

Spinal Cord Injury



ADULT SCI

Introduction



- Spinal Cord Injury (SCI) is a low-incidence, high cost disability
- SCI requires tremendous change in an individual's lifestyle
- 10,000 new cases in the USA each year
- What percentage do you think are male? _____

Etiology



- **TRAUMATIC**

- Most frequent cause of adult SCI
- Result from MVA, falls, GSW, etc

- **NON-TRAUMATIC**

- Approx 30% of all SCI
- Result from disease or pathological influence
- Congenital SCI
- Vertebral subluxations due to RA or DJD
- Infections
- MS
- ALS

Spinal Cord Anatomy Review



- How many cervical, thoracic, lumbar & sacral vertebrae are there?
- How many pairs of spinal nerves are there? Cervical, thoracic, lumbar & sacral?
- What does this mean in terms of spinal cord anatomy?

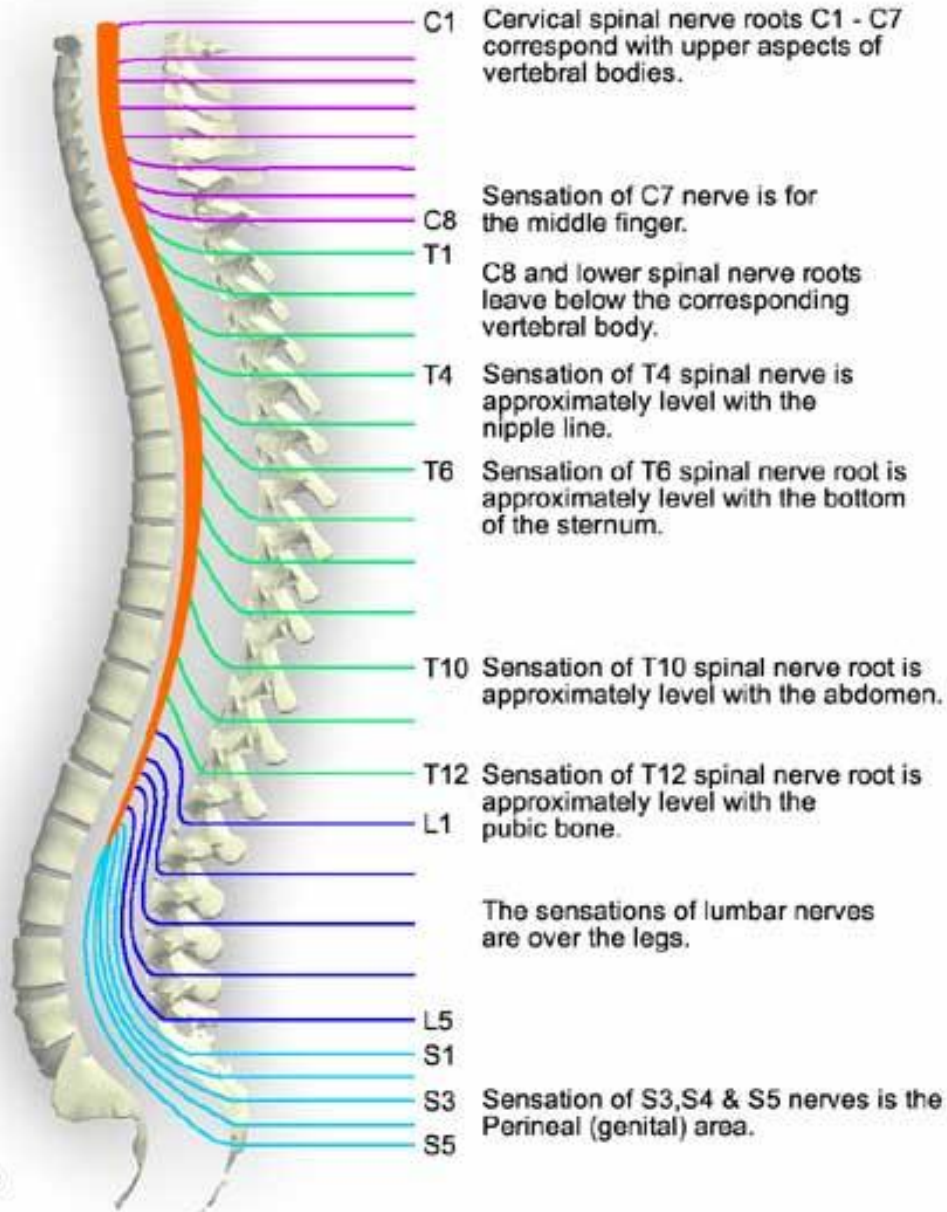
Bone notch at the base of the neck is C7.

