Diploma of the Greek spine society
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# Rehabilitation Following Spinal Cord Trauma

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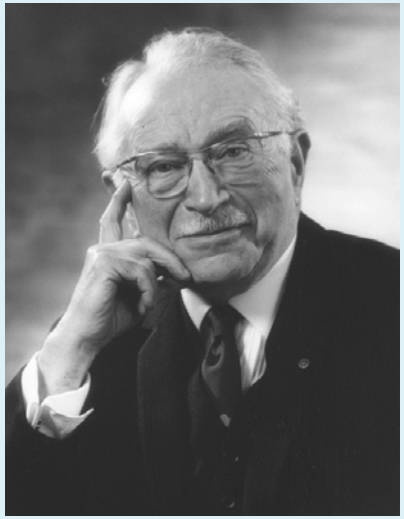
# Historical Perspective

- For thousands of years, injury to the spinal cord was **synonymous with death**, either instantly or after a period of great suffering
- Physicians were unable to successfully manage the consequences of spinal cord injury
- Only during the past 65 years has SCI been considered a **manageable condition**, which can be compatible with reasonably good health and a life expectancy approaching that of normal

# Historical Perspective

- In Great Britain during **World War II**, it was decided to congregate all casualties with SCI in special units supervised by an experienced physician
- Sufficiently staffed by nurses and therapists, housed in facilities with rehabilitation workshops, and organized to provide resettlement and aftercare services
- **Dr. Ludwig Guttmann** was placed in charge of such a unit at **Stoke Mandeville**, where he introduced comprehensive care and **interdisciplinary rehabilitation** for persons with SCI, a program that was widely modeled around the world

*Guttmann L: Spinal cord injuries: comprehensive management and research, Oxford, 1973, Blackwell Scientific Publications, 1976.*



# Subspecialty of Spinal Cord Injury Medicine

- Most physicians providing nonsurgical care for people with SCI in the United States have been **physiatrists**
- A creation of a **subspecialty of SCI medicine** was first advocated in the late 1970s and gained momentum in the early 1990s
- The **American Board of Medical Specialties** gave its approval in **1995** that such a subspecialty be established

American Board of Medical Specialties

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DeLisa JA: Subspecialty certification in spinal cord injury medicine: past, present, and future, *J Spinal Cord Med* 22:218-225, 1999.

# Life Expectancy and Causes of Death

- Life expectancy for persons with SCI has increased steadily for many decades but still remains below that of ablebodied individuals
- Diseases of the respiratory system, especially **pneumonia**, are the leading cause of death both during the first postinjury year and during subsequent years
- Diseases of the genitourinary system are currently the cause of death in only 3.7% of patients with SCI
- In the past, **renal failure** was by far the leading cause of death after SCI
- A great testament to the advances in urologic management during the past several decades

*DeVivo MJ: Epidemiology of traumatic spinal cord injury. In Kirshblum S, Campagnolo DI, DeLisa JA, editors: Spinal cord medicine, Philadelphia, 2002, Lippincott Williams & Wilkins.*

# Classification of Spinal Cord Injury

- Diagnosis of SCI → performing a neurologic examination
- The **International Standards for Neurological Classification of Spinal Cord Injury** (ISNCSCI) provides a procedure for classifying an SCI
- Systematic evaluation of all the dermatomes and extremity myotomes

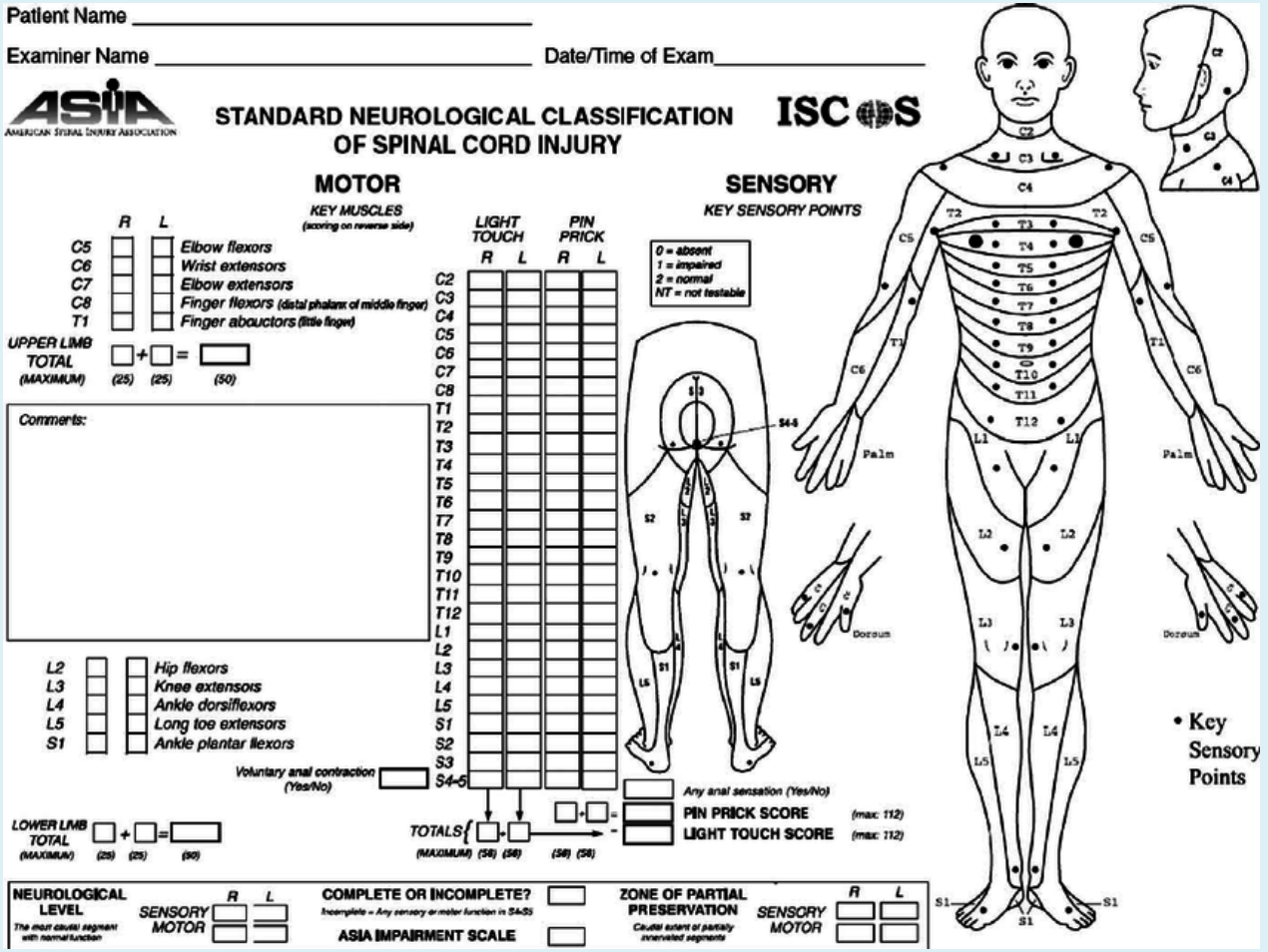
Marino RJ, Barros T, Biering-Sorensen F, et al: International standards for neurological Classification of spinal cord injury, *J SpinalCord Med* 26(suppl 1):S50-S56, 2003.

# Classification of Spinal Cord Injury

- **NLI** (neurologic level of injury) → the most caudal segment of the spinal cord with normal sensation and motor function bilaterally
- **Complete injury** → lack of any sensory or motor function in the lowest sacral segment (including sensation deep within the anus, sensation at the anal mucocutaneous junction, or a voluntary contraction of the external anal sphincter)
- **Incomplete injury** → there is at least partial sensory or motor function in the lowest sacral segment

# Classification of Spinal Cord Injury

- The ISNCSCI also includes a scale of impairment called the **ASIA Impairment Scale** (AIS)
- This classifies an SCI into five categories of severity, labeled A through E, based on the degree of motor and sensory loss



# Classification of Spinal Cord Injury

- Absence of any sensory or motor function in the sacral segments S4–S5 → AIS category of A (complete)
- Sensation preserved in the sacral segments S4–S5, but no motor function caudal to three segments below the NLI → the AIS is B
- Sensation preserved in the sacral segments S4–S5, but more than half the key muscles below the NLI have a muscle grade < 3/5 → the AIS is C
- Sensation is preserved in the sacral segments S4–S5, but at least half the key muscles below the NLI have a muscle grade ≥ 3/5 → the AIS is D
- When sensory and motor function is normal → the AIS is E
- AIS categories B through E designate incomplete injuries

