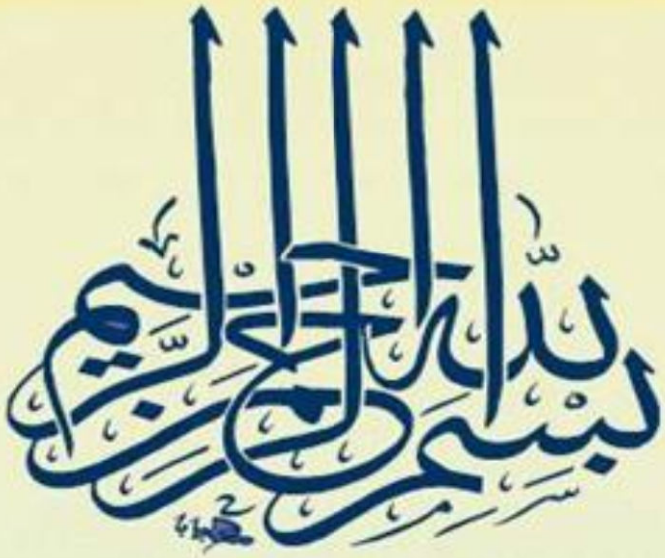

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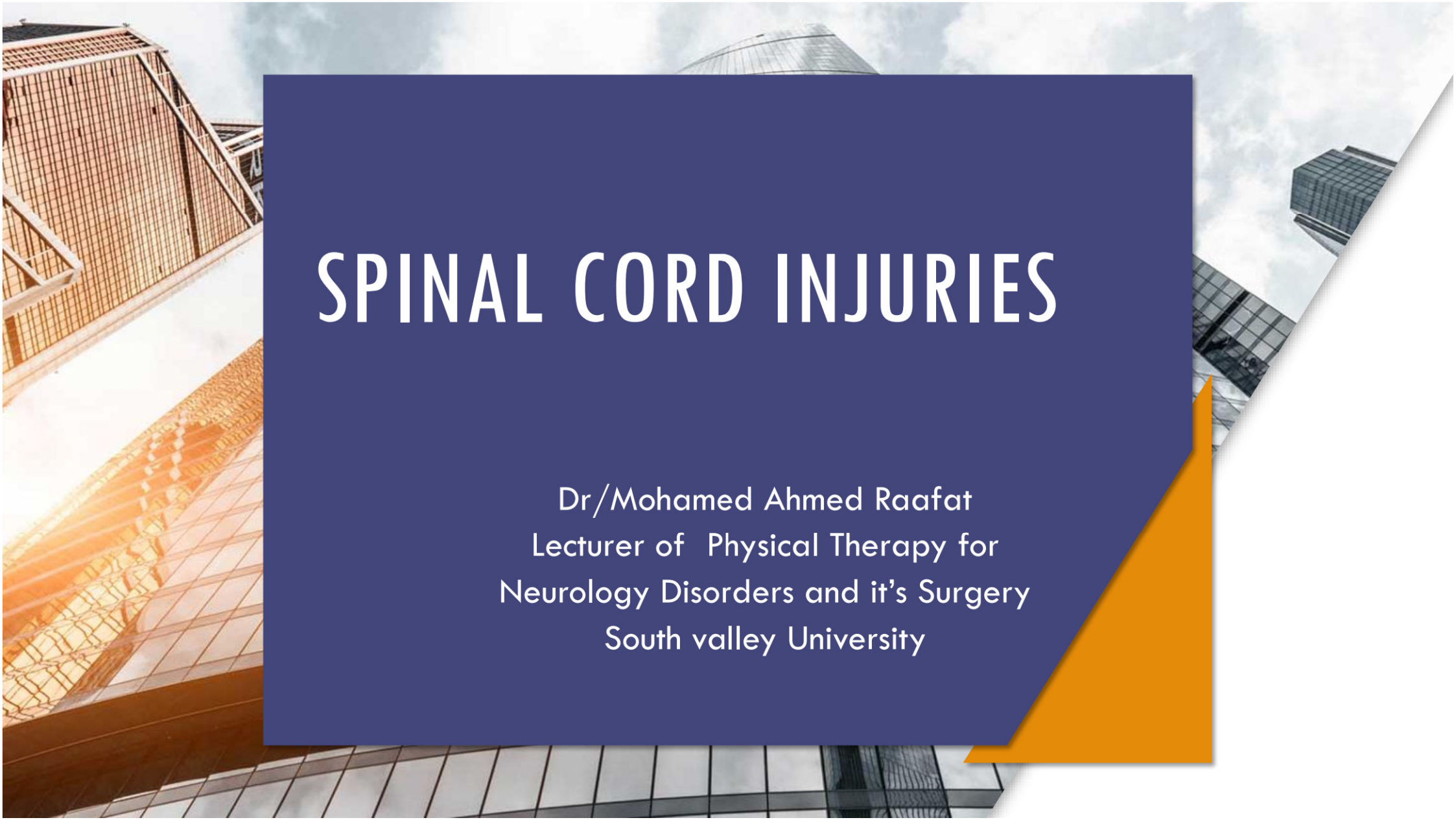
صدق الله العظيم

الآيه(32) سوره البقره

Mohammed Ali Sarhan

Lecturer of Physical Therapy for Orthopedics Disorders and it's Surgery

South valley University



SPINAL CORD INJURIES

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INTRODUCTION

most common causes of SCIs

- An estimated 17,730 new cases of spinal cord injury (SCI) occur **annually.**
- Within the United States, currently more than 291,000 people are **living** with SCIs.
- SCIs are most likely to occur in **young adults** between the ages of 16 and 30 years. , the average age at time of injury has also increased to 43 years.
- Approximately 78% of the individuals with SCIs are **male**.
- The **etiology** of SCIs continues to change. Previously, **motor vehicle accidents** and **sporting activities** were identified as the most likely causes of these injuries.

INTRODUCTION

most common causes of SCIs

- **most common causes of SCIs:**

✓ motor vehicle accidents (39.3%),

✓ falls (31.8%),

✓ Acts of violence (13.5%),

✓ sports and recreation related injuries (8.0%), and

✓ medical and surgical complications (4.3%)

INTRODUCTION

Life expectancies

- SCIs are still below those without SCI, and there has not been an improvement in this statistic since the 1980s.
- Individuals with SCIs can experience **a lifetime of disability** and **life-threatening medical complications**.
- **Potential causes of death** *that significantly affect life expectancy* include **pneumonia** and **septicemia**.

INTRODUCTION

The cost of medical care for SCIs individuals is in the billions of dollars

- high cervical injuries are approximately $5 million.
- paraplegia injuries are approximately $2.5 million.
- In addition to the direct costs of medical care, there are indirect costs associated with lost wages, employee benefits, and productivity—costs that can average $76,327 a year

ETIOLOGY

To understand the etiology of SCIs, it is necessary to review the anatomy of the region:

- There are 31 pairs of spinal nerves within the PNS.
- There are 8 pairs of spinal nerves in the cervical region.
- The first seven pairs exit above the first seven cervical vertebrae. Spinal nerve C8 exits between C7 and T1, because there is no eighth cervical vertebra.
- The remaining spinal nerve roots exit below the corresponding bony vertebrae. This holds true through L1.
- At this point, the spinal cord becomes a mass of nerve roots known as the cauda equina. **Fig. 13.1** *illustrates segmental & vertebral levels*.

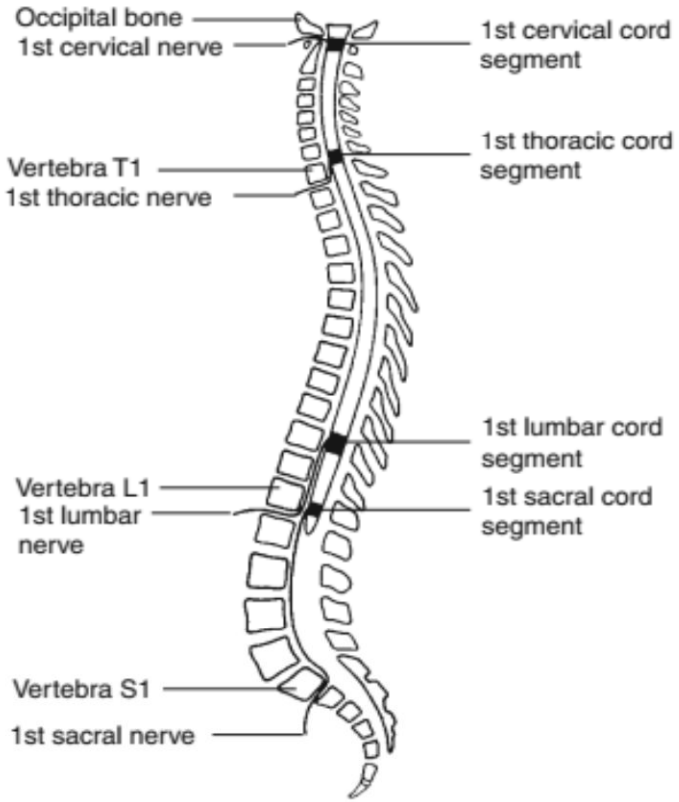


Fig. 13.1 **Segmental and Vertebral Levels Compared.** Spinal nerves 1 to 7 emerge above the corresponding vertebrae, and the remaining spinal nerves emerge below them. (From Fitzgerald MJT: *Neuroanatomy: basic and clinical, clinical neuroanatomy and related neuroscience*, ed 4, London, 2002, WB Saunders.)

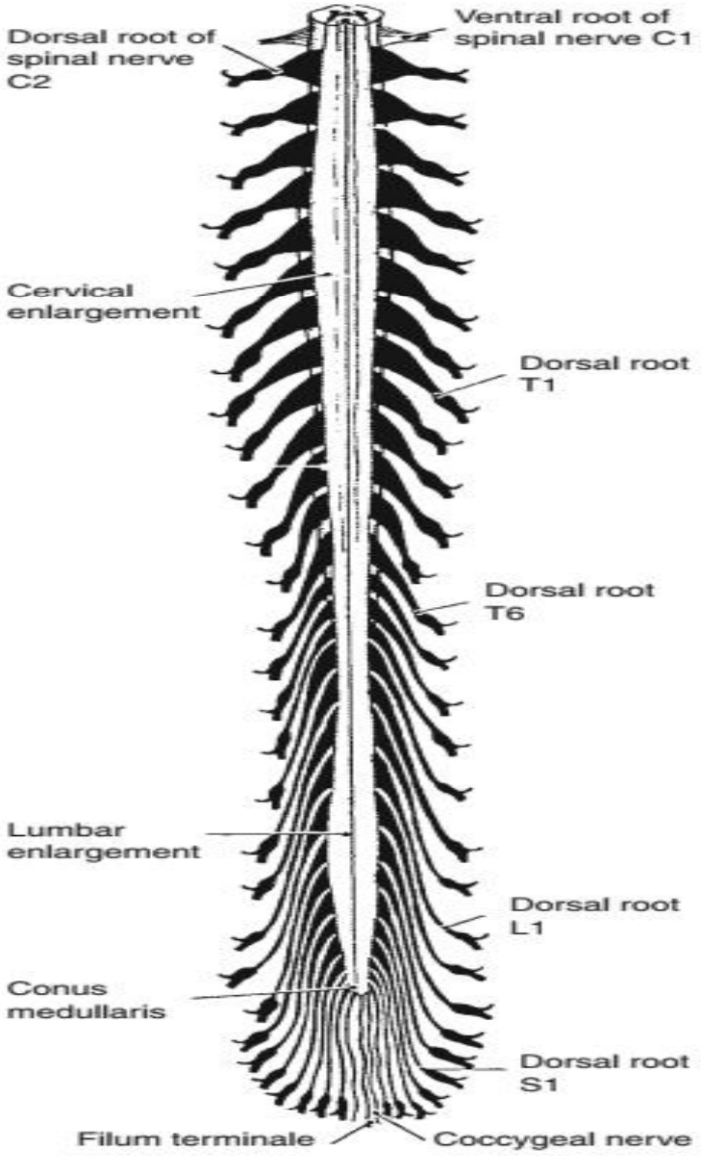


Fig. 13.2 Posterior view of the spinal cord showing the attached dorsal roots and spinal ganglia. (From Carpenter MB, Sutin J: *Human neuroanatomy*, ed 8, Baltimore, 1983, Williams & Wilkins.)