The spinal cord ends approximately between L1 & L2.

Sacral cord segments (S1-S5 "Cauda Equina") are level with T12-L1 Vertebrae.

The sacral vertebrae are fused to make up the sacrum.

The coccygeal vertebrae are fused to make the coccyx or "tail bone".



Classification of SCI



- **DESIGNATION OF LESION LEVEL**
 - LEVEL
 - COMPLETE OR INCOMPLETE
 - TETRAPLEGIA OR PARAPLEGIA

 - Example: C7 complete tetraplegia

Classification of SCI continued



- **LEVEL**
 - Is the most distal UNINVOLVED nerve root segment with normal function
 - Normal function: the muscles innervated by the most distal nerve root must have at least a 3+/5 MMT grade indicating sufficient strength for functional use

Classification of SCI continued



- **COMPLETE LESION**

- No sensory or motor function below the level of the lesion.
- Caused by a complete transection (or severing), severe compression, or extensive vascular impairment to the spinal cord

- **INCOMPLETE LESION**

- Preservation of some sensory or motor function below the level of injury
- Often result from contusions produced by pressure on the cord or swelling within the spinal canal
- Clinical picture is unpredictable

Classification of SCI continued



- **TETRAPLEGIA**
 - Involvement of all four extremities and the trunk, including the respiratory muscles
 - Results from lesions of the cervical cord
- **PARAPLEGIA**
 - Involvement of all or part of the trunk and both lower extremities
 - Results from lesions of the thoracic or lumbar spinal cord or sacral roots

ASIA Impairment Scale



A	Complete	No motor or sensory function is preserved in the sacral segments S4 to S5
B	Incomplete	Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4 to S5
C	Incomplete	Motor function is preserved below the neurological level, and more than half of key muscles below the neurological level have a muscle grade less than 3
D	Incomplete	Motor function is preserved below the neurological level, and at least half of key muscles below the neurological level have a muscle grade of 3 or more
E	Normal	Motor and sensory function is normal