# Outcomes of Traumatic Spinal Cord Injury

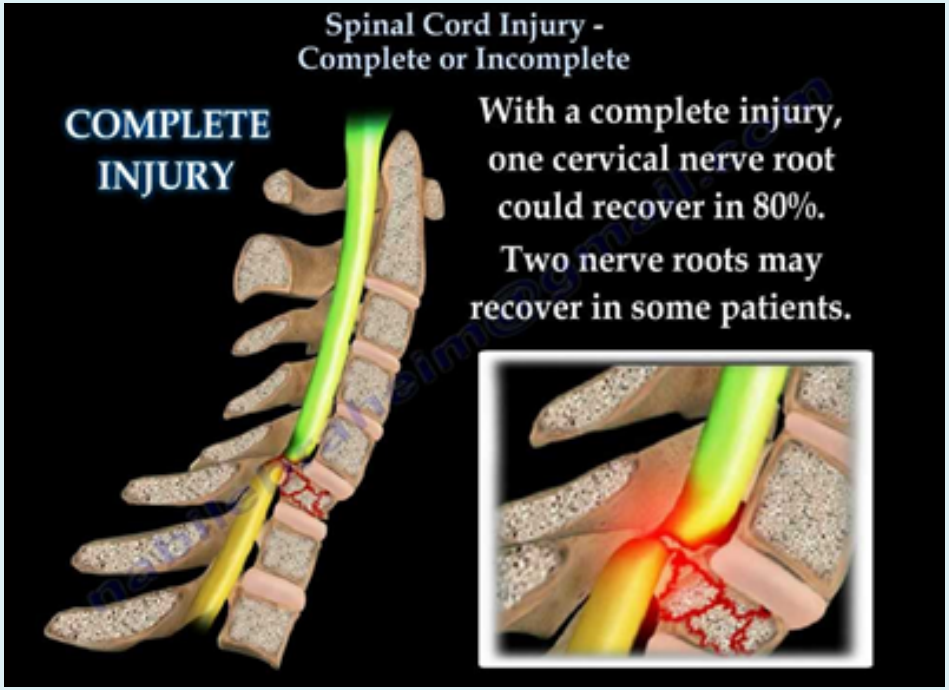
It is not uncommon for clinicians involved in the care of a person who has experienced a traumatic SCI to be asked the following questions:

- "Will I walk again?"
- "Will I regain use of my hands?"
- "Will I regain control of my bowel and bladder?"

Importance of prognosticating neurologic and functional outcomes as early as possible after an SCI, to allow **development of a specific treatment plan** and to allow psychologic adjustment to begin

# Neurologic Recovery in Complete Tetraplegia

- Persons with motor complete tetraplegia have a **poor prognosis** for recovering the ability to walk
- Only 2% to 3% of persons initially classified as having an AIS of A convert to AIS D by 1 year
- Overall, between 30% and 80% of persons with motor complete tetraplegia recover a single motor level, meaning gaining functional motor strength at that level, within 1 year of injury




Marino RJ, Ditunno Jr JF, Donovan WH, et al: Neurologic recovery after traumatic spinal cord injury: data from the model spinal cord injury systems, *Arch Phys Med Rehabil* 80:1391-1396, 1999.

# Neurologic Recovery and Ambulation in Incomplete Tetraplegia

- Persons with **preservation of pinprick sensation near the anus** have a greater than 70% chance of regaining ambulatory ability
- Persons who have spared light touch sensation only in the same region are unlikely to regain ambulatory ability

Crozier KS, Graziani V, Ditunno Jr JF, et al: Spinal cord injury: prognosis for ambulation based on sensory examination in patients who are initially motor complete, *Arch Phys Med Rehabil* 72:119-121, 1991.

- Among persons with motor incomplete SCI, age and initial motor strength → major determinants of ambulation

# Neurologic Recovery and Ambulation in Paraplegia

- Recovery of lower limb function in persons with paraplegia is dependent on the **completeness** of injury and the **level** of injury
- Among persons with **complete paraplegia**, **about 75% retain the same NLI at 1 year that they had at 1 month postinjury**, 20% gain a single level and 7% gain two neurologic levels

Waters RL, Yakura JS, Adkins RH, et al: Recovery following complete paraplegia, *Arch Phys Med Rehabil* 73:784-789, 1992.

- When the gained levels are truncal in distribution, there is usually no functional significance or change

# Neurologic Recovery and Ambulation in Paraplegia

- Persons with **incomplete paraplegia** have the **best prognosis for ambulation** among all the groups of persons with traumatic SCI
- **80% of individuals** with incomplete paraplegia regain functional hip flexion and knee extension within 1 year of injury, making both indoor and community-based ambulation possible

Waters RL, Adkins RH, Yakura JS, et al: Motor and sensory recovery following complete tetraplegia, *Arch Phys Med Rehabil* 74:242-247, 1993.

# Functional Recovery

Prognostication of functional outcome depends on:

- The **physical examination findings**
- Familiarity with the **published functional outcomes** of persons with SCI of different NLI
- Ability to integrate into a prognosis a **host of other factors** (preexisting medical conditions, concomitant injuries, secondary complications, cognitive impairments, age, body habitus, availability of financial resources and insurance coverage, psychologic factors, social factors, and cultural factors)

Whiteneck G, Adler C, Biddle AK, et al, editors: *Outcomes following traumatic spinal cord injury: clinical practice guidelines for health-care professionals.* Consortium for Spinal Cord Medicine Clinical Practice Guidelines, Washington, DC, 1999, Paralyzed Veterans of America.

# CASE REPORT

41 years old male with a complete paraplegia (AIS-A) NLI T10 due to fracture of T9 vertebrae after a reported car accident 1 month ago
Past medical history: no health problems
Profession: accountant
Married with 2 children
Spinal fusion T8-T12
Post injury infections
Indwelling urinary catheter - UTI
Pressure ulcer of the sacrococcygeal area and the right heel
Mild spasticity of the lower limbs
Constipation – Flatulence
Stress – insomnia
Neuropathic pain at the lower limbs
Not fully informed about his prognosis

# Rehabilitation Phase of Injury

Rehabilitation **goals** after SCI include:

- maximizing physical independence
- becoming independent in direction of care
- preventing secondary complications

# Inpatient rehabilitation setting

- The inpatient rehabilitation setting is the **cornerstone** of the rehabilitation process for persons with SCI
- Essential for attaining the above-mentioned broad goals of SCI rehabilitation
- Discharge from the hospital to the least restrictive possible setting, ideally to home

# The Interdisciplinary Team

- Interdisciplinary team approach → the model that has historically been used in the rehabilitation treatment of persons with SCI to achieve these goals
- The team is optimally led by a physician who has obtained subspecialty board certification in SCI medicine and has undergone formal training in the interdisciplinary team approach

# The Interdisciplinary Team

Other members of the team typically include:

- the person with SCI
- family members
- physical therapists
- occupational therapists
- nurses
- aides
- dieticians
- psychologists
- recreation therapists
- vocational therapists
- social workers or case managers
- other consultant physicians
- respiratory therapists
- speech pathologists
- clinician educators
- orthotists
- driving instructors

# Inpatient rehabilitation setting

- **Rehabilitation nurses**, in addition to performing their standard nursing duties, provide education on prevention and treatment of secondary complications, as well as training in bowel and bladder management
- **Psychologists** help to reduce depression and anxiety, as well as facilitate adjustment to a catastrophic and life-altering injury, by supporting persons with SCI (and their families) through the grieving process
- **Social workers** or case managers help individuals with SCI, their families, or their caregivers to obtain needed available resources, benefits, and services

# Physical Skill Training

- **Physical and occupational therapists** train persons with SCI in mobility, self-care skills, and other activities of daily living (ADL)
- Achieving **adequate joint ROM and strength**, necessary to perform these skills, is facilitated through **ROM exercises**, fabrication and use of appropriate **orthoses**, and **resistance exercises**
- Individuals whose injuries prevent them from being independent without assistance also need to be **educated about how to direct caregivers** to provide the assistance they need

# Physical Skill Training

- Performance of an adequate **daily stretching program** can prevent joint contractures
- **Splinting of joints** → often used to provide a prolonged stretch, to facilitate a functional joint position, and to prevent skin breakdown


# Physical Skill Training

- Training in activities that are performed on a therapy mat are commonly begun as soon as a patient is able to tolerate being out of bed
- **Mat activities** include rolling, prone on elbows positioning, prone on hands positioning, supine on elbows positioning, long sitting, short sitting, quadruped positioning, and transfer training
- When the tasks are mastered on the mat, they are performed in other more real-life environments, such as in bed

# Physical Skill Training

- **Transfer training** for a person with a complete paraplegia or lower tetraplegia is usually first taught with a **sliding board**

- The **floor-to chair transfer** is important for anyone who falls out of the wheelchair or otherwise ends up on the floor, and needs to get back into the chair or another higher surface

# Physical Skill Training

- Standing can be initiated on a **standing frame** or a **tilt table**
- Standing seems to **help lessen bone loss** after an acute injury, **improves physical self-concept**, and **improves self-reported health**

