   (d) Significant trauma


Clinical Activity 1.4
5. Which diagnostic study best detects sequestered disk fragments and vertebral body end plate changes?
   (a) Plain radiographs
   (b) Computed tomography
   (c) Magnetic resonance imaging
   (d) Bone scans


Educational Activity 2.1
6. Which muscle relaxant has the greatest abuse potential?
   (a) Carisoprodol (Soma)
   (b) Cyclobenzaprine (Flexeril)
   (c) Tizanidine (Zanaflex)
   (d) Metaxalone (Skelaxin)


Educational Activity 2.2
7. Advantages of cyclooxygenase-2 specific agents (celecoxib) include
   (a) low cost.
   (b) cardioprotection.
   (c) decreased gastrointestinal toxicity.
   (d) low potential for liver toxicity.


Educational Activity 2.3
8. Tramadol (Ultram) should be used with caution with which of the following medications?
   (a) diazepam (Valium)
   (b) acetaminophen (Tylenol)
   (c) fluoxetine (Prozac)
   (d) propoxyphene (Darvocet, Darvon)


Educational Activity 2.3
9. Which statement is TRUE regarding the metabolism of oral codeine?
   (a) It converts to morphone through the cytochrome P-450 system.
   (b) It exclusively blocks kappa opioid receptors.
   (c) It does not undergo first pass metabolism.
   (d) It blocks N-methyl-D-aspartate receptors.

Educational Activity 2.4
10. What is a mechanism of action of capsaicin?
   (a) Increasing substance P over time
   (b) Blocking mu opioid receptors
   (c) Increasing calcitonin gene–related peptide
   (d) Activating vanilloid receptors


Clinical Activity 3.1
11. According to a 2003 Cochrane Review of articles relating to the treatment of plantar heel pain, which factor is TRUE?
   (a) There was strong evidence that therapeutic ultrasound effectively reduced chronic heel pain.
   (b) Randomized trials showed surgery to be more effective in decreasing heel pain than no treatment.
   (c) There was limited evidence for the superiority of corticosteroid injections over orthotic devices in reducing heel pain.
   (d) Several articles showed that custom-made orthoses were superior to heel pads and stretching exercises in reducing heel pain.


Clinical Activity 3.2
12. After soft-tissue injury to the neck from an automobile accident (“whiplash”), which factor has statistically been found to delay return to work?
   (a) Full-time use of a soft cervical collar for 3 weeks
   (b) Referral to physical therapy
   (c) Instruction in a home exercise program
   (d) Use of nonsteroidal anti-inflammatory drugs


Clinical Activity 3.3
13. In patients with lateral epicondylitis, which treatment has been found to decrease pain significantly?
   (a) Counterforce bracing (forearm strap)
   (b) Isotonic eccentric exercise program
   (c) Extracorporeal shock wave therapy
   (d) Laser therapy


Clinical Activity 3.4
14. In published studies, which intervention for carpal tunnel syndrome was shown to improve symptoms?
   (a) Ultrasound treatment for 2 weeks
   (b) Nonsteroidal anti-inflammatory drugs
   (c) Use of ergonomic keyboards
   (d) Nocturnal splinting for 6 weeks


Educational Activity 3.5
15. The medical literature supports which statement regarding low-back pain (LBP)?
   (a) Lumbar supports prevent LBP.
   (b) Lumbar supports are more effective than other types of prevention for LBP.
   (c) Lumbar supports plus back school reduce days absent from work because of back injury.
   (d) Lumbar supports are more effective in reducing back pain than other types of treatment.


Educational Activity 4.1
16. The pathogenesis of trigger points includes
   (a) muscle fiber inflammation.
   (b) lower tissue oxygen levels.
   (c) focal muscle spasm.
   (d) endplate denervation.


Educational Activity 4.1
17. Pain associated with cervical zygapophyseal joints can be most reliably diagnosed by
   (a) physical examination.
   (b) plain radiographs.
   (c) medial branch blocks.
   (d) bone scan.


Educational Activity 4.1
18. Once cervical zygapophyseal joint pain has been confirmed by selective medial branch blocks, the most effective treatment is
   (a) radiofrequency neuroablation.
   (b) cervical fusion surgery.
   (c) trigger point injections.
   (d) intra-articular corticosteroid injection.


Educational Activity 4.2
20. Although there are risks associated with all injection procedures, which cervical injection technique has been associated with acute catastrophic neurologic injury?
(a) Facet joint injection
(b) Transformaminal epidural steroid injection
(c) Paraspinal trigger point injection
(d) Interlaminar epidural steroid injection


Clinical Activity 5.1
21. Sacroiliac pain and dysfunction can most reliably be diagnosed by
(a) physical examination.
(b) imaging studies.
(c) anesthetic block.
(d) bone scan.


Educational Activity 5.2
22. Which inflammatory marker is most commonly present in cases of lumbar disk herniation?
(a) Histamine
(b) Phospholipase A2
(c) Prostaglandin C
(d) C-reactive protein


Educational Activity 5.3
23. Once the diagnosis of zygapophyseal joint pain has been established, options for long-term relief of pain include
(a) phenol medial branch blocks.
(b) intra-articular corticosteroid injection.
(c) cage fusion.
(d) radiofrequency ablation.


Educational Activity 5.4
24. Findings on magnetic resonance imaging suggestive of acute annular tear include
(a) loss of disk height.
(b) high-intensity zone.
(c) vertebral endplate edema.
(d) Schmorl’s nodes.


Educational Activity 5.4
25. Options for nonsurgical treatment of annular tears include
(a) axial pain of less than 6 months in duration.
(b) disk protrusion beyond the posterior longitudinal ligament.
(c) 50% or greater preservation of disk height.
(d) low to moderate pain ratings and good levels of function.

Educational Activity 5.4
26. Which nonsurgical treatment option for diskogenic low-back pain is conclusively determined NOT to be effective?
(a) Intradiscal electrothermal annuloplasty
(b) Intradiskal steroid injection
(c) Percutaneous nucleoplasty
(d) Percutaneous lumbar disk decompression


Clinical Activity 6.2
27. The most effective nonsurgical treatment for de Quervain’s tenosynovitis is
(a) relative rest and anti-inflammatorios.
(b) splinting and ice packs 4 times a day.
(c) corticosteroid injection and splinting.
(d) corticosteroid injection alone.


Clinical Activity 6.3
28. Injection of corticosteroid into the carpal tunnel produces clinical improvement
(a) better than surgical decompression at 1 year.
(b) equal to iontophoresis or phonophoresis.
(c) in nerve conduction studies.
(d) that is augmented by insulin in non-insulin-dependent diabetes mellitus patients.

Ref: (a) Ozkul Y, Sabuncu T, Yazgan P, Nazligul Y. Local insulin injection improves median nerve regeneration in NIDDM patients with carpal tunnel syndrome. Eur J Neurol 2001;8:329-34.

Clinical Activity 6.4
29. The clinical practice of avoiding local corticosteroid injection into the Achilles’ tendon because of the risk of tendon rupture is based on
(a) randomized controlled trials.
(b) prospective studies.
(c) retrospective studies.
(d) case reports and case series.

(c) Read MT. Safe relief of rest pain that eases with activity in achillodynia by intrabursal or peritendinous steroid injection: the rupture rate was not increased by these steroid injections. Br J Sports Med 1999;33:134-5.

Clinical Activity: 6.5
30. The pain associated with corticosteroid injection of the plantar fascia can be successfully reduced by
(a) applying topical capsaicin cream before injection.
(b) mixing lidocaine with corticosteroid solution.
(c) using ultrasound guidance to avoid the calcaneus.
(d) administering a posterior tibial nerve block before injection.


Clinical Activity 7.2
31. Which factor places the aging worker at the greatest risk of occupational injury?
(a) Cumulative trauma disorders
(b) Vision impairment
(c) Cardiac disease
(d) Osteoarthritis

Educational Activity 7.4
32. How do aging workers differ from younger workers in injury outcome studies?
   (a) Their risk of developing chronic symptoms after injury is lower.
   (b) They have a lower return-to-work rate after serious injury.
   (c) Their incidence of fatality at the workplace is lower.
   (d) They have a lower rate of recurrent injury.


Clinical Activity 7.5
33. What is the most common musculoskeletal injury in the aging worker?
   (a) Rotator cuff tear
   (b) Low back pain
   (c) Hip fracture
   (d) Osteoporotic compression fracture


Educational Activity 7.9
34. Which factor has NO direct influence on the decision for premature retirement in an elderly worker?
   (a) Preinjury job satisfaction
   (b) Good physical health status
   (c) Quality of work environment
   (d) Difficulty of employer accommodating light-duty work

   (c) Stikeleather J. An older worker’s decision to “push or protect self” following a work-related injury. Work 2004;22:139-44.

Educational Activity 7.9
35. After injury, an older worker’s successful return to work is NOT enhanced by which aspect in the rehabilitation program?
   (a) Exercise to improve flexibility
   (b) A program to increase aerobic fitness
   (c) Fall prevention education
   (d) Return to worksite after symptoms resolve

### QUESTION ANSWER COMMENTARY

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>ANSWER</th>
<th>COMMENTARY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>(a)</td>
<td>Obesity is a risk factor for plantar fasciitis. Plantar fasciitis affects both men and women equally. It also most commonly occurs in people between the ages of 40 and 70 years. Factors that increase the tension on the plantar fascia, such as decreased subtalar motion, pes cavus, pes planus, and a tight Achilles’ tendon, may contribute to plantar fasciitis.</td>
</tr>
<tr>
<td>2.</td>
<td>(b)</td>
<td>The center of the automobile headrest should be at ear level.</td>
</tr>
<tr>
<td>3.</td>
<td>(c)</td>
<td>De Quervain’s disease results in pain in the abductor pollicis longus and extensor pollicis brevis tendons, which pass through the first dorsal compartment.</td>
</tr>
<tr>
<td>4.</td>
<td>(a)</td>
<td>Criteria for the early use of plain radiographs include age greater than 50 years, unplanned weight loss for longer than 6 months, the need to assess for ankylosing spondylitis, significant trauma, and neurologic deficits.</td>
</tr>
<tr>
<td>5.</td>
<td>(c)</td>
<td>Magnetic resonance imaging is the study of choice to detect sequestered disk fragments and vertebral body endplate changes, because it provides excellent osseous and soft-tissue detail that are not seen with the other diagnostic studies.</td>
</tr>
<tr>
<td>6.</td>
<td>(a)</td>
<td>Carisoprodol (Soma) is an older muscle relaxant that breaks down to meprobamate, which has been classified as a schedule 4 controlled substance. There are reports of abuse and impaired driving with carisoprodol.</td>
</tr>
<tr>
<td>7.</td>
<td>(c)</td>
<td>Cyclooxygenase-2 (COX-2)–specific agents, when used alone, have less serious gastrointestinal complications than traditional nonsteroidal anti-inflammatories. Whether one is on a COX-2–selective or –specific agent, the gastrointestinal protection may be compromised by concomitant use of even low-dose aspirin, and renal side effects are not decreased.</td>
</tr>
<tr>
<td>8.</td>
<td>(c)</td>
<td>Tramadol should not be administered to patients receiving monoamine oxidase inhibitors, and cotreatments with tricyclic antidepressants and serotonin selective reuptake inhibitors should be undertaken with caution to avoid serotonin syndrome and an increased risk of seizures.</td>
</tr>
<tr>
<td>9.</td>
<td>(a)</td>
<td>Codeine is a prodrug converted to morphine through cytochrome P-450 metabolism. Up to 10% of whites lack this enzyme, and this may be a reason why codeine is not effective in all patients.</td>
</tr>
<tr>
<td>10.</td>
<td>(d)</td>
<td>Capsaicin is a topical agent derived from red chili peppers. Topical capsaicin depletes substance P and calcitonin gene–related peptide, leading to a pharmacologic desensitization of nociceptors. Capsaicin activates vanilloid receptors, a newly found family of thermosensitive receptors.</td>
</tr>
<tr>
<td>11.</td>
<td>(c)</td>
<td>Nineteen randomized trials of treatment of plantar heel pain were reviewed. Trial quality was noted to be generally poor. There was no evidence to support effectiveness of therapeutic ultrasound. There were no randomized trials evaluating surgery. There was limited evidence for the superiority of corticosteroid injections over orthotic devices. There is limited evidence that stretching exercises and heel pads were associated with better outcomes than custom-made orthoses in people who stand more than 8 hours a day.</td>
</tr>
<tr>
<td>12.</td>
<td>(a)</td>
<td>A study in the United Kingdom randomized 108 consecutive patients after a “whiplash” injury into either an exercise group or a group that was immobilized in a soft cervical collar for 3 weeks followed by the same exercise program. No differences were found between the 2 groups for pain, range of motion, or activities of daily living at follow-ups at 3, 12, and 52 weeks postinjury. The collar-treatment group took significantly longer to return to work (34d) than did the early-exercise group (17d).</td>
</tr>
<tr>
<td>13.</td>
<td>(b)</td>
<td>In a randomized trial no significant differences in pain were found with counterforce bracing. A Cochrane review of the literature showed no significant benefit of extracorporeal shock wave treatment over placebo. One study of 39 patients with lateral epicondylitis showed significantly better reduction of pain in the group treated with an isotonic eccentric exercise program versus a contract-relax stretching program.</td>
</tr>
<tr>
<td>14.</td>
<td>(d)</td>
<td>Both nocturnal and full-time splinting have been found to alleviate symptoms in carpal tunnel syndrome. Use of nonsteroidal anti-inflammatory drugs, ergonomic keyboards, and short-term ultrasound have not been found helpful in controlled trials.</td>
</tr>
</tbody>
</table>
15. (c) Studies have generally found that lumbar supports have little to no effect in preventing or treating back injury, but 1 study showed fewer days of absence from work because of back injury in workers who used lumbar supports and attended back school compared with those who only attended back school.

16. (b) The exact pathogenesis of trigger points remains unknown; however, researchers have noted consistently lower oxygen levels in these muscle fibers. Inflammation has not been shown in trigger point muscle tissue biopsy. Electromyographic evaluation of trigger points has sometimes shown an increase in miendplate potentials, but this finding is not consistent or considered pathognomonic for trigger points. Electromyographic evaluation does not show evidence of spasm or denervation potentials associated with trigger points.

17. (c) Cervical zygapophyseal-joint pain can most reliably be diagnosed by selective block of the nerves that innervate the joint, the medial branches of the cervical dorsal rami. Imaging studies can detect abnormal joint morphology but not whether or not the joint is a source of pain. Bone scans may also help identify abnormal joints, but they, too, do not indicate whether or not the joint is a source of pain. Mechanism of injury and physical examination findings may be suggestive of zygapophyseal-joint dysfunction as a cause of axial neck pain but are considered nonspecific.

18. (a) Radiofrequency neurotomy/neuroablation is an effective treatment for primary zygapophyseal joint pain and dysfunction, with pain relief reported for 7 to 9 months or longer. In contrast, intra-articular injection of corticosteroid provides only short-term relief of 1 to 4 weeks. This finding was not statistically different from injection of local anesthetic alone. Trigger point injections are of limited, transient benefit and do not address the joint itself. Cervical fusion is not indicated for primary zygapophyseal joint pain.

19. (c) A small number of prospective studies has shown beneficial effects of epidural corticosteroid injections for treatment of cervical radiculopathy/radiculitis. No studies have been performed comparing the transforaminal and interlaminar approaches. Epidural steroid injections are not indicated for the treatment of axial neck pain from either the facet joints or intervertebral disks.

20. (b) Recent reports of acute catastrophic neurologic injury have been associated with the transforaminal approach for epidural injection of corticosteroids. These injuries were hypothesized to be secondary to intra-arterial injection of particulate solutions and subsequent infarction of the central nervous system. The vessels most likely involved are the vertebral artery and radicular arteries of the spinal cord. Techniques used to help avoid such events include the use of fluoroscopic guidance during injection of contrast to assess for vascular flow. Digital subtraction analysis may also be used to assess for vascular flow during injection. Intralaminar epidural steroid injection is also associated with complications and neurologic injury due to epidural hematoma, abscess, or direct puncture of the spinal cord; however, these injuries are usually subacute and rarely result in death if properly treated. The possibility of neurologic injury exists with cervical facet injections, but such injury is easily avoided with good technique, and there are no published reports of such injury. Paraspinal trigger point injections, if properly performed, are not likely to be associated with neurologic injury.

21. (c) Intra-articular injection of local anesthetic, with subsequent pain relief, is the only reliable means of diagnosing primary sacroiliac joint (SIJ) pain. Physical examination findings, imaging studies, and nuclear medicine studies may suggest SIJ abnormalities but do not establish the SIJ as a cause of pain. Referral patterns of SIJ pain overlap with other sources of lumbar and lower-limb pain, and differentiation is important to determine effective treatment.

22. (b) Phospholipase A2 has been shown as an enzymatic marker for inflammation associated with lumbar disk herniations. It is the enzyme responsible for the release of arachidonic acid and subsequent production of prostaglandins and leukotrienes. Prostaglandin E2 and leukotriene B4 are also associated with disc herniations, as are interleukin-1, tumor necrosis factor-α, nitric oxide, and thromboxane.

23. (d) In the patients whose low-back pain is caused by the zygapophysyeal joints, radiofrequency ablation of the medial branches has been shown to provide a 90% reduction in pain in at least 60% of selected patients, with 87% of patients obtaining at least 60% reduction in pain. Pain relief lasted at least 12 months in these patients. It is possible to repeat the procedure if and when pain recurs. Intra-articular injection of corticosteroid may provide some relief of zygapophysyeal joint pain but is usually short-lived, lasting only a few days to a few weeks. Phenol blocks of the medial branches are not an established treatment for zygapophysyeal joint pain and have not been studied. Cage fusion addresses anterior column/diskogenic pain and would not relieve posterior column/zygapophysyeal joint pain.
24. (b) A high-intensity zone is a focal area in the outer annulus that appears bright on T2-weighted magnetic resonance images. It was originally described by Aprill and Bogduk and thought to be associated with painful annular tears. The presumption of symptoms associated with imaging has been questioned and refuted by Carragee. A high-intensity zone may be found in 24% of asymptomatic people and 59% of symptomatic people. When a high-intensity zone is present, diskography is positive approximately 70% of the time in both symptomatic and asymptomatic people. It is currently thought that the high-intensity zone is associated with acute or subacute tears of the outer annulus; however, the clinical significance of the high-intensity zone remains questionable. The other options listed are abnormalities that may be seen on magnetic resonance imaging but are not specific to the disk annulus.

25. (c) Intradiskal electrothermy annuloplasty is used to address annular tears not associated with disc herniations that are less than 4mm and do not protrude past the posterior longitudinal ligament. Further, the disk should have less than 50% loss of disk height on magnetic resonance imaging compared with normal disks. Patient selection for this intervention also includes a lack of response to conservative care with pain persisting for at least 6 months. The patient should have no symptoms of nerve root compression or significant spinal stenosis. Patients with high pain ratings and lower levels of function pretreatment show greater benefit than those with low to medium pain ratings and high functional levels.

26. (b) Some evidence exists to support the use of intradiskal electrothermal annuloplasty, nucleoplasty, and percutaneous disk decompression in the treatment of painful lumbar disks. There is no evidence to support the use of intradiskal steroids. Not only have intradiskal steroids failed to show benefit, they may actually be harmful. Animal studies show disk degeneration in response to intradiskal steroid injections.

27. (d) Local corticosteroid injection is proven effective as a treatment for de Quervain’s tenosynovitis, both with and without splinting. Injection alone produced an 83% cure rate, with injection plus splinting producing a 61% cure rate. Splinting alone produced a 14% cure rate, and rest and anti-inflammatories were of no benefit.

28. (d) Insulin has been hypothesized to stimulate nerve regeneration, similar to nerve growth factor. Injection of corticosteroid into the carpal tunnel followed by similar injections of insulin produced more significant improvement than did corticosteroid alone in patients with non-insulin-dependent diabetes mellitus. This improvement was measured by global symptom score and median nerve motor/sensory distal latency improvement. Corticosteroid injection produced clinical improvement superior to surgical decompression at 3 months and equal to surgical decompression at 1 year. Results of corticosteroid injection were superior to iontophoresis and phonophoresis. Corticosteroid injection results in improved nerve conduction parameters and symptom severity in patients with mild to moderate carpal tunnel syndrome.

29. (d) Review of the medical literature does not show a clear association between local corticosteroid injection and Achilles’ tendon rupture. Animal studies indicate decreased tendon strength associated with intratendinous injection of corticosteroid, with presumed increase in tendon rupture. Clinical studies of peritendinous injections did not show an increase in rupture rate. Some clinicians advocate for injection under fluoroscopic or ultrasound guidance to avoid intratendinous injection. Evidence is inadequate to support the use of local corticosteroid injections as a treatment for Achilles’ tendinitis.

30. (d) Corticosteroid injections are an effective treatment for plantar fasciitis; however, patients may be reluctant to undergo the procedure because of the significant pain that is associated with injection. This pain can be significantly reduced or eliminated by blocking the posterior tibial nerve before performing the injection. This procedure also significantly increased the willingness of patients to undergo repeat injections. Mixing lidocaine with the corticosteroid would not decrease the pain associated with the injection, it might actually increase the pain. Topical capsaicin would not affect pain at the deeper levels. Although contact with the calcaneus may increase the pain associated with injection from contact with the periosteum, avoidance of the calcaneus would not eliminate the pain associated with injection.

31. (b) A multitude of factors place the aging worker at an increased risk for injury. Risks commonly cited in the literature include a decrease in vision and hearing with increasing age. Findings from the Health Retirement Study affirm that decreased hearing and vision are independent risk factors for occupational injury.
32. (b) Outcome studies of injured workers show a clear trend of older workers having longer periods of disability from their occupational injuries than do younger workers. Prospective trials affirm that older workers are less likely to return to work after injury, with longer periods of disability after injury when compared with younger workers. The incidence of injury-associated fatality advances with age. Development of chronic symptoms after injury is higher for workers aged 50 years and older, and they are at greater risk for recurrent injury.

33. (b) Low back pain injuries are the most common musculoskeletal injury in the aging workforce.

34. (d) Earlier-than-planned retirement correlates with preinjury job dissatisfaction, poor medical care, and poor physical and mental health status. Difficulty keeping up with job-related tasks and poor quality of the work environment has led to earlier retirement. Difficulty arranging alternative duty is associated with prolongation of work disability and thus may indirectly influence retirement decisions. Employers who are deemed rigid, inflexible, and nonsupportive are less likely to see their older workers return.

35. (d) Successful return to work is enhanced by a rehabilitation program that emphasizes improved flexibility, increased aerobic fitness, strengthening, education on fall prevention and lifting techniques, and early return to the worksite. Early return to the worksite has a higher success rate for return to work but may not be compatible with complete symptom resolution.
Spinal Cord Injury Medicine. 1. Epidemiology and Classification

Chester H. Ho, MD, Lisa-Ann Wuermser, MD, Michael M. Priebe, MD, Anthony E. Chiodo, MD, William M. SceIza, MD, Steven C. Kirshblum, MD


This self-directed learning module reviews the demographics of traumatic and nontraumatic spinal cord injuries (SCIs). It is part of the study guide on SCI medicine in the Self-Directed Physiatric Educational Program for practitioners and trainees in physical medicine and rehabilitation. This article specifically focuses on the changing demographics of traumatic SCI, the classification of SCI, the common causes of nontraumatic SCI, and the incidence and prevalence of myelomeningocele.

Overall Article Objective: To summarize the demographics and classification of traumatic and nontraumatic spinal cord injuries in adults and children.

Key Words: Classification; Meningomyelocele; Multiple sclerosis; Rehabilitation; Spinal cord injuries; Spinal cord neoplasms; Spinal stenosis.

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1.1 Educational Activity: To discuss the epidemiologic factors relevant to a 70-year-old man who fell and sustained a neurologically incomplete C4 injury.

Since 1973, THE NATIONAL Spinal Cord Injury Database (NSCID) has been collecting data on people with new spinal cord injuries (SCIs) from the facilities participating in the Model Spinal Cord Injury System (MSCIS). Analyses of these data have shown changing trends in traumatic SCI. Such epidemiologic data can guide us on the use of resources for preventing and treating SCI.