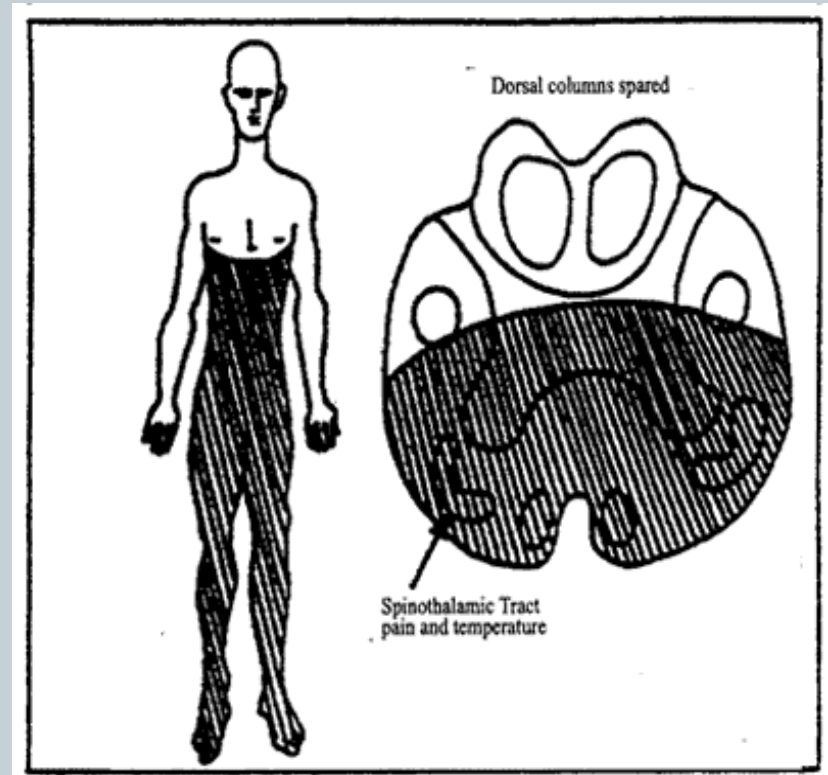
Specific Incomplete Lesions



- 1. Anterior Cord Syndrome
- 2. Brown-Sequard's Syndrome
- 3. Cauda Equina Injuries
- 4. Central Cord Syndrome
- 5. Posterior Cord Syndrome

Anterior Cord Syndrome

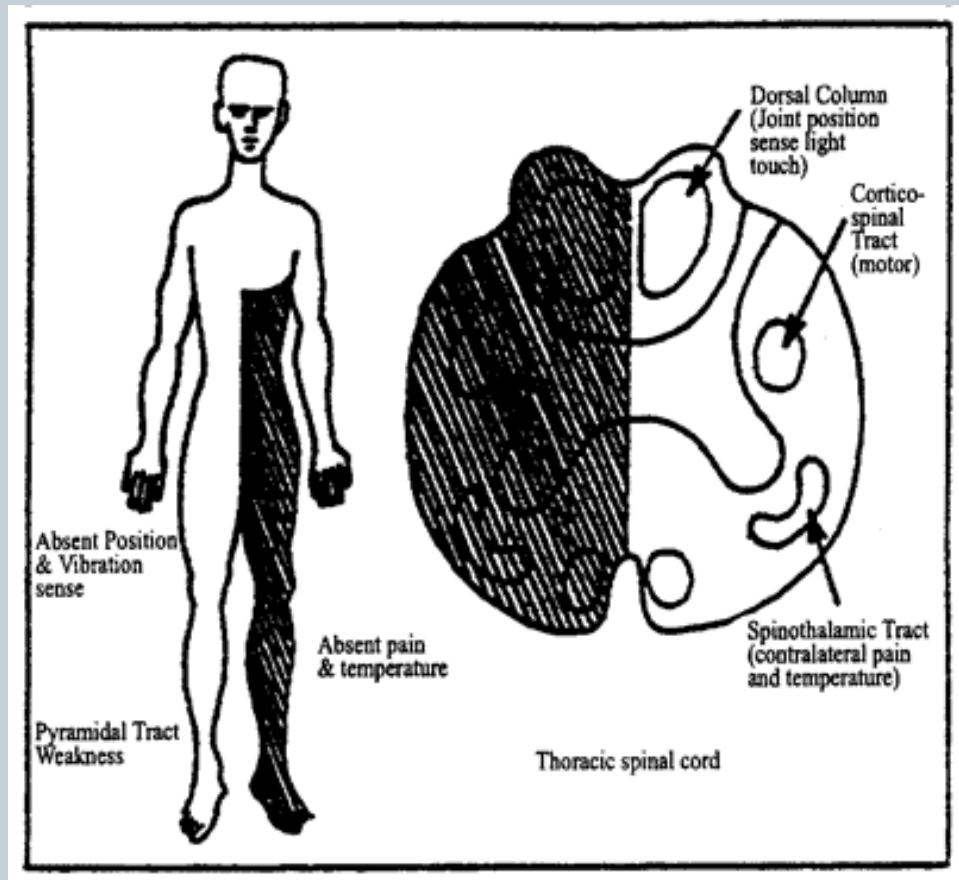
- Usually caused by cervical flexion, which compresses and damages the anterior part of the spinal cord or anterior spinal artery
- Motor function is lost bilaterally
- Pain and temperature sensation are lost bilaterally



Brown-Séquard Syndrome



- Result of hemisection of spinal cord (gunshot or stab wound)
- Ipsilateral paralysis, loss of proprioception & vibration
- Contralateral loss of pain & temperature sense