*de Bruin ED, Frey-Rindova P, Herzog RE, et al: Changes of tibia bone properties after spinal cord injury: effects of early intervention, Arch Phys Med Rehabil 80:214-220, 1999*

- Standing should be implemented only with caution in individuals with chronic SCI, because of osteoporosis (risk for fracture even without weight-bearing)

# Physical Skill Training

- Although ambulation is an expressed goal of most people who have experienced an SCI, **recovery of ambulation is variable**
- For persons with incomplete motor SCI, gait training can be facilitated by **body weight support (BWS)**
- For persons with complete thoracic level injuries who wish to undergo ambulation training, **orthoses that stabilize the knees and ankles** are required

# Physical Skill Training

Gait trainning begins in the parallel bars and includes:

- going from sit to stand
- balancing with extended hips
- push-ups in the standing position
- turning while standing
- recovery from a flexed hip position
- advancement of the lower extremities with hip hiking

# Wheelchair Skills

- Taught how to **fold or break down the chair** so it can be placed properly in a vehicle
- Taught **wheelchair propulsion**, first indoors over level surfaces, then outdoors over uneven terrain
- **Proper body mechanics** are taught to achieve efficient wheelchair propulsion patterns, including an ideal propulsive stroke and an ideal recovery stroke
- Performance of a **wheelie**, in which the individual in the wheelchair balances on the rear two wheels, which needs to be mastered, to become independent in curb and single-step climbing in a wheelchair

*Rofe Y, Algom D: Accuracy of remembering postdelivery pain, Percept Mot Skills 60:99-105, 1985.*

# Spinal Cord Injury Education

- A **comprehensive education program** is an essential part of any SCI rehabilitation program
- If properly designed, helps the person with SCI and the family members not only to **gain knowledge**, but also to **emotionally adjust** and **prepare for a successful community reintegration**
- With proper education and the ability to access appropriate information readily, the person with SCI becomes **best able to manage successfully the various impairments** and **ensure the highest possible function and quality of life**

# Home and Environmental Modifications

- Without **accessible environments** at home, school, work, and in the community, the dignity, self-sufficiency, and quality of life are severely jeopardized
- A **home evaluation** is best performed before a new wheelchair user returns home
- This begins with a **review of the floor plan**, followed by a **home visit**, recommendations for **architectural changes**, and contracting with architects and builders

# Driver Training

- Being able to drive an automobile **enhances the mobility and quality of life** for persons with SCI
- Most people with SCI can drive an automobile with the **proper adaptive equipment** and training
- All persons with disability wanting to drive should undergo a **driving evaluation by a specialist**, usually an occupational therapist certified by the Association of Driver Educators for the Disabled (ADED)
- Persons with physical disability do not have worse safety records than other drivers

Monga TN, Ostermann HJ, Kerrigan AJ: Driving: a clinical perspective on rehabilitation technology, *Phys Med Rehabil State Art Rev*

# Vocational Training

- Persons who have SCI and are employed report **higher levels of psychologic adjustment, satisfaction with life, independence, and general health** than those who are unemployed
- **Education** has been found to be the factor most strongly associated with postinjury employment

Johnson KL: Vocational rehabilitation. In Lin VW, editor: *Spinal cord medicine: principles and practice*, New York, 2003, Demos.

# Reconstructive Surgery of the Upper Limbs

- **Tenodesis** → surgical attachment of a tendon to a bone
- **Arthrodesis** → joint fusion whereby the joint cartilage is removed from either side of the joint, and the exposed bony ends are opposed and allowed to fuse
- **Tendon transfer** → detachment of a tendon of an expendable innervated muscle from one of its attachments, and reattachment of the innervated muscle and tendon to another tendon that lacks an innervated muscle but whose regained function is sought
- Functional upper limb surgical reconstruction has historically been **delayed for at least 1 year postinjury** to allow for neurologic recovery in targeted muscles

# Functional Electrical Stimulation (FES)

- **FES-assisted cycle ergometers** leading to improved muscular endurance, exercise tolerance, oxidative metabolism, cardiovascular fitness, glucose homeostasis, and lipid lipoprotein profiles, as well as decreased muscle atrophy
- FES in gait training
- FES is not effective in stimulating muscles paralyzed by LMN damage
- Application in the presence of cardiac pacemakers or implanted defibrillators is best avoided

Pollack SF, Axen K, Spielholz N, et al: Aerobic training effects of electrically induced lower extremity exercises in spinal cord injured people, *Arch Phys Med Rehabil* 70:214-219, 1989.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# Body Weight Support Ambulation Training on a Treadmill

- Clinical studies have shown that **specific intensive walking training** of persons with incomplete SCI significantly improves walking capabilities
- Such training consists of upright walking on a treadmill, with partial BWS provided by a suspending harness, with a therapist guiding and setting the limbs

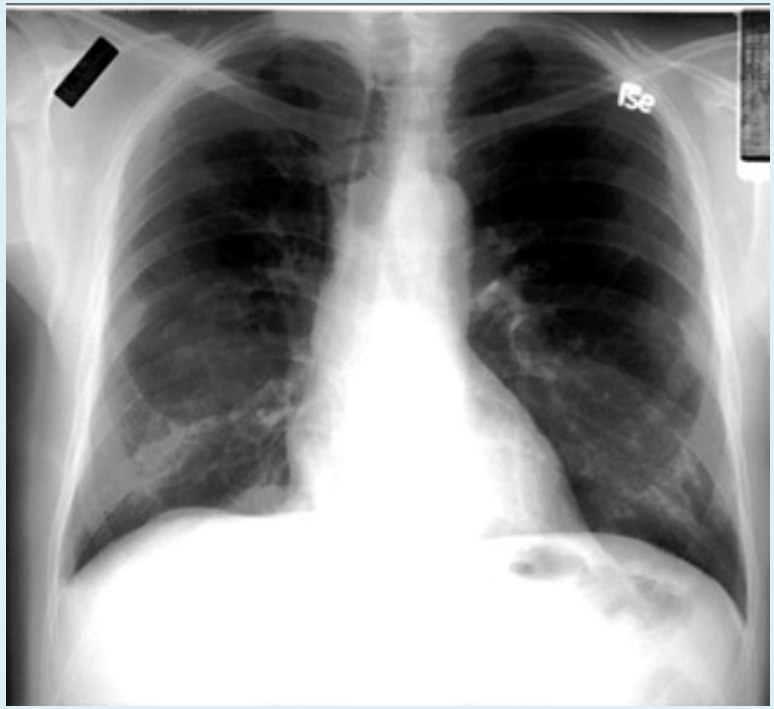
Wernig A, Nanassy A, Muller S: Laufband (LB) therapy in spinal cord lesioned persons, *Prog Brain Res* 128:89-97, 2000.

# Secondary Conditions

- Pulmonary System
- Vascular System
- Cardiovascular and Autonomic System
- Calcium Metabolism and Osteoporosis
- Gastrointestinal System
- Genitourinary System
- Sexuality and Fertility
- Pressure Ulcers
- Pain
- Spasticity
- Musculoskeletal Conditions (*Contractures, Fractures, Heterotopic Ossification)*

# Pulmonary System

- Pulmonary complications, including **atelectasis, pneumonia, respiratory failure, pleural complications, and pulmonary embolism (PE)**, are the **leading causes of death** for persons with SCI in all years after SCI
- SCI can lead to alterations in lung, chest wall, and airway mechanics
- The degree of respiratory dysfunction after SCI is strongly correlated to the NLI and degree of motor impairment



DeVivo MJ, Black KJ, Stover SL: Causes of death during the first 12 years after spinal cord injury, *Arch Phys Med Rehabil* 74:248-254, 1993.

# Management of Pulmonary Complications

- Intermittent positive pressure breathing, bilevel positive airway pressure, or continuous positive airway pressure (CPAP) devices can all be used with or without tracheostomy tubes to help with lung expansion and to prevent or treat atelectasis
- **Secretion mobilization techniques** include postural drainage and chest percussion or vibration
- **Secretion clearance techniques** include suctioning, manually assistive cough, use of a mechanical insufflator-exsufflator, and bronchoscopy

# Management of Pulmonary Complications

- **Bronchodilators** reduce airway hyperreactivity and inflammation that contribute to telectasis formation and sputum production, and stimulate the secretion of surfactant
- Use of a **β2-adenergic medication** has been shown to improve expiratory pressures, which can lead to a more effective cough
- **Mucolytics** can be given orally, such as guaifenesin, or via a tracheostomy tube or nebulizer, such as acetylcysteine
- **Adequate hydration** thins pulmonary secretions
- Use of an **abdominal binder** in the sitting position
- Phrenic nerve and direct diaphragm **pacing**

# Sleep Disorders

- **Obstructive sleep apnea** (OSA) → repetitive collapse of the upper airway during sleep
- Can cause fragmentation of sleep, loss of the restorative function of sleep, and increased sympathetic nervous system activity
- Results in excessive sleepiness, systemic and pulmonary hypertension, and an increased risk for developing stroke or myocardial infarction
- **CPAP**, a highly effective treatment that prevents narrowing and closure of the upper airway, is the treatment of choice
- Unfortunately, even in those without SCI, long-term compliance with CPAP is low

Epstein LJ, Brown R: Sleep disorders in spinal cord injury. In Lin VW, editor: *Spinal cord medicine: principles and practice*, New York, 2003, Demos.