The case of this 70-year-old man who fell illustrates several significant trends in traumatic SCI: the increasing average age of onset, the increasing incidence of falls as one of the leading causes of SCI, the increasing incidence of cervical injuries, and the continuing trend of people with incomplete tetraplegia as the largest group by neurologic classification.

Increasing Age at Onset of SCI

Between 1973 and 1979, the average age at injury was 28.7 years, with most of the injuries occurring between the ages of 16 and 30 years. The average age has since been increasing steadily to an average age of 37.6 years between 2000 and 2003.2 With the exception of violence as a cause of injury, this increase in the average age at injury has been found in all other etiology groups (motor vehicle crashes, falls, sports). A closer look at the data showed that, although the relative order of prevalence of SCI in the various age groups (0–15, 16–30, 31–45, 46–60, 65+y) has remained unchanged, the absolute percentage for each group has significantly changed over the last 3 decades. The prevalence in older adults above the age of 65 years has increased from 4.7% between 1973 and 1979 to 10.9% since 2000, whereas the prevalence among children between the ages of 0 and 15 years has decreased from 6.4% to 2.0% in the same periods2 (table 1). This trend of increasing average age of injury is significant; the larger percentage of elderly people with SCI has implications on the need to consider specific aging-related and geriatric needs in the rehabilitation of these people.

Changes in Etiology

The most common cause of SCI between 2000 and 2003 continued to be motor vehicle crashes (table 2). They account for 50.4% of all the causes for all age groups during the time period, compared with a similar rate of 48.7% between 1973 and 1979.2 However, the rates for falls have progressively decreased over the last 3 decades, from 16.5% in the 1970s to 23.8% between 2000 and 2003.2 Even though falls were still the second most common cause of SCI across all age groups, it was the only cause with a rate that has steadily increased over the last 3 decades. When data were stratified by age group, it was apparent that falls were by far the most common cause of SCI in people over age 60 years. Successful fall prevention education for the elderly may mitigate the prevalence of SCI in this population.

Examination of the other causes of SCI shows that the rates associated with sports have decreased over the decades, from 14.4% between 1973 and 1979 to 9% between 2000 and 2003. Violence as an etiology as reported by the NSCID initially increased from 13.3% between 1973 and 1979 to a peak of 21.8% in the 1990s. However, it has since declined to 11.2% between 2000 and 2003. When compared with international statistics, with the exception of acts of violence as causes of SCI, the etiologies of SCI were similar in other countries, including Denmark, Taiwan, and Spain.2

The Increasing Incidence of Cervical Injuries

Throughout all the time periods observed, cervical injuries occurred more often than thoracic and lumbar injuries. Furthermore, there was an increasing percentage of cervical injuries from 53.5% between 1973 and 1979 to 56.5% between 2000 and 2003. This increase was statistically significant but also has financial implications, because the lifetime costs for the care of
people with tetraplegia were much higher than for those with paraplegia. For all age groups since 2000, people with incomplete tetraplegia made up the highest number (34.5%), followed by complete paraplegia (23.1%), complete tetraplegia (18.4%), and incomplete paraplegia (17.5%).

Other Trends
NSCID data show that from the 1970s to the 1990s, the percentage of whites with SCI decreased from 76.8% between 1973 and 1979 to 59.9% between 1990 and 1999. However, the percentage has risen to 67.4% between 2000 and 2003. At the same time, the increase in percentage among African Americans and Hispanics from the 1970s to the 1990s was reversed between 2000 and 2003. During the periods when the percentage of ethnic minorities with SCI rose, there was a striking correlation with an increase in acts of violence as causes for SCI.

The percentage of females with SCI has increased since the 1970s, from 18.2% between 1973 and 1979 to 21.8% between 2000 and 2003. When the data from the Shriners Hospitals for Children SCI database were combined with the NSCID from 1973 to 2002, analysts noted that males were a consistently decreasing proportion of new SCI patients. Therefore, this finding appeared to reflect a trend observed across different age groups.

The NSCID has provided the most comprehensive and helpful epidemiologic data on SCI in the United States, noting the changing trends of traumatic SCI over the last 3 decades. However, the data represent only the facilities participating in the MSCIS. Furthermore, over the decades, the profile of the participating facilities has changed. Therefore, it is not clear how generalizable these data are to the general U.S. population. Such factors should be taken into account when interpreting these data.

1.2 Clinical Activity: To classify the injury for a 70-year-old man with diabetes mellitus who fell from a ladder.

Sensation
Examining the patient at 72 hours after injury, you note the following: sensation is normal to pin prick and light touch over the face and neck, in the supraclavicular region anteriorly, and over the acromioclavicular joints bilaterally. Sensation to pin-prick is diminished, but present, at the lateral antecubital fossa bilaterally and in all dermalomatal segments below. Light touch is intact throughout except at midcalf and below bilaterally. Proprioception is absent at the toes bilaterally.

Motor Function
Motor examination results are in Table 3.

Reflexes
Areflexia is observed in biceps, brachioradialis, and tricip reflexes bilaterally; hyperreflexia without clonus at the patella tendons; and areflexic at the Achilles’ tendon. There is an extensor response to plantar stimulation bilaterally.

Rectal Examination
The patient’s sensation to light touch is present at the anocutaneous junction with absent voluntary anal contraction. There is increased sphincter tone and a present bulbocavernous reflex. Based on these examination findings, this patient’s neurologic classification according to the American Spinal Injury Association (ASIA) International Standards for Neurological Classification of Spinal Cord Injury is as follows: sensory level of injury, C4 bilaterally; motor level of injury, C4 bilaterally; and degree of completeness, ASIA Impairment Scale (AIS) grade C. This combination of findings follows a pattern of central cord syndrome with an underlying peripheral neuropathy.

In 1982, ASIA published its first edition of the Standards for Neurological Classification of Spinal Injured Patients. This document arose from a need to more precisely define neurologic levels and the extent of incomplete injuries. The ASIA standards focused on key muscles and key sensory points to be tested during the neurologic assessment. Ten key muscles were selected, 5 in the upper limb and 5 in the lower limb (Table 4). Each muscle represents a single myotome from C5 through T1 and L2 through S1. The muscles were chosen to be testable with the patient supine and with minimal movement of the spinal column. Likewise, key sensory points were selected to represent each sensory dermatome from C2 through S4-5. A standardized form to be used as a flow chart for classifying spinal injuries was also developed by ASIA (Fig 1).

Over the next 10 years, refinements were made to definitions of neurologic levels, key muscles and key sensory points, the zone of partial preservation, and the Frankel Scale. In 1992 the fourth edition of the Standards was published. In this edition, the most important change incorporated was the definition of complete versus incomplete injuries using the sacral sparing basis for definition of completeness. An injury was defined as neurologically incomplete if there was any sparing present at the lowest sacral segments. This edition also included recommendations for use of the FIM instrument for assessment of disability. The Frankel Scale was further modified and was termed the ASIA Impairment Scale (AIS). Also in 1992, the International Medical Society of Paraplegia (now the International Spinal Cord Society) endorsed these standards, creating the International Standards for Neurological and Functional Classification of Spinal Cord Injury.

The International Standards document has evolved and improved over the past 20 years. These standards have become accepted as the appropriate method for describing the neurologic impairment of SCI for clinical and research use. The standards have been used in numerous clinical trials and have been incorporated into the International Core SCI Data Set. Although not all patients fit the International Standards matrix perfectly, most patients can be adequately classified using this approach.

Appendix 1 also lists the most common terms used in SCI medicine. Appendix 2 describes the steps to classify the SCI, and appendix 3 outlines the AIS. An ASIA Standards Teaching Package and Additional Teaching Manuals (2003, Revised) are available.

Table 1: Changes in Age at Onset of SCI

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>1973–1979</th>
<th>2000–Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average age at injury (y)</td>
<td>28.7</td>
<td>37.6</td>
</tr>
<tr>
<td>Percentage of people &gt;60y at injury</td>
<td>4.7</td>
<td>10.9</td>
</tr>
</tbody>
</table>

NOTE. Data from the National Spinal Cord Injury Statistical Center.

Table 2: Changes in Etiology of SCI

<table>
<thead>
<tr>
<th>Etiology of SCI</th>
<th>1973–1979</th>
<th>2000–Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor vehicle crashes</td>
<td>48.7</td>
<td>50.4</td>
</tr>
<tr>
<td>Falls</td>
<td>16.5</td>
<td>23.8</td>
</tr>
<tr>
<td>Sports</td>
<td>14.4</td>
<td>9</td>
</tr>
<tr>
<td>Violence</td>
<td>13.3</td>
<td>11.2</td>
</tr>
</tbody>
</table>

NOTE. Values are percentages. Data from National Spinal Cord Injury Statistical Center.
have been developed as a companion volume to the current standards. The teaching package provides a detailed explanation of the examination elements, rationale for inclusion, scoring instructions, and background references. It is available online from the ASIA Website.8

In the sample case the stocking-glove loss of sensation is most likely caused by the history of diabetes mellitus and is unrelated to the patient’s SCI. Although reflexes are an important part of the neurologic examination they are not used for classification in the International Standards.

1.3 Educational Activity: To identify the common causes of nontraumatic SCI pertinent to a 30-year-old woman who presents with subacute onset of paraplegia associated with a T6 sensory level.

Nontraumatic SCI affects a vast number of people and is a growing population for admission to inpatient rehabilitation. The percentage of inpatient rehabilitation admissions for SCI for nontraumatic injuries has been growing. In a comparison of traumatic and nontraumatic SCI, Chapman9 found that nontraumatic SCI was more likely to present with a neurologically incomplete lesion and was associated with a lower frequency of secondary conditions such as spasticity, deep vein thrombosis, and autonomic dysreflexia. However, among an older population, other comorbidities and generalized deconditioning more significantly affected functional outcome. In patients with nontraumatic SCI, there tended to be a longer period between diagnosis and rehabilitation than in traumatic SCI. Nontraumatic SCI patients had a lower rate of discharge home (73%), with favorable discharge seen in patients who had incomplete injury, were married, and had an established bowel and bladder management program and intact skin.

Excluding multiple sclerosis (MS) and degenerative central nervous system (CNS) diseases, causes for nontraumatic SCI have included neoplasms (25%), vascular disease (25%), inflammatory disease (19.5%), and spinal stenosis (18.6%).10 In another study,11 spinal stenosis (21%) and spinal cord tumors (14%) were the most common causes of nontraumatic SCI. Spinal stenosis patients with cord compression were more commonly paraplegic (73%) and neurologically incomplete (90%) than their traumatic SCI counterparts.12

Inflammatory disorders of the spinal cord were commonly represented among SCI patients who participate in rehabilitation. MS was most commonly seen in young adults, although pediatric and elderly presentations are common and may affect the spinal cord. Pediatric disease was usually relapsing-remitting and with a longer time course to disability, although disability occurs at an earlier age. Negative prognostic indicators among children were a short interattack interval, a high relapse rate, a relapsing-progressive course, a shift to the secondary progressive phase, and early accumulation of disability.13 Elderly presentation, representing 4% to 10% of cases, was often primary progressive with pyramidal or cerebellar involvement seen in more than half. Progression to disability is faster in elderly patients than younger patients. Differential diagnoses included cerebrovascular disease, hypertension-related encephalopathy, cerebellar degenerative diseases, other neurodegenerative diseases, and nutritional disorders. Diseases that mimic MS included Devic’s neuromyelitis optica and acute disseminated encephalomyelitis. Devic’s neuromyelitis optica was diagnosed clinically and by magnetic resonance imaging (MRI), with evidence of myelitis and optic neuritis. Poorer prognosis was seen clinically in people with relapses in the first 2 years of the disease, with older age, and in women.14 Antiphospholipid syndrome can clinically mimic MS. In MS, MRI is an accepted tool for monitoring disease progression, with the number of new lesions seen on T2 images and degree of brain atrophy being predictive of subsequent disease in primary progressive patients.

Transverse myelitis (TM) is another common inflammatory disorder of the spinal cord. It can be primary or may be secondary to vasculitis or rheumatologic disorders such as systemic lupus erythematosus or Sjogren’s syndrome. TM has a female-to-male ratio of 4:1, with peaks in the second and fourth decades. The time course of progression is longer than 48 hours and less than 6 weeks. At nadir, half have paraplegia, all have neurogenic bladder, and 80% to 94% have sensory symptoms. Over time, one third recovered, one third had neurologic deficits, and one third had paraplegia. Poor recovery was predicted by rapid progression, back pain, and spinal shock.15

SCI from epidural abscess in immunocompromised and diabetic patients is not rare. Epidural hematoma can be associated with anticoagulation, vascular malformations, or myelodysplastic diseases. Arterial disease associated with thrombosis or embolism to spinal arteries may cause spinal cord ischemia and injury. Infarction of the spinal cord can occur in many other vascular diseases, including vasculitis and diabetes. Idiopathic syringomyelia can also cause spinal cord damage.

Table 3: The Patient’s Muscle Grades by Location 72 Hours Postinjury

<table>
<thead>
<tr>
<th>Side</th>
<th>Elbow Flexion</th>
<th>Wrist Extension</th>
<th>Elbow Extension</th>
<th>Deep Finger Flexion</th>
<th>Finger Abduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>1/5</td>
<td>1/5</td>
<td>3/5</td>
<td>3/5</td>
<td>3/5</td>
</tr>
<tr>
<td>Left</td>
<td>0/5</td>
<td>0/5</td>
<td>1/5</td>
<td>1/5</td>
<td>1/5</td>
</tr>
</tbody>
</table>

Table 4: The 10 Key Muscles Tested to Determine an ASIA SCI Classification

<table>
<thead>
<tr>
<th>Muscle Group</th>
<th>Root Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper limb</td>
<td></td>
</tr>
<tr>
<td>Elbow flexors</td>
<td>C5</td>
</tr>
<tr>
<td>Wrist extensors</td>
<td>C6</td>
</tr>
<tr>
<td>Elbow extensors</td>
<td>C7</td>
</tr>
<tr>
<td>Long finger flexors</td>
<td>C8</td>
</tr>
<tr>
<td>Small finger abductors</td>
<td>T1</td>
</tr>
<tr>
<td>Lower limb</td>
<td></td>
</tr>
<tr>
<td>Hip flexors</td>
<td>L2</td>
</tr>
<tr>
<td>Knee extensors</td>
<td>L3</td>
</tr>
<tr>
<td>Ankle dorsiflexors</td>
<td>L4</td>
</tr>
<tr>
<td>Long toe extensor</td>
<td>L5</td>
</tr>
<tr>
<td>Ankle plantarflexors</td>
<td>S1</td>
</tr>
</tbody>
</table>
SCI in patients after thoracoabdominal aneurysm repair was reported in 9% to 18% of cases. Increased occurrence was associated with rupture, dissection, or prolonged surgery. Improved outcome has occurred with preoperative planning with spinal angiography, reattachment of intercostal arteries, good distal aortic perfusion, spinal cord hypothermia, intraoperative cerebrospinal fluid drainage, and intraoperative neurophysiologic monitoring.

Radiation myelopathy may occur months after treatment. This myelopathy involves an injury to the white matter that predominates in the lateral spinal cord. Etiology remains elusive, with injury to glial cells and vascular injury remaining as the most likely mechanisms.

Spinal cord tumors can be primary or metastatic, intradural, or extradural. In patients with intramedullary tumors, favorable functional outcome was observed in 94.1% of patients with vascular tumors, in 61.3% of patients with low-grade neuroepithelial tumors, and in 53.3% of patients with malignant tumors. The strongest predictors of functional outcome were the tumor type and the preoperative neurologic status. In patients with metastatic spine disease, quality-of-life measurements have been generally favorable except for those patients who have high emotional distress.

Comprehensive inpatient rehabilitation that included mobility, activities of daily living, bowel and bladder care, and patient and family training and equipment prescription was important for nontraumatic injuries. The prognosis of the underlying disease process will guide the rehabilitation goals. Inpatient rehabilitation lengths of stay were shorter, but FIM efficiency and home discharge rates were comparable with those of traumatic spinal cord patients.

1.4 Educational Activity: To discuss the epidemiologic factors related to a girl born with spina bifida at the L2 level with a lower motoneuron injury.

Embryonic development of the CNS starts with the formation of the neural tube at approximately day 18. Neural tube defects or, as they are most accurately termed, spinal dysraphism, result in failure of the ectodermal, mesodermal, and neuroectodermal tissues to develop properly. In the United States, spinal dysraphism incidence has dramatically decreased to about 3.2 per 10,000 live births. Recent trends show a uniform incidence in all ethnic groups with no geographic variation. The reduction in incidence is largely believed to be associated with better national nutritional habits. Folic acid...
supplementation of 0.4mg a day is recommended for all women of childbearing age to reduce the risk. The risk to siblings of those with spinal dysraphism increases to 2% to 5% with 1 affected sibling and to 10% to 15% with 2 affected siblings. In those with spina bifida, allergy to latex has a prevalence of up to 40%. It is immunoglobulin E mediated and may be mild with urticaria or more severe with laryngeal edema and bronchospasm; it is recommended that latex exposure be minimized as much as possible. Cognitive dysfunction, obesity, and precocious puberty are also commonly seen in people with myelomeningocele.

In spinal dysraphism’s most common form, myelomeningocele, neural elements are exposed, causing complete neurologic deficits. They can present anywhere throughout the spine but are most commonly seen in the thoracolumbar regions, resulting in paraplegia. After birth, in the presence of a myelomeningocele, immediate surgical closure is usually undertaken within 24 hours. Goals of the operation are to preserve neurologic function and to prevent infection. In a meningocele, the dural sac is exposed and the neural elements may be intact without neurologic deficits. Prompt closure is suggested for the same reasons as with myelomeningocele.

Occult spinal dysraphism refers to closed spinal deficits including spinal lipomas, diastematomyelia, and a tethered spinal cord. These conditions are suspected when a cutaneous marker such as a dimple with a pinhole tract, a hairy patch, or nevus is discovered. Neurologic deficits at the time of birth may or may not be present, but further investigation should ensue. Spinal lipomas may present with a subcutaneous fatty mass without any neurologic deficits but may gradually change over the first years of life and should be closely monitored. Surgical treatment is usually focused on untethering of the spinal cord. The lipomas are not typically removed, because neural tissue is usually enmeshed within them and removal would potentially create a more severe deficit. Spina bifida occulta is strictly a defect in bony closure of the posterior elements without neurologic deficit and is usually an incidental finding.

In people with myelomeningocele, hydrocephalus is seen in approximately 90% of patients and usually manifests itself after surgical closure. Most of these people will also require ventriculoperitoneal (VP) shunting, which is placed at the same time as the surgical closure. Classic symptoms of elevated intracranial pressure such as headache, nausea, vomiting, and lethargy may be present in shunt malfunctions and must be reviewed with the patient and his/her caregivers. Adolescents, however, may have a more subtle presentation, which may be irritability, worsening performance at school, and generalized weakness. Chiari II malformations are usually the underlying etiology of hydrocephalus, because they are present in almost all cases. Dysphagia, stridor, vocal cord paralysis, cranial nerve palsies, and central respiratory dysfunction may occur in about 20% of cases, and symptoms will primarily occur in the first several months of life. These symptoms are usually treated with VP shunting but sometimes will need a posterior fossa decompression to relieve pressure exerted on the brainstem. Cognitive dysfunction is also prevalent, with approximately 30% of people having below-normal intelligence.

Hydroxyrnygomyelina (syrinx) or cystic fluid-filled cavities within the spinal cord are common in myelomeningocele, but the precise prevalence is not known. The syrinx cavity can present in any portion of the spinal cord but is most common in the cervical segments. Classic presentation of syrinx formation includes cervical pain, new weakness, spasticity, and scoliosis. A syrinx may be asymptomatic and may not present clinically until adulthood. Possible etiologies could exist from a tethered spinal cord, which will place traction on the spinal cord over time and contribute to syrinx formation. Tethering of the spinal cord is usually from scar formation or traction of neural tissue attached to the dura. Symptoms of tethered cord are very similar to syrinx. If severe, surgical procedures can be performed to release the tethered area, but scar tissue will often allow them to recur in 15% to 20% of cases.

Scoliosis affects most people with myelomeningocele as well, especially when at the thoracic levels. Neuromuscular weakness, lower-extremity contractures, and primary vertebral abnormalities all contribute to the formation of scoliosis. Syrinx formation, uncompensated hydrocephalus, or tethered cord syndrome, as mentioned before, should be considered when a scoliosis abruptly worsens, especially in someone who is skeletally mature. Curvature generally less than 25° should be monitored closely. Greater curvature may require a thoracolumbosacral orthosis brace to prevent further curvature. Severe curves will occasionally require surgery.

**APPENDIX 1: GLOSSARY OF KEY TERMS USED IN SCI**

<table>
<thead>
<tr>
<th>Key muscle groups:</th>
<th>The 10 muscle groups that are tested in the standardized spinal cord examination.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Motor level:</strong></td>
<td>The most caudal key muscle group that is graded 3/5 or greater with the segments cephalad to that level graded normal (5/5) strength.</td>
</tr>
<tr>
<td><strong>Sensory level:</strong></td>
<td>The most caudal dermatome to have normal sensation for both pinprick and light touch on both sides.</td>
</tr>
<tr>
<td><strong>Neurologic level of injury:</strong></td>
<td>The most caudal level at which both motor and sensory modalities are intact.</td>
</tr>
<tr>
<td><strong>Complete injury:</strong></td>
<td>The absence of sensory and motor function in the lowest sacral segments.</td>
</tr>
<tr>
<td><strong>Incomplete injury:</strong></td>
<td>Preservation of motor or sensory function below the neurologic level of injury that includes the lowest sacral segments.</td>
</tr>
<tr>
<td><strong>Sacral sparing:</strong></td>
<td>Presence of motor function (voluntary external anal sphincter contraction) or sensory function (light touch, pinprick at S4/5 dermatome, or anal sensation on rectal examination) in the lowest sacral segments.</td>
</tr>
<tr>
<td><strong>Zone of partial preservation:</strong></td>
<td>All segments below the neurologic level of injury that have preserved motor or sensory findings; used only in complete SCI.</td>
</tr>
</tbody>
</table>

**APPENDIX 2: STEPS TO CLASSIFYING INJURY SEVERITY IN A PATIENT WITH SCI**

1. Perform sensory examination in 28 dermatomes bilaterally for pinprick and light touch, including S4/5 dermatome, and test for anal sensation.
2. Determine sensory level (right and left).
3. Perform motor examination in the 10 key muscle groups, including anal contraction.
4. Determine motor level (right and left).
5. Determine neurologic level of injury.
6. Classify injury as complete or incomplete.
8. Determine zone of partial preservation if ASIA A.

**APPENDIX 3: THE AIS**

A = Complete: No sensory or motor function preserved in the lowest sacral segments (S4/5).
B = Sensory incomplete: Sensory but no motor function preserved below the neurologic level including the sacral segments S4/5.
C = Motor incomplete: Motor function is preserved below the neurologic level, and more than half of the key muscles

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APPENDIX 3: THE AIS\textsuperscript{4} (cont’d)

below the neurologic level have a muscle grade less than 3.
There must be some sparing of sensory and/or motor function
in the segments S4/5.

D = Motor incomplete: Motor function is preserved below
the neurologic level, and more than half the key muscles below
the neurologic level have a muscle grade greater than or equal
to 3. There must be some sparing of sensory and/or motor
function in the segments S4/5.

E = Normal: Sensory and motor functions are normal.
Patient may have abnormalities on reflex examination.

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Spinal Cord Injury Medicine. 2. Acute Care Management of Traumatic and Nontraumatic Injury

Lisa-Ann Wuermser, MD, Chester H. Ho, MD, Anthony E. Chiodo, MD, Michael M. Priebe, MD, Steven C. Kirshblum, MD, William M. Scelza, MD


This self-directed learning module highlights the basic acute care management of traumatic and nontraumatic spinal cord injury (SCI). It is part of the chapter on SCI medicine in the Self-Directed Physiatric Education Program for practitioners and trainees in physical medicine and rehabilitation. Acute traumatic SCI is optimally managed in a level 1 trauma center. Decompression of the neural elements, stabilization of the spine, and maintenance of tissue perfusion are fundamental to optimizing outcomes. SCI patients are at high risk of pressure ulcers, venous thromboembolism, stress ulceration, bowel impaction, dysphagia, and pulmonary complications. Physiatric interventions are needed to prevent these complications. Prognostication of neurologic outcome based on early examination is an important skill to aid in creating a rehabilitation plan and to test for efficacy of early interventions. Nontraumatic SCI is an increasing population in rehabilitation centers. Establishing a diagnosis and treatment plan is essential, in conjunction with prevention of complications and early physiatric intervention.