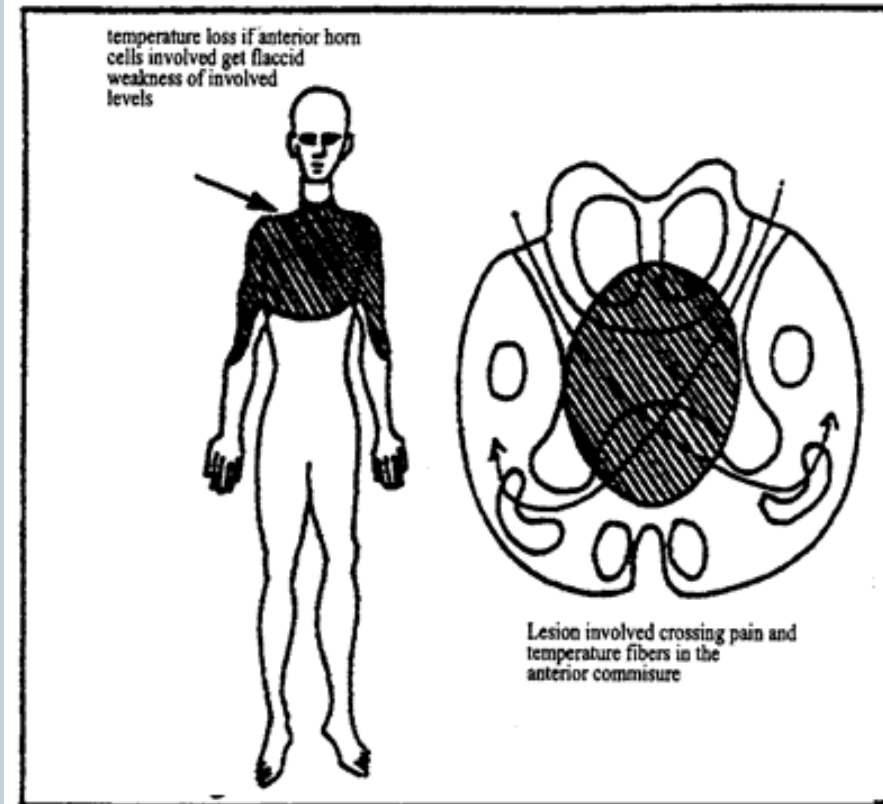
Cauda Equina Injuries



- Injuries below the L1 vertebral level
- Results in a LMNL (lower motor neuron lesion)
- Usually incomplete; can be complete
- Results in flaccidity, areflexia, and impairment of bowel & bladder function
- Regeneration of peripheral nerves is possible

Central Cord Syndrome

- Hyperextension injuries
- Impairment of function in the UE > LE
- High % of patients will attain ambulatory function, B & B control and hand function



Posterior Cord Syndrome



- Very rare
- Compression by tumor or infarction of the posterior spinal artery
- Proprioception, stereognosis, two-point discrimination and graphesthesia are lost below the lesion
- Motor function is preserved

Kevin Everett



- <http://www.youtube.com/watch?v=9SoDPFhT-u8>
- http://www.youtube.com/watch?v=G_RPHu1Xkk8
- http://www.youtube.com/watch?v=oV6_ziHQ9tY

Mechanisms of Injury



- Various mechanisms, often in combination, produce SCI
- Most frequently from indirect forces produced by movement of the head and trunk
- Some areas of the spine are more vulnerable to injury due to mobility & lack of stability

○ _____ & _____

Mechanisms of Injury



- Flexion
- Compression
- Hyperextension
- Flexion-rotation
- Shearing
- Distraction

Clinical Manifestations



- **SPINAL SHOCK**

- Immediately following SCI there is a period of areflexia called spinal shock
- Not clearly understood
- Characterized by absence of all reflex activity, flaccidity, and loss of sensation below the level of the lesion
- Can last hours to weeks, but typically subsides within 24 hours

Clinical Manifestations



CATEGORIZED AS:

- 1) Motor paralysis or paresis
- 2) Sensory loss
- 3) Respiratory dysfunction
- 4) Impaired temperature control
- 5) Spasticity
- 6) Bowel and bladder dysfunction
- 7) Sexual dysfunction

Clinical Manifestations



- **1. & 2. Motor & Sensory Loss**
 - Following SCI there will be either complete or partial loss of muscle function below the level of the lesion
 - Disruption of ascending sensory fibers results in impaired or absent sensation below the level of the lesion
 - The clinical presentation of motor and sensory impairment depends on the specific features of each injury/lesion