# Vascular System

Persons with SCI are prone to:

- **Stasis of the venous circulation** → direct result of the loss of the muscle-pumping action of the lower limbs and peripheral vasodilatation
- **Hypercoagulability** → release of procoagulant factors after injury
- **Intimal vascular injuries** → can occur from trauma

These risk factors for development of deep vein thrombosis (DVT) are known as **Virchow's triad**

PE and the postphlebitic syndrome are not uncommon sequelae of DVT

Merli GJ, Crabbe S, Paluzzi RG, et al: Etiology, incidence, and prevention of deep vein thrombosis in acute spinal cord injury, *Arch Phys Med Rehabil* 74:1199-1205, 1993.

# Vascular System

- **Low-molecular-weight heparin LMWH** is more effective in preventing both DVT and PE after SCI
- Prophylaxis should continue until the time of discharge for those with motor incomplete SCI
- For **8 weeks** for those with **uncomplicated complete injuries**
- For **12 weeks** for those with complete motor injuries with **additional risk factors** such as lower limb fracture, previous thrombosis, cancer, heart failure, obesity, or age greater than 70 years
- **Pneumatic compression boots** are also recommended during the first two weeks after injury

[Anonymous]: Prevention of thromboembolism in spinal cord injury. Consortium for Spinal Cord Medicine, *J Spinal Cord Med* 20:259-283, 1997.

# Cardiovascular and Autonomic System

## *Fitness and Exercise*

- Persons who have SCI, both paraplegia and tetraplegia, often lead **sedentary lives**, resulting in **poor physical fitness** and an increased risk for untoward **cardiovascular events**
- High prevalence of asymptomatic coronary artery disease as detected by thallium stress testing
- More than one third of persons with SCI have a **low HDL level** (a known risk factor for coronary artery disease)
- **Impaired glucose tolerance** and **reduced lean body mass** are also significantly more prevalent in persons with SCI than those without SCI

Bauman WA, Spungen AM: Disorders of carbohydrate and lipid metabolism in veterans with paraplegia or quadriplegia: a model of premature aging, *Metabolism* 43:749-756, 1994.

# Cardiovascular and Autonomic System

### *Fitness and Exercise*

- **Upper limb ergometry** performed at a moderate intensity for 20 minutes three times per week → enhance fitness and raise HDL levels in persons with SCI
- **Cycling, using FES** → enhance fitness, decrease insulin resistance, and increase lean body mass in persons with SCI
- When **combined** with upper limb ergometry, the gains in fitness are greater than those achieved with electrically stimulated cycling alone


Mutton DL, Scremin AM, Barstow TJ, et al: Physiologic responses during functional electrical stimulation leg cycling and hybrid exercise in spinal cord injured subjects, *Arch Phys Med Rehabil* 78: 712-718, 1997.

# Cardiovascular and Autonomic System

## *Fitness and Exercise*

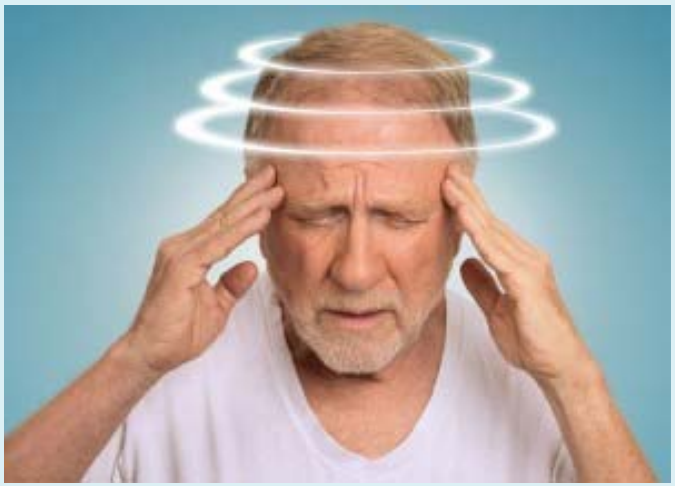
- Participation in a regular, vigorous exercise or **wheelchair sports program** can improve heath status, and also challenge individuals with SCI to overcome physical obstacles and to achieve greater functional independence
- Common organized wheelchair sports include basketball, tennis, table tennis, swimming, softball, snow skiing, sled hockey, track and road racing, rugby for those with tetraplegia (quad rugby), air rifle and pistol, archery, fencing, billiards, and bowling


Glaser RM, Janssen TWJ, Suryaprasad AG, et al: The physiology of exercise. In Sowell TT, editor: *Physical fitness: a guide for individuals with spinal cord injury*, Washington, DC, 1996, US Veterans Health Administration.

# Cardiovascular and Autonomic System

## Orthostatic Hypotension

- Immediately after SCI, there is a **complete loss of sympathetic tone**, resulting in **neurogenic ("spinal") shock** with hypotension, bradycardia, and hypothermia
- Hypotension occurs as a result of systemic loss of vascular resistance, accumulation of blood within the venous system, reduced venous return to the heart, and decreased cardiac output
- Over the course of time, the **sympathetic reflex activity returns**, with normalization of blood pressure
- The **symptoms** associated with orthostatic hypotension include light headedness, dizziness, yawning, pallor, and occasionally syncope



# Cardiovascular and Autonomic System

## Orthostatic Hypotension

Management of orthostatic hypotension includes:

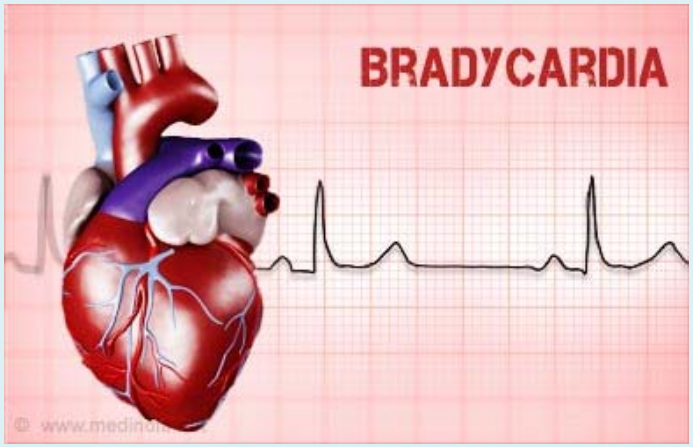
- application of **elastic stockings** and **abdominal binders**
- adequate **hydration**
- gradually progressive daily **head-up tilt**
- administration of **salt tablets**, **midodrine**, or **fludrocortisone**

Campagnolo DI, Merli GJ: Autonomic and cardiovascular complications of spinal cord injury. In Kirshblum S, Campagnolo DI, DeLisa JA, editors: *Spinal cord medicine*, Philadelphia, 2002, Lippincott Williams & Wilkins.

# Cardiovascular and Autonomic System

## Bradycardia

- Bradycardia occurs in almost all persons with neurologically complete high-level SCI immediately after injury, because of the **unopposed parasympathetic effect**
- As the neurogenic shock resolves and sympathetic tone returns, usually within 2 to 4 weeks after injury, heart rate returns to near normal
- Bradycardia can still occur with vagal stimulation thereafter, such as during **tracheal suctioning**
- Bradycardia is **rare during the chronic phase** of SCI, except during episodes of intense vagal stimulation (episodes of autonomic dysreflexia)



# Cardiovascular and Autonomic System

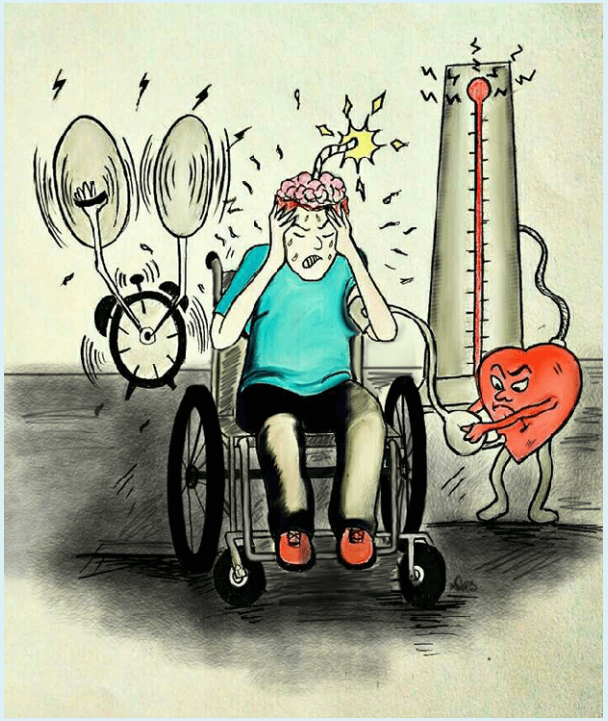
## Autonomic Dysreflexia

- A syndrome that affects persons with SCI at the **T6 level or above**, which is above the major splanchnic outflow
- Caused by a **noxious stimulus below the injury level**, which **elicits a sudden reflex sympathetic activity**, uninhibited by supraspinal centers, resulting in **profound vasoconstriction** and other **autonomic responses**


Braddom RL, Rocco JF: Autonomic dysreflexia: a survey of current treatment, *Am J Phys Med Rehabil* 70:234-241, 1991.