Overall Article Objectives: (a) To describe the diagnostic evaluation of traumatic and nontraumatic spinal cord injuries and (b) to summarize the medical, surgical, and physiatric interventions during acute hospitalization for these injuries.

Key Words: Acute care; Prognosis; Rehabilitation; Spinal cord injuries.

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Reprints are not available from the author.


2.1 Clinical Activity: To discuss the acute care management of a 20-year-old man admitted to the trauma center with a C4 American Spinal Injury Association grade A spinal cord injury after a snowboarding accident.

Patients with acute traumatic spinal cord injury (SCI) should be managed at a trauma center with SCI experience, particularly patients with concomitant injuries. Level 1 trauma centers have been shown to have better outcomes in acute SCI than lower-level trauma centers or nondesignated hospitals, although the differences between level 1 and level 2 were small in isolated SCI.1 Transfer to such a center is advocated as soon as the patient is stable, with the suggestion that emergency medical services in urban areas should consider bypassing the nearest hospital to take SCI patients to level 1 trauma centers directly.2 Level 1 trauma centers are required to have in-house neurosurgical consultation and can therefore more rapidly assess patients and intervene. These centers also often have well-defined, evidence-based protocols for SCI care and staff well-trained in SCI because of a higher volume of an otherwise low-incidence injury.

Principles of spine stabilization are well established and have changed little in recent years. Timing of decompression of the neural elements, however, is controversial. Animal data have consistently suggested increased neuronal loss from prolonged compression.5–7 Human studies have been conflicting, but comparisons are marred by differences in time points chosen, types of injuries included, and surgical procedures performed. It is likely that little difference exists in outcome between patients undergoing surgical decompression later than 48 hours and those treated even later than that.8 However, decompression within 24 hours may improve neurologic recovery, particularly in patients with incomplete injuries, but to date, data are inadequate to mandate such a standard.9 These studies agree that there is not an increased risk of neurologic deterioration from early surgery, as was previously thought. Further, early surgery is associated with fewer complications and shorter acute care lengths of stay.7,8

Although adopted as a standard of care more than a decade ago,9,10 the use of high-dose methylprednisolone as a neuroprotective agent in acute SCI has now been called into question, based on methodologic concerns of the primary studies.11 In light of the enrollment of a high number of patients with minimal deficit into the National Acute Spinal Cord Injury Study (NASCIS) trials, it is particularly difficult to determine the benefit of the protocol in people with complete SCI and in people who have incomplete SCI with a significant deficit. Both the neurosurgical guidelines12 and the Consortium for Spinal Cord Medicine clinical practice guideline13 consider the use of high-dose methylprednisolone to be a treatment option rather than a standard. Concerns have been expressed about the increased risk of infection and gastrointestinal bleeding associated with the 48-hour–long infusion. Steroid myopathy has been shown to be associated with both the 24-hour–long and
the 48-hour–long infusions. The prevalence and functional implications of this myopathy are presently unknown. Despite these caveats, the use of the NASCIS protocol remains high in the United States.

Spinal cord perfusion has been a recent area of exploration for neuroprotection. Hypotension has been recognized as a contributor to secondary neurologic injury and should be avoided. However, clear data on optimal blood pressure to ensure adequate perfusion, as well as any other intervention to improve spinal cord perfusion in traumatic SCI, are lacking. Routine use of a lumbar drain to reduce cerebrospinal fluid (CSF) pressure has reduced the prevalence of ischemic SCI associated with abdominal aortic aneurysm repair. The effect of this intervention in traumatic SCI is currently in clinical trial. Although human data are limited, the neurosurgical guideline has recommended that the mean arterial pressure be maintained at 85 to 90mmHg for the first 7 days after injury.

However, a randomized controlled trial is needed to confirm the safety and efficacy of this intervention. Physiatrists may facilitate transfer of patients receiving this care out of the intensive care unit (ICU) by advocating for the use of abdominal binders, lower-limb compression, and oral vaspressors such as midodrine as other options to maintain adequate cord perfusion.

Autonomic dysfunction is common in acute SCI and is particularly noticeable in cervical level injuries. Bradycardia and neurogenic shock are commonly seen in the acute care setting, but autonomic dysreflexia may also occur in this early period and will certainly be a concern in hospitalized chronic SCI patients. Spinal shock and neurogenic shock, although related, are separate entities. Spinal shock refers to the loss of reflex neurologic activity in the spinal cord, and is defined by loss of all spinal reflexes. Neurogenic shock is loss of adequate tissue perfusion associated with hypotension of neurologic origin. However, acute SCI patients may have multiple causes of shock. Sepsis, hypovolemia, and cardiogenic shock must all be considered in the early period of SCI. Volume resuscitation is an appropriate initial measure, but vasopressors are often necessary. Patients using antihypertensive medications before injury may be particularly difficult to control until the medication effects are inactive. Bradycardia occurs because of unopposed vagal tone, with a greater effect seen in higher levels of injury. Stimulation of vagally innervated tissue may further lower heart rate, as is seen commonly during deep tracheal suctioning. Although the bradycardia is often self-limited, atropine may be used either as treatment or as pretreatment in the case of identifiable triggers. External pacing may be of benefit as well. Autonomic dysreflexia requires intact spinal cord reflexes and so will not be seen until emergence from spinal shock. Although hypertensive emergencies are uncommon in the early period, the instability of blood pressure as low-level dysreflexia occurs and resolves can be confusing to the acute care team. The physiatrist can be helpful not only with management but in identifying the source of dysreflexia. Hyperthermia is not a component of autonomic dysreflexia but may indicate the source of dysreflexia. However, heat dispersion is impaired in SCI, such that fever from a typical source may result in higher temperatures and longer periods of fever compared with a neurologically intact population. Strictly speaking, environmental fevers are unlikely in the ICU setting, considering its constant environmental control. However, a fever in the early weeks after tetraplegia without any identified source, or “quad fever,” can occur. This is a diagnosis of exclusion and may be related to a heightened febrile response to atelectasis.

Preventing complications remains vital in acute SCI. Prophylaxis of venous thromboembolism should begin no later than 72 hours after the onset of SCI and should include anticoagulation for most injuries. Low–molecular-weight heparin has been compared with unfractionated heparin, at 5000U 3 times daily, with similar rates of deep vein thrombosis but higher rates of pulmonary embolism (PE) and bleeding in the unfractionated heparin group found. In light of the high rate of PE, an inferior vena cava (IVC) filter should be used in SCI patients who have contraindications to anticoagulation. If the contraindication is temporary, a temporary filter can be placed until pharmacologic prophylaxis can be instituted. There is no evidence to support routine placement of IVC filters.

SCI confers a substantially higher risk of stress ulceration than all other kinds of trauma. Those with cervical injuries appear to be at particularly high risk. Either H2-blockers or proton pump inhibitors are indicated, to be started at admission and continued for 4 weeks. The use of acid-reducing agents beyond 4 weeks is not indicated unless other risk factors for peptic ulceration are present, such as a bleeding disorder, mechanical ventilation, or history of ulcer disease. Ongoing use of acid reducing agents may increase the risk of Clostridium difficile bowel infection.

### 2.2 Clinical Activity: To summarize the physiatric interventions (in acute care) for the prevention of complications in this young man with an acute SCI.

The physiatrist is an important member of the team caring for the person with SCI in the acute care setting, both during the period immediately after injury and during any subsequent hospitalization. Although prevention of complications common to SCI is a fundamental role, balancing the standard practices used in acute care with the unique physiology of SCI is equally important.

Interventions that may be considered routine in any rehabilitation setting must not be overlooked during an acute hospital stay. Range of motion (ROM) should be started as soon as there are no medical or orthopedic contraindications to do so. Loss of shoulder ROM in the early period has been associated with increased shoulder pain during the rehabilitation phase.

There may be reluctance to provide full range out of concern for spine stability, but there is no evidence that shoulder ROM in a supine patient wearing a hard cervical collar alters spinal alignment (with the exception of patients withankylosing spondylitis). The swimmer’s radiographic view, which provides full range of the shoulder, is used routinely in emergency departments to evaluate for cervical spine injury, without concern that it might induce neurologic deterioration, even in an intact patient. Depending on the likely length of stay, splinting and orthoses may also be appropriate to preserve joint ROM in the highly susceptible areas of the hands and feet.

Bowel and bladder management are also fundamental needs in the acute care setting. The initiation of a bowel program should begin soon after enteral feeding is initiated. After a new injury, patients must be assessed for the presence or absence of the bulbocavernous reflex to ascertain whether an upper motoneuron or lower motoneuron bowel program is appropriate. Established guidelines for bowel management need minimal adaptation for the acute care setting, although training of personnel may be necessary. In those with chronic SCI, the physiatrist should assist the acute care team in implementing the patient’s usual program so far as feasible. See section activity 3.5 for further discussion. A bladder program may also be initiated during the acute period, although this does not have the same urgency as the bowel program. The
removal of an indwelling urinary catheter and initiation of intermittent catheterization can be recommended as soon as the patient no longer requires intravenous fluids and the medical status does not require strict monitoring of urinary outputs. However, physiatrists should be aware of the diuresis of third spaced fluid associated with mobilizing the patient and warn against volumes higher than 500mL per catheterization. The routine use of prophylactic antibiotics to prevent urinary tract infections is not recommended.

Pulmonary complications are the leading cause of mortality in the first year after SCI. Pulmonary complication rates during the acute hospitalization have been reported to be 84% for C1-4 levels of injury, 60% for C5-8, and 65% for thoracic levels, indicating that all neurologic levels of injury are at risk. The primary contributors to pulmonary dysfunction after SCI are difficulty handling secretions, atelectasis, and hypventilation.

Clearance of secretions is primarily achieved by abdominal muscle contraction producing a forced expiration or cough. Weak or paralyzed abdominal muscles preclude an effective cough. Techniques of manually assisted cough have been shown to be more effective in clearing secretions than standard suctioning, which is limited to effective clearance of only the mainstem bronchus. This is significant because pneumonia is most common in SCI in the left lower lobe. In addition, larger and firmer mucus plugs can be mobilized that cannot be accommodated by the suction catheter. The “quad cough,” or abdominal thrust, and the tussive squeeze or costophrenic technique, in which the hands are placed over the lower rib cage instead of the epigastrium, are both easily applied in the acute care setting. Contraindications to the abdominal thrust are abdominal injuries or recent surgery. A recently placed IV filter is a relative contraindication because of potential migration of the filter. Contraindications to the tussive squeeze include lower-rib fractures and thoracic injury or surgery. Neither should be performed within 1 hour of a meal. The mechanical insufflator–exsufflator (M-IE) is extremely effective and can be administered via tracheostomy or mouth piece. Contraindications to use of the M-IE include a history of pneumothorax, barotrauma, or emphysma. There is also risk, as with traditional suctioning, of excessive vagal stimulation and bradycardia in those with tetraplegia.

After SCI, a restrictive ventilatory deficit occurs and there is a resultant decrease in all lung volumes. Vital capacity (VC) declines in tetraplegia and high paraplegia from respiratory muscle weakness. Prompt mechanical assistance (either intubation or noninvasive means) should be performed in people with severe respiratory distress or in patients whose VC is below 15mL/kg. Tissue tension is estimated to be present in 60% of SCI patients on admission to rehabilitation facilities. The Consortium for Spinal Cord Medicine clinical guidelines for Respiratory Management Following Spinal Cord Injury supports the use of higher tidal volumes than those usually used in intensive care settings in patients requiring mechanical ventilatory assistance. The tidal volume is titrated upward while monitoring the airway pressure, until the atelectasis resolves on chest radiograph and the patient is afebrile.

In a retrospective review, this protocol was shown to speed resolution of atelectasis and decrease ventilator weaning time. However, it is well established that low-volume ventilation improves outcomes in the general trauma setting, primarily because of the high frequency of acute lung injury and adult respiratory distress syndrome in this population. Therefore, these 2 disorders should be resolved or ruled out before initiation of a high-volume weaning protocol.

Dysphagia is also a contributor to respiratory deterioration after SCI. Although up to 30% of patients with tetraplegia have dysphagia at admission to inpatient rehabilitation, up to two thirds of patients undergoing elective cervical spine surgery have postoperative dysphagia, which has been shown in both anterior and posterior cervical spine approaches. It is likely, then, that the rate of dysphagia in acute SCI is higher than that documented later in the course in the rehabilitation setting. People with cervical spine surgery, tracheostomy, prolonged orotracheal intubation, halo stabilization, and concomitant brain injury should be evaluated for dysphagia. A dysphagia evaluation in this early phase should be considered in all people with cervical SCI. Older age is also associated with increased risk of dysphagia in both the acute and rehabilitation settings. In the presence of a rigid cervical orthosis or halo, it is difficult to compensate for dysphagia using a typical chin-tuck position. Use of nasogastric access for short-term enteral feeding can be used until the risk of aspiration diminishes.

An understanding of acute SCI physiology is needed to optimize early nutrition as well. Nutrition is a key parameter in outcomes of trauma patients. However, estimates of nutritional needs after SCI are difficult. Nitrogen loss is obligatory after SCI and cannot be prevented by increased protein feeding. Therefore, measuring urine urea nitrogen is an unreliable way to estimate nutritional needs. Even commonly used caloric estimates for people with SCI have been shown to cause overfeeding in the acute period. Whenever possible, a metabolic cart should be used to determine actual needs. Although it is now common practice to initiate nutritional support within 72 hours in all trauma patients, 1 study has suggested that early feeding of people with acute traumatic SCI confers no benefit and may increase risk of pneumonia. Further data are needed in this area.

Pressure ulcers are a leading cause of failure to make progress in acute inpatient rehabilitation and so should be a primary concern for the physiatrist during the acute stage. Pressure ulcers are largely preventable, and prevention strategies should start as soon as possible after an injury and continue throughout hospitalization. During acute hospitalizations, when patients are most often supine, the sacrum, heels, and occiput are the most common sites of injury. Time on the backboard should be minimized, because this is a predictor of sacral breakdown. Rather, flat supine positioning should be used during the immediate diagnostic and resuscitative period. Once complete, concerns of spine stability may still produce reluctance among staff to appropriately turn the patient and offload pressure areas. Rotating beds designed for the unstable spine are indicated in this case. Patient positioning must be monitored, however, to ensure that the patient is not sliding laterally in the bed with each turn, creating sacral shear and increasing the risk of skin breakdown. Once the spine is stable, routine turning every 2 hours should be implemented. Although the choice of surgery and spine orthosis are primarily the purview of the surgeon, physiatrists are expert in the functional implications of these choices. Case discussions with surgical teams may facilitate optimal decisions for both short- and long-term rehabilitation goals. The physiatrist and therapeutic team also have a role in preparing the patient and his/her family for the rehabilitation process. Education about the injury, about the rehabilitation process in general, about specific aspects of the intended rehabilitation location, and about living with SCI may all be started during the acute period as the patient and the family begin to ask those questions.
2.3 Clinical Activity: To prognosticate the extent of neurologic recovery for this newly injured person with SCI discussed above.

It is important to be able to prognosticate neurologic recovery of people who have sustained an SCI to provide accurate information to patients and their families, to guide each patient's rehabilitation, and to help determine if new treatment methods are effective. Prognosis for neurologic recovery after SCI is best predicted by the neurologic physical examination, using the International Standards for Neurological Classification of Spinal Cord Injury.44,45 The examination at 72 hours postinjury is superior to that at 24 hours postinjury for predicting recovery.

The major factors in predicting recovery in the first year after traumatic SCI include the initial neurologic level of injury, the patient's initial motor strength, and, most importantly, whether by examination the injury is classified as neurologically complete or incomplete.46

Complete Tetrplegia

Most upper-extremity (UE) recovery occurs during the first 6 months, with the greatest rate of change during the first 3 months. Motor recovery can continue, however, especially for patients with initial 0/5 strength, with lesser gains seen in the second year. Most patients with complete cervical lesions will recover 1 root level of function. The initial strength of this muscle is a significant predictor of achieving antigravity strength by 1 year postinjury. If the first level below the neurologic level of injury has 0/5 strength at 72 hours to 1 week, only 30% to 40% of patients will recover to 3/5 strength in that muscle. However, if 1/5 or 2/5 strength is present, 70% to 80% of patients will regain antigravity strength at 1 year. Presence of sensation at that level increases chances of recovery. Also, the faster an initial 0/5 muscle starts to recover some strength, the better the prognosis for recovery. Only a small percentage of subjects have motor recovery below the first level caudal to the neurologic level of injury. Muscles 2 levels below the neurologic level of injury have only a 10% of recovering any strength at 1 year if they are still 0/5 at 1 month and less than a 1% chance of achieving antigravity strength.46

Incomplete Paraplegia

UE motor recovery is approximately twice as great in incomplete tetraplegia as in complete tetraplegia, with the potential for varying degrees of lower-extremity (LE) motor recovery and functional ambulation. For patients who are sensory incomplete initially, the prognosis for motor recovery is more favorable in those with sparing of pin sensation rather than those with light-touch sensation alone. The basis of a more favorable outcome for pinprick sparing may be explained by the close anatomic relation of the motor tracts (lateral corticospinal tract) to the sensory tracts carrying pain and temperature fibers (lateral spinothalamic tract).47 Functional and neurologic recovery is even more favorable for patients with an initial motor incomplete injury.

Most motor recovery occurs within the first 6 months after injury, and the early return of motor function suggests a better functional outcome. Motor recovery in the UEs and LEs occurs concurrently rather than sequentially.

Complete Paraplegia

The potential for LE motor recovery improves with lower initial neurologic levels of injury: 15% of patients with a neurologic level of injury between T9-11 and 55% of those with an initial neurologic level of injury below T12 recover some strength in the lower limbs. Most movement gained is in the proximal LE musculature and may represent recovery of partially injured lumbar roots or “root escape.”46 There are no recent studies that report the likelihood of conversion from complete to incomplete neurologic status in thoracic SCI.

Incomplete Paraplegia

People with incomplete paraplegia have the best prognosis for LE motor recovery and ambulation. Eighty percent of people with incomplete paraplegia regain antigravity hip flexors and knee extensors at 1 year. People with no LE motor control at 1 month may still show significant return by 1 year.

Late Recovery

The Model Spinal Cord Injury Systems (MSCIS) data report that up to 16% of patients classified initially as neurologically complete improve at least 1 classification grade from initial early examination to the 1-year follow-up, with 5.8% improving to grade C and 3% to grade D.50 Burns et al57 recently reported that at year 1 or later, 6.7% (2/30) of American Spinal Injury Association (ASIA) grade A subjects initially tested within 2 days without factors affecting examination reliability converted to ASIA grade B status, and none developed volitional motor function below the zone of injury. Between 4% and 10% of patients may convert from neurologically complete to incomplete after 30 days. Late conversion has been reported to occur even years after injury, although usually only to ASIA grade B or C. In a retrospective review of MSCIS data,50 late conversion (improvement of ASIA Impairment Scale) after 1 year occurred in up to 5.6% of cases, but only up to 2.1% of cases improved to a motor incomplete injury at the 5-year examination. There was greater potential for conversion in people with tetraplegia than in those with paraplegia. Approximately 20% of subjects improved their motor level and their neurologic level of injury from the first to fifth year postinjury. Functional changes were not studied.

Other Predictors of Neurologic Recovery

The presence of spinal shock may play a role in prognosis: for the same degree of SCI, the presence of spinal shock implies a more rapid evolution of injury and a poorer prognosis. The order that reflexes return in the postinjury period may help prognosticate outcome. The delayed plantar response, which may be the first reflex to return, usually occurs within hours or days after SCI, and its persistence shows a high correlation with complete injuries and a poor prognosis for LE motor recovery and function (ambulation).52 The presence of the crossed adductor response to patellar tendon taps in the acute stage is highly predictive of functional motor recovery.53 If absent, motor recovery does not usually take place.

For similar severity of the injury, older people may have a less favorable outcome with regard to neurologic recovery, walking, and bowel and bladder independence than younger patients, and they have more associated medical problems.54 This decreased recovery may be caused by a decrease in neural plasticity as one ages. Estrogen may have neuroprotective properties relative to central nervous system disorders. Only a few studies have looked at gender in relation to neurologic recovery in SCI, and these show either no difference or only a slight improvement in neurologic recovery for women.55,56

Radiologic and electrodiagnostic results early after injury help confirm the prognosis obtained from the clinical evaluation. The type of fracture may correlate with whether one has a neurologically complete or incomplete injury. Normal cord
signal intensity on magnetic resonance imaging (MRI) is considered a positive predictor for neurologic recovery. The greater the extent of cord signal abnormality on MRI, the greater the chance of having a complete injury. An intramedullary hemorrhage correlates with a more severe initial neurologic deficit and carries a poorer prognosis. The location of the hemorrhage corresponds anatomically to the level of the neurologic injury. In the chronic stage after SCI, people with persistent cord signal changes on MRI show little improvement in ASIA grades compared with the improvements made by patients whose signal abnormalities resolve.

Electrophysiologic techniques include nerve conduction studies, late responses (H-reflex and F-wave responses), somatosensory evoked potentials, motor evoked potentials, and sympathetic skin responses that can supplement clinical and neuroradiologic findings. These tests, however, are most useful in differentiating lesions between the central and peripheral nervous system. They may also help differentiate between a neurologically complete versus incomplete injury in uncooperative or unconscious patients or rule out a conversion disorder, because they do not require the cooperation of the patient. They are not a routine part of the acute investigation of a newly injured person to offer prognosis for neurologic or functional outcome.

Cortical stimulation examines the corticospinal tract by recording from different peripheral muscles. Motor evoked potentials can document the level of injury in the UE and may help predict mobility and activities of daily living. They are not currently part of the routine evaluation for people with SCI.

2.4 Clinical Activity: To describe the acute evaluation of a 30-year-old woman who presents with a profound and rapid onset incomplete tetraplegia categorized as a nontraumatic SCI.

The initial evaluation includes a comprehensive history and physical examination, electrodiagnostic studies, and radiologic evaluation. The importance of the history and physical examination cannot be underestimated. Classic examples illustrating this need include people with spinal stenosis with myelopathy, motoneuron disease, and presumed multiple sclerosis (MS). For people presenting with neck or back pain, symptoms or signs, including a history of bowel and bladder disturbances, gait disorder, weakness, clumsiness, sensory loss, and changes in reflexes, will lead one to suspect myelopathy. Specific findings will lead the clinician to the appropriate diagnostic investigation. To illustrate the importance of the examination, in a study performed at an academic center, the history and examination identified an alternative diagnosis for 70% of patients who presented with abnormal MRI findings and presumed MS.

MRI has revolutionized the anatomic evaluation of the spinal cord. MRI can identify cord changes associated with cervical and lumbar stenosis and is the study of choice in evaluating nontraumatic SCI. Contrast enhancement is essential for evaluating inflammatory and neoplastic lesions of the spinal cord. MRI with gadolinium enhancement and T2-weighted imaging in diagnosing MS is highly sensitive, yet the specificity is limited because other diseases can mimic it by MRI criteria. After a diagnosis of presumed MS, disease progression depends on the identification of new lesions. A characteristic finding in transverse myelitis is T2 hyperintensity centrally involving more than two thirds of the volume of the spinal cord. Intramedullary tumors are typically hyperintense on T1-weighted images.

Vascular abnormalities can be identified by MRI and magnetic resonance angiography. Spinal angiography is the criterion standard for the diagnosis of spinal cord arteriovenous malformations and their characterization for treatment. When extradural spinal lesions are suspected, computed tomography scan is most helpful to evaluate for primary bone metastases and bony metastases of the vertebral column.