Clinical Manifestations



- **3. Respiratory Dysfunction**
 - Level of respiratory impairment is dependent on
 - ✦ Level of the lesion
 - ✦ Additional trauma sustained at time of injury
 - ✦ Premorbid respiratory status

Clinical Manifestations



- **Respiratory Dysfunction continued**
 - Inspiration
 - ✦ Diaphragm and external intercostals
 - ✦ Impairments = decreased chest expansion & lowered inspiratory volume
 - Expiration
 - ✦ Abdominals and internal intercostals
 - ✦ Impairments = decrease expiratory efficiency

Clinical Manifestations



- 4. Impaired Temperature Control
 - After SCI, the hypothalamus can no longer control cutaneous blood flow or sweating below the lesion
 - Lose the ability to shiver, absence of thermoregulatory sweating below the level of the lesion
 - This lack of sweating is often associated with excessive compensatory **diaphoresis** above the level of the lesion

Clinical Manifestations



- **5. Spasticity**
 - Characterized by hypertonicity, hyperactive stretch reflexes, and clonus
 - Typically occurs below the level of the lesion after spinal shock subsides
 - Gradually increases during first 6 mo and plateaus by 1 year
 - Increased by internal & external stimuli (position changes, cutaneous stimuli, environmental temperature, tight clothing, bladder or kidney stones, fecal impaction, catheter blockage, UTI, decubitus ulcers, emotional stress)

Clinical Manifestations



- **6. Bladder Dysfunction**
 - During Spinal Shock:
 - Spastic or reflex Bladder
 - Flaccid or nonreflex Bladder

Clinical Manifestations



- **6. Bowel Dysfunction**
 - Spastic Bowel (UMNL)

 - Flaccid Bowel (LMNL)

Clinical Manifestations



- **7. Sexual Dysfunction**

- Sexual information is as vital and as normal a part of the rehabilitation process as is providing other information to enable the patient to better understand and adapt to his medical condition
- Male erection & ejaculation are possible depending on the level of the lesion and complete/incomplete
- Female menses and fertility remain unchanged

Complications



- 1. Pressure Ulcers
- 2. Autonomic Dysreflexia
- 3. Orthostatic Hypotension
- 4. Contractures
- 5. DVT
- 6. Osteoporosis & Renal Calculi

Complications



- **1. Pressure Ulcers**

- Frequent medical complication

- Influencing factors in development of wounds:

- ✦ 1.

- ✦ 2.

Complications



- 2. Autonomic Dysreflexia
 - Definition: A very dangerous complication occurring in patients with lesions above T6 in which a noxious stimulus below the level of the lesion triggers the autonomic nervous system causing a sudden _____ in blood pressure, which if untreated can lead to convulsions, hemorrhage, and death
 - Symptoms: high BP, severe HA, blurred vision, stuffy nose, profuse sweating, goose bumps below & vasodilation (flushing) above the level of the injury
 - Common Causes: distended or full bladder, kink or blockage in the catheter, bladder infection, pressure ulcer, extreme temperature change, tight clothing, ingrown toenail

Complications



- 2. Autonomic Dysreflexia (continued)
 - Treatment: The first reaction should be to check the catheter for blockage. The bowel should also be checked for impaction. A patient should **REMAIN IN THE SITTING POSITION**, or be brought to the sitting position from supine. Lying a patient down is contraindicated as it will further elevate the BP. The patient should be examined for any other irritating stimuli and if the cause remains unknown, then the patient should receive immediate medical intervention.

Complications



- **3. Orthostatic Hypotension**
 - Definition?
 - Symptoms?
 - How do you minimize the effects?