ETIOLOGY

Certain areas of the spinal column are more susceptible to injury than others.

- **In the cervical spine,** the spinal segments of *C1, C2, and C5 through C7* are often injured,
- **thoracolumbar area**, *T12 through L2* are most often affected.

The biomechanics of the vertebral column accentuates this situation:

- ✓ **Movement (rotation) is greatest at these segments** … inc. instability
- ✓ **spinal cord is larger in these areas** because of the large number of nerve cell bodies, which are located here. Fig. 13.2

NAMING THE LEVEL OF INJURY

The health care professional first identifies the vertebral or bony spine segment involved

- For example, **cervical injuries** are designated with **C, thoracic injuries** with **T,** and **lumbar injuries** with **L.**
- This designation is **followed by** the **last spinal nerve root segment in which innervation is present.**

NAMING THE LEVEL OF INJURY

FUNCTIONAL ETIOLOGY

Individuals with injuries to the **cervical region** of the spine are classified as having **tetraplegia**, (impairments to UL, LL, trunk, & pelvic organs).

Individuals with injuries to **thoracic spine** can produce **paraplegia**. UL function is spared, but there are varying degrees of LL, trunk, and pelvic

Injuries to the **spinal roots at L1 or below** are called **cauda equina injuries**

THE AMERICAN SPINAL INJURY ASSOCIATION (ASIA)

- developed **a classification system** to assist clinicians with a standard mechanism to document a patient's **sensory** + **motor** function after an SCI.
- **The International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI)**

✓ allows health care providers to determine the **level** + **severity** of a patient's injury objectively,

✓ assists in the determination of the patient's **prognosis**, and

✓ promotes improved consistency in the **communication** among the health care team.

THE AMERICAN SPINAL INJURY ASSOCIATION (ASIA)

neurologic level

most caudal segment of the cord with intact sensation + antigravity (3 or more) muscle function strength, provided that *there is normal (intact) sensory + motor function rostrally respectively*"

- The neurologic level is determined by testing key dermatomes (sensory areas) and myotomes (muscles) in **a supine position.**

THE AMERICAN SPINAL INJURY ASSOCIATION (ASIA)

A patient's sensory level

It is determined by assessing both **light touch** & **pinprick sensation** ***bilaterally*** *in the extremities and trunk*

By (3-point ordinal scale), where 0 is absent, 1 is impaired, and 2 is normal.

A patient's motor level

the lowest key muscle with a **manual muscle testing grade of fair (3/5), provided that the key muscles above this level have intact (normal, 5/5) strength.**

THE AMERICAN SPINAL INJURY ASSOCIATION (ASIA)

A patient's motor level

- ✓ **ASIA has chosen these muscles because they are consistently innervated by the designated segments of the spinal cord and are easily tested in a clinical setting.**

For example, the **elbow extensors (C7)** are a key muscle group.

Patients with C7 innervation have the potential to transfer independently without a sliding board because of their ability to extend the elbow and perform a lateral push-up.

- ✓ **The ASIA standards also recognize that muscles are innervated by more than one spinal cord segment.**

Muscle innervation by one spinal nerve in the absence of additional innervation will result in muscle weakness.

- ✓ **In areas where no specific myotomes exist to test, the motor level is presumed to correspond to the sensory level if the muscles above that level are judged to have normal strength**

Key muscle

TABLE 13.1 ASIA Identification of Key Muscles That Can Provide Greatest Functional Improvements

Level	Key Muscles
C5	Elbow flexors
C6	Wrist extensors
C7	Elbow extensors
C8	Finger flexors
T1	Finger abductors
L2	Hip flexors
L3	Knee extensors
L4	Ankle dorsiflexors
L5	Big toe extensors
S1	Ankle plantar flexors

Data from American Spinal Cord Injury Association: *International standards for neurological classification of spinal cord injury, revised*, Richmond, VA, 2019, American Spinal Injury Association.

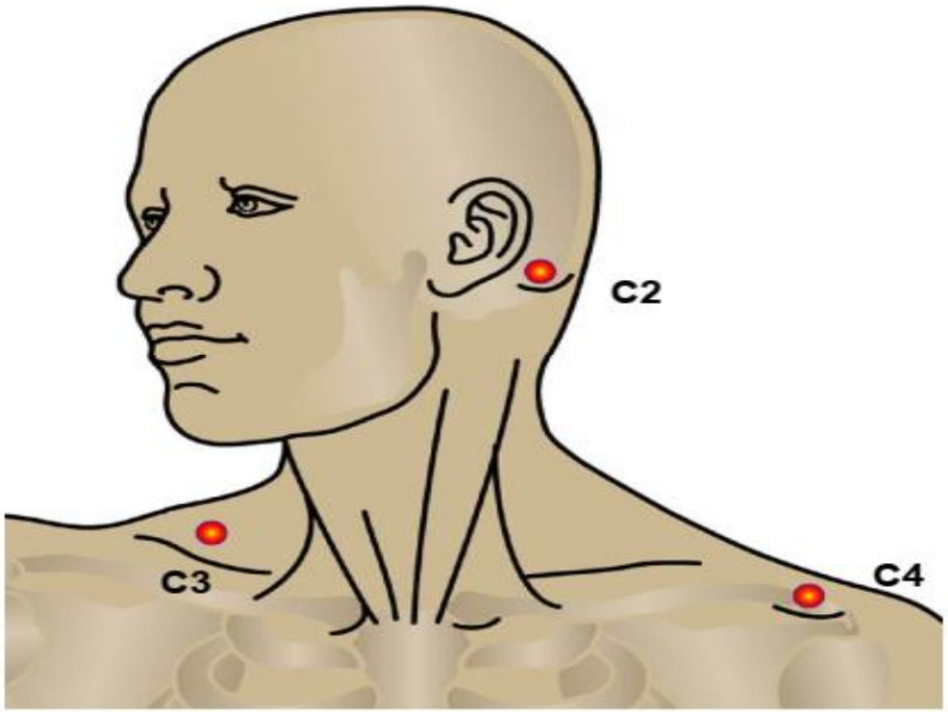
Key Sensory Points

Key Sensory Points

C2 At least one cm lateral to the occipital protuberance at the base of the skull. Alternately, it can be located at least 3 cm behind the ear.

C3 In the supraclavicular fossa, at the midclavicular line.

C4 Over the acromioclavicular joint.

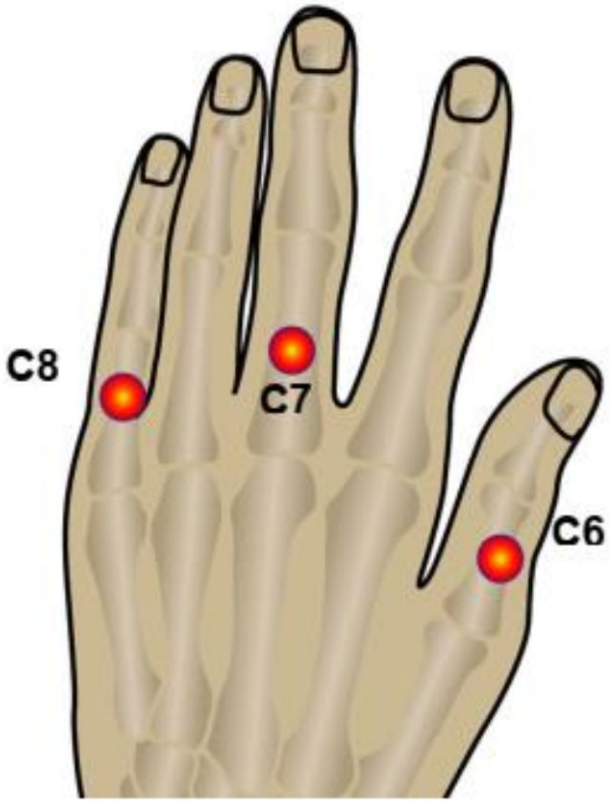


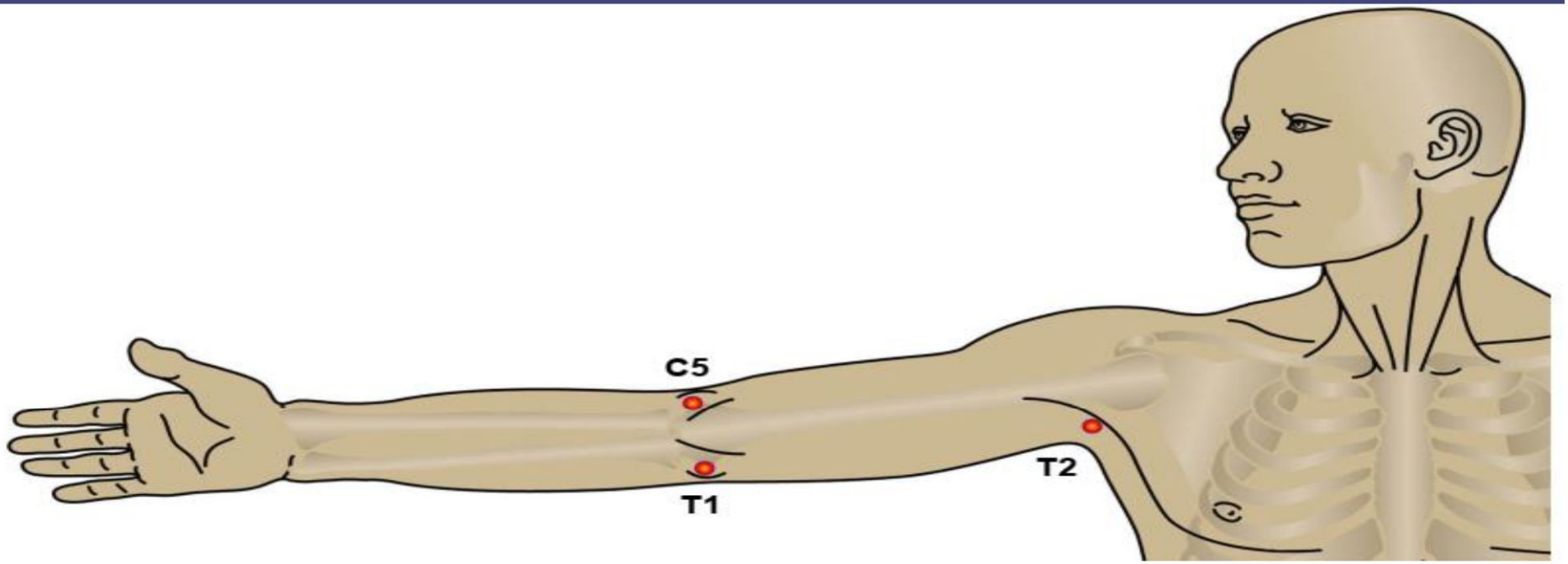
C5 On the lateral (radial) side of the antecubital fossa just proximal to the elbow (see image below).

C6 On the dorsal surface of the proximal phalanx of the thumb.