CSF evaluation is important in diagnosing inflammatory disorders of the spinal cord. In MS, the common tests include myelin basic protein antibodies, oligoclonal bands, and a host of other immunologic assays. Despite the utility of CSF antibodies in the diagnosis and prognosis of MS, some contention remains that MS is a metabolically dependent degenerative disease rather than an autoimmune disorder. The presence and persistence of CSF oligoclonal bands almost universally allows the distinction between MS and Devic’s neuromyelitis optica. Further CSF evaluation includes the evaluation of viral titers, especially in cases of suspected transverse myelitis.

Serum laboratory investigation is directed at diseases that cause spinal cord pathology. Serology tests for Lyme disease, syphilis, human immunodeficiency virus, and other viral agents should be ordered. Rheumatologic studies should be investigated for causes of spinal vasculitis that could mimic MS and transverse myelitis. Glucose tolerance testing and serum hemoglobin A1C should be ordered for evidence of diabetes mellitus. Antiphospholipid antibodies should be tested, although with up to 32% of MS patients being positive, antibodies to β2 glycoprotein I should be included in this investigation to make the diagnosis.

References

*Key Reference.


Determining the Potential Functional Outcome of a Person After Spinal Cord Injury (SCI) is essential to formulating a rehabilitation plan. Functional outcomes are determined based on the level of SCI and the American Spinal Injury Association (ASIA) Impairment Scale (AIS) classification, in conjunction with knowledge of the age, medical status, medical comorbidities, motivation, and family support of the patient. Generalized projected outcomes have been published to document the optimal functional potential of people with SCI.1,2 Rehabilitation begins in the intensive care setting and includes addressing the SCI-specific needs to help each person meet his/her potential in terms of medical, physical, social, emotional, recreational, vocational, and functional recovery. If early medical complications can be prevented, the inpatient rehabilitation course is facilitated, and the total cost of care is lessened. Early initiation of SCI-specific rehabilitation is extremely important. A delay in starting these interventions may negatively influence a patient’s ultimate functional capability and increase his/her length of rehabilitation stay.3,4 A specialized unit is preferred to provide for comprehensive management of a person with SCI.5 One of the primary goals of rehabilitation during the early recovery period is to convey that life with an SCI can be fulfilling.

The interdisciplinary approach of the rehabilitation team, including the patient and family, is important for the optimal care of a person with SCI. Each team member plays a vital role in the rehabilitation process providing care and patient and family education. As the lengths of stay shorten in acute rehabilitation, coordination of the entire team becomes even more important if a person is to have a timely and safe discharge back to the community. Frequent team conferences with an early home evaluation should be performed.

Once a patient’s motor level of injury, AIS grade, and prognosis for neurologic recovery are determined at the onset of rehabilitation, short- and long-term functional goals can be formulated and a therapy prescription established. Tables 1 and 2 list the functional goals by injury level expected for a person with a motor complete injury to achieve at 1 year. The ideal outcome may not always be achieved for each patient, because individual outcomes vary, despite similar levels of injury. These variations are related to age, sex, and comorbidities.

Outcomes by Motor Level of Injury

C1-4 level. People with motor levels at or above C3 will usually require long-term ventilator assistance, whereas most people with lesions at C4 will be able to wean off the ventilator. The benefit of specialized acute rehabilitation for these people is justifiable, despite their inability initially to tolerate 3 hours a day of therapy and having what may seem to be limited goals. The SCI medical and nursing care given during the first few months after injury are crucial for monitoring, treating, and preventing medical complications that can lead to future morbidity and mortality. Patient and family education, training so that the patient can direct his/her own care, emotional and social support, and exposure to advanced technology that may allow independence in the proper environment make the difference between returning to the family/community or living in

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No commercial party having a direct financial interest in the results of the research supporting this article has or will confer a benefit upon the author(s) or upon any organization with which the author(s) are associated.

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a long-term care facility. Appropriate equipment evaluation and prescription is an integral aspect of the rehabilitation. 

**C5 level.** The C5 motor level adds the key muscle group of the elbow flexors (biceps), the deltoids and rhomboids, and partial innervation of the brachialis, brachioradialis, supraspinatus, infraspinatus, and serratus anterior. It is important during the acute period after SCI to prevent elbow flexion and forearm supination contractures caused by unopposed biceps activity. New advances in power-assist and power wheelchairs should be introduced. Driving a specially modified van is possible at this level, with a lift for wheelchair access enabling a patient to be fully independent.

**C6 level.** The C6 level adds the key muscle group that performs wrist extension (extensor carpi radialis), as well as

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### Table 1: Projected Functional Outcomes for Motor Complete SCI at 1 Year Postinjury, by Injury Level

<table>
<thead>
<tr>
<th>Measure</th>
<th>C1-4</th>
<th>C5</th>
<th>C6</th>
<th>C7</th>
<th>C8-T1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeding</td>
<td>Dependent</td>
<td>Independent with adaptive equipment after setup</td>
<td>Independent with or without adaptive equipment</td>
<td>Independent</td>
<td>Independent</td>
</tr>
<tr>
<td>Grooming</td>
<td>Dependent</td>
<td>Minimal assistance with equipment after setup</td>
<td>Some assistance to independent with adaptive equipment</td>
<td>Independent</td>
<td>Independent</td>
</tr>
<tr>
<td>UE dressing</td>
<td>Dependent</td>
<td>Requires assistance</td>
<td>Independent</td>
<td>Independent</td>
<td>Independent</td>
</tr>
<tr>
<td>LE dressing</td>
<td>Dependent</td>
<td>Requires assistance</td>
<td>Independent</td>
<td>Some assistance to independent with adaptive equipment</td>
<td>Usually independent</td>
</tr>
<tr>
<td>Bathing</td>
<td>Dependent</td>
<td>Dependent</td>
<td>Some assistance to independent with equipment</td>
<td>Some assistance to independent with equipment</td>
<td>Independent</td>
</tr>
<tr>
<td>Bed mobility</td>
<td>Dependent</td>
<td>Requires assistance</td>
<td>Requires assistance</td>
<td>Independent to some assistance</td>
<td>Independent</td>
</tr>
<tr>
<td>Weight shifts</td>
<td>Independent in power chair with power tilt or recline mechanism</td>
<td>Requires assistance unless in power chair</td>
<td>Independent</td>
<td>Independent</td>
<td>Independent</td>
</tr>
<tr>
<td>Transfers</td>
<td>Dependent</td>
<td>Requires maximum assistance</td>
<td>Some assistance to independent on level surfaces</td>
<td>Independent with or without board for level surfaces</td>
<td>Independent</td>
</tr>
<tr>
<td>Wheelchair propulsion</td>
<td>Independent with power chair; dependent in manual wheelchair</td>
<td>Independent with power chair; independent to some assist in manual wheelchair with adaptations on level surfaces</td>
<td>Independent with manual wheelchair with coated rims on level surfaces</td>
<td>Independent, except for curbs and uneven terrain</td>
<td>Independent</td>
</tr>
<tr>
<td>Driving</td>
<td>Unable</td>
<td>Independent with adaptations</td>
<td>Independent with adaptations</td>
<td>Independent in car with hand controls or adapted van</td>
<td>Independent in car hand controls or adapted van</td>
</tr>
</tbody>
</table>

NOTE. Adapted from Kirshblum et al.² Adapted with permission.  
Abbreviations: LE, lower extremity; UE, upper extremity.

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### Table 2: Potential Functional Outcomes at 1 Year Postinjury for Complete Paraplegia, by Injury Level

<table>
<thead>
<tr>
<th>Measure (ADLs, grooming, feeding, dressing, bathing)</th>
<th>T2-9</th>
<th>T10-L2</th>
<th>L3-S5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bowel/bladder Transfers</td>
<td>Independent</td>
<td>Independent</td>
<td>Independent</td>
</tr>
<tr>
<td>Ambulation</td>
<td>Standing in frame, tilt table, or standing wheelchair; exercise only</td>
<td>Independent</td>
<td>Independent</td>
</tr>
<tr>
<td>Braces</td>
<td>Bilateral KAFOs with forearm crutches or walker</td>
<td>KAFOs with forearm crutches</td>
<td>Possibly KAFO or AFOs, with canes or crutches</td>
</tr>
</tbody>
</table>

NOTE. Adapted from Kirshblum et al.² Adapted with permission.  
Abbreviations: AFOs, ankle-foot orthoses; KAFO, knee-ankle-foot orthoses.
partially innervating the supinator, pronator teres, and latissimus dorsi. Active wrist extension can permit tenodesis to occur: the opposition of the thumb and index finger with flexion as these tendons are stretched with wrist extension. One should avoid overly stretching the finger flexors initially after injury (“selective tightening”) in patients injured at the C5 and C6 motor levels. Stretching these flexors prematurely may result in a loss of the tenodesis action. Tenodesis may allow some people with this level of injury to perform an intermittent catheterization program (ICP). C7 and C8 levels. The C7 motor level adds the elbow extensors (triceps) as the key muscle group, and C8 adds the long finger flexors. The C7 level is considered the key level for becoming independent in most activities at the wheelchair level, including weight shifts, transfers between level surfaces, and light meal preparation. Bowel care on a padded commode seat, especially suppository insertion, may still require assistance or the use of adaptive devices (ie, suppository inserter). T1-12 levels. For most people with higher levels of thoracic injury, community ambulation is not a functional long-term goal. The lower the level of injury, the greater the trunk control associated with abdominal and paraspinal muscle innervation. Although people with injuries at the high-thoracic and midthoracic levels may be interested in gait training and should undergo this if there are no medical contraindications, it is usually not an inpatient goal. The improved trunk control associated with lower levels of thoracic injuries facilitates ambulation training with bilateral lower-extremity orthoses. Such training permits exercise and short-distance household ambulation once the patient has mastered basic wheelchair skills. L1-2 levels. Muscles gained at these levels include the hip flexors and part of the quadriceps. Although the person may be able to ambulate for short distances, a wheelchair will still be required for functional mobility. Bladder care is usually by ICP. L3-4 levels. The knee extensors are fully innervated with some strength of ankle dorsiflexion. Ambulation usually requires ankle-foot orthoses with assistive devices (ie, canes, crutches). Bowel and bladder management should be independent. These injuries are typically lower motoneuron in nature, and bowel management is usually by contraction of abdominal muscles and manual disimpaction. Suppositories will not be effective because of the loss of sacral reflexes. Bladder management is usually performed by ICP or Valsalva’s maneuver if postvoid residuals are within normative limits and urologic investigation shows no contraindication to this method. Absorbent pads can be used. L5 level and below. These people should be independent in all activities unless there are associated problems such as severe pain or cardiac conditions.

Ambulation

Ambulation after SCI is often 1 of the first goals that many people with SCI set for themselves. It is important that patients with SCI understand their prognosis in terms of achieving this goal and when it should be initiated. There are 4 general categories of ambulation: community ambulation, household ambulation, ambulation for exercise, and nonambulatory. Community ambulation requires independence in performing transfers, the ability to go from the sit-to-stand positions, and ambulating unassisted in and outside the home for reasonable distances (>45m [>150ft]) with or without braces and assistive devices. Household ambulation is the ability to ambulate only within the home with relative independence, but the person may require assistance for transfers. Ambulation for exercise is appropriate for a person who requires significant assistance for ambulation.

Although there is no one definite level at which patients should not perform training with braces, there are factors that will contribute to difficulty in ambulation, including older age, greater weight, lack of motivation, poor agility and coordination, and greater spasticity. All patients with the potential for ambulation should be given a trial if they want to pursue it. For people with thoracic-level injuries, training should usually not be initiated until transfer training and wheelchair activities are mastered.

Community ambulation requires bilateral hip flexors strength to be graded stronger than 3/5 and 1 knee extensor to be graded at least 3/5, with a maximum amount of bracing of 1 long leg brace and 1 short leg brace. Prognosis for ambulation can be determined early after injury by the initial injury level and the AIS classification. Of people with incomplete tetraplegia, 46% advance to community ambulation at 1 year, with an additional 14% performing household ambulation. This is compared with 5% of complete paraplegies and 76% of incomplete paraplegies regaining community ambulation. The percentage of people with incomplete tetraplegia able to achieve community ambulation is lower than for incomplete paraplegia with equivalent lower-extremity motor strength, because the upper-extremity strength may be compromised and insufficient to enable assistive device ambulation if required.

3.2 Clinical Activity: To describe the potential impact on the rehabilitation program that a concomitant brain injury has on a 70-year-old patient with a C4 ASIA grade C SCI.

The presence of concomitant traumatic brain injury (TBI) in people with SCI (“dual diagnosis”) is common and presents a challenge to the rehabilitation staff because of the associated cognitive and behavioral difficulties. There are only a few studies that quantify these cognitive deficits and define the impact that these deficits have on functional outcome and quality of life. Approximately 25% to 64% of people with acute SCI sustain a concomitant TBI.6-11 In these studies, the presence of TBI was determined retrospectively using medical records documenting a loss of consciousness and coma and by decreased performance on neuropsychologic testing when available. It is likely that many mild to moderate brain injuries sustained at the time of acute SCI may be undiagnosed and therefore untreated.13

Variables that put people with SCI at higher risk for sustaining a concomitant TBI include (1) tetraplegia resulting from a high-energy deceleration crash, (2) loss of consciousness at time of injury, (3) evidence of cortical or brainstem neurologic damage, and (4) respiratory support required at time of injury.6

In a retrospective review of 41 pairs of subjects with SCI matched with subjects with SCI and TBI after rehabilitation, subjects with both injuries had significantly lower cognitive subscale scores on the FIM instrument both at admission and discharge and lower overall motor FIM change scores.7 There was no significant effect on length of stay or discharge place-

ment. However, length of time before rehabilitation admission averaged 24 days in the dual-diagnosis group compared with 12 days for those with SCI only.2

Specific issues that require attention in patients with dual diagnosis include the effect of TBI on new learning and on initiation of self-care in the prevention of secondary conditions. Finding ways to break down the sequence of the tasks is often important in training these people. Of key importance is understanding how to manage the behavioral changes, such as
agitation, often seen in TBI. Behavioral and pharmacologic interventions for the cognitive changes after brain injury are important to implement. One should be familiar with the interaction of medications often used in SCI that should be prescribed with caution in people with brain injury. These include centrally acting medications that interfere with new learning, that is, neuroleptics, benzodiazepines, and other centrally acting antispasticity medications.

Dowler et al evaluated long-term cognitive outcome in subjects who sustained SCI in acceleration–deceleration accidents. Approximately 60% of subjects with chronic SCI had long-term cognitive impairment, although it is unclear if these patients suffered a TBI initially. In this era of medical cost containment, early identification of people with dual diagnosis of SCI and TBI is important for the appropriate delivery of rehabilitation services. A need exists for research to elucidate the true impact of a dual diagnosis on functional outcomes and quality of life.

### 3.3 Clinical Activity: To formulate a plan to prevent and treat common medical complications in the first 6 months postinjury for a 20-year-old man with traumatic SCI (C6 ASIA grade A).

People with injury levels at T6 and above are at risk for developing autonomic dysreflexia (AD). AD is a symptom complex that arises from a noxious or intense stimulus below the level of injury that leads to an unopposed discharge of the sympathetic nervous system. This sympathetic discharge is unable to be modulated from higher cerebral centers and often results in hypertension. Many people with SCI have a baseline systolic blood pressure in the 90- to 110-mmHg range, and an increase of the baseline blood pressure of 20 to 40mmHg may be a sign of AD. A reflex bradycardia is classically observed in many cases as a compensatory response because the carotid baroreceptors stimulate an increase in vagal tone; however, tachycardia may also be seen. If left undetected and untreated, hypertension associated with AD can lead to stroke, intracranial or retinal hemorrhages, seizures, myocardial infarction, and death. AD will generally not appear within the first month after an injury or while the patient is in spinal shock. It is estimated that 92% of people who develop AD will have their first episode of it within the first year after their injury. Late onset of AD should alert the clinician of other etiologies, that is, syrinx or cervical cord compression.

Signs and symptoms of AD include hypertension, bradycardia, and a severe headache. Above the level of injury, flushing, sweating, and nasal congestion can occur because of a compensatory increase in parasympathetic tone. Below the level of injury, increased and unmodulated sympathetic tone predominates and will lead to piloerection, pallor, and cool extremities. Occasionally, patients will also have silent AD, when they will not have any obvious symptoms but blood pressure will be significantly elevated.

The most common cause of AD is related to bladder dysfunction such as an overdistended bladder, detrusor sphincter dyssynergia, and kidney and bladder stones. Other causes include ingrown toenails, menstrual cramps, infections, bowel impaction, pressure ulcers, or undetected musculoskeletal conditions. The primary treatment for AD includes sitting the patient upright, removal of any constricting garments, and identifying and eliminating the underlying cause. When evaluating the urinary system, the first priority is to empty a distended bladder by intermittent catheterization or correction of a kinked or clogged indwelling catheter. If this initial survey does not identify the cause, the patient should undergo a complete head-to-toe evaluation including a rectal examination to identify fecal impaction. Acute abdominal pathology should also be considered, because typical signs of abdominal pain or distress may not be obvious because the affected areas are insensate. Control of hypertension may require rapidly acting antihypertensive agents and close monitoring of the patient for persistent hypertension and rebound hypotension.

Neurogenic bowel is ubiquitous among people with SCI. Constipation and incontinence may lead to social isolation. Some bowel programs can take 2 hours or more to take effect, leading to frustration. It is, therefore, quite important to educate patients regarding appropriate techniques for effective bowel care.

People with upper motoneuron bowel dysfunction can take advantage of the intrinsic reflex activity of the bowel. Bowel programs are ideally performed on a daily to every third day basis depending on each person desired or preinjury patterns. Sitting upright on a padded commode can facilitate a more natural position and is preferred to a side lying position. Key components of bowel management include the use of digital stimulation, high-fiber dietary intake, use of oral medications, and rectal evacuants. Fluid intake should be adequate to maintain soft stools and is recommended at 2 to 3L a day. Caffeine may act as a stimulant and is sometimes used strategically before a bowel program to help facilitate fecal evacuation. Dietary or supplemental fiber acts as a bulking agent and can enhance colonic transit time. It is suggested that the daily intake of fiber be at least 30g a day. It is also advisable to have a regular pattern of food intake.

The use of oral agents should be individualized to the patient. Chronic use of these agents is not necessarily required. If changes are made in the bowel program regimen, they should be done one at a time, and at least 3 to 4 bowel cycles should be completed to realize the effects of the change. The use of large-volume enemas may be indicated for episodes of constipation but are not recommended for chronic use. Bisacodyl is an active ingredient in most suppository preparations. Those suppositories with a water-soluble base (Magic Bullet) have been shown to dissolve more quickly and to significantly shorten the time to complete a bowel program compared with standard preparations with a vegetable oil base.

People with a lower motoneuron injury often have a much more difficult time with bowel programs. They are not able to use the reflexes of the bowel, and digital stimulation and stimulant preparations are usually not effective. There also is decreased anal sphincter tone, which can lead to incontinence with any type of the Valsalva’s maneuver. These people will often have to perform rectal checks and manual removal of stool sometimes as frequently as 3 times a day.

Colostomy is used by some people for bowel management in cases where a consistent program is difficult to establish. Studies show that subjects who have undergone a colostomy are generally happy with the procedure and wish they had pursued it sooner.

Orthostatic hypotension (OH) is a common problem initially encountered in the inpatient SCI rehabilitation unit. It may occur acutely after a spinal injury, that is, spinal shock, which is the absence of all spinal cord–mediated reflexes below the level of injury including sympathetic responses. As a consequence, once a person starts to sit up, orthostasis may occur. Lack of muscle tone in the lower extremities also contributes to OH. Initial compensatory measures should include using gradual positional changes, and blood pressure will usually normalize. Ace wraps or compression stockings can also be initially used to enhance venous return. Abdominal binders also help compress the abdominal contents to combat venous pooling.
that occurs. Over time, as the spinal reflexes return, OH will usually resolve. If treatment is necessary, the use of salt tablets can increase circulating blood volume. In addition, $\alpha$-adrenergic agonists (ie, midodrine) may be used. If symptoms persist, mineralocorticoid supplements (fludrocortisone) may also be used to enhance intravascular blood volume, but one must watch closely for the subsequent development of edema. The clinician should monitor the patient closely for the development of AD and taper the medications when able.

Immobilization hypercalcemia can present during an acute rehabilitation phase. It is most common in young men with a neurologically complete injury. Common clinical signs include nausea, vomiting, decreased appetite, lethargy, and polyuria. Initial resorption of bone mass will occur within the first week and usually present itself clinically within 1 to 2 months postinjury. Hypercalcuria will occur first, and when the calcium burden becomes too great for the kidneys to compensate, hypercalcemia will occur and the constellation of clinical symptoms may become apparent. Initial treatment includes hydration with intravenous fluids. The use of intravenous pamidronate, a bisphosphonate used to treat hypercalcemia in cancer patients, is an effective way to manage elevated calcium levels.22

Heterotopic ossification (HO) also usually presents during the acute rehabilitation phase after SCI. Its incidence is between 16% and 53% in SCI, with 10% to 20% clinically significant and 3% to 5% developing into ankylosis. Swelling of the extremities may be present with a decrease in range of motion of a joint. Most commonly, HO presents in the hips, followed by the knees, elbows, and shoulders. Deep venous thrombosis must also be ruled out, because there is an association between the 2 conditions. HO is more common in people with a neurologically complete injury who present with spasticity. The diagnosis is confirmed initially with a triple-phase bone scan, because plain films may take a few weeks to show periaricular bone formation radiographically. Serum alkaline phosphatase can be elevated but may be nonspecific. C-reactive protein and creatine phosphokinase are markers of inflammatory activity related to HO.23,24 The treatment of HO consists of etidronate at 20mg/kg orally for 3 to 6 months. Nonsteroidal anti-inflammatory drugs (NSAIDs) may be used if there are no contraindications. Surgery is usually performed in cases of significant HO that causes functional limitations; surgery is delayed until there are signs of HO maturity. It is often followed by use of radiation, NSAIDs, and etidronate.25

After the period of spinal shock, spasticity may develop in people with upper motoneuron injuries. Spasticity may or may not be detrimental for the patient. At times, spasticity may be beneficial; that is, a patient may use extensor muscle tone to perform stand pivot transfers. Initial management of spasticity includes range-of-motion activities. Modalities may also be used but tend to be less effective and are not sustained. Any noxious stimulus below the level of injury may worsen spasticity and should be sought as a cause of increasing symptoms. A urinary tract infection, for example, may cause an abrupt increase in muscle tone. Identifying and treating the infection should bring the spasticity back to its baseline level. If the spasticity is painful, interfering with positioning, transfers, or hygiene, pharmacologic treatment may be indicated. Commonly used agents during the acute rehabilitation process include baclofen, benzodiazepines, dantrolene sodium, and $\alpha_2$ agonists (tizanidine, clonidine). One must use caution, because the primary side-effect profile of these medications includes sedation. Other treatments for localized spasticity include the use of chemical neurolysis with botulinum toxin or phenol. Surgery or intrathecal baclofen also may be considered should there be inadequate or intolerable side effects with oral drug therapies, but these treatments are not commonly used during the acute rehabilitation phase.

Difficulty with emotional adjustment after SCI is extremely common. Complications include depression, drug addiction, and, if married, divorce. Depressive disorders are the most common form of psychologic distress after SCI, estimated to affect 20% to 45% of those injured and usually occurring within the first month. Depression should be viewed as a complication that is amenable to treatment rather than as a stage through which the patient must pass. The suicide rate after SCI is 2 to 6 times greater than that of the able-bodied population. Suicide is the leading cause of death in people who have SCI and are younger than 55 years, with 75% of the suicides occurring within 5 years of injury. The suicide rate is higher for those with paraplegia and for those “marginally” injured (incomplete grade D or E) who have a near-complete recovery. Treatment includes psychologic counseling for the patient and his/her family and pharmacologic intervention.26 The rehabilitation staff can help to reduce depression, anxiety, and self-neglect behaviors by promoting self-directed behaviors and engaging patients in problem-solving to find personally acceptable solutions. Peer support is extremely helpful for adjustment issues. Substance abuse prevention and treatment programs should be included as part of SCI rehabilitation.

3.4 Clinical Activity: To assist with the discharge planning of a 20-year-old man with C4 ASIA grade A who is ready for discharge to an accessible home.