Complications

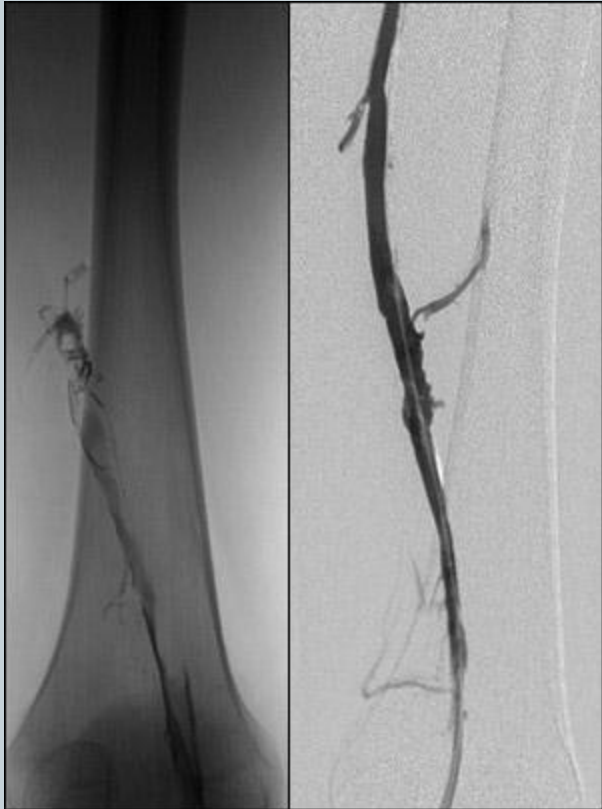


- **4. Contractures**
 - Develop due to...
 - Leads to...
 - PTA role...
 - Most common contractures:
 - ✦ Hip flexion, IR, add
 - ✦ Shoulder flex or ext, IR, add

Complications



- **5. DVT**
 - definition?...
 - Symptoms?...
 - Patients with SCI have greater risk of developing DVTs because...
 - Special test to confirm the presence of a DVT?...
 - Preventing DVT includes....
 - Treatment...



Complications



- **6. Osteoporosis & Renal Calculi**
 - Changes in calcium metabolism following SCI lead to osteoporosis and renal calculi
 - More osteoclasts than osteoblasts, leading to net loss of bone mass
 - Greater risk of fracture
 - Large concentrations of calcium in urinary system due to more bone resorption (osteoclasts) than production (blasts)
 - Exact mechanism causing bone changes is not clear, agree that contributing factors are immobility and lack of stress to skeletal system in WBing
 - Treatment: dietary management, early WBing activities, hydration, bladder drainage program

Prognosis



- The potential for recovery from SCI is directly related to the extent of damage to the spinal cord and/or nerve roots
- Formulation of a prognosis is initiated only *after* spinal shock has subsided, once it is known if the injury is complete or incomplete

Functional Outcomes



- Must understand the key muscles by segmental innervation:

Level	Key Muscles
C4	diaphragm
C7	triceps
T7-T9	upper abdominals
L2-L4	quadratus lumborum
L4-L5	quadriceps, medial hamstrings, posterior tibialis
S1	plantarflexors, glut max

Functional Outcomes for COMPLETE lesions



- Look at the Handout provided
- Break up into 4 groups
- Each group gets a “column”
- You have *15 minutes to prepare* **a 5 minute** presentation to your classmates, which will include:
 - ✦ Which muscles you think the patient HAS USE OF
 - ✦ Therefore which movements are available to the patient
 - ✦ Level of assistance generally required for all ADLs listed in the table

Christopher Reeve Sesame Street



- <http://www.youtube.com/watch?v=OzHvVoUGTOM>

Potential for Functional Ambulation



Level	Potential
C8 and higher	Functional ambulation not feasible
T1-9	May walk for exercise, but not functionally, will use lofstrand crutches or walker and KAFOs
T10-L2	Household ambulation only, w/c use outside of home, will use lofstrand crutches or walker and KAFOs
L3-4	Community ambulator with lofstrand crutches or walker and AFOs/KAFOs; likely to use w/c for longer distances
L5 and below	Community ambulator with or without cane and AFOs

Medical Intervention



- Acute
 - Immobilization
 - Trauma center
 - Administration of methylprednisolone or GM-1
 - Stabilizing the patient medically

Physical Therapy Intervention



- **During Acute Phase, emphasis is on...**
 - Respiratory management
 - Prevention of secondary complications
 - Maintaining ROM
 - Facilitating active movement in available musculature
 - Limited strengthening activities pending orthopedic clearance