C7 On the dorsal surface of the proximal phalanx of the middle finger.

C8 On the dorsal surface of the proximal phalanx of the little finger.





T1 On the medial (ulnar) side of the antecubital fossa, just proximal to the medial epicondyle of the humerus.

T2 At the apex of the axilla.

T3 At the midclavicular line and the third intercostal space, found by palpating the anterior chest to locate the third rib and the corresponding third intercostal space below it.

T4 At the midclavicular line and the fourth intercostal space, located at the level of the nipples.

T5 At the midclavicular line and the fifth intercostal space, located midway between the level of the nipples and the level of the xiphisternum.

T6 At the midclavicular line, located at the level of the xiphisternum.

T7 At the midclavicular line, one quarter the distance between the level of the xiphisternum and the level of the umbilicus.

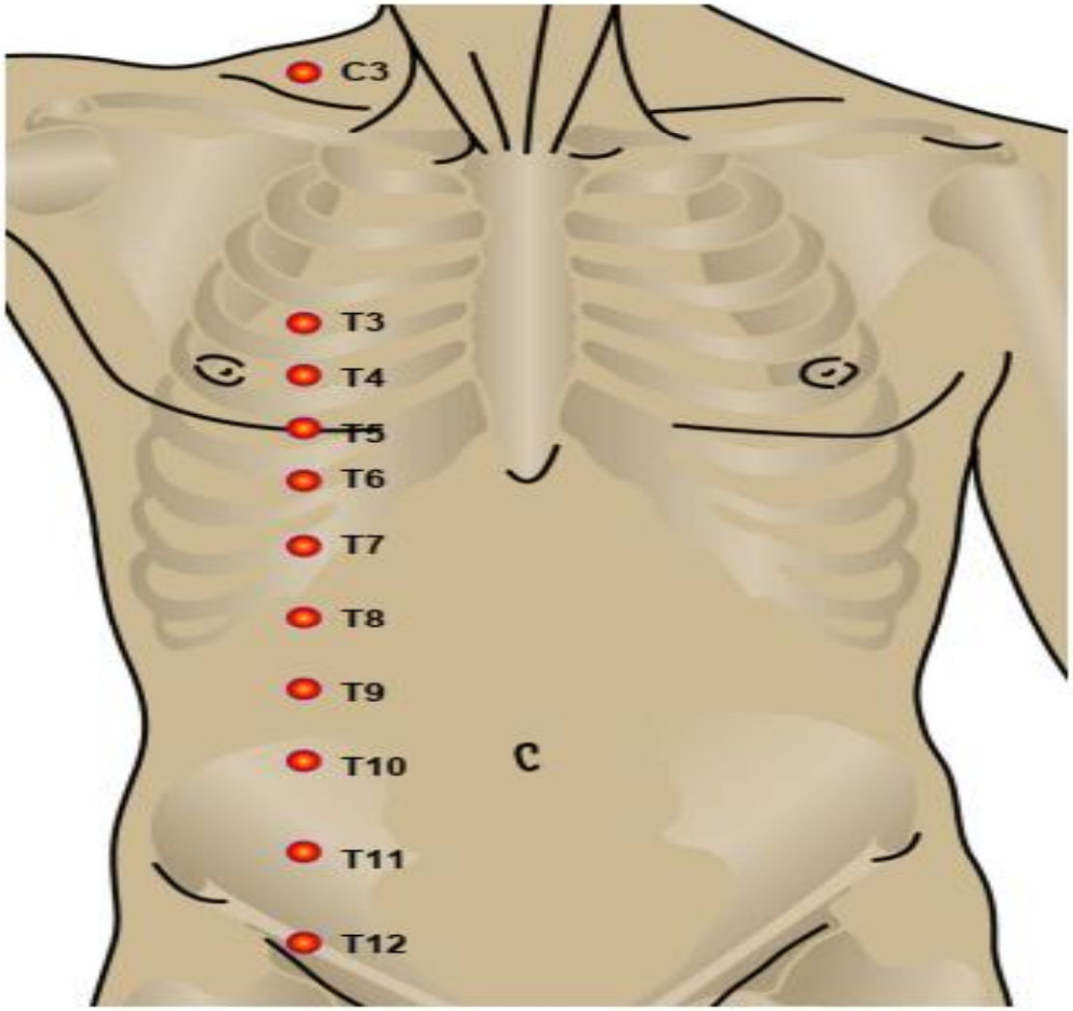
T8 At the midclavicular line, one half the distance between the level of the xiphisternum and the level of the umbilicus.

T9 At the midclavicular line, three quarters of the distance between the level of the xiphisternum and the level of the umbilicus.

T10 At the midclavicular line, located at the level of the umbilicus.

T11 At the midclavicular line, midway between the level of the umbilicus and the inguinal ligament.

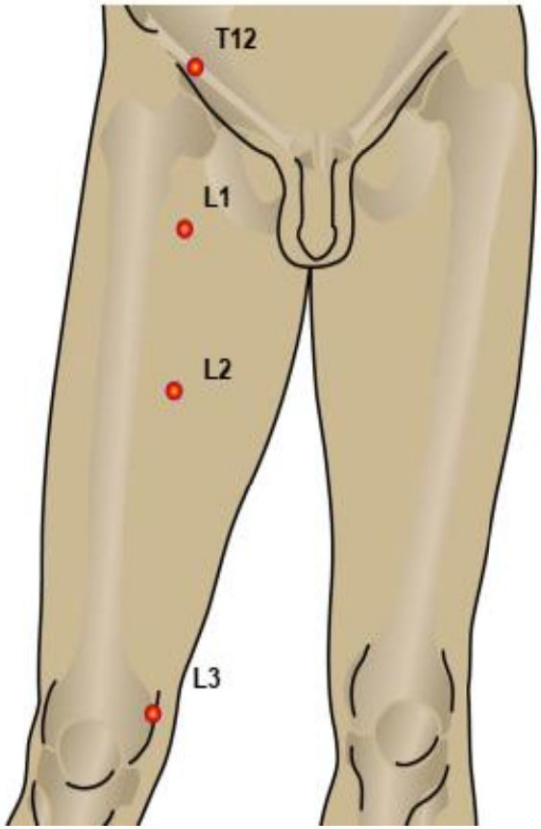
T12 At the midclavicular line, over the midpoint of the inguinal ligament.



L1 Midway between the key sensory points for T12 and L2.

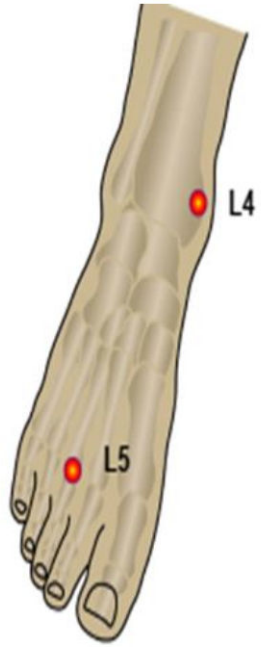
L2 On the anterior-medial thigh, at the midpoint drawn on an imaginary line connecting the midpoint of the inguinal ligament and the medial femoral condyle.

L3 At the medial femoral condyle above the knee.



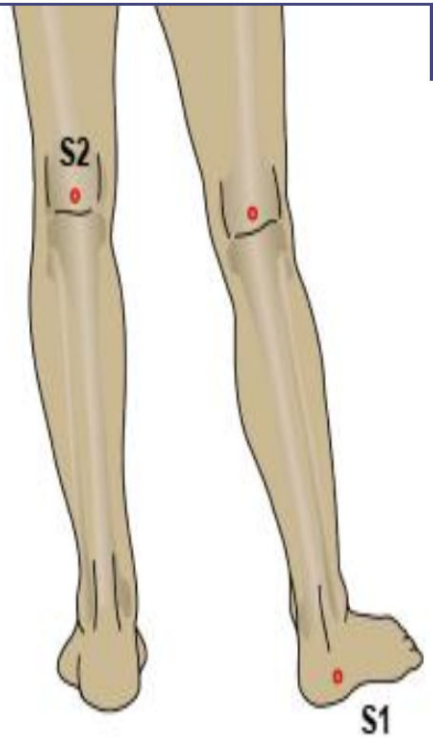
L4 Over the medial malleolus.

L5 On the dorsum of the foot at the third metatarsal phalangeal joint.



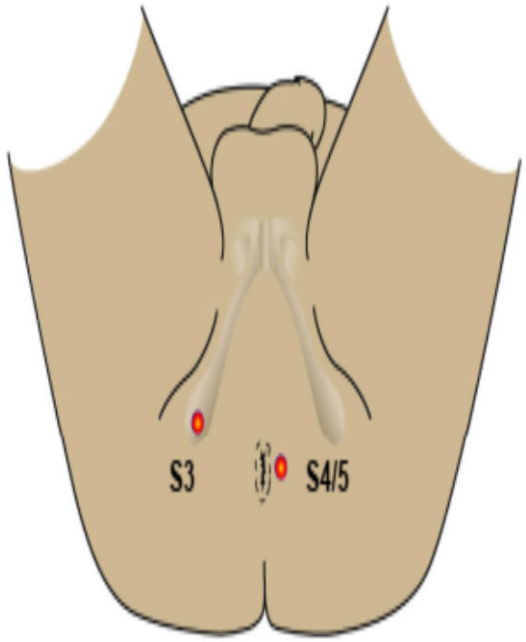
S1 On the lateral aspect of the calcaneus.

S2 At the midpoint of the popliteal fossa.

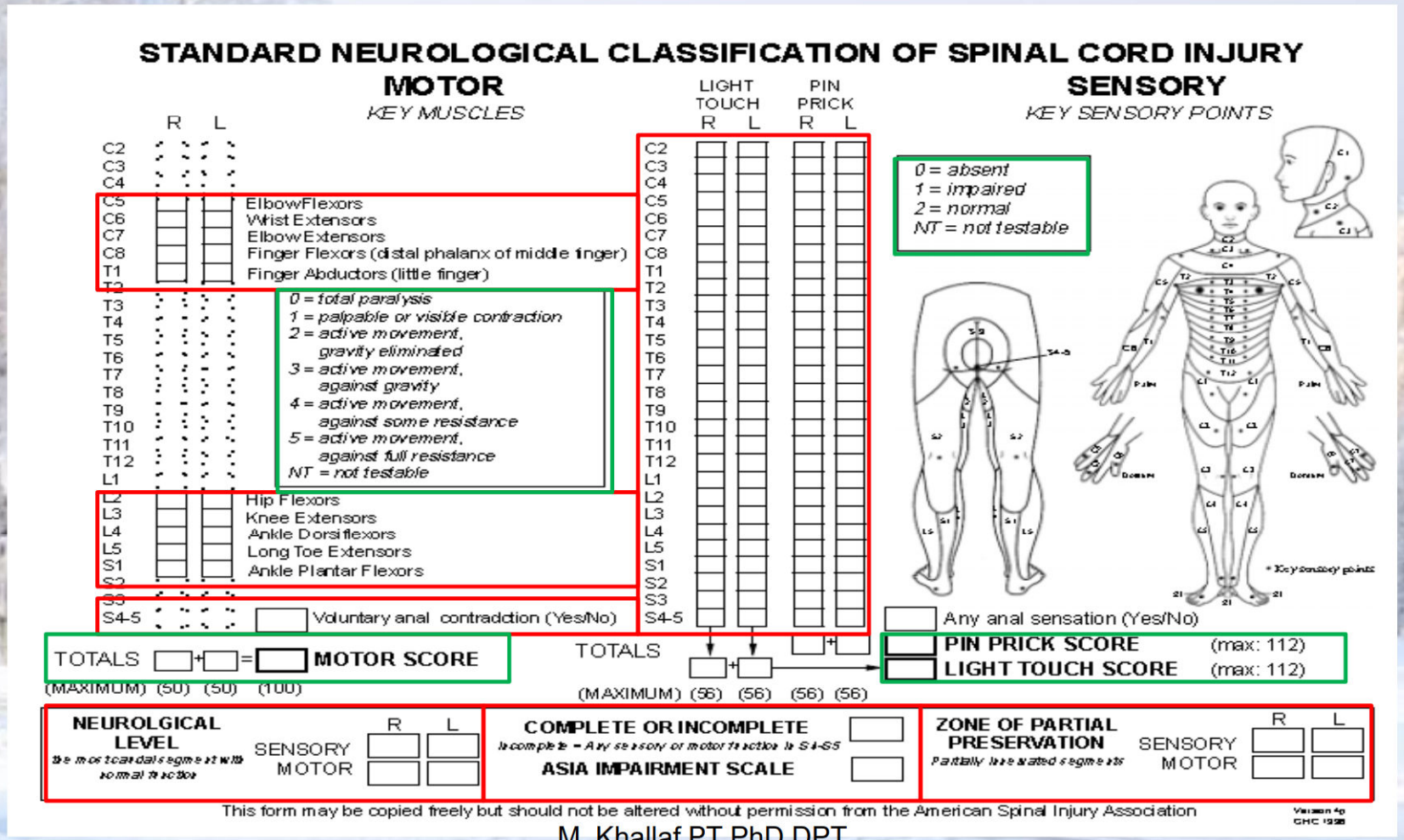


fold (depending on the patient their skin can move up, down or laterally over the ischii).