Rehabilitation goals for people with high cervical SCI primarily include prevention of secondary medical complications, education and training of the patient and family members, and prescription of appropriate durable medical equipment and environmental modification. The Outcomes Following Traumatic Spinal Cord Injury: Clinical Practice Guidelines for Health-Care Professionals1 delineates expected functional outcomes and equipment needs based on the level of injury for people with SCI. Anticipated equipment based on level of injury is included in table 3.

It is important to recognize the unique support that patients with higher levels of injury require if they are to return to their home environments safely. Lifestyle adaptations include a lift to assist in transfers and a padded commode or shower chair. A power wheelchair with head, chin, or breath control mechanism should be prescribed for independent mobility. The wheelchair should be equipped with a pressure-relief cushion and recline and/or tilt features for independent pressure relief. A manual wheelchair with a high back that tilts or reclines should be prescribed to use as a back-up wheelchair for assisted mobility in the home and in the community as needed.

To facilitate independence in their interpersonal communications and in control of their local environment, patients should be evaluated for a mouth stick, computer access, an environmental control unit, and other technologies. An attendant-operated van with a lift and tie-down or accessible public transportation is necessary for community mobility.

Housing evaluation and modifications should ensure that safe wheelchair access and egress and space to maneuver a wheelchair in the home are available. Access to bathing and toileting areas and adequate heating, cooling, and ventilation systems should also be in place. The home should be free from fire, health, and safety hazards, and an adequate electrical supply to meet the needs of additional medical equipment must be present. The local power company and emergency services
should be alerted to the patient’s status and condition before discharge.

Determining the appropriate equipment and support services is made more complex by variations unique to each person’s social support and discharge location. A trained SCI rehabilitation team is required to fully assess each case. Family and social support; financial resources; personal preferences; educational, vocational, and avocational goals; and living arrangements after discharge must be fully considered during the evaluation. Support throughout the day is needed for morning and evening activities of daily living (ADLs), bowel and bladder care, nighttime turning, and meal preparation and feeding. Postacute medical, psychosocial, and rehabilitation care should be prescribed in the home or outpatient setting. Although the evaluation process requires input from many specialist team members, the physiatrist is ultimately responsible for medical justification of all equipment decisions and should be directly involved in the durable medical equipment evaluation and prescription process.

### Table 3: Suggested Equipment for Complete Tetraplegia

<table>
<thead>
<tr>
<th>Measure</th>
<th>C1-4</th>
<th>C5</th>
<th>C6</th>
<th>C7</th>
<th>C8-T1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orthotics</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>BFO (mobile arm support)</td>
<td>X</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resting hand splint</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long opponens splint</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Spiral splint</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wrist-driven tenodesis splint</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rachet tenodesis splint</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Short opponens splint</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Universal cuff</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Lumbrical bar</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Mouthstick</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
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<tr>
<td>Transfers/mobility</td>
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<td></td>
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<tr>
<td>Power/mechanical lift</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Transfer board</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Power wheelchair with tilt/recline</td>
<td>X</td>
<td>X</td>
<td>?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power wheelchair</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual wheelchair</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Power-assist wheelchair</td>
<td>X</td>
<td>X</td>
<td>?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feeding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adapted equipment (eg, plate)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utensils with built-up handles</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grooming and dressing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADL splints (eg, wash mitt, razor holders)</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dressing equipment (pant loops, sock aide, dressing stick, long shoehorn)</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Gooseneck mirror</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental control unit</td>
<td>X</td>
<td>X</td>
<td>?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Book holder</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Bathing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grab bars</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Reclining shower/commode chair</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tub seat/shower chair (padded)</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Hand-held spray attachment</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Beds</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full electric hospital bed</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full specialized mattress</td>
<td>X</td>
<td>X</td>
<td>?</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Overlay mattress</td>
<td></td>
<td></td>
<td>X</td>
<td>?</td>
<td></td>
</tr>
</tbody>
</table>

NOTE. Adapted from Kirshblum et al.² Adapted with permission. Abbreviations: BFO, balance forearm orthosis; X, yes; —, no; ?, possible.

#### 3.5 Educational Activity: To identify the advances in rehabilitation research to improve functional outcomes after SCI.

Rehabilitation research in SCI has brought advances in the functional outcomes of people with SCI. The key areas of rehabilitation research in SCI include functional electric stimulation (FES), wheelchair technologies and designs, partial body weight—supported ambulation, the use of robotics, and the potential use of brain control for assistive technology, robots, and neuroprostheses.

**Functional Electric Stimulation**

The use of FES has evolved to support functional gains in people with SCI across multiple body systems. FES can be applied through surface stimulation, percutaneous fine wires, or implanted electrodes. Advances in electrode designs have led to the development of microelectrodes, which are potentially more easily implanted. Although electrode implantation is more...
invasive than surface stimulation, it has 2 advantages: precise stimulation of target muscles and elimination of the need to don and doff the electrodes. With the advances in implantation precautions and techniques, the risk of infection has been minimized. For FES to be effective, no significant lower motoneuron injury should be present. The use of FES is shown to improve the following functions: upper-extremity use (in particular hand grasp), lower-extremity use, bladder control, respiration, and cardiovascular and tissue health.28,31

The upper-extremity FES system is an implanted system that allows people with C5 and C6 tetraplegia to achieve a hand grasp. If necessary, it can be implanted in conjunction with tendon transfer surgery; this intervention can dramatically improve the person’s ability to perform ADLs and can restore functional use of the upper extremities. The principle of tendon transfer surgery is to use the functional proximal muscles to control the paralyzed distal parts. For instance, someone with C5 motor level is not able to extend his/her arm or to use his/her hand. This person may have functioning deltoid muscles and brachioradialis muscles (both with primarily C5 innervation) but not wrist extensors (primarily C6 innervation) or triceps (primarily C7 innervation). With posterior deltoid-to-triceps tendon transfer surgery, this person may now achieve elbow extension, which significantly increases functional reach. It may also allow the person to assist with transfers, pressure relief, and wheelchair propulsion. Therefore, this person with C5 injury may now perform some activities as someone with a C7 motor level. With brachioradialis-to-wrist extensor (extensor carpi radialis brevis) tendon surgery, this person may now achieve wrist extension, which allows tenodesis for hand grasp. He/she may now function as someone with a C6 motor level injury. Together with an FES system that enables hand grasp, the functional activity level of this person may be noticeably improved. Currently, research on the use of such an FES system, as well as the use of different control switches, is underway on people with C4 tetraplegia.28

Lower-extremity FES is an implanted system that allows people with appropriate paraplegia and tetraplegia without significant lower motoneuron damage to stand up, to transfer, and to ambulate with necessary assistive devices, for instance, a walker. Initially, this system was designed for people with complete injuries, but now appropriate candidates with incomplete injuries can also benefit from this system. A hybrid system combining lower-extremity FES and bracing is being studied. The implantation of electrodes in the lumbar paraspinal muscles and the lower extremities may potentially improve trunk control.28

Bladder FES has been widely adopted around the world. It is an implanted system that controls bladder contraction by stimulation of the sacral nerve roots. The current system is usually combined with posterior sacral rhizotomy to improve continence and bladder capacity. Benefits of this FES system include supporting effective voiding, bladder continence, and the reduction of urinary tract infections.28 This sacral nerve stimulation system can also be used for erectile dysfunction, a common problem after SCI. Despite the effectiveness of this system, some eligible people with SCI would prefer to avoid posterior sacral rhizotomy, thus eliminating the possibility of its implantation. Current research on a new generation of bladder FES is exploring the use of such a system without posterior rhizotomy.28

The restoration of respiratory function has been achieved by the use of various FES methods. Phrenic nerve pacing was the original method, and diaphragmatic pacing is now being studied.27 Phrenic nerve pacing is a more involved procedure, and the nerve may become fatigued with prolonged stimulation. Diaphragmatic pacing is performed by laparoscopic implantation of FES electrodes at motor points of the diaphragm without any denervation. People with high tetraplegia and respiratory failure who require mechanical ventilation may be weaned off of the ventilator through the use of this FES system, which has also shown significant improvements in the physiologic measures of respiration.30 These changes also enhance speech production and the quality of life.

Cardiovascular fitness can be improved by the use of FES cycling, through surface stimulation of the lower extremities. This approach is significant because aerobic exercises are otherwise difficult for people with SCI to perform. Several systems are commercially available, but they all share the same principle—the generation of a cycling motion of the lower extremities by computer-coordinated surface stimulation of the hip and knee muscles. Other beneficial effects of such an exercise regimen have been reported, including muscle bulk preservation and spasticity control.

Another innovative use of FES is the management of tissue health. Pressure ulcers are a common complication after SCI, affecting the rehabilitation progress of SCI patients. Health providers have used surface electrode stimulation for wound care for many years, although its effects on the underlying muscles and vasculature are largely unknown. More recently, the development of an FES system implanted in the gluteal muscles has shown hypertrophy of the gluteus maximus muscles and dynamic pressure relief of the sacral seating surface by the alternating stimulation of bilateral gluteal muscles.31 This treatment modality warrants further investigations.

Wheelchair Designs and Technologies

Advances in wheelchair technologies have generated new wheelchairs that further increase functional independence. Pushrim-activated power-assist wheelchairs are such an example. These manual wheelchairs have a motor linked to each rear hub. With each manual propulsion by the user, supplementary power is provided by the motor. Therefore, the force required of the user for propulsion over the same distance is decreased when compared with a regular manual wheelchair without power-assist. This feature is particularly useful for people with tetraplegia and hence weakness in the upper extremities or those with paraplegia and overuse injury causing shoulder pain. In a research study,32 investigators noted that pushrim-activated power-assist wheelchairs can help improve the ADLs in people with tetraplegia compared with the use of regular manual wheelchairs.

Another recent significant wheelchair development is the Independence iBOT 4000 Mobility System.8 One of its unique functions is the ability to negotiate curbs and stairs. The dimensions of the stairs should meet the recommended guidelines, and there must be at least 1 sturdy handrail. The user must also ascend the stairs backward, that is, facing down. The iBOT device is not necessarily appropriate for all power-wheelchair users, because users must meet certain prerequisites. To climb the stairs, upper-extremity function adequate to grab the handrail and to stabilize the iBOT device while initiating the climbing movement is necessary. Otherwise, stair negotiation can be performed with the assistance of a caregiver. There are only a few training and evaluation centers in the United States at the current time.

Advances in wheelchair research have provided useful data on appropriate manual wheelchair propulsion methods that will preserve the upper extremities of people with SCI. A multicenter trial13 with paraplegic people found that during manual wheelchair propulsion, lower peak forces, slower cadence, and a circular propulsive stroke in which the hand falls below the
pushrim during recovery may help prevent injury of the upper extremities. This finding is particularly important, because overuse injuries of the upper extremities are a major cause of pain and morbidity in people with SCI.

**Locomotor Training**

Partial body weight—support treadmill training (PBWSTT) has generated much interest in the field of rehabilitation. PBWSTT is based on the principle of generating normative, locomotor-like sensory input to promote the recovery of the spinal cord neural circuitry. With PBWSTT, the weight of the person is partially supported by an overhead harness while the therapists guide the hips and legs, enabling the person to walk on the treadmill.

Studies performed in subjects with neurologically incomplete lesions (mostly chronic injuries) have shown improvement in ambulatory capacity. However, a multicenter trial of 146 subjects with acute, neurologically incomplete injuries undergoing conventional gait training versus PBWSTT did not find a significant difference in subjects regaining the ability to ambulate. Gait training with conventional PBWSTT is labor intensive, and PBWSTT with automated robotic systems is available (eg, Lokomat). To date, however, there is no evidence that robotic PBWSTT produces superior outcomes to therapist-assisted PBWSTT.

**Brain-Based Command Signals**

The use of brain-based command signals for controlling assistive technology, robotics, or neuromechanoses is a newer area of rehabilitation engineering research. It may prove useful for people with tetraplegia and upper-extremity impairments. Brain signals are collected and processed through electrodes that may be placed or implanted at various levels. Intracortical signals can be collected directly from microelectrodes in the brain, or electroencephalogram (EEG)/field potentials can be detected through electrodes placed at any level between the surface of the brain and the scalp. The detection of EEG/field potentials is less invasive, but the signal will also have lower resolution and provide potentially less useful information, whereas intracortical microelectrode placement is more invasive but will acquire higher resolution and probably deliver more useful information. Once the signal has been processed, it can potentially be used to control various devices, from computers and environmental control units to neuromechanoses (eg, through an FES system) or robotic devices for assistance with ADLs. Therefore, the ability to use brain signals may be a breakthrough in the design of control units for assistive devices. Currently, the BrainGate system is being developed by the Cyberkinetics Neurotechnology Systems. It involves the implantation of electrodes in the brain, with the detected signals being transmitted to a computer system. A pilot study of the BrainGate system on subjects with SCI, muscular dystrophy, and stroke is underway at 3 rehabilitation centers in the United States. The goal of this investigational medical device study is to show the system’s ability to record subjects’ brain activity and translate their thoughts directly into a computer control signal. At present no clinical product is available for brain-based command signals, and much more research is necessary for its application.

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c. Hocoma AG, Industriestr 4, CH-8604 Volketswil, Zurich, Switzerland.

d. Cyberkinetics Neurotechnology Systems, 100 Foxborough Blvd, Ste 240, Foxborough, MA 02035.

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This self-directed learning module highlights community reintegration after spinal cord injury (SCI). It is part of the study guide on spinal cord injury medicine in the Self-Directed Pharmacotherapeutics Education Program for practitioners and trainees in physical medicine and rehabilitation. This article specifically focuses on physical, social, psychologic, and environmental barriers that affect people with SCI and on how these issues affect relations with others. Recreational and exercise options are also discussed.

Overall Article Objective: To summarize the barriers and opportunities of community reintegration for people with spinal cord injury.

Key Words: Exercise; Interpersonal relations; Recreation; Rehabilitation; Spinal cord injuries. © 2007 by the American Academy of Physical Medicine and Rehabilitation

4.1 Educational Activity: To describe barriers and opportunities that may be encountered by the 20-year-old man described in chapter 3 who has spinal cord injury and who is planning his return to school and work.

The goal of rehabilitation is to promote the assumption or resumption of culturally and developmentally appropriate social roles after injury or illness. Rehabilitation should promote the full inclusion and participation of people with disabilities in the physical and psychosocial environment. Participation in community activities correlates strongly with subjective quality of life. However, most of what occurs in spinal cord injury (SCI) rehabilitation today is directed toward minimizing functional limitations. Specific interventions to maximize community participation are limited. As a result, the potential for full reintegration of a person into his/her community is often incompletely met. Community integration is a complex issue, with obvious and not-so-obvious barriers and opportunities that affect its success. Advocacy for accessibility, both physical and societal, has had a major impact on the ability of people with SCI to resume many of their preinjury roles. However, much remains to be done to enable people with disabilities to participate in their communities to the fullest extent desired.

Demographic variables, including level and severity of neurologic injury, are not generally good predictors of many long-term psychologic and productivity outcomes in SCI. These outcomes are more strongly affected by factors such as family support, emotional adjustment, and coping style. However, in 1 study, people with less severe neurologic injury, longer duration of injury, and younger age at injury had better community participation outcomes.

The physical environment has traditionally been viewed as an important but modifiable barrier for people with mobility impairments. Changes in public policy that resulted in the presence of curb cuts, elevators, and accessible public transportation systems, to name a few, have greatly improved the ability of people in wheelchairs to participate in society. Recent studies have reported that environmental factors have only a small effect on community integration. Factors including family support, self-esteem, informational support, and coping style had a much greater impact. Physical accessibility in many communities has improved dramatically in the past 20 years and therefore, it is conceivable that the environment in those communities no longer acts a major barrier. However, in communities where the physical environment remains inaccessible, people with disabilities continue to be faced with major barriers. An important barrier to full community participation is limited community resources—that is, those medical and social services needed by people with disabilities to live in the community. Independent living services (ILS) are designed to minimize barriers to physical independence, mobility, occupation, social integration, and economic self-sufficiency, but access to these services may not be ideal. The transition from acute rehabilitation to home is especially critical, because people are confronted with many obstacles as they attempt to resume participation in the community. If services are made available to assist with this transition, successful reintegration is more likely. Unfortunately, many people with SCI do not receive adequate ILS, resulting in many unmet needs (table 1).

Centers for independent living (CILs) can play an important role in facilitating successful reintegration by providing peer mentoring and role modeling, access to transportation, accessible housing, attendant care personnel, and general knowledge about independent living, advocacy, and other community resources. However, communication between the CIL and the medical rehabilitation community is often inadequate.

Maintaining community participation is a separate, but equally important, consideration for people with SCI as they grow older. A longitudinal study of people with longstanding...
SCI found a general decline in community integration over time, specifically in physical independence, mobility, occupation, and social integration. However, economic self-sufficiency appeared to improve over time. Measures of emotional distress—that is, of stress, life satisfaction, depression, psychological well-being, and perceived quality of life—were not related to changes in community integration. Changes in health status and social support systems, as well as changes in cultural expectations and personal preferences for participation, occur as a person ages, resulting in different patterns of community participation over time. More research is needed to determine how to meet the changing needs of the SCI population to allow them to continue to be active throughout their lives.

4.2 Clinical Activity: To outline recreational and fitness options available for a 30-year-old woman with transverse myelitis with a T6 neurologic-level injury who has successfully completed postacute care rehabilitation.

People with SCI are on the lowest end of the fitness spectrum, and people with paraplegia, despite having more ability and opportunity for physical fitness, are only marginally more fit than those with tetraplegia. Sedentary lifestyles in those with SCI are thought to contribute to a number of abnormal metabolic and fitness parameters. After SCI, the decreased baseline energy expenditure can contribute to weight gain and obesity if physical activity is not adequately increased. Twenty-two percent of people with SCI were found to have diabetes compared with 6% of able-bodied controls; 34% had glucose intolerance compared with 12% in a control group. It is recommended that people with power wheelchairs use aircraft accessibility features are required in newly built aircraft. The Paralyzed Veterans of America (http://www.wsusa.org) boast membership representing thousands of people with disabilities. The 2005–2008 mission of this organization is “to promote sports and recreation for people with physical disabilities by facilitating and developing a national community-based outreach program, providing resources and education, conducting regional and national competitions, and providing access to international competitions.” Their guiding principles are to “promote the opportunity to experience competitive sport, increase self esteem, develop social and life skills, improve health and fitness, and raise society’s expectations of people with disabilities.”

Other types of recreational activities are also available. Wheelchair dance and theater also have representative groups for those interested in the arts. People with tetraplegia and other high-level injuries have a range of adapted sports and activities to choose from as well. In July 2005, the film Murderball introduced the sport of wheelchair rugby and the lives of its participants. Handcycling has opened the opportunity for people to ride with their families as well as to compete and maintain fitness. Other publications such as Spinal Network offer personal stories of people with SCI and their recreational pursuits.

Travel and transportation are other ways for people with SCI to expand their recreational options and endeavors. The 1986 Air Carrier Access Act prohibits discrimination against people with physical or mental impairments; boarding assistance and aircraft accessibility features are required in newly built aircraft. It is recommended that people with power wheelchairs...
or other special equipment contact the airlines before travel and that they arrive early at the airport. Despite the provisions required by law, however, people should make provisions for their own personal needs. Seat cushions for pressure relief should be brought into the aircraft if needed; those using air-filled cushions should be aware of the possibility of expansion with altitude changes. Plans for bladder management (e.g., catheterization, emptying of drainage appliance, medications) should be addressed in case there is a delay. It is also wise for the person to have all necessary medication and equipment at all times and not checked into baggage.

Driving is an option that most people with SCI can pursue. A predriving assessment needs to be completed by a certified occupational therapist during which a person’s medical history, functional capacity, vision, reaction time, and necessary mobility equipment are assessed. Many automobile manufacturers will often allow up to $1000 for adaptive equipment. People with C5 injuries are thought to have the highest level of injury compatible with independent driving. A van with adapted driving technologies and a remote-control ramp or lift system will be required for high-level injuries; an adapted vehicle can cost about $60,000.

4.3 Educational Activity: To discuss the adjustment issues that influence the health and community reintegration of a 30-year-old woman with a T6 neurologic level of injury.

Psychologic issues affect outcome after SCI. Premorbid issues such as alcohol and other substance abuse, depression, psychosis or behavioral or learning disorders will affect rehabilitation and long-term outcome. Psychosocial issues such as relationship outcome, peer group acceptance, and family resources have a greater impact on functional outcome and secondary conditions than does the neurologic level of injury.17 Higher education, better physical health, and lack of negative mood states improve overall level of functional independence.18 Cognitive-behavioral therapy results in fewer hospital admissions, less medication use, and improved subjective adjustment when conducted during the inpatient phase of rehabilitation. Decreases in anxiety and improved mood were sustained for at least 2 years after postinjury rehabilitation.19 FIM efficiency and length of stay are adversely affected by premorbid alcohol problems.20

In a large study of people with SCI at least 1 year postinjury, 14% had alcohol abuse issues; 11% had used illegal drugs or misused prescription medications.21 Substance abuse was more commonly seen in younger single men and those who were less educated. Substance abuse is associated with more pain and less satisfaction with life. Pressure ulcers are associated with substance abuse, although their relation to other secondary conditions is unknown.21

In a study 1 year postinjury, 11.5% of patients had probable major depression.22 This finding was not related to neurologic American Spinal Injury Association classifications but was seen more frequently in middle-aged people and less in people who were single. Depression was associated with poor subjective health, decreased satisfaction with life, and more difficulty with daily role functioning. It also was not related to demographic or injury variables.22 Minorities and women are at particularly high risk of depression. Education and income correlate negatively with depression.23

Suicide is seen in 7.3% of patients who have sustained a major acute illness and 25% who have a concomitant major depressive disorder; this finding holds true for patients with SCI.24 The suicide rate in a paraplegic cohort was 10 times the rate in an able-bodied control group.25 Functional status, sex, and socioeconomic status at the time of injury did not predict suicide risk, although premorbid psychiatric disorder did.26

The Consortium for Spinal Cord Injury Medicine guidelines on depression after SCI27 provide a very comprehensive tool for assessment, diagnosis, and treatment of depression after an SCI. A treatment plan for depression will depend on previous history of psychologic disorders, suicidal ideation, complex psychiatric diagnoses, and substance abuse, and these factors should be assessed so appropriate referral to qualified mental health professionals can be undertaken. Treatment of underlying medical disorders and pain also must be addressed. Psychologic counseling should also be a core component of the treatment plan. Referral to social workers, peer and family support groups, and rehabilitation counselors are other tools that can help newly injured patients cope with the recent loss. Having such resources available facilitates transition into the community. The use of pharmacologic agents should be tailored to each person, and education about side effects of the specific agents being used is a key component to antidepressant therapy. A comprehensive list of the different classes and side-effect profiles of individual classes and agents can be reviewed in the Consortium Guidelines.27

4.4 Educational Activity: To summarize, while speaking to a patient/family support group, the challenges of interpersonal relationships after SCI.

Among many sources of uncertainty after SCI, there is concern about potential and existing relationships, most particularly romantic relationships. Historically, a bias has existed against the desirability of a romantic partner with a disability, to such an extent that social scientists sought to determine the psychopathology of people who chose to enter into such relationships.28 Advances in social and vocational integration of people with disabilities have helped to dispel such myths, but negative personal biases and assumptions sometimes pervade these discussions.

Studies have shown that the rate of divorce after SCI is higher among preinjury marriages than in the general population, with a higher risk of divorce among women who sustain SCI, childless couples, those with prior divorce, and African Americans. These divorces most commonly occur within 3 years of injury. Postinjury marriages have similar emotional quality to marriages among able-bodied peers, and these couples show better marital adjustment than do couples in preinjury marriages.28 However, variability exists in findings about marriage among different cultures and countries.

Single people with SCI are less likely to become married compared with age- and sex-matched controls. However, over their lifespans up to 80% of single people with SCI eventually marry. People with SCI who are socially and vocationally active are more likely to establish stable relationships and marry. Their partners are noted to be similar in personality traits to the general population, except for a lower tendency to respond according to rules and convention and more likely to assert themselves in social situations.29 Models of courtship are also similar to those of non-disabled peers.