# Cardiovascular and Autonomic System

## Autonomic Dysreflexia



The **symptoms** of AD are somewhat variable but include:

- a pounding **headache**
- systolic and diastolic **hypertension**
- profuse **sweating** and cutaneous **vasodilatation** with **flushing** of the face, neck, and shoulders
- **nasal congestion**
- **pupillary dilatation**
- **bradycardia**

The hypertension can be profound and **result in cerebral hemorrhage and even DEATH**

# Cardiovascular and Autonomic System

## Autonomic Dysreflexia

- The noxious stimulus responsible for AD frequently stems from the sacral dermatomes, most often from a **distended bladder**
- Other causes include **fecal impaction**, pathology of the bladder and rectum, **ingrown toenails**, labor and delivery, surgical procedures, orgasm, and a variety of other conditions

# Cardiovascular and Autonomic System

## Autonomic Dysreflexia

- Treatment of acute AD must be prompt and efficient to prevent a potentially life-threatening crisis
- **Recognition of symptoms** and **identification of the precipitating stimulus** are paramount
- The patient should be sat up, constrictive clothing and garments should be loosened, the blood pressure monitored every 2 to 5 minutes, and **evacuation of the bladder** done promptly to ensure continuous drainage of urine

# Cardiovascular and Autonomic System

## Autonomic Dysreflexia

- If symptoms are not relieved by these measures, **fecal impaction** should be suspected and, if present, **resolved**
- **Local anesthetic agents** should be used during any manipulations of the urinary tract or rectum
- If hypertension is present, **fast-acting antihypertensive agents** should be administered, usually **nitroglycerin** or **nifedipine**
- After resolution of the AD episode, the person's symptoms and blood pressure should be **monitored for at least 2 hours**

[Anonymous]: Acute management of autonomic dysreflexia: adults with spinal cord injury presenting to health-care facilities. Consortium for Spinal Cord, *J Spinal Cord Med* 20:284-308, 1997

# Cardiovascular and Autonomic System

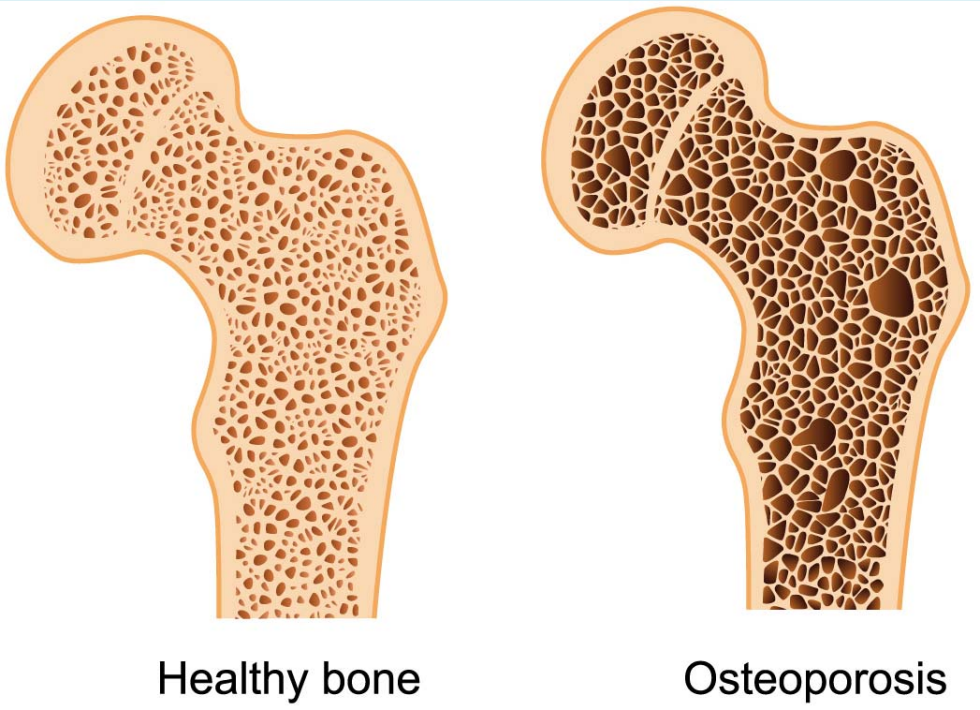
## Thermal Regulation

- Thermal regulation is impaired in persons with SCI, especially in those with **complete lesions above T6**, because of **loss of supraspinal control**
- People with SCI therefore tend to have a higher body temperature in warm environments and a lower temperature in cold environments **(*poikilothermia*)**
- **Proper heating and cooling of the environment** is needed to ensure continuous thermal stability, especially for those with high-level SCI
- **Appropriate clothing** should be worn, strenuous exercise in a hot environment avoided, and cool moist compresses applied when body temperature rises

Cesario TC, Darouiche RO: Thermal regulation in the SCI patient. In Lin VW, editor: *Spinal cord medicine: principles and practice*, New York, 2003, Demos.

# Calcium Metabolism and Osteoporosis

- An **imbalance between bone formation and bone resorption** occurs after SCI
- The potential adverse clinical effects of this imbalance are fractures related to osteoporosis, hypercalcemia, and renal calculi resulting from **hypercalciuria**
- Primary bone resorption resulting from SCI is prominent during the first several months after SCI
- The degree of lower limb bone mineral density (BMD) after SCI has been correlated with **fracture risk**




Roberts D, Lee W, Cuneo RC, et al: Longitudinal study of boneturnover after acute spinal cord injury, *J Clin Endocrinol Metab* 83: 415-422, 1998.

# Calcium Metabolism and Osteoporosis

- Individuals with SCI who perform **passive weight-bearing standing** with the aid of a standing device might have better-preserved BMD in their lower limbs than those who do not stand
- **FES cycle ergometry** has been shown to provide modest reductions in the rate of bone loss
- Several **oral bisphosphonate antiresorptive therapies** (alendronate, etidronate, clodronate, tiludronate) have been shown to be effective in either maintaining lower extremity BMD after acute SCI or improving low BMD
- **Calcium and vitamin D** are usually administered in conjunction with the antiresorptive agents, especially if there is evidence of a vitamin D deficiency
- Vitamin D supplementation in and of itself has also been shown to protect against bone loss after SCI

Goemaere S, Van Laere M, De Neve P, et al: Bone mineral status in paraplegic patients who do or do not perform standing, *Osteoporos Int* 4:138-143, 1994.

# Bowel Management

- An SCI that damages segments above the sacral segments produces a **reflexic or UMN bowel** in which defecation cannot be initiated by voluntary relaxation of the external anal sphincter, although there can be **reflex-mediated colonic peristalsis**
- In contrast, an SCI that includes **destruction of the S2–S4 anterior horn cells or cauda equine** produces an **areflexic or LMN bowel** in which there is no reflex-mediated colonic peristalsis
- There is only **slow stool propulsion** coordinated by the intrinsically innervated myenteric plexus
- The anal sphincter of an LMN bowel is typically atonic and prone to **leakage of stool**

[Anonymous]: Clinical practice guidelines: neurogenic bowel management in adults with spinal cord injury. Spinal Cord Medicine Consortium, *J Spinal Cord Med* 21:248-293, 1998.

# Bowel Management

- A **bowel program** is a treatment plan for managing a neurogenic bowel, with the goal of **allowing effective and efficient colonic evacuation** while **preventing incontinence and constipation**
- A bowel program should be scheduled at the same time of day, usually every day in the beginning
- The program should be scheduled later on **at least once every 2 days** to avoid chronic colorectal overdistention

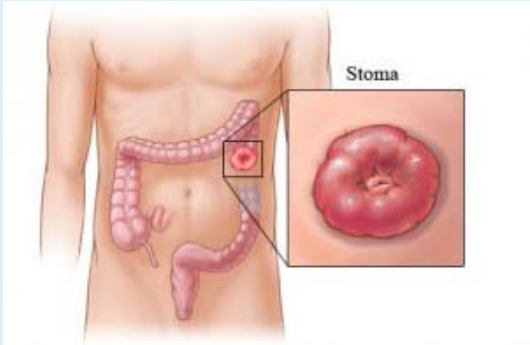
[Anonymous]: Clinical practice guidelines: neurogenic bowel management in adults with spinal cord injury. Spinal Cord Medicine Consortium, *J Spinal Cord Med* 21:248-293, 1998.