S4/5 In the perianal area, less than one cm. lateral to the mucocutaneous junction.



Physical therapy Intervention for SCI: Assessment



M. Khallaf PT PhD DPT

TYPES OF LESIONS

Complete Injuries

- ✓ **NO sensory & motor function** *below the level of the injury + S4 & S5.*
- ✓ complete spinal cord transection.
- ✓ It is possible that an individual with a complete injury may have *partial innervation of motor or sensory function in up to three segments below the injury site*.

The most caudal segment with some sensory or motor function (or both) is defined as the **Zone of Partial Preservation**

TYPES OF LESIONS

Incomplete Injuries

- ✓ **partial preservation of some motor or sensory function** *below NL + S4 & S5 (sacral sparing) .*
- ✓ **Perianal sensation** or **voluntary contraction of the external anal sphincter**
- ✓ **Therapists should now record ZPPs for patients with complete as well as incomplete injuries.**
- ✓ **"Motor ZPPs** are now defined and should be documented in *all cases including patients with absent voluntary anal contractions.*
- ✓ **sensory ZPP** on a given side is defined *in the absence of sensory function in S4-5 on this side as long as deep anal pressure is not present*"

TYPES OF LESIONS

Incomplete Injuries

- The clinical picture of incomplete injuries is highly variable and unpredictable.
- Several clinical findings help to confirm a diagnosis of an incomplete injury. **Sacral sparing** is one such finding. Because the *sacral tracts run most medially within the spinal cord, they are often salvaged.*

✓ Patients with sacral sparing may have **perianal sensation** and/or the ability to have **voluntary control over the rectal sphincter muscle**. These spared motor and sensory functions can be of great functional benefit to the patient because they ***may provide for normal bowel, bladder, and sexual activities.***

✓ Another clinical finding observed in patients with incomplete injuries is abnormal tone or **muscle spasticity**. Resistance to passive stretching, **clonus**, **increased deep tendon reflexes**, and **muscle spasms** may be present. Decreased inhibition from descending supraspinal pathways,

TYPES OF LESIONS

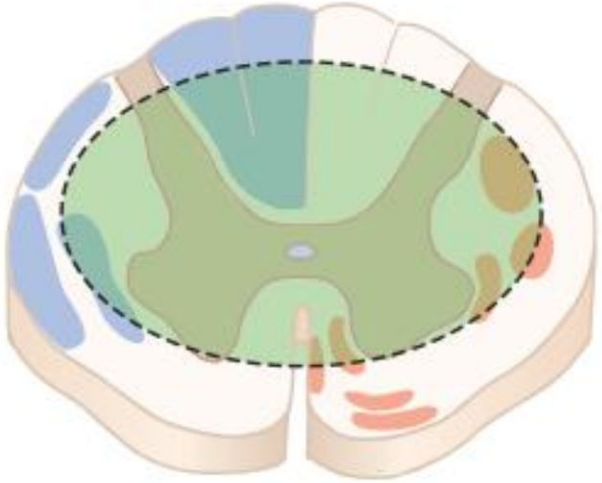
SCI are classified into two primary types according ASIA: complete and incomplete.

TABLE 13.2 ASIA Impairment Scale

Grade	Impairment
A = Complete	No motor or sensory function is preserved in the sacral segments S4–S5.
B = Sensory Incomplete	Sensory, but not motor, function is preserved below the neurologic level and includes the sacral segments S4–S5, and no motor is preserved more than three levels below the motor level on either side of the body.
C = Motor Incomplete	Motor function is preserved below the neurologic level for voluntary anal contraction or the patient meets criteria for sensory incomplete. Some sparring of motor function more than 3 levels below the ipsilateral motor level on the right or left. For AIS C, less than half of key muscles have a grade greater than 3/5.
D = Motor Incomplete	Motor function is preserved below the neurologic level, and at least half of key muscle functions below the neurologic level have a muscle grade of 3 or greater.
E = Normal	Motor and sensory functions are normal in all segments, and the patient had prior deficits.

From American Spinal Cord Injury Association: *International standards for neurological classification of spinal cord injury, revised*, Richmond, VA, 2019, American Spinal Injury Association.

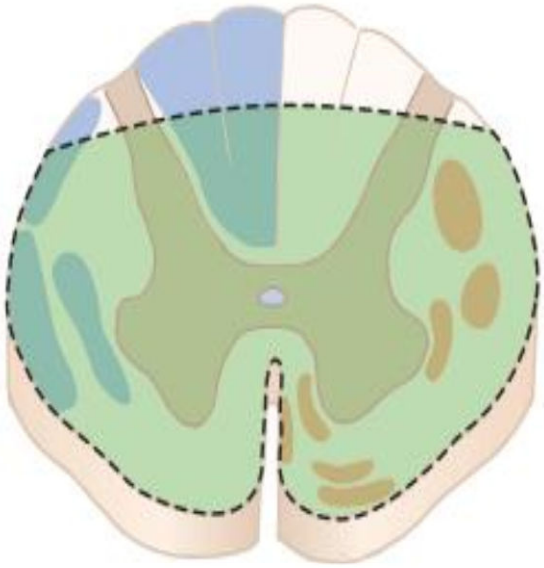
CENTRAL CORD SYNDROME



Central cord syndrome

- most common SCI syndrome.
- hyperextension injuries to the cervical region OR Progressive stenosis.
- Damage of all three tracts of the (UI) (cervical tracts are more centrally located) than of the LL.

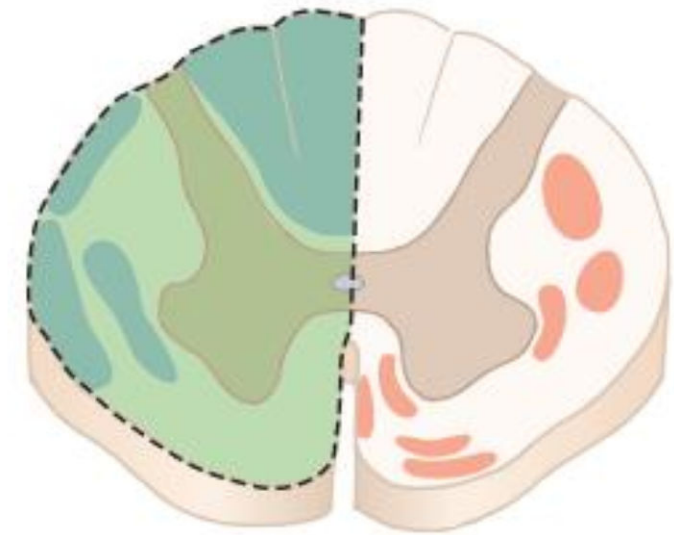
ANTERIOR CORD SYNDROME



Anterior cord syndrome

- flexion injuries of the cervical region + # dislocation
- damage to the anterior portion of the cord and/or its vascular supply from the anterior spinal artery.
- (corticospinal tract damage) and (spinothalamic tract damage) below the level of the lesion.
- Position and vibration sense intact

BROWN-SEQUARD SYNDROME



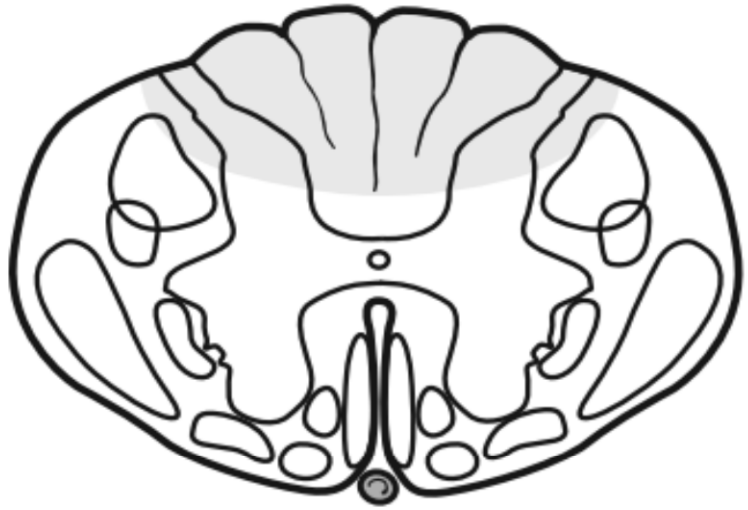
Brown-Sequard syndrome

- hemisection of the SC (damage to one side)
- Ipsilateraparalysis and sensory loss.(at level)
- ipsilateral loss of proprioception, light touch, and vibratory sense is due to damage to the dorsal column;
- Loss pain and temperature on the side *contralateral* to the lesion.