Recent data on marriage in people with spina bifida are not available, with previous studies reporting few marriages in this population. Sexual activity may serve as proxy data for dating and future marriage. Among young adults (age range, 16–25y) with spina bifida, nearly half had been sexually active, and 25% had a partner at the time of a cross-sectional study.30 However, 20% of women in this study reported unwanted sexual activity.
Rates of sexual and physical abuse are similar between people with disabilities and the general population, although people with disabilities tend to experience abuse for longer periods of time. As with the general population, abusers are most likely to be intimate partners. However, people with disabilities experience higher rates of physical and sexual abuse at the hands of nonintimate caregivers, including paid attendants and health care providers. Most data are based on standard instruments to screen for abuse and fail to ask for disability-specific forms of abuse. The Abuse Assessment Screen–Disability was developed to remedy this by expanding the standard screening tool to include questions on whether a necessary assistive device was withheld or necessary assistance from a usual caregiver was denied. Compared with this specific tool, standard tools have been shown to miss up to 20% of abuse.

Perceived burden of care is a key concern among many people with SCI, with newly injured patients often expressing distress over the demands on spouses, parents, or other relatives. Spouses who serve as caregivers report higher levels of stress, burnout, fatigue, resentment, and depression compared with spouses who are not caregivers. Greater levels of stress in partners were associated with increased burden of care of patients. Interestingly, two thirds of partners reported no need for further assistance. Additional predictors of higher perceived burden of care were greater psychologic problems of the patient, older age of the partner, female partner of a male patient, and proximity to onset of injury. Studies on parenting have failed to show substantial differences in parental satisfaction and outcomes of children between parents with SCI and able-bodied parents, regardless of whether the parent with SCI is the mother or father. Although differences exist in how parents with SCI and their partners perceive their children and their own lives and in parenting technique, these differences have not been shown to result in differences in behavioral or social outcomes of the children nor in parental satisfaction of either parent.

References
Spinal Cord Injury Medicine. 5. Long-Term Medical Issues and Health Maintenance

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This self-directed learning module highlights long-term care issues in patients with spinal cord injury (SCI). It is part of the study guide on SCI in the Self-Directed Physiatric Education Program for practitioners and trainees in physical medicine and rehabilitation. The most common secondary medical complications include pressure ulcers, pneumonia, and genitourinary issues. Health care maintenance is important to prevent medical complications, for general health as well as for issues specific to SCI. Women with SCI have gender-specific issues regarding amenorrhea, sexuality, fertility, and menopause. Options exist to assist disabled men with sexuality and fertility complications. Pain is a common complication after SCI. Many new areas of research in the field of SCI are discussed.

Overall Article Objective: To discuss long-term care issues in patients with spinal cord injury, including health maintenance, secondary conditions, women’s health, sexual function, pain, and spinal cord regeneration and recovery.

Key Words: Pain; Rehabilitation; Sexual disorders; Spinal cord injuries; Women’s health.

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5.1 Educational Activity: To formulate a list of secondary medical conditions that commonly occur in a 20-year-old man with a C4 American Spinal Injury Association grade A spinal cord injury who is 1 year postinjury.

SECONDARY MEDICAL COMPLICATIONS are extremely common in patients with chronic spinal cord injury (SCI). The Model Spinal Cord Injury Systems data indicate that the incidence of secondary conditions changes based on the number of years that a person has had an SCI. Pressure ulcers are the most common secondary condition, with the incidence increasing with time postinjury. Pneumonia rates are highest in tetraplegia and in older patients. Rehospitalization rates have remained static over the last 10 years. The most common reasons for rehospitalization include genitourinary complications, pressure ulcers, and respiratory complications. Urinary complications and pressure ulcers are more frequently reported in people with complete injuries. Pneumonia is more common in people with tetraplegia, whereas pressure ulcers are more common in people with paraplegia. Patients from skilled nursing facilities, those with lower motor scores on the FIM instrument, or who are using state or federal health insurance plans have a higher rehospitalization rate. Pressure ulcers are common but tend to cluster in a select population of patients. In 1 study 75% of participants failed to report recurrent pressure ulcers (never had any or had them only immediately after SCI onset), whereas 13% reported a clear pattern of recurring pressure ulcers of 1 or more per year. Only pressure ulcer history, cigarette use, and use of sleep medication predicted future recurrent pressure ulcers. Treatment options outlined in the Consortium Guidelines are presented in abbreviated form in appendix 1.

Urologic issues are detailed in the Consortium Guidelines, and bladder management strategies are abbreviated in appendix 2. The use of prophylactic antibiotics to prevent urinary tract infections (UTIs) after SCI continues to be unsupported by prospective studies. Intratetressor bovitum toxin type A is effective in treating spastic bladder in SCI. Intravesical resintofitoxin is also effective but is not currently approved by the U.S. Food and Drug Administration (FDA). Major risk factors for the development of urolithiasis among patients with SCI include recurrent UTIs, indwelling catheters, vesicoureteral reflux, prior kidney stones, and immobilization hypercalcuria. Shock wave lithotripsy success is 50% to 90%, and percutaneous nephrolithotomy is as successful as in the able-bodied population. Chronic indwelling catheters, smoking, and kidney stones are risks factors for bladder cancer. Gross hematuria should be aggressively evaluated as the most common sign of bladder cancer. False-negative rates for cystoscopy approach 20%. Fifty percent survival is seen at 17 months from the time of diagnosis. Although renal failure rates have declined dramatically over the last 50 years, the best test to monitor renal function has not been experimentally determined.

Diseases of the respiratory system are the leading cause of death after SCI. Of deaths from respiratory diseases, 72.3% are specifically due to pneumonia. Pneumonia is the leading cause of death for each age group and all time periods postinjury and is highest in tetraplegia. Mortality rates because of respiratory diseases have been increasing in people with SCI. Pulmonary management issues are detailed in the Consortium Guidelines. Sleep disordered breathing is seen in as many as 60% of people with tetraplegia within 4 weeks of injury. Sleep apnea in patients with SCI is as responsive to continuous or bilevel positive airway pressure treatment as the general population.

Musculoskeletal issues including loss of bone mineral density (BMD), fractures, and overuse injuries are other important...
secondary conditions. In a study of men with SCI, 61% met the World Health Organization criteria for osteoporosis, 19.5% were osteopenic, and 19.5% had normal BMD. Fracture after SCI occurred in 34%. Considered simultaneously with age, duration of SCI, and level of SCI, BMD was the only significant predictor of the number of fractures. Ten milligrams of alendronate daily has been shown to have some limited positive effect on osteoporosis in chronic SCI patients measured by dual-energy x-ray absorptiometry, but there is no strong evidence for routine use in this population to decrease risk of fracture. Functional electric stimulation cycling applied shortly after SCI does not significantly attenuate bone loss.

5.2 Educational Activity: To detail the recommendations for health maintenance after SCI for this 20-year-old man with SCI.

People with SCI require regular and comprehensive health care throughout their lifetimes. This care includes routine health monitoring and treatment for non-SCI problems as well as for SCI-specific problems. The altered physiology and the absence of many typical symptoms for common problems after SCI pose a unique problem for health care providers.

The Canadian Task Force on Preventive Health Care and the U.S. Preventive Services Task Force for Periodic Health Examinations have provided guidelines for routine screening and preventive health care. These guidelines are, for the most part, appropriate to use as a starting point for people with SCI. Every periodic health examination should include the following components: current concerns and medications, review of systems (ROS), social history, medical history, family history, physical examination, counseling, and a plan for age-appropriate screening, immunizations, and treatment for problems identified. Areas of focus should also include the unique issues of SCI and aging with a disability.

Some of the important aspects to record include screening for gingivitis, decreased vision, hearing, flexibility, and cognitive slowing, as well as a screen for depression and suicide risk. Questions of smoking and counseling for smoking cessation, alcohol and drug use, exercise, risks for sexually transmitted diseases, and current employment status also should be included.

An expanded ROS is needed to address the specific problems common in SCI. Questions about bladder and bowel control, blood pressure control, skin integrity, pain, spasticity, sexual function, equipment needs, and changes in strength, sensation, and functional ability are important SCI-specific problems to address. In 1 study, subjects with SCI reported that 1 of the most important components of the comprehensive annual physical examination was the ability to talk to their physician about problems, especially muscle strength and weakness, bladder issues, pain, bowel and digestion problems, and equipment needs.

In addition to a general physical examination, a skin examination for abnormal moles and an examination of the oral cavity in smokers, ex-smokers, and alcoholics are recommended. A digital rectal examination for men over age 50 years, pelvic examination with Papanicolaou smear, gonorrhea and chlamydia swab if at high risk, and examination for ovarian masses are gender-specific, evidence-based recommendations. The general physical examination for people with SCI should be expanded to include an SCI-specific neurologic examination to document changes in motor or sensory function, a skin examination to assess for risk and/or presence of pressure ulcers, and a musculoskeletal examination to identify problems related to aging with SCI and pain.

Counseling for smoking cessation, advice for daily personal and annual professional dental care, sun exposure, and safety issues including use of safety belts, drinking and driving, bicycle helmet use, and hearing protection if exposed to loud machinery is recommended. Counseling is recommended for lifestyle issues including diet and nutrition, physical activity, and advice against alcohol abuse and prevention of sexually transmitted diseases if earlier screening identifies a problem. Counseling regarding wheelchair and other equipment maintenance and safety, pressure ulcer prevention, and compliance with the person’s bladder management program are issues that should be included for people with SCI.

Recommendations for the general periodic health examinations include screening for colon cancer with either fecal occult blood testing or flexible sigmoidoscopy for those over age 50 years and colonoscopy if at high risk. Mammography is recommended for women every 1 to 2 years between ages 50 and 69 years. A tuberculosis skin test, human immunodeficiency virus testing if at high risk, fasting glucose every 3 years for those over age 40 years or annually for people with risk factors for type 2 diabetes, screening for nutritional deficiencies with complete blood count, B₁₂, albumin and iron levels if at risk, fasting lipid profile for men over 40 years and for women over 50 years, and prostate-specific antigen testing in men between ages 50 and 70 years or after age 45 years if at increased risk are also recommended. These screening interventions appear to be appropriate for people with SCI who fall into high-risk categories for many of the diseases being screened, including diabetes, lipid abnormalities, and osteoporosis. However, few studies have formally evaluated these recommendations in the SCI population. Routine laboratory screening in a population of people with chronic SCI resulted in low diagnostic and therapeutic yield (<1.5%) except for serum glucose and lipid tests. In 1 study of 100 non-SCI outpatients, ROS and physical examination had a higher therapeutic yield than chest radiography, electrocardiography, and routine laboratory tests, except for the lipid profile. Further research is needed to define which screening tests are appropriate for the SCI population.

Because people with SCI are at significant risk for renal complications, regular screening of the urinary tract is important. Eighty-five percent of urologists in the United States surveyed recommended annual renal ultrasound, and 20% recommended renal scintigraphy as the preferred screening examination for the upper urinary tract. For surveillance of the lower urinary tract (LUT), 65% used annual visual urodynamics and 25% recommended cystoscopy, whereas 35% performed no routine surveillance and only examined the LUT when patients had recurrent UTIs or abnormalities were found on renal ultrasound or scintigraphy. However, routine screening with renal ultrasound was found to be cost effective only if used in SCI patients with genitourinary symptoms or signs. The addition of abdominal radiography did not increase the sensitivity or specificity of renal ultrasound for identifying renal stones in people with SCI. Creatinine clearance is unreliable as a monitor for renal function because of its poor repeatability, primarily because of the difficulty of obtaining correctly collected 24-hour urine specimens. Rubella vaccination is recommended for women with no history of previous immunization who become pregnant. Immunization for pneumonia and influenza are especially important for people with SCI who are considered to be a high-risk population.

Communication among medical providers for a person with SCI is critical to prevent duplication of some services while...
overlooking others. In 1 study, 27 93% of people with SCI had a family doctor, 63% were followed up by an SCI specialist, and 56% were followed up by both. There was significant duplication in general medical and preventive services, although lifestyle and emotional issues were not addressed in more than 75% of the sample.

5.3 Educational Activity: To address the health issues for a tetraplegic 30-year-old woman with traumatic SCI. With the exception of a relatively brief period of amenorrhea in the acute and subacute periods after injury, the hypothal·mic–pituitary axis returns to normal. Management of menstruation is a common concern after SCI, because erratic onset is particularly problematic with an insensate perineum. Although women report lower rates of menstrual cramping after SCI, nearly 25% report increased spasticity, bladder spasm, and dysautonomia during menstruation.28 Advances in hormone-based contraceptives, particularly those producing quarterly menstrual periods rather than monthly, may prove helpful.

There are no data to suggest a decline in fertility among women after SCI. Issues of contraceptive choice, however, remain clouded by insufficient data regarding additional risks in the presence of SCI. Although the risk of oral contraceptive–associated thromboembolism increases with age and smoking in nondisabled people, few data exist to determine if chronic paralysis increases risk as well. Concerns that an insensate uterus would result in failure to detect problems with an intra-uterine device in the early stages have led to little use of this device in SCI. Compared with their nondisabled peers, women with disabilities are more likely to use surgical methods, including hysterectomy, or a natural method, and are less likely to use hormonal or barrier methods.29

Pregnancy in women with SCI is generally categorized as high risk, primarily from a high rate of complications specific to SCI, including UTI, autonomic dysreflexia (AD), and functional deficits.30 The SCI physician should work in collaboration with the obstetrician to manage these issues. Women with SCI may be more likely to have low–birth-weight infants but are no more likely to have a preterm infant or an infant with congenital abnormality.31 They are more likely to have a forceps delivery or Cesarean section, but no more likely to experience a miscarriage or stillbirth. Surprisingly, despite recommendations that labor and delivery in women with SCI, specifically those prone to AD, be managed with epidural/spinal anesthesia,32 50% of labors among women with SCI were managed without any anesthetic.28

Women with SCI experience menopause at similar ages and with most symptoms similar to women without SCI. As with menstruation, women with SCI report increased spasticity, bladder spasm, and dysautonomia during menstruation. However, women with SCI also report a higher rate of psychologic symptoms and sleep disturbances compared with women without SCI. Physiologic parameters of sexual function in women with SCI have been described in recent years. Libido is generally preserved after injury.31 Genital vascongestion creates the lubrication and engorgement necessary for intercourse. Preservation of psychogenic genital vascongestion is associated with the preservation of sensation in the T11-L2 dermatomes.32 Reflexogenic vascongestion can be induced via manual genital stimulation in women with upper motoneuron injuries. Approximately 50% of all women with SCI are able to achieve orgasm, although time to orgasm is prolonged compared with women without SCI.33 Functional magnetic resonance imaging studies suggest that the vagus nerve, which bypasses the spinal cord, carries genital sensory afferents to the brain, mediating the orgasm response.34 However, lower motor neuron injury affecting the S2-5 levels greatly reduces the ability to achieve orgasm. Sildenafil has been shown to improve subjective arousal when used with manual stimulation and may improve genital vascongestion as well.33

There are no data to suggest that women with SCI have different rates of disease affected by estrogen, such as breast or uterine cancer. Although rates of screening for these cancers has consistently been shown to be lower among women with disabilities than among nondisabled women,35 more recent data show less disparity based on disability alone, with differences accounted for by race and socioeconomic status.36 Heart disease is now the leading cause of death among women with SCI who have survived the first year of injury, as it is with men and women without SCI.

Premenopausal women with SCI do not appear to have any greater risk of osteoporosis than men with SCI. It is unclear to what degree women with chronic SCI experience subsequent menopause-related bone loss. One cross-sectional study37 has suggested that postmenopausal women with SCI have lower bone mass below the level of injury than premenopausal women with SCI, but there are no longitudinal data to confirm these findings. Whether women with osteoporosis who sustain an SCI have further bone loss from immobilization is also unclear. Little evidence exists to guide treatment of SCI-related bone loss, regardless of sex or menopausal status, and studies on the use of bisphosphonates in both acute and chronic SCI are conflicting.43 Although these studies include women, the numbers have been too small to draw conclusions in this subpopulation.

5.4 Clinical Activity: To counsel a 20-year-old man with C4 American Spinal Injury Association grade A SCI on options regarding sexual function and fertility.

As a person assimilates into the community after an injury, issues relating to his/her sexuality and fertility are crucial components to a healthy transformation. For men, SCI significantly impacts erectile and ejaculatory dysfunction. It is reported that although 92% of men with SCI are able to achieve an erection, only 44% with complete injuries and 56% with incomplete injuries are successful with intercourse and less than 5% of men can have an unassisted ejaculation.38 Treatment options for erectile dysfunction (ED) include devices, implants, intracavernosal injections, and pharmacologic agents. Vacuum suction draws blood into the erectile tissue and a constrictor ring is placed at the base of the penis. This device can be used only for less than 30 minutes, and the potential for skin breakdown limits its use. Penile implants can be in the form of a malleable metal rod or an inflatable implant activated by a pump implanted into the abdomen or scrotum. The potential for penile erosions caused by decreased or absent sensation and the high risk of infection make implantable devices unfavorable, especially with the advancements in pharmacologic options. Phosphodiesterase type 5 inhibitors (sildenafil, tadalfil, vardenafil) are now the most commonly used agents to treat ED. These agents enhance the nitrous oxide–mediated vasodilatation of the erectile tissue. Stimulation is required to activate the erectile response, and these agents are more efficacious in men who have reflexogenic erections. In reviewing randomized control trials, it is estimated that up to 94% of subjects with SCI reported their erections were improved with sildenafil.39 Side-effect profiles include hypotension, headache, facial flushing, and visual disturbances. Simultaneous use of nitrate-based medications or alpha receptor blockers should be
avoided because of a potentiated hypotensive event. Side-effect profiles of the phosphodiesterase type 5 inhibitors can closely mimic symptoms of AD (ie, headache, facial flushing). Patients taking these medications should advise their clinicians and avoid the use of nitrates to treat AD, should pharmacologic means be necessary. Intracavernosal injections with alprostidil, a prostaglandin derivative, are an effective means to treat ED after SCI. Injections can cause priapism and are not routinely recommended to use more than 3 times a week to prevent penile fibrosis. An intrarethral form of the prostaglandin did not prove to be effective. ED treatments have little effect on one’s ability to have an ejaculation.

Newer technologies and advances in fertility care now make it increasingly possible for men with SCI to father children, with success rates as high as 40%.40 Barriers to fatherhood include anejaculation, poor semen quality, and the need for assistive reproductive technologies to achieve a pregnancy. Thus, interventions directed by urologists and reproductive endocrinologists must be used. Penile vibratory stimulation has long been known to produce ejaculation and is the first line of treatment if a person is unable to ejaculate on his own. The vibrator is held over the frenulum of the penis until ejaculation occurs. Recent research shows that parameters of 2.5mm amplitude and frequency of 100Hz are optimal.41 For injuries at T10 and above, intact bulbocavernous reflex and a triple flexion response to plantar stimulation are good prognostic factors for success with this stimulation method. If unsuccessful, electroejaculation can be attempted. Rectal probes will directly stimulate deep pelvic nerves to stimulate ejaculation. For men with intact sensation, and those with injuries at T6 and above susceptible to AD, this procedure must be performed in a monitored setting. Electroejaculation is generally more reliable, with success rates of 80% to 90%. As a last resort, direct testicular extraction of sperm can be performed.

Poor sperm quality is a routine finding in men with SCI. Sperm counts may be normal, but their quality and motility can be poor. The precise etiology of the abnormal semen characteristics is not known and likely multifactorial. Time since injury has not been shown to influence sperm quality. As a result, assistive reproductive technologies are generally required to achieve pregnancy. The simplest is intrauterine insemination, a direct injection of a sperm into the uterus. A home technique can also be performed with the semen being directly inserted into the vagina with a syringe. In-vitro fertilization (IVF) requires the use of fertility drugs and invasive procedures to obtain eggs that will be fertilized outside the womb and reimplanted into the uterus 48 to 72 hours later. Intracytoplasmic sperm injection (ICSI) requires only a few healthy motile sperm that are directly injected into an egg under microscopic guidance for fertilization and are then reimplanted as with IVF. Given the poor semen quality in men with SCI, ICSI has greatly improved the chances of a couple achieving pregnancy.42 The cost of these technologies is expensive.

5.5 Clinical Activity: To assess a 20-year-old tetraplegic man who presents with diffuse pain.

Subjective pain in the SCI population varies from 64% to 80%. Forty-seven percent of SCI patients reported onset of chronic pain within the first year after their SCI.43 Chronic pain affects mood, function, and quality of life. Most patients are typically dissatisfied with current treatment efforts, and at least 19% in 1 study and 39% in another study reported experiencing severe pain.43 Pain severity is associated with completeness of injury, depression, and unemployment and is not associated with level of injury.45 Two common classifications for pain are currently used in SCI. The International Association for the Study of Pain (IASP) taxonomy has 3 tiers based on pain type. The Bryce and Ragnarsson Classification46 (table 1) is similar to the IASP but has a greater number of pain categories, which are based on location and etiology.

Nociceptive pain is caused by injury at a specific site, with the nerve activation occurring at the site of injury at local nerve endings. Visceral pain is not well defined but arises from damage to, or irritation or distention of, internal organs (ie, bowel, bladder) or supporting ligaments. It is reported in 15% of patients with chronic SCI, with 38% characterizing it as severe. In contrast, neuropathic pain is caused by injury of a nerve; that is, pain at the level of the injured spinal cord, at the nerve root, or at the site of a local nerve injury (eg, carpal tunnel syndrome). Sympathetic pain is a type of neuropathic pain caused by activation of the autonomic nervous system in response to a noxious stimulus.

Neuropathic pain is reported below the level of injury in 19% to 24% of patients with SCI, with 27% of them rating it as severe. At the level of injury, 11% to 36% of SCI patients had neuropathic pain, with 39% reporting the pain as severe.43 Neuropathic pain is more common in patients older than 40 years and in patients whose injuries are motor and sensory complete.47 Neuropathic pain is more commonly seen in patients injured by gunshot wounds. Studies point to neuropathic pain as being the most difficult to treat; this is especially true of neuropathic pain at or below the level of injury.48

Approximately 42% of SCI patients reported musculoskeletal pain, with 22% rating it as severe. Upper-extremity pain after SCI is most likely associated with repetitive overuse during transfers, pressure relief, and wheelchair mobility; 65% of the time, it interferes with a patient’s ability to transfer.49

The most common upper-extremity pain problems occur in the shoulders (75%), wrists (53%), hands (43%), and elbows (35%). Shoulder pain is associated with time since injury, limitations in shoulder range of motion, lower overall health, and lower function.50-51 It is also associated with acromio-
viceral joint narrowing, rotator cuff muscle imbalances, and adductor weakness in the general and elite athlete SCI population. It is suspected that imbalances lead to glenohumeral motion abnormalities that trigger impingement, inflammation, and pain. Anterior muscular tightness with posterior muscular weakness is also a common association.

The diagnostic investigation of pain in SCI must be specific to the symptoms being evaluated. A thorough history, physical examination, radiologic studies, and electrodiagnostic evaluation may help delineate the exact diagnosis. Identifying the etiology of the pain is crucial to determining appropriate treatment.

Treatment of neuropathic pain in SCI can be complex and should have a multifaceted approach. This approach includes the use of modalities, medications, psychotherapy, and surgical interventions. The clinical use of anticonvulsants, antidepressants, antispasticity, and other adjunct medications is common, with some benefit shown in the SCI population. Although opioids were historically rated as an effective treatment, more recent studies show that they have little effect on neuropathic pain and are associated with decreased leisure activity and increased affective complaints. Surgical procedures include spinal cord stimulators, intrathecal medications, and the dorsal root entry zone procedure with intramedullary electric guidance.

Treatment of musculoskeletal shoulder pain includes shoulder stretching and strengthening, which specifically improves muscle balance, biomechanics, and endurance training. These activities are associated with a decrease in the severity and frequency of shoulder pain and improvement in function. Local injections and systemic medications such as nonsteroidal anti-inflammatories and opioids are used. Activity restriction is recommended but may be difficult because of functional needs. Many already limit their activities because of pain, which has a significant impact on functional skills and independence.