PT – Acute Phase



- **Respiratory Management**
 - Diaphragmatic breathing
 - Glossopharyngeal breathing
 - <http://www.youtube.com/watch?v=32tw8qR1ZQs>
 - Strengthening
 - Assisted coughing
 - Abdominal support
 - Stretching

PT – Acute Phase



- **ROM & Positioning**

- While patient is immobilized, need to do full ROM daily except in areas that are contraindicated or require selective stretching

- ✦ Contraindications

- Paraplegia: SLR > 60 degrees; hip flex > 90 (with combined hip & knee flexion)
- Tetraplegia: motion of head and neck contraindicated pending ortho clearance
- Stretching of the shoulders should be avoided during acute stage, however they should be positioned out of the usual position of comfort (which is: shoulder IR, add, ext, elbow flex & pron, wrist flex)

PT – Acute Phase



- **ROM & Positioning (continued)**
 - Selective stretching: the process of understretching some muscles and full stretching of others to improve function.
 - ✦ some joints benefit from allowing tightness to develop in certain muscles to enhance function.
 - Tetraplegia: tightness of lower trunk muscles will improve sitting posture & stability; tightness in the long finger flexors will provide improved tenodesis grasp
 - ✦ Some muscles require a fully lengthened range
 - After the acute stage, hamstrings will require SLR to 100 degrees required for sitting, transfers, LE dressing, self-ROM

Tenodesis Grip



- <http://www.youtube.com/watch?v=oYrDRvm-saU>

PT – Acute Phase



- **Strengthening**

- During the course of rehab, all remaining musculature will be strengthened maximally. However, during the acute phase, certain muscles must be strengthened very cautiously to avoid stress at the fracture site
- During the first few weeks, resistance may be contraindicated to:
 - ✦ Tetraplegia: scapula and shoulder muscles
 - ✦ Paraplegia: hip and trunk muscles
- Bilateral UE exercises are important to avoid asymmetric, rotational stresses on spine

PT – Acute Phase



- **Orientation to the Vertical Position**
 - Once there is stability of fracture site, pt is cleared for upright activities
 - Gradual acclimation is important
 - Use abdominal binder, elastic stockings, & elastic wraps placed over the stockings
 - Monitor vital signs
 - Example: elevate HOB , reclining W/C with elevating leg rests, tilt table

PT – Subacute Phase



- Skin inspection
- Continue activities and interventions from acute phase
- Mat programs
 - Rolling, POE, prone on hands (paraplegia), supine on elbows, sitting, quadruped, kneeling, transfers
- Prescriptive wheelchair
- Ambulation in patients with paraplegia

Study #1: exercise & SCI



- RCT: 23 participants with SCI of 1-24 yrs duration
- Both groups received monthly education session on topics such as exercise physiology for SCI, osteoporosis after SCI, relaxation techniques, etc.
- In addition to the education sessions, the exercise group received 9 months of twice-weekly supervised progressive exercise training and the control group did not.
- Subjects were assessed for one rep max strength, arm ergometry performance and several indices of quality of life and psychological well being at baseline, 3, 6, and 9 months

Study #1: exercise & SCI



- Results: at baseline: no significant differences between the 2 groups
- Following training, exercise group had significant increases in upper body strength, arm ergometry power output and the control group had none.
- The exercise group reported less pain, stress and depression after training and scored higher than the control group in indices of satisfaction with physical function, level of perceived health, and overall quality of life.
 - Hicks et al (2003)

Study #2: UBE & high SCI



- 4 male subjects with SCI trained for 5 weeks with UBE, 30 minutes per session, 3X/week at intensity = 60-80% of maximal heart rate.
- Statistically significant improvement in VO_2 max values
- In patients with high SCI who only have small muscle mass available for training, exercising on a modified cycle ergometer is an effective means of endurance training.
 - DiCarlo et al (1983)



- http://www.youtube.com/watch?v=7_EGCPmnqB8

Wrap Up of Today's Lecture



REFERENCES



- DiCarlo SE, Supp MD, Taylor HC. (1983) Effect of Arm Ergometry Training on Physical Work Capacity of Individuals with Spinal Cord Injuries. *Journal of the American Physical Therapy Association.* 63: 1104-1107.

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