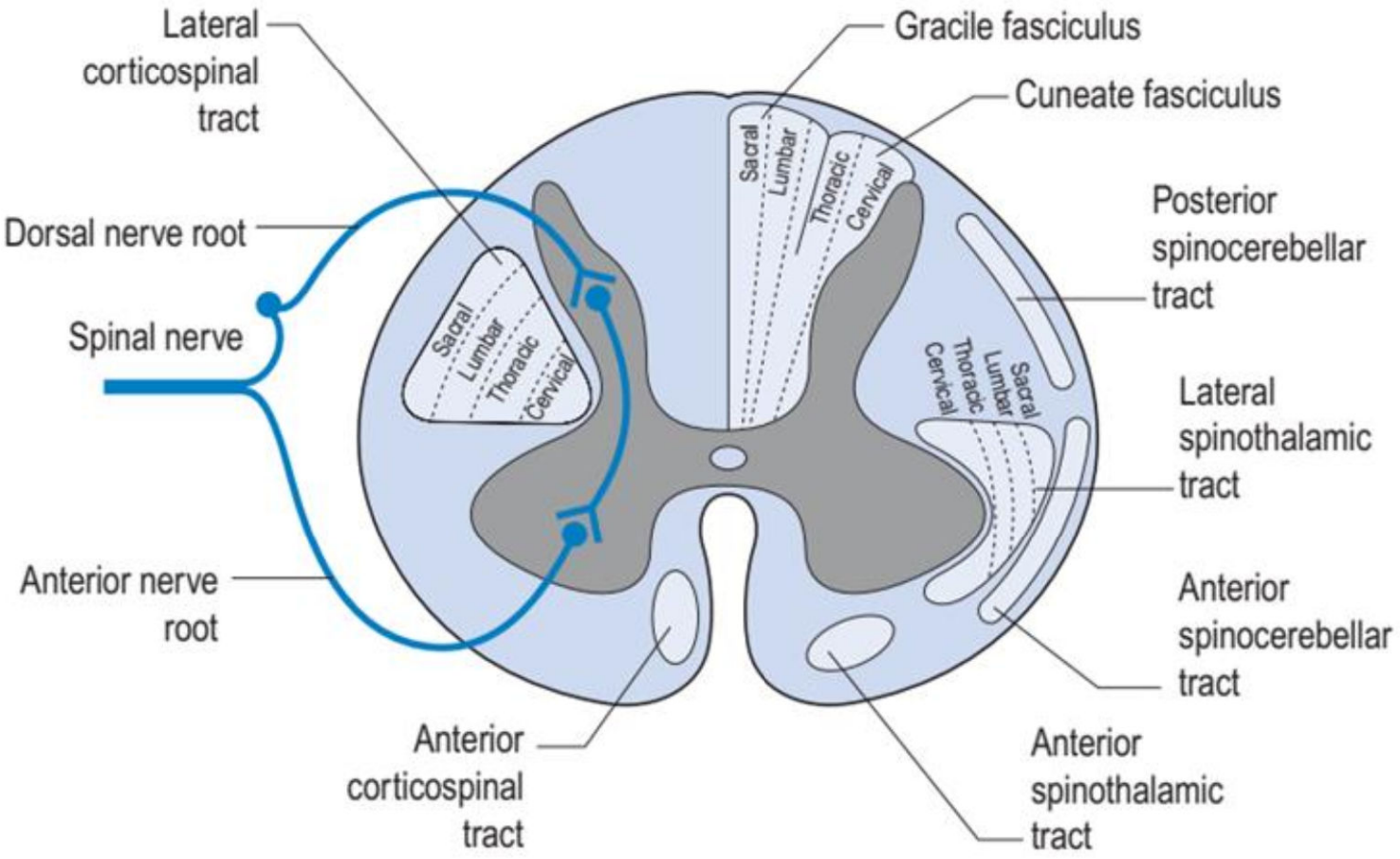
(below level)

DORSAL COLUMN OR POSTERIOR CORD SYNDROME

- Compression of the posterior spinal artery by tumor or vascular infarction.
- Loss of proprioception and vibration bilaterally



D Dorsal column syndrome


Lateral corticospinal tract
Dorsal nerve root
Spinal nerve
Anterior nerve root
Anterior corticospinal tract
Gracile fasciculus
Cuneate fasciculus
Posterior spinocerebellar tract
Lateral spinothalamic tract
Anterior spinocerebellar tract
Anterior spinothalamic tract
Sacral
Lumbar
Thoracic
Cervical

CAUDA EQUINA INJURIES

- Direct trauma from a fracturedislocation below L1
- Complete transections in this area are **rare**.
- areflexic bowel and bladder + saddle anesthesia.
- Cauda equina lesions are peripheral nerve (LMN) injuries.
- full return of innervation is not common

- *Conus medullaris syndrome* :back pain, flaccid paralysis, and areflexic bowel and bladder function. Sacral sensation is also decreased..

ROOT ESCAPE

- Damage to the nerve root within the vertebral foramen can lead to PN Ingury.

- **Root escape** is preservation or return of motor or sensory function in various nerve roots at or near the site of injury.

- Therefore, a patient may experience some improved function or a *return of function in the muscles innervated by the peripheral nerve several months after the initial injury*.

MECHANISMS OF INJURY

Traumatic impact is a common cause of SCI.

- traumatic injuries are often **caused by** compression, **penetrating injury**, and hyperextension or hyperflexion **forces**.

- **Associated injuries** to the vertebral bodies may also lead to spinal cord damage. Vertebral subluxation (separation of the vertebral bodies), compression fractures, and fracture-dislocations can further damage the spinal cord by encroachment or additional compression of the spinal cord.

Cervical Flexion and Rotation Injuries

- the most common type of injury.
- **PLL rupture, + uppermost vertebra is displaced over the one below it + Rupture of the IVD**
- in severe cases, the **ALL** can also occur.
- Transection of the spinal cord is often associated with this type of injury.
- **Rear-end motor vehicle accidents** frequently produce flexion and rotation injuries. **Fig. 13.4, A**

MECHANISMS OF INJURY

Cervical Hyperflexion Injuries

- A pure hyperflexion force → an anterior compression fracture of the vertebral body + stretching of PLL (remain intact).

A head-on collision or a blow to the back of the head

wedge-type fracture of the vertebral bodies.

severs the anterior spinal artery and results in an **incomplete anterior cord syndrome**.

MECHANISMS OF INJURY

Cervical Hyperextension Injuries

- Hyperextension injuries are common in the older adult as a result of a fall.

The individual's chin often strikes a stationary object, and this leads to neck hyperextension.

→ ruptures the ALL + compresses & ruptures the IVD

central cord type of injury

spinal cord can become compressed between the ligamentum flavum and the vertebral body

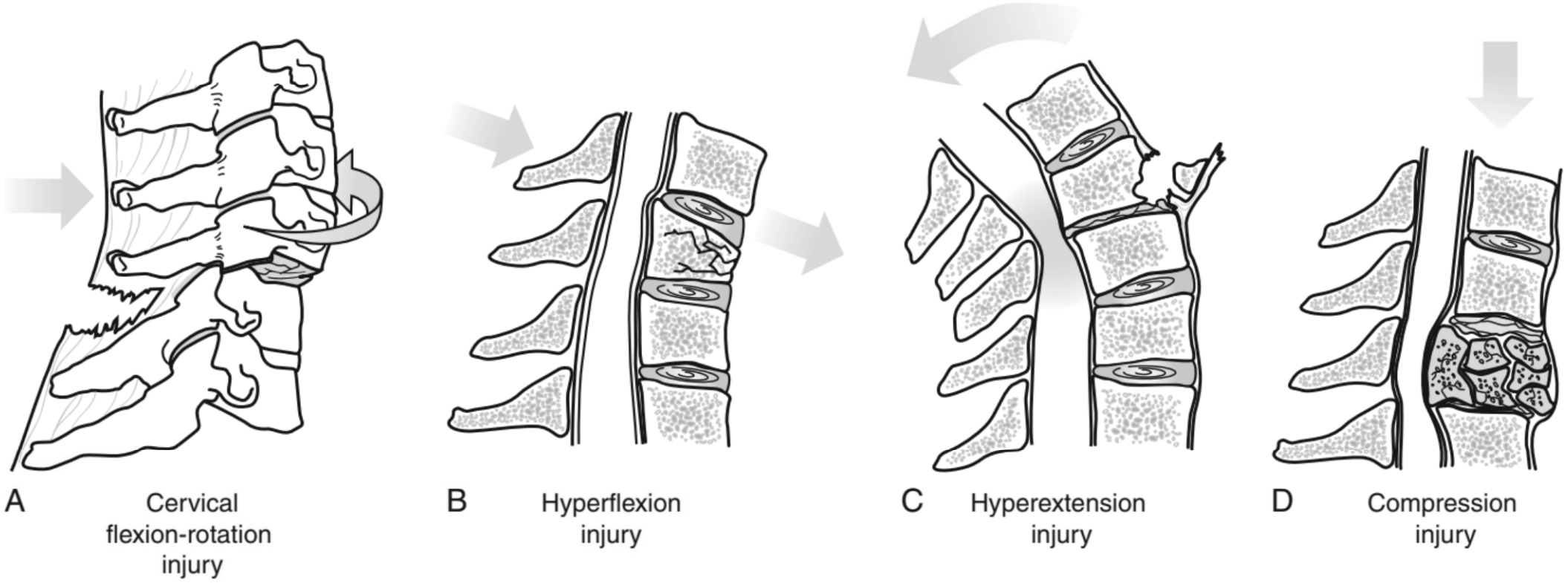


Fig. 13.4 **A–D,** Types of spinal cord injuries.

MECHANISMS OF INJURY

Compression Injuries

Diving accidents
+
Falls from elevated surfaces

Vertical compressive forces

- ✓ # of the vertebral end plates
- ✓ movement of nucleus pulposus into vertebral body.
- ✓ The longitudinal ligaments are stretched but remain intact

- Compression injuries caused by the effects of osteoporosis, osteoarthritis, or rheumatoid arthritis can also *produce an SCI in the older adult.*

MEDICAL INTERVENTION

acute SCI,

- ❑ patient should be **immobilized and transferred to a trauma center.**
- ❑ **Proper management** during the acute care phase of the injury can *make a significant difference in the patient's long-term functional outcome.*
- ❑ Monitoring the **patient's respiratory** + **neurologic function** is critical during this period.
- ❑ New pharmacologic interventions are under investigation ***to limit cell death at the site of injury and promote tissue sparing.***
- ✓ Current guidelines discourage the administration of **steroids** after injury because there is *limited evidence of benefit in the clinical setting*

MEDICAL INTERVENTION

Once the patient is medically stable, a primary concern on the physician is **stabilization of the spine** to prevent further spinal cord or nerve root damage.

- **Surgery is indicated in the following situations:**

(1) to restore the alignment of bony vertebral structures;

(2) to decompress neural tissue;

(3) To stabilize the spine by fusion or instrumentation;

(4) to minimize deformities; and

(5) to allow the individual earlier opportunities for mobilization

MEDICAL INTERVENTION

Surgery

- **Several different stabilization procedures are available to the surgeon:**

✓ Skeletal traction

✓ fusion of the fracture fragments

✓ Bone grafting from the iliac crests, combined with placement of internal fixation devices, is often employed during this procedure.

In some situations, surgery is not indicated, and external fixation with **a halo jacket**, **a hard cervical collar**, or **a rigid body jacket** may be all that is needed to stabilize the involved spinal segments. Bony fusion is usually complete in 6 to 8 weeks. Fig. 13.5 shows various types of spinal orthoses.