5.6 Educational Activity: To discuss the current research on interventions for neurologic recovery in SCI for a 30-year-old tetraplegic woman after traumatic SCI.

Numerous changes occur within the spinal cord after initial injury that hinder return of function. Many of these changes have been elucidated in this last decade. According to recent findings, potential treatments fall into 1 or more of 5 categories: (1) protection, to prevent death of neuronal cells undamaged by the initial injury; (2) stimulating axonal growth, to enhance the intrinsic regenerative capacity of spinal and supraspinal neurons or to block or remove endogenous inhibitors; (3) bridging, to provide a permissive substrate for elongating axons and replacing lost tissue; (4) enhancing axonal transmission, to alleviate conduction block in spared or regenerated axons; and (5) rehabilitation, to enhance functional plasticity in surviving tissue or to promote repair.

Many animal studies have focused on these experimental aspects of treatment. Appendix 3 lists some of the areas of research in each of the categories of treatment after SCI. The text below summarizes recently completed trials, current or ongoing trials, or trials planned for human clinical investigation in the near future.

EXPERIMENTAL TREATMENTS

Protection

Methylprednisolone was previously discussed in Activity 2.1. Although the initial report of the second National Acute Spinal Cord Injury Study indicated no beneficial effects of methylprednisolone, a subsequent report found that patients with incomplete lesions treated with naloxone within 8 hours had significantly greater recovery than patients treated with placebo. An initial small study treating patients with monoiodoanglioside (Sygen) within 48 hours of injury for an average of 26 days found greater mean recovery at 1 year, including some improved recovery in muscles that had no strength at entry of the study. A subsequent large multicenter study reported a trend toward improvement in neurologic recovery in people with American Spinal Injury Association (ASIA) grade B at 26 weeks after being treated for 8 weeks, as well as a significant effect in people who received Sygen who did not have surgery. No significant effect was noted at the principle endpoint of 26 weeks in the total group of patients studied.

Improving perfusion to the cord in the acute phase after injury includes the use of a lumbar drain to decrease intraspinal resistance to perfusion, elevation of mean arterial pressure, and calcium channel blockers. Calcium channel blockers decrease vasospasm and improve blood flow with improved axonal function; however, they also cause systemic hypotension that may compound the ischemic deficit. In animal models, minocycline, a semisynthetic tetracycline antibiotic, showed improved hindlimb function and strength; human trials may begin soon.

The ProCord study was an international multicenter trial for people with an acute, neurologically complete SCI. Macrophages isolated from the patient’s blood were activated through a process proprietary to Proneuron and then injected directly into the patient’s injured spinal cord by day 14 after injury. In a phase 1 trial initiated in 2000, a greater number of a small group of those subjects improved from neurologically complete to incomplete status by 1 year. In the phase 2 trial, subjects with a neurologically complete SCI between C5 and T11 were randomized in a 2:1 ratio of treatment to control subjects. Control subjects did not receive the procedure, but all subjects received standard SCI rehabilitation and follow-up testing for 1 year. After two thirds of the subjects were recruited, the trial was halted because of financial constraints.

Stimulating Axonal Growth

A phase 1 clinical trial was performed on 10 subjects with neurologically complete injury (AISA Impairment Scale [AIS] grade A) between the levels of C5 and T10, using oscillating field electric stimulation (OFS). The OFS device was implanted within 18 days of the injury and was removed at 15 weeks. At 1 year, the degree of pain as measured by the visual analog scale pain score was decreased, with improvement noted in light touch and pinprick sensation as well as some muscle strength improvement. The FDA has given permission to extend the study.

Cethrin (BA-210), a Rho pathway antagonist that may promote neuroregeneration and neuroprotection in the central nervous system, is currently in clinical trial. Cethrin is applied to the surface of the dura mater of the spinal cord together with Tissel, a fibrin sealant normally used to repair small dural tears, within 7 days of injury. The study is being performed in centers in the United States and Canada for people with a neurologically complete SCI.

Bridging

Peripheral nerves have been implanted at the site of the injury with mixed results. Olfactory ensheathing glial (OEG) cell grafting in humans is being performed in a number of centers around the world. Preliminary results of a study...
investigating OEG in Australia were published, with no reports of neurologic improvement at 1 year in 3 subjects but without any noted adverse events. Lima reported on the first 7 patients who underwent autologous OEG transplantation at the site of the lesion. These patients with neurologically complete injuries had some sensory and motor function recovery. \textsuperscript{65,66} Results of fetal stem cell implants in China were published (not a controlled study), \textsuperscript{67} with reports of almost immediate and dramatic improvement in some cases. Clinical follow-up was limited and the results have been questioned.\textsuperscript{68}

**Enhancing Axonal Transmission**

Preliminary work with 4-aminopyridine (Fampridine), a potassium (K+) channel blocker, in subjects with chronic incomplete SCI (phase 1 and 2 studies) showed trends toward improvement in pain and spasticity. Phase 3 multicenter trials were completed and did not show significant results, although there were improvements in multiple sclerosis (MS) trials and further study is currently underway in MS subjects. \textsuperscript{69}

A phase 2 trial has been completed using HP-184, a K+ and sodium channel blocker, although data have not yet been published. The phase 1 trial in 48 subjects with chronic incomplete SCI resulted in increased motor index scores.\textsuperscript{70} The phase 2 trial has recruited 240 subjects with chronic incomplete SCI (AIS grades C and D), with injury levels C4-T10. Outcome measures include changes in motor index score and gait. A number of the above-mentioned surgical procedures may enhance axonal regrowth as well as serve as a bridge for axonal recovery. Some of the animal work listed in Appendix 3 has shown promise, and human-based studies are being planned.

**Rehabilitation**

New rehabilitation techniques and research are covered in Educational Activity 3.5. Research to discover therapies for SCI has made steady progress, and a number of clinical trials are being proposed for subjects with SCI. Recommended guidelines have been proposed for the planning, initiation, and conduct of these trials.\textsuperscript{71} These guidelines include the following: the proposed clinical trial should be based on supportive preclinical animal efficacy data that would be considered predictive of lasting clinical benefits; there should be a high benefit-to-risk ratio, especially with invasive studies; outcome measures should be objective and should include safety, pain issues, and maintenance of function both above and below the lesion; and placebo control groups should be included when possible.

Great excitement exists in the field of SCI medicine over research that has moved from the laboratory to human clinical trials. Despite the excitement with respect to cure and the optimism regarding the development of therapies, at present no pharmacologic, surgical, or rehabilitative therapy exists that can cure all of the impairments caused by the injury. Most likely, a combination of the treatments discussed above will be required to address the complex issues of SCI. Further study is required, not only to find treatments to enhance neurologic and functional recovery but also to decrease medical complications and optimize the quality of life of people with SCI.

**APPENDIX 1: WOUND CARE MANAGEMENT ISSUES IN SCI**

1. Prevention considerations
   a. Inspection
   b. Pressure relief
   c. Seating and positioning (including pressure mapping)

**APPENDIX 1: WOUND CARE MANAGEMENT ISSUES IN SCI (cont’d)**

d. Cushion and support surface prescription
   e. Psychologic and social factors

2. Correction of underlying factors
   a. Nutrition
   b. Incontinence
   c. Spasms and contractures
   d. Smoking
   e. Heterotopic ossification
   f. Wound infection
   g. Bowel and bladder management

3. Débridement options
   a. Autolytic
   b. Enzymatic
   c. Mechanical
   d. Sharp
   e. Surgical

4. Wound care
   a. Moist dressings
   b. Débridement
   c. Infection control
   d. Vacuum-assisted closure system
   e. Growth factors
   f. Impact of caregiver time

**APPENDIX 2: BLADDER MANAGEMENT IN SCI**

Pharmacologic interventions
- Anticholinergic medications
- ß-blockers
- Botulinum toxin
- Intermittent catheterization
- Credé and Valsalva maneuvers
- Indwelling catheterization
- Reflex voiding
- Urethral stents
- Transurethral sphincterotomy
- Electric stimulation and posterior sacral rhizotomy
- Bladder augmentation
- Continent urinary diversion
- Cutaneous ileovesicostomy

**APPENDIX 3: RESEARCH CATEGORIES IN THE TREATMENT OF SCI**

**Protection against SCI**

Previously studied methods
- Methylprednisolone, naloxone, calcium channel blockers, GM-1
- Present and future studies
- Minocycline, erythropoietin, rituzole, sulfonlyureas, hyperdynamic therapy, and cerebral spinal fluid drainage

**Stimulating axonal growth**

Electric stimulation (oscillating field stimulator), Nogo-blocking antibody, myelin associated glycoprotein, oligodenrocyte myelin glycoprotein, Rho inhibitors (eg, Cethrin), activated macrophages, chondroitin sulfate proteoglycans, inosine, heparan sulfate proteoglycans, keratan sulfate proteoglycans, nerve growth factors, estrogen, and serotonin selective reuptake inhibitors

**Bridging**

Peripheral nerve grafts, Schwann cells, olfactory ensheathing glial cells, and nanotubes

**Enhancing axonal transmission**

Schwann cells, olfactory ensheathing glial cells, 4-aminopyridine, HP-184, neuroprogenitor cell transplants (stem cells)
APPENDIX 3: RESEARCH CATEGORIES IN THE TREATMENT OF SCI (cont’d)

Rehabilitation

Electric stimulation, weight-supported ambulation

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This self-directed learning module presents a variety of social and economic issues facing people with spinal cord injury (SCI). It is part of the study guide on SCI medicine in the Self-Directed Physiatric Education Program for practitioners and trainees in physical medicine and rehabilitation. This article focuses on the economic consequences of SCI, ethical issues in SCI, and the legislative efforts that have improved access and quality of life for people with disabilities. Costs of SCI include direct health care expenditures and lost earnings as a result of unemployment after SCI. Lifelong costs can be anticipated with the development of a comprehensive life care plan. Barriers to vocational reintegration continue to limit full participation for most people with SCI. Ethical issues central to SCI are related to the principles of autonomy and justice. As care research becomes clinically applicable, the SCI community must work together to develop appropriate procedures to respect moral decision-making by all parties. Key legislation in the past century has resulted in important advances in the rights of people with disabilities.

Overall Article Objectives: (a) To review the economic consequences of spinal cord injury, including lifelong direct costs, life care planning, and factors affecting employment and (b) to identify current ethical issues facing the spinal cord injury community and review the advances made in the rights of people with disabilities in the United States through legislation.

Key Words: Economics; Ethics; Legislation; Rehabilitation; Spinal cord injuries.

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6.1 Educational Activity: To predict the life-long economic costs of a 22-year-old man with complete tetraplegia after a traumatic spinal cord injury.

Spinal cord injury (SCI) is expensive. Significant costs are incurred throughout the life of a person with SCI, including initial hospitalization and acute rehabilitation, home and vehicle modifications, and recurring costs for durable medical equipment, medications, supplies, and personal assistance.

The average hospital charges for initial hospitalization and rehabilitation were reported to be $282,245 in 2003, the most recent year the Model Spinal Cord Injury System (MSCIS) has complete data for analysis of hospital charges.1 Mean length of stay in acute care and rehabilitation has been relatively stable for the past decade at approximately 18 days and 45 days, respectively.1,2 The level and extent of injury are important factors contributing to first-year costs. People with high tetraplegia incurred over 3 times the charges that people with incomplete, motor functional SCI incurred.3 The estimated first-year and annual recurring costs for medical care, medications, supplies, durable medical equipment, and personal assistance, as well as estimated lifetime costs adjusted for age at injury, are shown in table 1.

Home and vehicle modifications can be expensive and are important for community reintegration. However, they are not consistently included in the estimated expenses of people with SCI. Home modifications averaged $21,000 (in 1996 dollars) for people with SCI who required them.2 The most common modifications were building ramps (83%), widening doors (57%), and remodeling bathrooms (46%) or other rooms in the house (43%). Because over 88% of people with acute SCI are discharged to home,1 housing accessibility is vital to successful discharge planning and social reintegration. Vehicle modifications—whether to allow the person with SCI to drive or for transportation with an attendant driving—range greatly, from less than $1000 to over $65,000. Costs depend on the modifications needed and the type of vehicle being modified; minivans are the most expensive to modify and cars least expensive.2

One study found that for people who required assistance with activities of daily living (ADLs), the average estimated annual costs for attendant care exceeded $21,000 (in 1996 dollars). Approximately 61% of this was paid assistance, with the remainder provided by family members or others without direct payment.2

In addition to the direct costs described above, there is the loss of wages, fringe benefits, and productivity related to unemployment or underemployment after SCI. These costs are estimated to be more than $57,000 annually but vary widely depending on education, severity of injury, and type of preinjury employment.3

Arch Phys Med Rehabil Vol 88, Suppl 1, March 2007
6.2 Clinical Activity: To analyze the components of a life care plan for a 54-year-old man with T6 paraplegia.

A life care plan is a comprehensive interdisciplinary document that delineates the future medical and rehabilitative needs of the person who has sustained a catastrophic injury or illness. It is an extension of the rehabilitation process and has evolved into a valuable tool for rehabilitation planning and long-term management.4,7

The life care plan should not be undertaken until the patient with SCI has stabilized medically and functionally. Components of the life care plan (appendix 1) are the medical problem list (eg, bowel and bladder functions, skin integrity, spasticity); psychologic, vocational, recreational, and social issues; rehabilitative goals (eg, for mobility, ADLs); prognosis for improvement; and the short- and long-term equipment needs and sources for them (ie, equipment, therapy, architectural, home care). Complications of the aging process are estimated; preventive measures are recommended to minimize complications and maximize functional independence, with the goal being to reduce complications and hospitalizations. Last, the projected costs of needed equipment and services over the person’s estimated life span is estimated.4,5

The life care plan is based on patient need rather than on financial situation or insurance benefit. If a life care planner is completing the document, the SCI physician should be involved to offer the medical and rehabilitative needs and the preventive measures required. The costs cited should represent the ranges of the local market rate where the patient resides and estimated inflation.

Problems with life care planning include unexpected complications and the cost of new technology not available at the time of the initial life care planning. These cannot be reliably calculated in the final cost analyses, and all parties should be informed of the potential for these. Recommendations of costs are determined on recommendations based on a reasonable degree of medical necessity and probability.

The life care plan often serves as an educational tool on which patients and families may rely to make informed decisions, anticipate changes throughout the life span of the patient, and plan for future care. By defining a patient’s long-term needs, identifying costs of care and rehabilitation, and decreasing complications by recommending proactive preventive interventions, a life care plan can enhance the quality of life (QOL) of a person with SCI.5

6.3 Educational Activity: To describe the determinants of return to work for this 54-year-old man with T6 paraplegia after SCI.

Overall rates of employment for people after SCI range from 13% to 58%.8,9 Berkowitz et al reported that although 44% of their sample had been employed at some time since their injury only 27% were employed at the time of the survey. The MSCIS data indicate that in the first year after injury only 14% return to work; by year 10, 27% are working, and by 20 years after injury nearly 40% are employed.1 Berkowitz2 reported a rather concerning finding: 66% of people with SCI have stopped working and/or are no longer looking for work. Because they are “out of the labor force,” these people are not counted in national unemployment statistics. The most common reason for no longer looking for a job was being “physically unable” (64%), followed by “retired” (13%), and “in school” (8.5%).2

Whether a person returns to work after SCI is greatly influenced by that person’s educational level. Although this is true for the general public, it is especially important for the SCI population. The more education a person has at the time of injury, the more likely it is that he/she will return to work. Over 54% of people with a bachelor’s degree and 77% of those with a master’s degree have been employed after SCI, whereas only 14% of people with a high school diploma and 9% of those who did not graduate from high school were employed.2

The rates of employment also depend on functional status. People with paraplegia are employed more frequently (32.8%) than those with tetraplegia (24.7%).1 More specifically, those people who require assistance with ADLs are less than half as likely (18.2%) employed to return to work than those who do not require ADL assistance (42% employed).4 The presence of a vehicle modified to allow the person with SCI to drive correlated highly with employment after SCI. The employment rate for people who could drive and had a vehicle adapted for independent driving was 40%, compared with 12% for those who did not.4 Another study reported similar findings—those who could use transportation independently and had a higher level of functional independence were more likely to be employed after injury.8

Being employed at the time of injury is not consistently a significant factor predicting return to work. However, being employed in a white-collar job before injury increased a person’s likelihood of postinjury employment. Possibly more important was the finding that those who had computer experience in their preinjury jobs increased the likelihood of postinjury employment by nearly the same degree. Of people with SCI who are employed, 67% use a computer at work compared with 47% in the general population.6 Before injury, two thirds of the people with SCI were working in blue-collar jobs. However, of those who had returned to work since injury, 86% were working in white-collar jobs, especially managerial, administrative support, and professional positions. There was also an interesting shift away from private sector jobs to not-for-profit or government jobs and to self-employment.7

The above findings were replicated in a study of adults with SCI who were injured before the age of 18 years, 51% of whom were employed. Four factors were found to predict employment—education, community mobility, functional independence, and fewer medical complications.10 Therefore, to max-
imize a person’s likelihood of returning to work after SCI, obtaining a college degree; maximizing functional independence (including learning to use a computer for work purposes); optimizing access to community transportation, which may include having access to a vehicle adapted for independent driving; and maintaining a higher level of health appear to be important factors.

6.4 Clinical Activity: To educate your 22-year-old patient with complete tetraplegia regarding basic principles of medical ethics, in an effort to encourage an optimal self-direction during his lifespan.

In the United States, 4 principles are considered fundamental to biomedical ethics: autonomy, benevolence, nonmalevolence, and justice. The principle of autonomy has evolved in the last few decades, in particular, and has coincided with the advancement of the independent living movement, such that autonomy of people with disabilities is sometimes used an example of countering paternalism. Advocates of patient autonomy support a model of joint decision-making, with health care providers educating patients and then assisting them in making treatment decisions based on their own preferences and needs. This approach is ideal in SCI, where education is a vital part of patient care and patients seek information from many sources, including peers, the Internet, and consumer groups.

A more complex aspect of autonomous decision-making regards life-sustaining treatment. Although patients and/or family members are the primary decision makers, health care professionals frame the discussion based on their own biases regarding QOL. According to Kohari, “It is difficult to imagine a healthcare professional providing hope to patients and families when the professional actually believes the quality of life after such an injury is poor.” Unfortunately, there is a vast discrepancy between perceived and actual QOL of people with SCI. In 1 study, most emergency care providers presumed that people with SCI have a poor QOL, with only 18% predicting that a person with tetraplegia would be “glad to be alive,” compared with an actual rate of 92%. This study also reported that 41% of emergency care providers thought that resuscitation after SCI was too aggressive, and 22% would want no treatment whatsoever if they sustained an SCI themselves. Bringing information about actual QOL among those with SCI to the treatment discussions in acute care is a key role of SCI professionals.

Advance directives are also flawed. For example, although these documents and the discussions that accompany them routinely include prolonged mechanical ventilation, rarely have families considered chronic ambulatory ventilation or noninvasive ventilatory support. The use of a proxy decision maker, or health care power of attorney, permits exploration of situations that are not covered by an advance directive. However, in hypothetic situations, surrogate decision makers and patients only agree about 70% of the time, even when the surrogate is specifically instructed to answer according to what the patient would say, not what the surrogate thinks is “best.” Uncertainty about potential for recovery reduces accuracy.

“Optimizing informed consent” has been advocated in cases of requests for withdrawal of care after SCI. In this paradigm, such a request is not honored until the patient has had an opportunity to fully understand the potential for life with disability. Depression remains a concerning factor in requests to terminate treatment.

In chronic SCI, the use of advance directives is low. Although only 8% of people with SCI had completed an advance directive in 1 survey, most were interested in doing so after having learned about them. Contrary to those advance directives executed before SCI, those initialized after SCI are based on a more realistic understanding of life with SCI and future needs. SCI professionals play an important role in initiating discussions of advance directives and designation of health care power of attorney and in assisting in discussions regarding options.

An increasing area of moral concern for rehabilitation providers is resource utilization, embedded within the ethical principle of justice. Payers frequently deny expensive assistive technology and skilled caregiver needs. SCI, in particular, as a low-incidence event, lacks influence on insurance plan development. The absence of evidence to prove the utility of many customary interventions adds to the difficulty of obtaining coverage for services. Private payers also assume that most people with SCI will not return to work and so will move to the public system in the first years after injury. Arguments of long-term cost effectiveness and prevention therefore fail. Banja reminds us that insurance plans are contracts, so that denial of a noncovered item is not unethical at an individual level. At a broader level, however, consumer groups and rehabilitation professionals should advocate parity in care for disability-related needs, including equipment and rehabilitation services.

Advances in neuroprotective and neuroregenerative interventions will also raise moral dilemmas for the SCI physician. News coverage of amazing benefits in animal models raises hope among those with SCI and their loved ones. Although the future does hold promise, the press rarely comments on the many years and studies needed to determine if humans would benefit as well. People with disability have historically been called the “incurable.” That people with SCI are so desperate to find a “cure” has created an environment suggesting tolerance of significant risk for unclear benefit. To combat this, the community of SCI researchers has to set standards for conducting clinical trials in SCI, including ethical standards. These are discussed in greater detail in activity 5.6.

Embryonic stem cell transplants for SCI are on the horizon. Approaching patients, particularly in the very early period after injury, will be delicate. Some health care providers may themselves be reluctant to participate in such trials on moral grounds. The SCI community must work together to develop appropriate procedures to respect moral decision-making by all parties.

6.5 Clinical Activity: To educate your 22-year-old patient with tetraplegia by describing key legislation that has advanced rights of people with SCI.

The 20th century saw many important advances in the rights of people with disabilities, including those with SCI. The Soldier’s Rehabilitation Act of 1918 established federally funded vocational rehabilitation services for veterans. This was expanded in 1920 to include civilians, with block grants to states to establish services, but the Act was not made a permanent program until the Social Security Act of 1935. Medical services and income replacement were added to serve the needs of disabled veterans of World War II. The enormous expansion of vocational rehabilitation over these 2 decades supported advances in the emerging field of rehabilitation medicine, with increasing professionalism and legitimacy as an academic discipline. Unfortunately, people with disabilities themselves were not among the vocational professionals, and the communities of people with disabilities became alienated. In an environment of civil rights struggles and social activism, the Inde-
Independent Living Movement was born. Centers for independent living (CIL) began as the Physically Disabled Students Program, which was established by a group of disabled students at the University of California–Berkeley in the early 1960s to improve accessibility on campus. These former students formally incorporated as the CIL in 1972, with a goal of creating communities accessible to all people. Later that year, Congress passed the Rehabilitation Act, only to be vetoed by President Richard Nixon. It was reintroduced in 1973 and again vetoed, but nationwide protests and letter-writing campaigns garnered enough support to override the veto, and the bill became law. The Rehabilitation Act guaranteed the civil rights of people with disabilities within federal programs and also established the concept that the person with a disability was a “consumer” rather than a patient or client. In 1975, the Education of All Handicapped Children Act (now called the Individuals with Disabilities Education Act) was passed, establishing public education for children with disabilities in the least restrictive environment possible.

By 1990, an entire generation had grown up seeing people with disabilities as peers in their own classrooms and members of their communities in public places. The civil rights movement of the sixties and seventies laid the groundwork for a much broader nondiscrimination law: The Americans with Disabilities Act (ADA). Signed into law in 1990 by President George H. Bush, it has proved both landmark and controversial. In the 2 decades since its passage, it has been challenged at the U.S. Supreme Court level over 20 times, resulting in a perceived weakening of the legislation. Yet for people with SCI, the ADA remains a key protection, because even incomplete SCI continues to meet the definitions of disability established through case law. To date, 2 cases have involved plaintiffs with SCI. In Barrios v Dupont, the plaintiff was awarded back pay and punitive damages for over $1 million, establishing that functional capacity evaluations to establish eligibility for employment must be related to individual job functions. In Specter v Norwegian Cruise Line, the plaintiffs asserted that the cruise line was ill-equipped to accommodate people with disabilities. The district court, ruling in favor of the plaintiffs, was upheld by the Supreme Court, establishing that foreign-flagged ships that operate in U.S. waters and ports are required to meet the provisions of the ADA.