# Bowel Management

- The scheduling of a bowel routine after a meal can take advantage of the **gastrocolic response**
- A **diet high in fiber** can help produce a bulky, formed stool and promote continence
- Medications can also be used, such as **stool softeners** to modulate stool consistency, and stimulant and hyperosmolar laxatives to improve bowel motility.
- **Mini enemas** and **suppositories** can be used to trigger colonic reflex evacuation in persons with an UMN bowel.
- **Stimulant and hyperosmolar laxatives**, if used, are usually taken 8 to 12 hours before the evacuation portion of a bowel routine

# Bowel Management

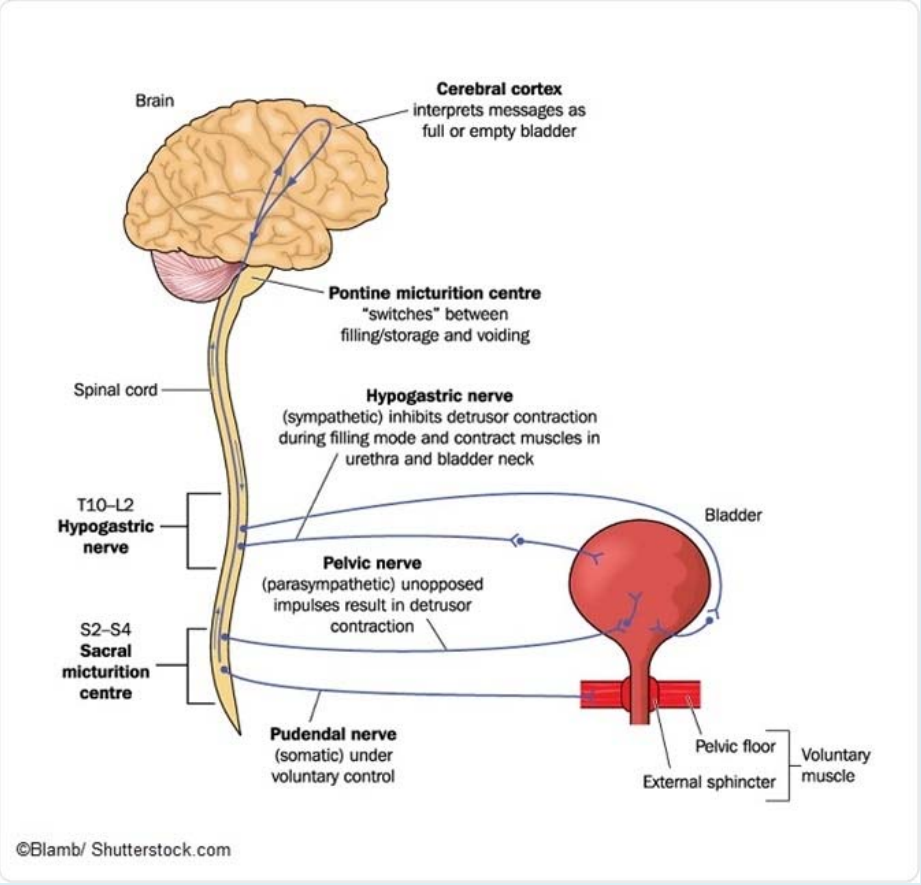
- Two **mechanical methods** are used to evacuate the rectum: **digital stimulation and digital evacuation**
- **Abdominal wall massage**, starting in the right lower quadrant and progressing along the course of colon, is a useful adjunct for attempting to move stool along the colon
- **Pulsed water irrigation** → a rectal catheter with an inflatable balloon is inserted into the rectum to allow pulsed warm water to facilitate colonic peristalsis and stool evacuation
- Placement of a **colostomy** → effective in eliminating bowel accidents, dramatically decreasing the time it takes to perform bowel care, and decreasing the amount of assistance needed to perform bowel care




Christensen P, Krogh K, Buntzen S, et al: Long-term outcome and safety of transanal irrigation for constipation and fecal incontinence, *Dis Colon Rectum* 52:286-292, 2009.

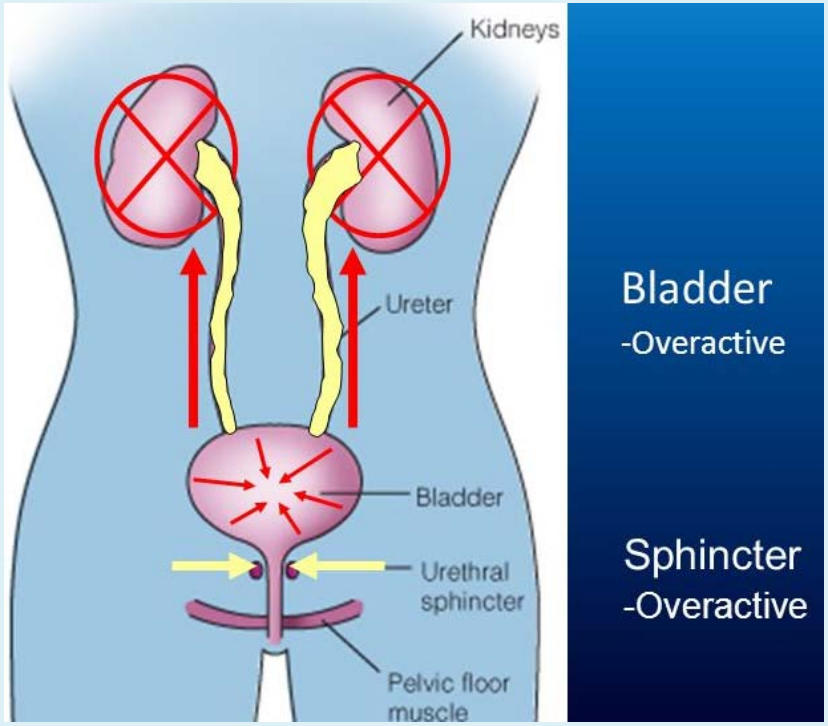
# Management of Neurogenic Bladder

- SCI that damages segments above the sacral segments produces a **reflexic or UMN bladder** in which urination cannot be initiated by voluntary relaxation of the external urinary sphincter, although reflex voiding can occur
- SCI that includes **destruction of the S2–S4 anterior horn cells or cauda equina** produces an **areflexic or LMN bladder** in which there is no reflex voiding
- The external urinary sphincter of an LMN bladder is typically atonic and prone to leakage of urine



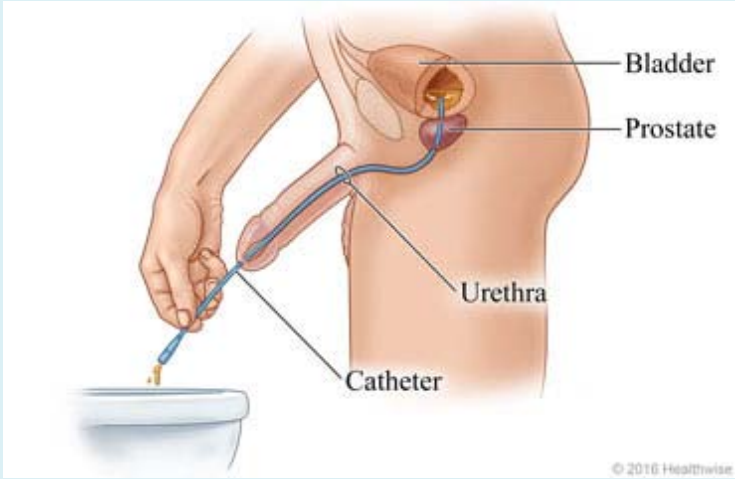
# Management of Neurogenic Bladder

- **Central coordination of normal voiding** is thought to occur **at the level of the pons**
- In a person with an UMN bladder resulting from SCI, **coordination** of contraction (or relaxation) of the bladder with relaxation (or contraction) of the external urinary sphincter **is lost**
- This leads to a pattern of **simultaneous reflex contractile activity** called d**etrusor-sphincter dyssynergia,** which often results in **elevated bladder pressures**



# Management of Neurogenic Bladder

- The **goal** of management of a neurogenic bladder is to **achieve a socially acceptable method of bladder emptying**, while **avoiding complications** such as infections, hydronephrosis with renal failure, urinary tract stones, and AD
- **Intermittent bladder catheterization** (IC) is generally accepted as the best option, other than regaining normal voiding, for the long-term bladder management of persons who can perform IC themselves
- This is because of the physiologic advantage of **allowing for regular bladder filling and emptying**, the **social acceptability** of not needing a drainage appliance, and **fewer complications** than with other methods




Barkin M, Dolfin D, Herschorn S, et al: The urologic care of the spinal cord injury patient, *J Urol* 129:335-339, 1983.