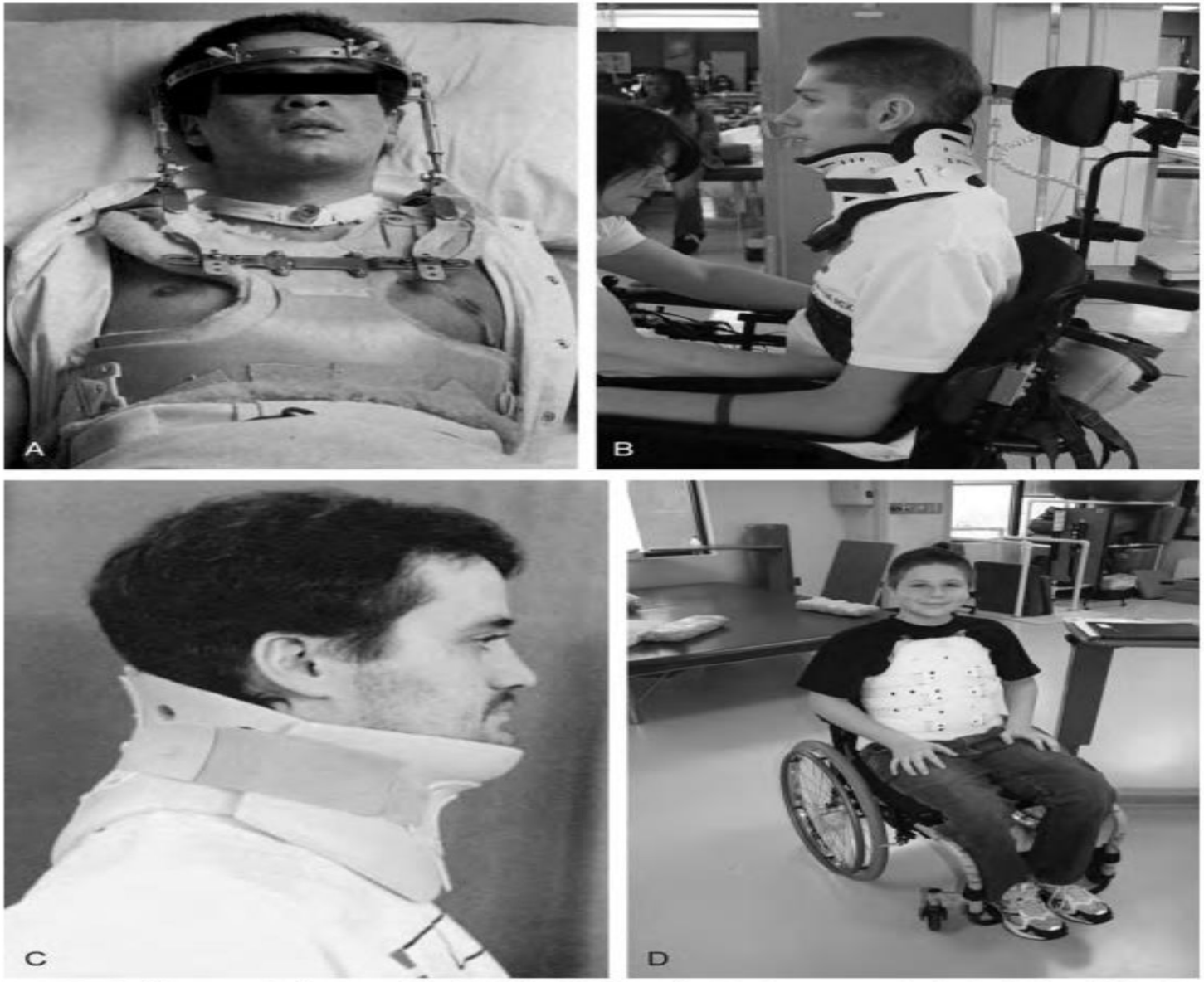


Fig. 13.5 **A,** Halo vest. **B,** Aspen collar. **C,** Philadelphia collar. **D,** Custom-made body jacket. (**B–D**, From Umphred DA, editor: *Umphred's neurological rehabilitation*, ed 6, St. Louis, 2013, Elsevier, pp 464, 466.)

PATHOLOGIC CHANGES THAT OCCUR FOLLOWING INJURY

firstly, the primary injury phase,

- ✓ occurs immediately after the injury
- ✓ includes the structural damage that is sustained with the injury.

The secondary injury phase

- ✓ Following spinal cord injury, ischemia, hypoxia, edema, and biochemical changes will cause **cell death (necrosis)** and **excitotoxic damage**

PATHOLOGIC CHANGES THAT OCCUR FOLLOWING INJURY

Electrolyte changes,

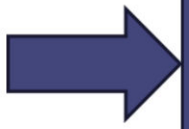
- ✓ inc. Intracellular ca++
- ✓ inc extracelluar k+
- ✓ inc Na+ permeability

→ Calcium entrance into the neuronal cell activates various cellular processes that can lead to cell death.

- ✓ Accumulation of excitatory neurotransmitters,
- ✓ prostaglandin, and
- ✓ free radical production
- ✓ lipid oxidation can

→ cause additional ischemia, edema, "membrane destruction, cell death, and eventually **permanent neurologic deficits**"

✓Ischemia
✓microhemorrhage
into the **gray matter** of the spinal cord occur after the injury.



✓Neuronal cell death
✓Macrophages
proliferate and digest the necrotic tissue forming fat.

- ✓ necrosis of the **axons** that were damaged by the actual injury
- ✓The **myelin sheathes** begin to disintegrate secondary to direct injury to the oligodendroglial cells.

- ✓ immune system appears to **release nerve growth factor**, which can be *protective to some cells* but *toxic to others* within the spinal cord.
- ✓ **a scar forms around the injury site**. This scar serves as barrier to axonal regeneration
- ✓ The injury may ascend one or two levels because of vascular changes.

CLINICAL MANIFESTATIONS OF SPINAL CORD INJURIES

- depends on the level of the injury and the muscle and sensory functions that remain.
- In addition, one must consider whether the injury is complete or incomplete.
- **In general, the following signs or symptoms may be present in an individual who has sustained an SCI:**

(1) **Motor paralysis** or paresis below the level of the injury or lesion;

(2) **sensory loss** *(sensory function may remain intact two spinal cord segments below the level of the injury);*

(3) **cardiopulmonary dysfunction;** (4) **impaired temperature control;**

(5) **spasticity;** (6) **bladder and bowel dysfunction;** and

(7) **sexual dysfunction.**

COMPLICATIONS OF PATIENTS WITH SCI

SPINAL SHOCK

- **total areflexia lasts approximately 24 hours.**
- **followed by a gradual return of reflexes 1 to 3 days.**
- **period of increasing hyperreflexia lasting 1 to 4 weeks.**

- **Impairment of autonomic regulation, resulting in *hypotension* and *loss of control of sweating* and *piloerection***

SPINAL SHOCK

The earliest reflexes that return are the sacral level reflexes.

As a result, reflexive bowel & bladder function may return.

- ✓ **Flexor withdrawal responses** may also become apparent.
- ✓ As time goes on, **upper or lower extremity spasticity** can develop in muscle groups that lack innervation.
- ✓ **Additional muscle tightness** and shortening become evident as a result of static positioning and muscle imbalances.

For example, tightness in the hip flexors can develop as the patient spends increased amounts of time sitting upright in a wheelchair.

SPASTIC HYPERTONIA

- **common in people with cervical-level injuries.**
- gradual increase in spastic hypertonia during 1ST 6 months, an
- **a plateau is usually reached 1 year after injury.**

- **Pt with minimal to moderate involvement may learn to trigger the spasticity at appropriate times to assist in functional activities.**

PROS/CONS OF SPASTICITY

- **PROS**
  - May assist with transfers or bed mobility
  - Maintain muscle tone and mass
  - Reduce bone loss
  - Promote blood circulation and improve breathing
  - May act as a warning sign
    - Next slide

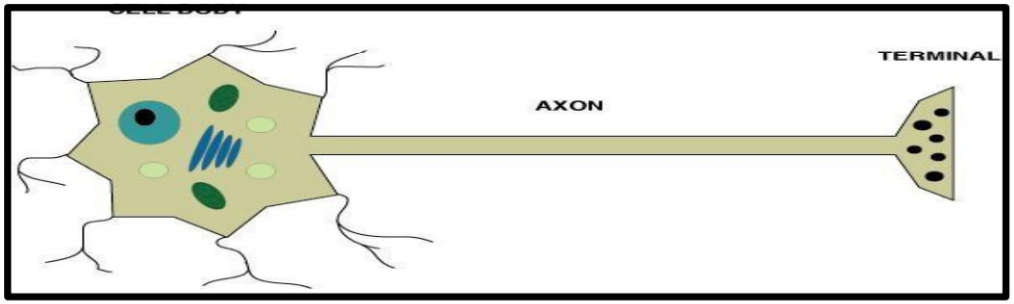
- **CONS**
  - Decrease functional activities
  - Pain
  - Positioning issues
  - Increase risk for pressure sores
  - Cause unwanted bladder or bowel release

EFFECTS OF SH

- Spastic Hypertonia can act as a warning sign
  - Pressure sores
  - UTI, Ingrown toenail, tight clothing
  - Autonomic Dysreflexia
  - Broken bone or cyst
  - Appendicitis or kidney stones
- Patient education must include increasing patients body awareness.
  - Can they identify when spasms get worse
  - Is there function being impacted

AGING

- **Increase in age may decrease spasticity**
  - **Nerve conduction slows**
  - **Nerve cells may degenerate**
  - **Decreased muscle mass and fibers**
  - **Blood circulation diminishes**

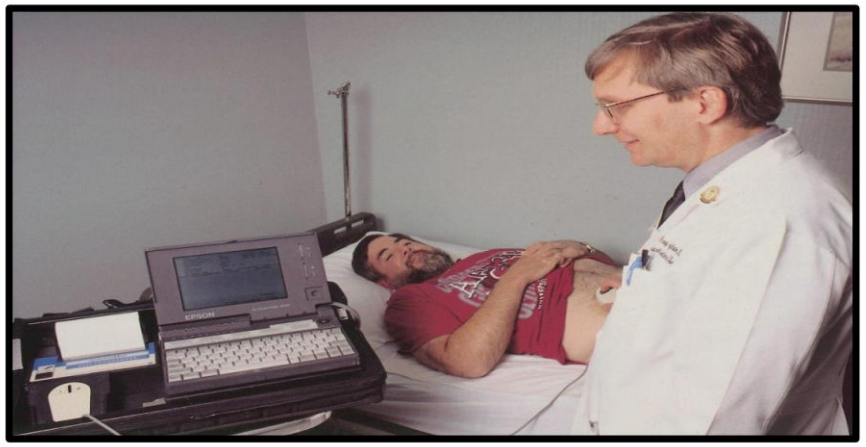


IMPACT ON QUALITY OF LIFE

- How does SH affect quality of life and function?
  - Losing sleep
  - Decreased independence
  - Safety
  - Increased risk of pressure ulcers
- Are the side effects of treatment worse than the treatment itself?

TREATMENT OPTIONS

- Rehabilitation
- Medications
- Motor point block
- Surgical
  - Intrathecal pump



TAKE HOME MESSAGE

- **Look at the big picture of the impact on quality of life**

- **Critical to know SH effects**
  - **Skin**
  - **Seating/positioning**
  - **Function**
  - **Transfers/Dressing/Mobility**

Thermoregulation

- Damage to the SC ⇨ hypothalamus can no longer control *cutaneous blood flow* or *level of sweating*.
- initially after injury, hypothermia may occur due to peripheral vasodilation.
- Later, hyperthermia is more likely due to the lack of sympathetic control of sweat glands.

Thermoregulation

- 100° temp in SCI could be from environment (don't assume infection)

- Important to use appropriate clothing (keep lower body warm even if no sensation)

Patient Education

- Extreme caution should be taken when ambient temperature is high to prevent heat stroke
- Can overheat very quickly
- Important to use appropriate clothing (keep lower body warm even if no sensation)

Take Home Message

- **Patient Education**
  - Educate on preventing overheating (spray bottle, loosen clothes, air conditioning)
  - Understand the environment
  - Consider clothing options
  - Outside temperature regulation
- **Staff Education**

Autonomic Dysreflexia

- Potentially life-threatening condition
- Occurs in lesions above T6
- **Caused by**:

noxious stimuli below level of injury ⇨ acute onset of autonomic activity ⇨ BP elevation.

- **Normally:**

impulses stimulate the receptors in the ***carotid sinus*** and ***aorta*** ⇨ signal the ***vasomotor center*** to readjust peripheral resistance.

Table 20.1 Initiating Stimuli and Signs and Symptoms of Autonomic Dysreflexia

Initiating Stimuli	Signs and Symptoms
Bladder distention/irritation*	Hypertension (rise in systolic BP 20–30 mm Hg)
Bowel distention/irritation*	Bradycardia
Stimuli that would normally be painful below level of lesion	Severe headache
Gastrointestinal irritation	Feeling of anxiety
Sexual activity	Constricted pupils
Labor	Blurred vision
Skeletal fracture below level of injury	Flushing and piloerection above level of lesion
Electrical stimulation below level of lesion	Dry, pale skin below level of lesion (due to vasoconstriction)
	Nasal congestion
	Increased spasticity
	May be asymptomatic

*Most common triggers of AD.