The effect of the ADA is difficult to measure by case law, because many of the more important adaptations in the public sector and workplaces have occurred without dispute. These adaptations include curb cuts, accessible bathrooms, and lowered retail and service counters. However, employment discrimination remains a key concern. People with SCI are now included among the ranks of graduate and professional schools in nearly every field. However, employment of people with SCI who were not planning on pursuing undergraduate and graduate degrees remains low. The potential loss of access to public health insurance was identified as a barrier to work, resulting in the passage of the Ticket to Work and Work Incentive Improvement Act in 1999. In addition to creating a ticket that a disabled consumer could use to purchase needed services, it expanded the earning guidelines for Medicare and Medicaid to allow more people with disabilities to be employed while maintaining medical coverage.

APPENDIX 1: COMPONENTS OF A LIFE CARE PLAN

Patient data (eg, individual medical, social, and functional status obtained from the patient, family, and medical record) form the basis of a life care plan, with the following specific components:

1. Medical rehabilitation problem list and current status.
2. Recommendations/interventions, including projected evaluations by physicians, therapists, psychologists, social workers, nurses, vocational rehabilitation counselors, and caregivers. Projected therapeutic interventions (frequency, duration, and type) and diagnostic testing requirements should be included.
3. Ongoing medical needs, including medications, home care assistance, projected medical and surgical needs, and disposable medical supplies.
4. Housing and architectural adaptations for accessibility.
5. Equipment needs, including home equipment, exercise equipment, driving and transportation needs, orthotics, wheelchair needs, and recreational equipment.
6. Recommendations for preventive actions and interventions to decrease the frequency, severity, and duration of complications.
7. Estimated length of each required service.
8. Estimated costs for each required service.

References


*Key reference.

Selected Reading
Educational Activity 1.1
1. According to the Standards for Neurological Classification of Spinal Cord Injury published by the American Spinal Injury Association (ASIA)
   (a) shoulder abductors are 1 of the 5 key upper-extremity muscle groups.
   (b) the zone of partial preservation is only pertinent in complete spinal cord injury.
   (c) if half the key muscles below the neurologic level of injury have a muscle grade less than 3, the ASIA grade is D.
   (d) the patient should be examined in a seated position.

Educational Activity 1.1
2. The only cause of spinal cord injury that has steadily increased over the last 3 decades is
   (a) violence.
   (b) falls.
   (c) motor vehicle crashes.
   (d) sports.

Educational Activity 1.3
3. Compared with traumatic spinal cord injury (SCI), non-traumatic SCI is more likely to be associated with
   (a) an incomplete lesion.
   (b) a higher incidence of spasticity.
   (c) a higher rate of home discharge.
   (d) a shorter time between diagnosis and rehabilitation.

Educational Activity 1.3
4. Transverse myelitis
   (a) results in paraplegia 70% of the time.
   (b) progresses in more than 1 week and less than 4 weeks.
   (c) is associated with a poor recovery if there is a rapid progression.
   (d) is rarely associated with sensory symptoms.

Educational Activity 1.4
5. In people with myelomeningocele
   (a) the majority have below-normal intelligence.
   (b) posterior fossa decompression is frequently required.
   (c) hydroxyringomyelina (syrinx) is uncommon.
   (d) hydrocephalus is seen in approximately 90% of patients.

Clinical Activity 2.1
6. Which treatment is NOT standard management for acute care of spinal cord injury?
   (a) Prophylaxis for venous thromboembolism within 72 hours
   (b) Volume resuscitation to optimize spinal cord perfusion
   (c) High-dose methylprednisolone as a neuroprotective agent
   (d) Assessment and treatment of spinal and neurogenic shock

Clinical Activity 2.1
7. Which statement is TRUE concerning autonomic dysfunction?
   (a) It is associated with injury below T9.
   (b) It is common in the acute period.
   (c) Bradycardia occurs in response to blood pressure elevations.
   (d) Hypothermia is common because of poor thermoregulation.

Clinical Activity 2.2
8. Which statement is TRUE concerning bladder management considerations in acute spinal cord injury?
   (a) Increased urine volumes occur with immobilization.
   (b) Intermittent catheterization may begin once intravenous fluids are discontinued and strict urine outputs are not needed.
(c) Intermittent catheterization volumes should be greater than 250mL.
(d) Prophylactic antibiotics for prevention of urinary tract infections are recommended.


Clinical Activity 2.3
9. Which statement is TRUE about neurologic recovery in tetraplegia?
(a) Recovery occurs sequentially in the upper, then lower extremities.
(b) Most complete cervical lesions will recover 1 root level of function.
(c) Neurologic examination at 24 hours is superior to 72 hours postinjury for predicting recovery.
(d) The presence of the crossed adductor response in the acute stage indicates a poor prognosis for lower-extremity motor recovery and function.


Clinical Activity 2.4
10. In a magnetic resonance imaging evaluation of the spinal cord, contrast enhancement is most useful in the evaluation of
(a) spinal stenosis.
(b) arteriovenous malformation.
(c) intramedullary tumor.
(d) primary or metastatic bone lesion.


Clinical Activity 3.1
11. A patient with a C6 spinal cord injury would typically have partial innervation to which muscle group?
(a) Anconeus
(b) Supinator
(c) Extensor carpi ulnaris
(d) Flexor digitorum profundus

Ref: Clinical Activity 3.1.

Clinical Activity 3.2
12. Compared with people with the single diagnosis of spinal cord injury (SCI), people with a dual diagnosis of SCI and traumatic brain injury have a
(a) longer length of stay (LOS) in an acute care hospital before admission to a rehabilitation hospital.
(b) longer LOS in a rehabilitation hospital.
(c) higher likelihood of being discharged to an institutional setting.
(d) lower cognitive FIM score at admission but not at discharge from a rehabilitation hospital.


Clinical Activity 3.3
13. In spinal cord injury, heterotopic ossification presents most commonly in the
(a) shoulders.
(b) elbows.
(c) knees.
(d) hips.

Ref: Clinical Activity 3.3.

Educational Activity 3.5
14. The biggest barrier to the acceptance and use of the functional electric stimulation system implanted to improve bladder function has been
(a) the need for a posterior sacral rhizotomy.
(b) the potential loss of penile erectile function.
(c) the need for a sacral laminectomy.
(d) the increased risk of urinary tract infections.

Ref: Educational Activity 3.5.

Educational Activity 3.5
15. Which wheelchair propulsion method decreases injury to the upper extremities?
(a) Circular propulsive stroke in which the hand falls below the pushrim during the recovery phase
(b) Figure-of-eight motion in which the hand rises above the pushrim at the midpoint of the recovery phase
(c) Faster cadence and an attempt to limit the time the hand is on the pushrim during the stroke phase
(d) Maximum peak force and an attempt to increase the duration of the recovery phase


Educational Activity 4.1
16. Which factor is the LEAST important for successful community reintegration of people with disabilities?
(a) Self-esteem
(b) Family support
(c) Physical environment
(d) Informational support


Educational Activity 4.1
17. People with SCI exhibit a decline over time in all of the following EXCEPT
(a) mobility.
(b) economic self-sufficiency.
(c) occupation.
(d) social integration.


Clinical Activity 4.2
18. Which factor limits the participation of people with spinal cord injury in physical exercise?
   (a) Lack of accessibility
   (b) Lack of privacy
   (c) Fear of injury
   (d) All of the above


Educational Activity 4.3
19. How does the suicide rate in paraplegics compare with the rate in an able-bodied control group?
   (a) Equal rate
   (b) Twice as high
   (c) Five times as high
   (d) Ten times as high


Educational Activity 4.4
20. Which subgroup of patients with spinal cord injury (SCI) has a higher rate of divorce than the general population?
   (a) African Americans
   (b) Couples with children
   (c) Male partners with SCI
   (d) Couples in postinjury marriages


Educational Activity 5.1
21. Which statement is TRUE about the incidence of complications after the first year of a spinal cord injury?
   (a) Pressure ulcer frequency increases from year 1 to year 10 postinjury.
   (b) The frequency of pulmonary embolus increases from year 1 to year 10 postinjury.
   (c) Pneumonias are more frequent in year 1 postinjury than in year 10.
   (d) The incidence of deep venous thrombosis increases from year 1 to year 10.


Educational Activity 5.1
22. The most common reason for rehospitalization for medical complications after spinal cord injury is disease of the
   (a) skin and subcutaneous system.
   (b) respiratory system.
   (c) genitourinary system.
   (d) musculoskeletal system.


Educational Activity 5.1
23. Which statement was found to be TRUE in a meta-analysis of studies of antimicrobial prophylaxis in people with spinal cord dysfunction?
   (a) Antimicrobial prophylaxis is associated with a reduced number of symptomatic urinary tract infections.
   (b) Antimicrobial prophylaxis is associated with a reduction in bacteriuria in the first 90 days after spinal cord injury.
   (c) Antimicrobial prophylaxis results in a 4-fold increase in the proportion of antimicrobial-resistant bacteria.
   (d) Antimicrobial prophylaxis is more effective in preventing symptomatic urinary tract infections in women than in men.


Clinical Activity 5.5
24. What is the most common type of pain experienced by people with spinal cord injuries more than 6 months previously?
   (a) Visceral
   (b) Below-level neuropathic
   (c) Sympathetic
   (d) Musculoskeletal


Educational Activity 6.1
25. Which expense is NOT considered a direct cost of spinal cord injury?
   (a) Initial hospitalization
   (b) Rehabilitation
   (c) Loss of wages
   (d) Home modification


Clinical Activity 6.2
26. A life care plan does NOT address
   (a) complications of the aging process.
   (b) costs of new technology.
   (c) prognosis for improvement.
   (d) rehabilitative goals.

Educational Activity 6.3
27. Factors found to predict employment after spinal cord injury include
(a) unemployment at time of injury.
(b) community mobility.
(c) functional dependence.
(d) greater medical complications.

Clinical Activity 6.4
28. Which statement is TRUE regarding autonomy and advance directives in people with a spinal cord injury (SCI)?
(a) Surrogate decision makers are able to decide what is “best” for the patient.
(b) Quality-of-life biases are not a factor in the determination of life-sustaining treatment.
(c) Health care providers are better able to make treatment decisions in cases of SCI.
(d) There is minimal use of advance directives in chronic SCI.

Clinical Activity 6.5
29. The landmark law passed in the 1990s to advance the rights of all people with disabilities was the
(a) Rehabilitation Act.
(b) Americans with Disabilities Act.
(c) Social Security Act.
(d) Individuals with Disabilities Education Act.
Ref: Clinical Activity 6.5.
1. (b) The 5 key upper-extremity muscle groups are elbow flexion, wrist extension, triceps, finger flexors, and intrinsics. The examination as described in the Standards was designed to be performed in a supine position.

2. (b) The most common cause of spinal cord injury (SCI) over the last 30 years continues to be motor vehicle crashes. Falls remain the second most common cause of SCI and are the only cause that has steadily increased over the last 3 decades. Falls are the most common cause of SCI in people over the age of 60 years. Sports-related SCI has decreased over the decades. Violence, although a rising cause of SCI through the 1990s, declined to a 30-year low between 2000 and 2003.

3. (a) Nontraumatic spinal cord injury (SCI) is a growing population for admission to inpatient rehabilitation. The nontraumatic SCI population is more likely to present with a neurologically incomplete lesion and was associated with a lower frequency of secondary complications such as spasticity, deep vein thrombosis, and autonomic dysreflexia. Patients with nontraumatic SCI had a lower rate of discharge to home (73%), with favorable discharge seen in patients whose injuries were incomplete, who were married, and who had an established bowel and bladder management program and intact skin.

4. (c) Transverse myelitis has a female-to-male ratio of 4:1, with peaks in the second and fourth decades. The time course of progression is more than 48 hours and less than 6 weeks. At nadir, half have paraplegia, all have neurogenic bladder, and 80% to 94% have sensory symptoms. Over time, one third recovered, one third had neurologic deficits, and one third had paraplegia.

5. (d) Hydrocephalus is seen in approximately 90% of patients with myelomeningocele and usually manifests itself after surgical closure. Most of these people will also require ventriculoperitoneal (VP) shunting. Symptomatic hydrocephalus is usually treated with VP shunting but sometimes will need a posterior fossa decompression to relieve pressure exerted on the brainstem. Hydrosyringomyelia (syrinx) is commonly seen in myelomeningocele.

6. (c) The Consortium for Spinal Cord Injury Medicine Clinical Practice Guidelines consider the use of high-dose methylprednisolone to be a treatment option rather than a standard. The effectiveness of high-dose methylprednisolone as a neuroprotective agent has been questioned, and it has been associated with increased risk of infection, gastrointestinal bleeding, and steroid myopathy.

7. (c) Autonomic dysreflexia is more common in cervical and high-thoracic (above T6) injuries. Autonomic dysreflexia may be seen in the early period but requires intact spinal reflexes and, therefore, will not be seen until spinal shock has resolved. Bradycardia occurs in response to initial hypertension, but later heart rate may increase. There is impaired heat dissipation in spinal cord injury, resulting in hyperthermia or “quad fever” in the early weeks after tetraplegia.

8. (b) Intermittent catheterization may begin once intravenous fluids are discontinued and monitoring of strict urine outputs is no longer necessary. Mobilization of the patient will cause a diuresis of third space fluids and an increase in urine output. Intermittent catheterization volumes should not exceed 500mL. Prophylactic antibiotics are not recommended.

9. (b) Most upper-extremity recovery occurs in the first 6 months, with the greatest rate of change during the first 3 months. Motor recovery in the upper and lower extremities occurs concurrently rather than sequentially. The neurologic examination at 72 hours has greater predictive value for recovery than the 24-hour examination. The crossed adductor response to patellar tendon taps is highly predictive of functional motor recovery.

10. (c) Magnetic resonance imaging with gadolinium enhancement is useful in evaluating inflammatory and neoplastic lesions of the spinal cord. Spinal angiography is the criterion standard for the diagnosis of spinal cord arteriovenous malformations. Computed tomography scan is most helpful in evaluating primary or metastatic bone lesions. Contrast is not routinely used for evaluation of spinal stenosis with myelopathy.

11. (b) A patient with a C6-level spinal cord injury has the extensor carpi radialis as the key muscle group and partially innervates the supinator, pronator teres, and latissimus dorsi. The anconeus is usually innervated by C7-T1; flexor digitorum profundus C8, T1; and extensor carpi ulnaris C7, C8.
Patients with a dual diagnosis had significantly lower cognitive FIM scores both at admission and at discharge, but no significant effect has been reported on the rehabilitation hospital length of stay or discharge placement. However, length of time in the acute care hospital was 24 days compared with 12 days for people with a spinal cord injury only.

Most commonly, heterotopic ossification presents in the hips, followed by the knees, elbows, and shoulders.

The current bladder functional electric stimulation (FES) is an implanted system that stimulates the sacral nerves and is combined with a posterior sacral rhizotomy to improve continence and bladder capacity. Research studies have shown the benefits of the bladder FES to be improved voiding, bladder continence, and reduced urinary tract infections. However, eligible people with spinal cord injury did not choose it because they want to avoid a posterior sacral rhizotomy.

It has been found that lower peak forces, slower cadence, and a circular propulsive stroke may help prevent injury of the upper extremities.

Economic self-sufficiency actually improved over time in a longitudinal study of people with long-standing spinal cord injury.

Depression and suicide are significant problems in people with spinal cord injury. The suicide rate in paraplegics was found to be 10 times the rate of that for an able-bodied control group.

The divorce rate is higher for couples married before the injury than for those in postinjury marriages. The rates are also higher in women spinal cord injury, childless couples, persons with prior divorce, and African Americans.

The frequency of pressure ulcers increases from 15% to 23% in the 10 years after a spinal cord injury. Pulmonary embolus and pneumonia incidence is unchanged during this time period. Deep venous thrombosis is more common at year 1 (2.1%) than at year 10 (0.7%).

Diseases of the genitourinary system are the most common reason for rehospitalization according to a multicenter analysis of 3978 patients with SCI, which found that genitourinary cases (n=284) were most common, followed by diseases of the skin (n=230), respiratory system (n=117), and musculoskeletal system (n=99).

In a meta-analysis article, antimicrobial prophylaxis was found to be only associated with a reduction in bacteriuria (asymptomatic urinary tract infection). Antimicrobial prophylaxis results in a 2-fold increase in bacterial resistance.

Musculoskeletal is the most common type of pain experienced by people with chronic spinal cord injury (44%). It is followed in incidence by below-level neuropathic pain (24%), visceral pain (15%), and sympathetic pain (6%).

Loss of wages is an indirect cost of spinal cord injury (SCI). The other choices are all direct costs of SCI.

A life care plan is a comprehensive document that delineates the future medical and rehabilitative needs of the person who has sustained a catastrophic injury or illness. It includes the medical problem list; psychologic, vocational, recreational, and social issues; rehabilitative goals; prognosis for improvement; short- and long-term equipment needs; complications of the aging process estimates; preventive measure recommendations; and projected costs over the person’s estimated life span. It does not include unexpected complications and cost of new technology, although the potential for these is understood.

Four factors found to predict employment after spinal cord injury are education, community mobility, functional independence, and fewer medical complications. Employment at the time of injury is not consistently a significant factor predicting return to work.

As determined by a survey, only 8% of people with spinal cord injury (SCI) had completed an advance directive, although most were interested in doing so after having learned about them. Surrogate decision makers are supposed to make decisions based on what the patient would want and not on their own personal judgment as to what they think is “best.” Health care providers’ perceptions of quality of life after SCI may introduce bias into treatment decisions. A vast discrepancy continues to exist between perceived and actual quality of life in people with SCI. The concept of autonomy supports a joint decision-making model, with health care providers educating patients and then assisting them in making treatment decisions, instead of making decisions for the patient.
29. (b) The Americans with Disabilities Act was the landmark legislation passed in 1990 that advanced the civil rights of all people with disabilities. The Rehabilitation Act was passed in 1973 and guaranteed the civil rights of people with disabilities within federal programs and established the concept of the person with disability as a consumer. The Social Security Act of 1935 established federally funded vocational rehabilitation services for civilians. The Individuals with Disabilities Education Act passed in 1975 and established public education for children with disabilities in the least restrictive environment.
** INDUSTRIAL MEDICINE AND ACUTE MUSCULOSKELETAL REHABILITATION**

PROGRAM EVALUATION

CME CERTIFICATES WILL NOT BE PROCESSED WITHOUT THE COMPLETION OF THE RELEVANT PROGRAM EVALUATION(S)

OVERALL ARTICLE OBJECTIVES:

Objective 1: To understand the important components of a history, physical examination, and concise diagnostic testing when evaluating acute industrial and musculoskeletal injuries.

Objective 2: To summarize medication options in the treatment of acute musculoskeletal pain in the setting of injured workers.

Objective 3: To review the medical literature that may help clinicians make treatment decisions regarding modalities, therapeutic exercise, and orthotic devices for treating common work-related conditions in the upper and lower limbs.

Objective 4: To give an overview of current state of the art regarding diagnostic and nonsurgical invasive treatment procedures for neck pain with and without referred upper-limb pain.

Objective 5: To give an overview of the current state of diagnosis and treatment options for low back pain with or without referred leg pain focusing on interventional procedures.

Objective 6: To review the medical literature to help clinicians make treatment decisions regarding corticosteroid and other injections in the upper and lower limbs, in injured workers.

Objective 7: To recognize diagnosis and treatment issues that are unique to the aging worker.

INDICATE THE DEGREE TO WHICH YOU AGREE OR DISAGREE WITH EACH STATEMENT ABOUT THE ** INDUSTRIAL MEDICINE AND ACUTE MUSCULOSKELETAL REHABILITATION** STUDY GUIDE AND SAE-P.

<table>
<thead>
<tr>
<th>Objective</th>
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<th>Disagree</th>
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<td>8. The material was fair, objective, and unbiased toward any product or program.</td>
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If you circled “Agree” or “Strongly Agree,” please give one example:

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INDICATE THE DEGREE TO WHICH YOU AGREE OR DISAGREE WITH EACH STATEMENT ABOUT THE ** INDUSTRIAL MEDICINE AND ACUTE MUSCULOSKELETAL REHABILITATION** STUDY GUIDE AND SAE-P.

12. In what ways did/will you utilize the ** INDUSTRIAL MEDICINE AND ACUTE MUSCULOSKELETAL REHABILITATION** Study Guide and SAE-P in your medical practice? I have used/will use it to: (Check all that apply.)

- [ ] Confirm previous knowledge and reinforce clinical practice
- [ ] Study for recertification examination
- [ ] Serve as initial resource for clinical problems
- [ ] Apply new techniques/procedures to the care of my patients
- [ ] Use the information to train staff
- [ ] Share the information with colleagues
- [ ] Help develop new policy and procedures
- [ ] Other (please specify): ______________________________________________________________

Too Basic | Just Right | Too Advanced
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13. The content was: ................................................ TB... JR... TA...

14. Please share any general comments, recommendations, or an elaboration of any item on this form:

______________________________________________________________________________

______________________________________________________________________________

Evaluation data collected from this form will be processed confidentially by a third party and will only be reviewed by Academy staff in the aggregate.
Overall Article Objectives:

Objective 1: To summarize the demographics and classification of traumatic and nontraumatic spinal cord injuries in adults and children.

Objective 2a: To describe the diagnostic evaluation of traumatic and nontraumatic spinal cord injuries.

Objective 2b: To summarize the medical, surgical and physiatric interventions during acute hospitalization for these injuries.

Objective 3: To describe outcomes and issues that may arise during the rehabilitation phase after spinal cord injury.

Objective 4: To summarize the barriers and opportunities of community reintegration for individuals with spinal cord injury.

Objective 5: To discuss long-term care issues in patients with spinal cord injury, including health maintenance, secondary conditions, women’s health, sexual function, pain, and spinal cord regeneration and recovery.

Objective 6a: To review the economic consequences of spinal cord injury, including lifelong direct costs, life care planning, and factors affecting employment.

Objective 6b: To identify current ethical issues facing the spinal cord injury community and review the advances made in the rights of people with disabilities in the United States through legislation.

Indicate the degree to which you agree or disagree with each statement about the **Spinal Cord Injury Medicine** Study Guide and SAE-P.

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If you circled “Agree” or “Strongly Agree,” please give one example:

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13. In what ways did/will you utilize the **Spinal Cord Injury Medicine** Study Guide and SAE-P in your medical practice? I have used/will use it to: (Check all that apply.)

- Confirm previous knowledge and reinforce clinical practice
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14. The content was: _____________________________ TB JR TA

15. Please share any general comments, recommendations, or an elaboration of any item on this form:

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CME PROCESSING FEES

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   - [ ] AAPM&R Member Membership/ID Number: [ ] [ ] [ ] [ ]
   - [ ] Non-Member

2. The relevant Program Evaluation(s).

3. Number of hours:
   The AAPM&R has designated each set of Study Guide articles and corresponding SAE-P for a maximum of 15 Category 1 CME credits toward the AMA Physician’s Recognition Award. Each physician should claim only those hours of credit that he/she actually spent on the educational activity. Credit may be obtained until March 31, 2010.

   By checking this box I confirm that I studied the **Industrial Medicine and Acute Musculoskeletal Rehabilitation** articles, consulted the reference materials as needed, and completed the SAE-P.

   Therefore, I claim _____ (fill in blank) CME Category 1 credit hours (up to 15 hours).

   By checking this box I confirm that I studied the **Spinal Cord Injury Medicine** articles consulted the reference materials as needed, and completed the SAE-P.

   Therefore, I claim _____ (fill in blank) CME Category 1 credit hours (up to 15 hours).

4. To ensure that we accurately process your CME certificate, please print/type your full name, degree(s), and address as they should appear on your certificate.

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   E-mail: __________________________________________________________
   Signature: ___________________________ Date: __________________________

Completing Study Guide activities is an acceptable form of the self assessment required for Maintenance of Certification by the American Board of Physical Medicine and Rehabilitation (ABPMR).

PLEASE COMPLETE AND RETURN THIS APPLICATION, EVALUATION(S) AND CHECK PAYMENT TO:

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Your CME certificate will be mailed to you following receipt of your application, evaluation(s), and check payment to the AAPM&R. The AAPM&R will document your participation in Study Guide activities to the ABPMR.