# Management of Neurogenic Bladder

- IC is usually performed **several times daily** with a target catheterized volume of **500 mL each time**, for a total fluid intake of approximately **2000 mL/day**
- IC often needs to be **combined with anticholinergic medications** in persons who have an UMN bladder, to inhibit voiding between catheterizations
- **Injections of the neurotoxin botulinum toxin** have been shown to be effective; however, they must be repeated on a regular basis
- **Augmentation cystoplasty**, a procedure that involves harvesting a portion of intestine and attaching the portion of intestine to the native bladder to create a high-capacity but low-pressure reservoir

Ehren I, Volz D, Farrelly E, et al: Efficacy and impact of botulinum toxin A on quality of life in patients with neurogenic detrusor overactivity: a randomised, placebo-controlled, double-blind study, *Scand J Urol Nephrol* 41:335-340, 2007.

# Management of Neurogenic Bladder

- **Reflex voiding** is another viable option for males with UMN bladder in whom bladder pressures are generated that are greater than the outlet pressures of the sphincters to allow spontaneous voiding
- Reflex voiding is a poor option for females with SCI, because an acceptable external collecting device for women does not exist at this time
- The completeness of voiding can be determined by **measurement of a postvoid residual urine volume**
- High residual volumes predispose to **urinary tract infection** (UTI) and **bladder stone formation**
- Furthermore, reflex voiding is often associated with **elevated voiding pressures**, which can predispose to **vesicoureteral reflux**, **hydronephrosis**, and eventual **renal failure**

# Management of Neurogenic Bladder

- It is critically important for reflex voiders to undergo **regular urodynamic testing** to measure bladder pressures, and to have an imaging study such as a **renal ultrasound** to identify reflux or hydronephrosis
- **α-Adrenergic blocker medications**, such as prazosin, terazosin, doxazosin, tamsulosin, or alfuzosin, are often effective in decreasing bladder outlet resistance and secondarily decreasing bladder pressures and postvoid residual volumes
- Nondestructive placement of a **tubular wire mesh stent** at the level of the external sphincter
- **Transurethral external sphincterotomy**, performed either with a scalpel or a laser
- **Botulinum toxin** has also been shown to be effective when injected into the sphincter to improve bladder emptying

Perkash I: Efficacy and safety of terazosin to improve voiding in spinal cord injury patients, *J Spinal Cord Med* 18:236-239, 1995.

# Management of Neurogenic Bladder

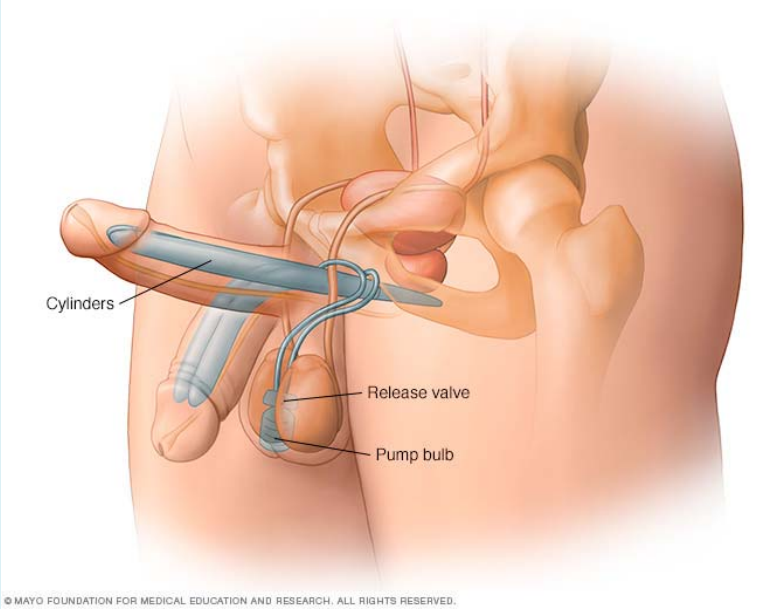
- Long-term bladder drainage with an **indwelling catheter** is a reasonable option for persons with tetraplegia who are unable to perform IC, or males who are unable to effectively maintain an external catheter on their penis
- Use of an indwelling catheter inserted through the urethra is **associated with UTI, bladder stone formation, epididymitis, prostatitis, hypospadias, and bladder cancer**
- Placement of a **suprapubic cystostomy tube** in persons requiring long-term indwelling catheters can avoid some of these complications, such as prostatitis, epididymitis, and hypospadias

Weld KJ, Dmochowski RR: Effect of bladder management on urological complications in spinal cord injured patients, *J Urol* 163:768-772, 2000.

# Sexuality and Fertility

Effective treatments for **male erectile dysfunction**, not ejaculatory dysfunction, resulting from SCI include:

- **Oral medications** (type 5 phosphodiesterase inhibitors such as sildenafil, vardenafil, and tadalafil)
- **vacuum tumescence devices**
- **Intracavernous (penile) injections** (papaverine, phentolamine, or prostaglandin E1)
- penile **implants**




Deforge D, Blackmer J, Garritty C, et al: Male erectile dysfunction following spinal cord injury: a systematic review, *Spinal Cord* 44: 465-473, 2006.

# Sexuality and Fertility

- Pregnancy rates are approximately 50% in partners of males with SCI using **assisted ejaculation** or advanced fertility treatments such as **testicular biopsy or aspiration, invitro fertilization**, or **intracytoplasmic sperm injection**
- Women with SCI are not thought to have decreased fertility, although this has not been closely evaluated
- Most women experience **temporary amenorrhea postinjury** that lasts for an **average of 4 months**

Jackson AB, Wadley V: A multicenter study of women's self-reported reproductive health after spinal cord injury, *Arch Phys Med Rehabil* 80:1420-1428, 1999.

# Pressure Ulcers

- Persons with SCI are highly susceptible to developing pressure ulcers because of **impaired mobility** and **sensation**
- Pressure ulcers can be prevented with proper care
- **Secondary risk factors** → immobility, incontinence, spasticity, limited activity levels, impaired nutrition, altered level of consciousness, and low satisfaction with life
- **Assessment of a pressure ulcer** → notation of location, stage of wound, size, characteristics of the ulcer cavity, and characteristics of the surrounding skin
- **Determination of the potential causes** of the breakdown should be made

# Treatment of Pressure Ulcers

- **Removal of necrotic tissue** can be done by a number of different methods of debridement, including autolysis and chemical, sharp, and mechanical debridement
- **Numerous dressing products** (transparent films, hydrocolloids, hydrogels, foams, alginates, and gauze dressings) are on the market that have different properties, and they can be used to maintain optimal moist wound healing within the ulcer cavity
- Other modalities → **vacuum-assisted closure**, **electrical stimulation**, and the use of **pulsed electromagnetic energy**
- **Bed and wheelchair support surfaces** and **proper positioning** in them can help prevent pressure ulcers from developing, and help to heal them if they occur
- **Adequate nutrition** is essential to heal a pressure ulcer (caloric need and protein requirements are increased)

Alexander LR, Spungen AM, Liu MH, et al: Resting metabolic rate in subjects with paraplegia: the effect of pressure sores, *Arch Phys Med Rehabil* 76:819-822, 1995.

# Pain

- Approximately **80% of people with SCI report chronic pain**, while approximately one third report chronic, severe pain that interferes with activity and affects quality of life
- **Nociceptive pain** is defined as pain arising from activation of peripheral nerve endings or sensory receptors that are capable of transducing and encoding noxious stimuli
- **Neuropathic pain** is defined as pain that arises as a direct consequence of a lesion or disease affecting the somatosensory system

# Spasticity

- Spasticity is a syndrome of different components, including a **velocity-dependent increased resistance to passive motion**, involuntary muscle contractions or spasms, and hyperreflexia
- Although spasticity can cause difficulty with mobility, positioning, and comfort, and might even predispose to skin breakdown, it **can also be helpful** for ambulating and performing ADL
- The decision of whether to treat spasticity, and how to do so, should be based on an **evaluation that has identified all the activities and other medical issues** that are helped or hindered by one or more of the components of spasticity

# Treatment of Spasticity

- **Steady static stretching**, to the limits of the ROM of a joint, has been shown to result in a reduction of reflex activity that can last for several hours after the exercise
- **ROM exercises** should be performed regularly on all affected joints by members of the rehabilitation team, support staff, or family members, after instruction in proper technique
- **Proper positioning, in bed or in wheelchairs**, can effectively control increased muscle tone, as well as provide a prolonged static stretch to spastic muscles.
- The **use of positioning orthoses or serial casts** can improve spasticity by placing the affected muscle in a position of sustained stretch
- **Passive standing on a standing frame or tilt table** can also provide a significant stretch to the hip, knee, and ankle plantar flexors

# Treatment of Spasticity

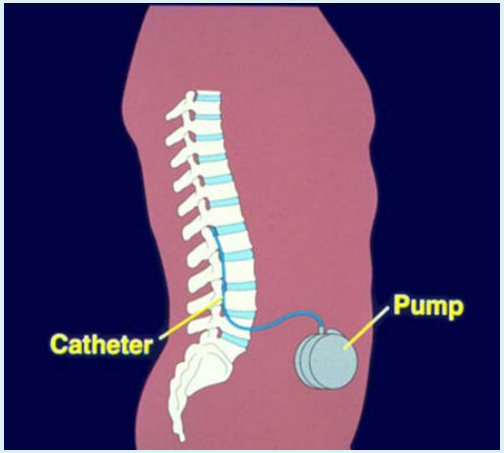
Many pharmacologic options are available for the treatment of spasticity:

- **Baclofen** is a structural analog of γ-aminobutyric acid (GABA)
- **Diazepam** and other benzodiazepines bind to the GABAA receptor
- **Tizanidine hydrochloride** is a central α2-adrenergic agonist
- **Dantrolene sodium** has a peripheral rather than a central mechanism of action

Gracies JM, Elovic E, McGuire J, et al: Traditional pharmacological treatments for spasticity. I. local treatments, *Muscle Nerve Suppl* 6:S61-S91, 1997.