Management

- Sit patient up!
- Check for kinked catheter
- Last bowel movment
- Loosen clothing
- Check for impaction
- Lidocaine for sores
- Assess for acute abdomen

During Exercise

- Monitor thermal dysregulation at rest and during exercise
  - Hydrate, loose clothes, monitor for overheating
- Patients with tetraplegia have *blunted heart rate* response usually *yielding mid-120 beat per minute*
- Perform active cool down after exercise to support *venous return*

Take Home Message

- **Patient/family education**
  - Many residents in emergency rooms (even facilities) do not know about autonomic dysreflexia. The patient must be able to articulate the problem and what needs to be done.
- **Empty leg bags before exercise or mat activities**
- **Observation during treatments**

Cardiovascular Impairment

- cardiovascular function is regulated by the brain stem and hypothalamus via the sympa/para NS.
- Parasympathetic(vagus n.) signals to the heart ⇨ decreasing heart rate and contractility.
- Sympathetic outflow (spinal segments T1 to L2) ⇨ Increasing heart rate and heart contractility and peripheral vasoconstriction.

- More specifically, sympathetic outflow to ***heart*** and BV of ***upper body comes*** from the cervical and upper thoracic region **(above T6),** while sympathetic outflow to BV of the ***lower body*** come from **below T6** (T6–L2).

- **higher SCI (above T6)** will result in loss of sympathetic control to the heart and BV below the level of the injury and intact parasymp. input to the heart.

Orthostatic Hypotension

- Vasodilation below level of injury with resultant venous pooling secondary to poor muscular tone
- BP drop of more than 10-15 mm Hg in erect position (remember Tetras have low BP normally 80/40)

Take Home Message

- **Management**
  - –Abdominal binder
  - –slow progression to the vertical position.
  - –Antiembolic stockings or wrap legs
  - –Use of compressive stockings
  - –If dizzy once up then recline and put legs up
  - –HYDRATION
- **Monitor Vitals!**
  - –Treat only if symptomatic

Bladder and Bowel Impairment

- people with SCI report having a UTI 1 year after injury.
- lesions that occur *above the conus medullaris* develop a ***spastic or hyperreflexic bladder (***contracts and reflexively empties in response to a certain level of filling pressure)
- lesion of the sacral segments or conus medullaris, a *flaccid* or ***areflexic bladder*** (unable to relax).
- lack of Coordination between detrusor and sphincters ***(dyssynergia).***

Bladder Management

- ✓ minimize UT complications. These include UTIs, *hydronephrosis* (swelling of kidney due to backup of urine), renal calculi, bladder calculi,
- ✓ psychosocial implications for the patient,
- ✓ early stage of recovery, while the patient is still in spinal shock, the bladder is flaccid and an ***indwelling catheter*** is inserted.
- ✓ during rehabilitation, the most frequently used is ***intermittent catheterization***.
  - ➢ Initially, the patient is catheterized every 4 hours. A record is maintained of voided and residual urine.
  - ➢ suprapubic tapping **(UMN bladder)**
  - ➢ the Valsalva maneuve **(areflexive bladder)**

Bowel Dysfunction

- Over 98% of people with SCI report problems with bowel care
- *above S2,* there is a spastic or reflex bowel **(UMN lesion).**
- *In S2–S4 or cauda equina* lesions, a *flaccid* or *areflexive bowel* **(LMN lesion)**

  (externalsphincter is flaccid, incontinence can occur.)

Bowel Management

- ✓ typical bowel program involves establishing *a daily (or every other day) pattern* of eliciting a bowel movement.
- ✓ The ***exact time of day*** is chosen by the patient based on lifestyle needs a
- ✓ suppositories and digital stimulation tech(lubricated gloved finger or an orthotic digital stimulator**.(UMN L)**
- ✓ Valsalva maneuver and abdominal massage . **.(LMN L)**
- ✓ Other factors (diet with appropriate amount of fiber, fluid intake, physical activity, stool softeners, laxatives, and bulking agents.)

Heterotrophic Ossification (HO)

- Development of bone in abnormal areas, usually in soft tissues
- Incidence 16%-53% of SCI individuals
- Occurs ***below level of injury***
- Referred to as neurogenic HO because results from neurologic deficits

Common Sites

- Hips
  - Flexor and adductor areas
  - Most common site
  - Interferes with function
- Knees
  - Along medial-collateral ligament
- Ankles
- Shoulders
  - Generally mild and does not interfere with function
- Elbows, paravertebral areas and seen at base of pressure sores

Causes

- Unknown etiology
- Connective tissue cells change characteristics to bone forming cells
- Inflammatory reaction
- Usually begins within 4 months of injury
- If >year post injury – septic hip

Symptoms

- Swelling of the leg
- Decrease in function
- Redness, swelling and low grade fever
- Need to distinguish from deep vein thrombosis (DVT) (Venogram and bone scan)
- May have both DVT and HO

Treatment

- Reasonably aggressive ROM – slow sustained stretch
- Anti-inflammatory drugs (Didronel)
  - Definite effect on preventing HO
- Surgery (controversial)
  - Remove wedge of bone
  - Total hip replacement

Take Home Message

- The goal is to catch this as early as possible.
- Constantly assess and monitor during transfers, bed mobility, and dressing.
- Educate patient to notify you if any self range of motion activities increase in difficulty or they notice any swelling.

Pain

- Pain is common after spinal cord injury
- Key is finding cause of the pain
- Important to work as a team to address the pain
- Can experience several types of pain

Neuropathic Pain

- **Central pain** – pain at or below your level of injury. Damage or dysfunction in the nervous system.

Burning, shooting or sharp. Can use meds-neurotin

- **Nerve root entrapment** – brief waves of stabbing or sharp pain. Occurs below level of injury.

Musculoskeletal Pain

- **Muscle spasm** – muscles are strained. Dull or aching with improvement with rest and worsening with movement. Treat spasm.
- **Overuse syndromes** – can occur months or years later, caused by overuse (rotator cuff). Modify activities (w/c, pressure relief technique).
- **Mechanical instability of spine** – damaged ligaments occurring after injury (instability). Relieved by stabilization.

Visceral Pain

- Vague and dull or diffuse sensation, or feeling of discomfort or bloating
  - Can occur in the abdomen or stomach area
  - Pain can be referred to the shoulder area or can present as a migraine when lacking sensation

- Can treat with meds (opiates or neuropathic pain relievers, disimpaction or bowel program

Take Home Message

- Comprehensive documentation when a patient complains of pain will be the most beneficial to everyone.
- Be as specific as possible with the following:
  - Use the visual analog scale and note the time pain was measured
  - Location
  - Type of pain, anything that relieves the pain
  - Any additional symptoms

Pressure Sores

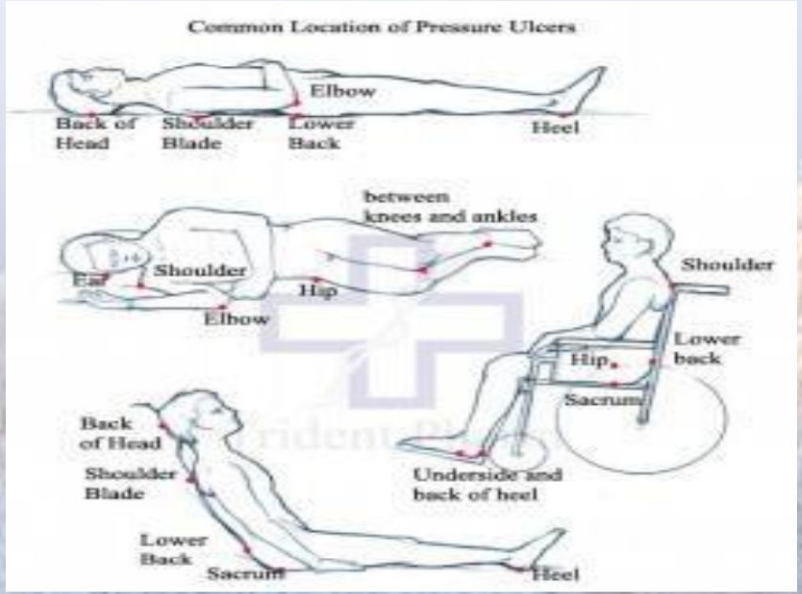
- Definition: an area of skin or underlying tissue that is dying as a result of loss of blood flow to the area
- Estimated up to 80% of SCI patients will have a pressure sore
- 30% will have more than one
- 95% of pressure sores are preventable

Causes

- Prolonged pressure (with lack of sensation)
- Bruises or scrapes
- Prolonged wetness on the skin
- Burns
- Sitting or lying on hard objects
- Frostbite
- Sheering with transfers

Location of Pressure Sores

- Most common areas
  - Sacrum
  - Heel
  - Ischium
  - Foot (bony areas like the ankle)
  - Trochanter



Risk Factors for SCI

- Limited mobility
- Bladder and bowel accidents
- Spasticity
- Lack of sensation

Risk Factors for SCI

- Aging
- Circulatory problems
- Skin disorders
- Diseases
  - Diabetes
  - Cancer
- Weight
  - Overweight
  - Underweight

Management

- Pressure spots on skin develop with as little as 30 minutes of pressure from a hard surface (padded commode)
- Skin checks, regular turns, positioning
- Pressure reliefs
- Nutrition
- Bed rest

Pressure Reliefs

- C_5 or higher – use power tilt/recline for regular pressure relief or forward with assist
- C_{5-6} – lean forward or side- to side
- C_7 or below – lean forward or side-to side or can perform press –up (not preferred)

Pressure Reliefs

- Mean duration of pressure relief required to raise tissue oxygen to unloaded levels for most individuals is 1 min 51 seconds

- Coggrave and Rose. A specialist seating assessment clinic: changing pressure relief practice. Spinal Cord. 2003;41:692-695.