# Treatment of Spasticity

- When only a few specific muscles are affected by problematic spasticity, **targeted injections** of these muscles with a neurotoxin (e.g., **botulinum toxin**) or an alcohol (e.g., benzyl alcohol [phenol] or ethyl alcohol) can be carried out
- The administration of **baclofen intrathecally** is the most effective treatment for severe, generalized spasticity in persons with SCI


Penn RD: Intrathecal baclofen for spasticity of spinal origin: seven years of experience, *J Neurosurg* 77:236-240, 1992.

# Musculoskeletal Conditions

A variety of musculoskeletal conditions can affect persons with SCI and cause pain and reduce functional ability:

- Contractures
- Fractures
- Heterotopic Ossification

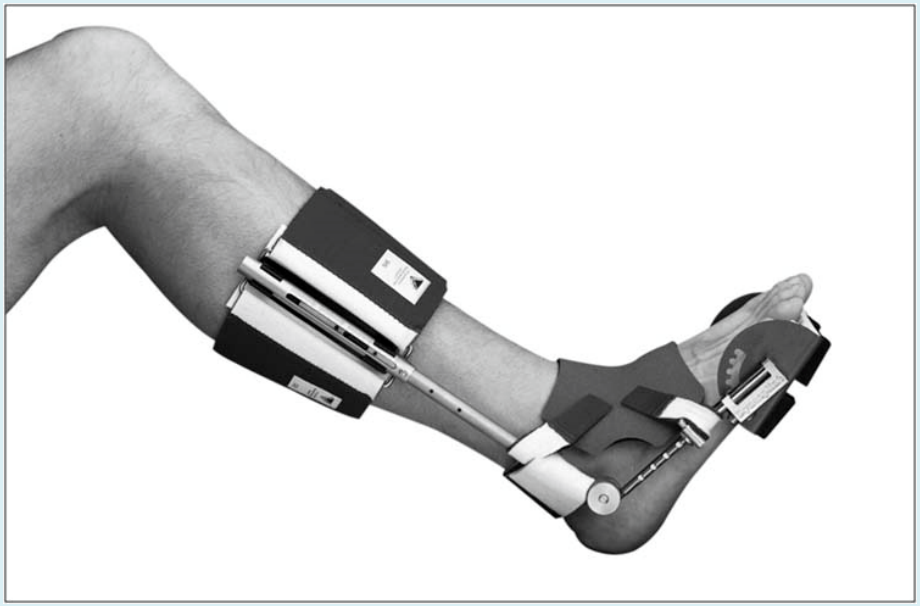
# Contractures

- A **fixed stiffness of a soft tissue** that limits joint motion in a particular direction
- Joint contractures can prevent achievement of full functional capacity, inhibit hygiene, lead to abnormal positioning with resultant pain or pressure ulcer development, and prevent use of a joint in the future should motor recovery occur in a delayed fashion
- The primary cause of contracture is **prolonged joint immobilization**, but secondary factors include edema, muscle imbalance, spasticity, and local trauma

Kirshblum S, Druin E, Planten K: Musculoskeletal conditions in chronic spinal cord injury, *Top Spinal Cord Inj Rehabil* 2:23-35, 1997.

# Contractures

- Best prevented by **proper positioning in bed**, by performing **passive ROM and stretching exercises** of all joints at least daily, and sometimes by use of **prophylactic static splints**
- Additional preventive measures include effective **management of spasticity and edema**
- Once a contracture is present, aggressive ROM exercises should be started, which often require pretreatment with pain medications
- In addition, **static and dynamic splints** are used to maintain the maximally corrected position
- **Surgical interventions** are occasionally required, such as tenotomies and tendonlengthening procedures

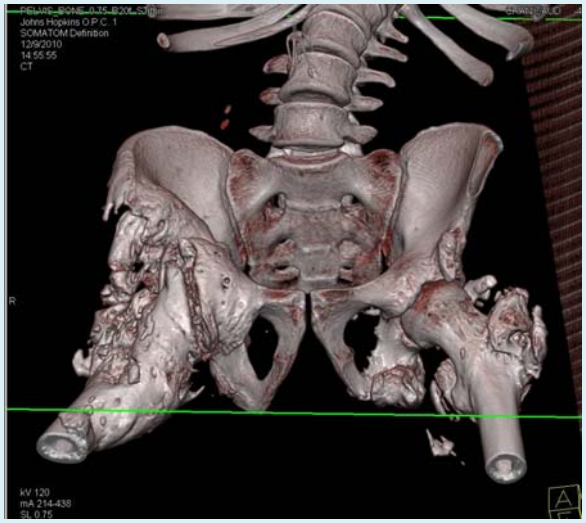


# Fractures

- Major trauma can result in a fracture of any bone, but in persons with SCI, fractures in the paralyzed lower limbs without major trauma are of particular concern
- Significant **osteoporosis** develops in the lower limbs during the first few months after SCI, which makes the bones brittle and prone to fractures
- The goal of treatment is to preserve prefracture function, avoid complications, and secure proper healing and alignment

# Heterotopic Ossification

- True bone in extraskeletal ectopic sites
- Most often develops **around the hips** (90%), but other locations where it can appear include the knees, shoulders, and elbows
- Presents clinically as a **warm local swelling adjacent to a joint**, followed by a more generalized edema of the affected paralyzed limb
- Low-grade fever can be present, and in time, **joint mobility** can be reduced
- The **serum alkaline phosphatase** level during the acute stage is elevated, and a **bone scan** of the area is **positive**
- As the HO matures, it becomes more visible on plain films, but the serum alkaline phosphatase level and radioisotope uptake gradually decrease




Subbarao JV, Garrison SJ: Heterotopic ossification: diagnosis and management, current concepts and controversies, *J Spinal Cord Med* 22:273-283, 1999.

# Heterotopic Ossification

- Treatment of established HO should begin promptly and is aimed at **halting the ossification process**, as well as **maintaining joint ROM and function**
- Prophylactic use of **nonsteroidal anti-inflammatory** drugs to prevent HO has been shown to be effective
- Intravenous **etidronate**, 300 mg/day for 3 days, followed by oral etidronate, 20 mg/kg per day for 6 month,
- **Radiation therapy** for HO is effective, but it is uncommonly used because of unknown long-term risks
- **Gentle ROM exercises** are generally recommended, but forceful stretching is thought to be contraindicated until the acute inflammation has subsided
- **Surgical resection** of HO can be done when joint mobility is severely restricted

Banovac K, Sherman AL, Estores IM, et al: Prevention and treatment of heterotopic ossification after spinal cord injury, *J Spinal Cord Med* 27:376-382, 2004.

# CASE REPORT

After a rehabilitation programme of 2,5 months:

- Independent at all ADL's with a lightweight wheelchair
- Mild spasticity at the lower limbs that causes no problems
- No pain complaints
- Ability to walk for short distances with special orthoses (walkabout) and a walker
- Driving ability
- Pressure ulcers healed
- CISC x 4 / day with no UTI's
- No constipation – defecation every day with digital stimulation
- Stress reduced – no sleeping disorders
- Returned to community, to his family and to his work

# *Conclusions*

- SCI is a **catastrophic event** that results in physical disability and impaired function of various organ systems
- Despite decades of intense research, **a cure still does not exist**
- Great **progress** has occurred, however, in the management of SCI and its associated conditions

# *Conclusions*

- The **ultimate goal** of persons with SCI and those who care for them is to find a cure for this condition, which is to **reverse the neurologic damage of SCI**
- Until that elusive goal is reached, persons with SCI, their families, their caregivers, and society at large must work together to **eliminate barriers** to health care and ensure their **full participation** in all aspects of community life

***Thank you for your attention!***