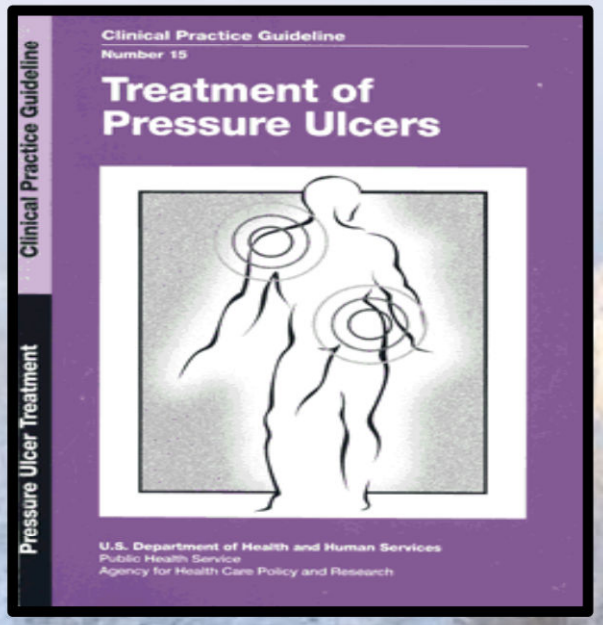
Demonstrations

- Forward pressure relief and checking underneath ischials to make sure they clear
- Side pressure relief

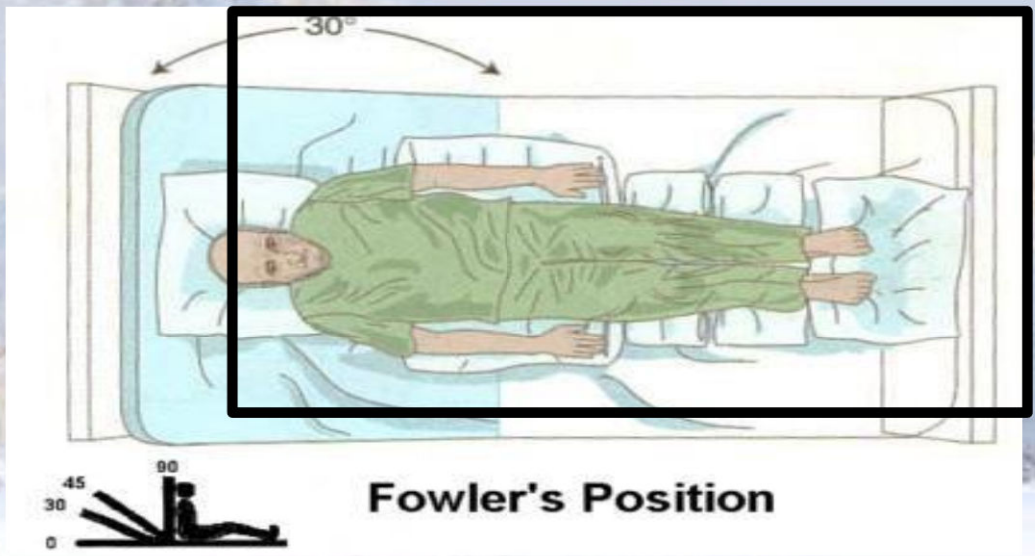

95% of all pressure sores
are
preventable

Treatment

- Prevention of infection
- Patient education
- Debride necrotic tissue
- Maintain a clean and moist wound environment



- DO NOT ever sit on a donut
- Use pressure mapping if available
- If sacral sore present do not position HOB>30°



If Skin Breakdown - Remember

- Never change a patients cushion to solve the problem before addressing cause and location of the wound
  - When did it start? Has anything changed? (type of car, commode chair, old padding on tub seat)
  - Look at the entire day (supine and sitting)

- This is especially true when you have a patient that has been fine for a period of time and "out of nowhere" gets a sore
  - Example of Michael with extra long solid back brackets added resulting in a sacral sore

Take Home Messages

- Performing pressure reliefs are critical – have them demonstrate!
- Always know status of patient skin
  - Understand general descriptors
- If patient has ha muscle flap surgery – stretch before getting up

Pulmonary Impairment

- **primary muscle of inspiration** are the *diaphragm*. , *scalenes* & intercostals also play important roles by stabilizing and elevating the ribs.
- **primary muscles of expiration** are the *abdominals* and *internal intercostals*.
- relaxed expiration is essentially a passive process that occurs through elastic recoil of the lungs and thorax.
- play an important role in maintaining intrathoracic pressure for effective respiration.
- push the diaphragm upward during forced expiration.

Table 20.2 Innervation of Muscles of Inspiration and Expiration

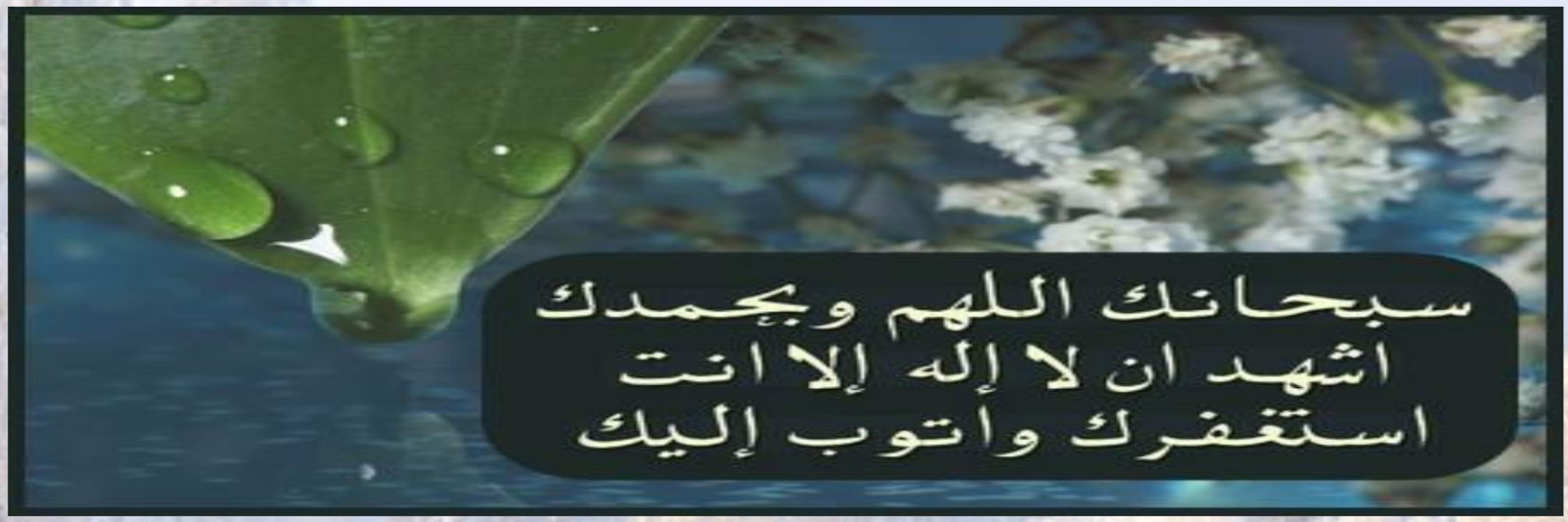
Level of Spinal Cord Injury	Inspiratory Muscles* (Innervation)	Forced Expiratory Muscles* (Innervation)
C1–2	Sternocleidomastoid and upper trapezius (accessory cranial nerve)	
C3–C4	Partial diaphragm (C3–C5), levator scapulae (C3–C5), scalenes (C3–C8)	
C5	Diaphragm (C3–C5)	Pectoralis major—clavicular (C5–6)
C6–8	Pectoralis major—sternal (C7–T1), pectoralis minor (C6–T1), serratus anterior (C5–C7)	
T1–T5	Intercostals (T1–T11), serratus posterior superior (T1–T3)	Intercostals (T1–T11)
T6–T10	Abdominals (T6–L1)	Abdominals (T6–L1), serratus posterior inferior (T9–T12)
T11 and below	All of the above	All of the above, quadratus lumborum (T12–L4)

*Lower-level SCI have intact innervation to muscles above level of SCI. There are slight differences among sources in regards to muscle innervation levels.

- **lesions at C1 and C2,** An artificial ventilator or **phrenic nerve stimulator** is required to sustain life.

- **C3- and C4-level injuries** have partial diaphragm innervation, as well as scalenes and levator scapulae function. require **mechanical ventilation**. With recovery and training, they will likely be able to **breathe on their own**.

- **C5–C8** have a fully innervated diaphragm, as well as many accessory muscles of inspiration. **not likely to require ventilator support** but, **forced expiration is severely impaired.**
- weak or absent **abdominal** and **intercostal** musculature have impaired *airway clearance ability* and be at a greater risk for developing *pneumonia* and *atelectasis*.



Thank you

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FUNCTIONAL OUTCOMES

A patient's functional outcome following an SCI depends on many factors:

- it depends on many factors:
  - ✓ age
  - ✓ the type and level of the injury,
  - ✓ the motor and sensory function preserved,
  - ✓ the patient's general health and preinjury activity level,
  - ✓ status before the injury,
  - ✓ body build, support systems, financial security, motivation, access to medical and rehabilitation services, and preexisting personality traits—all play a role in the patient's eventual outcome

Key Muscles by Segmental Innervation

- Before we can begin to talk about functional capabilities in an individual with SCI, we *must review key muscles and their actions*.

- The **innervation of key muscle groups** *allows patients to achieve a certain level of functional skill and independence*.

TABLE 13.4 Key Muscles by Segmental Innervation

Spinal Level	Muscles
C1–C2	Facial muscles, partial sternocleidomastoid, capital muscles
C3	Sternocleidomastoid, partial diaphragm, upper trapezius
C4	Diaphragm, partial deltoid, sternocleidomastoid, upper trapezius
C5	Deltoid, biceps, rhomboids, brachioradialis, teres minor, infraspinatus
C6	Extensor carpi radialis, pectoralis major (clavicular portion), teres major, supinator, serratus anterior, weak pronator
C7	Triceps, flexor carpi radialis, latissimus, pronator teres
C8	Flexor carpi ulnaris, extensor carpi ulnaris; patient may have some hand intrinsics
T1–T8	Hand intrinsics, top half of the intercostals, pectoralis major (sternal portion)
T7–T9	Upper abdominals
T9–T12	Lower abdominals
T12	Lower abdominals, weak quadratus lumborum
L2	Iliopsoas, weak sartorius, weak adductors, weak rectus femoris
L3	Sartorius, rectus femoris, adductors
L4	Gluteus medius, tensor fascia latae, hamstrings, tibialis anterior
L5	Weak gluteus maximus, long toe extensors, tibialis posterior
S1	Gluteus maximus, ankle plantar flexors (gastrocnemius, soleus)
S2	Anal sphincter

FUNCTIONAL OUTCOMES

- **Strength of a muscle must be at least fair-plus to perform a functional activity**

- It is important to keep in mind that these functional expectations should serve **only as a guide** and that **individual patient differences** must be considered when developing patient goals or the plan of care.

Physical therapy Intervention for SCI: Assessment

Functional Potential for Patients with SCI

Level	Muscles	Present Potential	Limitations
Above C4	C1–C2: Facial muscles C3: Sternocleidomastoid, upper trapezius	Vital capacity 20%–30% of normal Power recline wheelchair with breath control or chin control and portable ventilator Full-time attendant required Ability to direct care verbally Use of environmental control units with assist	Dependent on ventilator Dependent in all ADLs Dependent in pressure relief Dependent in transfers
C4	Diaphragm Upper trapezius	Vital capacity 30%–50% of normal Power wheelchair with mouth stick or chin control 30° of cervical motion needed to drive a wheelchair with a chin control Maximum assistance with bed mobility Independent pressure relief with Power reclining wheelchair Full-time attendant required Ability to direct care verbally Use of environmental control units	No upper extremity innervation Dependent in transfers Dependent in all ADLs
C5	Deltoid Biceps Rhomboids Lateral rotators (teres minor and infraspinatus)	Vital capacity 40%–60% of normal Power wheelchair with hand controls Manual wheelchair with rim projections Moderate assistance for bed mobility Maximum assistance with transfers (sliding board or sit pivot) Independent forward raise for pressure relief with loops attached to the back of the wheelchair Possible independence with some self-care activities with adaptive equipment (wrist splints) Attendant needed for activity setup Use of environmental control units	Has only elbow flexors, prone to elbow flexion contractures Must consider energy and time requirements for activity completion

Physical therapy Intervention for SCI: Assessment

Functional Potential for Patients with SCI

C6	Extensor carpi radialis Pectoralis major (clavicular portion) Teres major	Vital capacity 60%–80% of normal Independent rolling Independent pressure relief via weight shift Independent sliding board transfers Independent manual wheelchair propulsion with rim projections Independent feeding with adaptive equipment Independent upper extremity dressing; requires assistance for lower extremities Ability to drive automobile with hand controls Vocation outside the home possible Prehension with flexor hinge splint Possible A.M. and P.M. care needed Assistance needed for commode transfers	No elbow extension or hand function (patient prone to contractures)
C7	Triceps Latissimus dorsi Pronator teres	Vital capacity 80% of normal Independent living possible Independent pressure relief via lateral push-up Independent self–range of motion of lower extremities Independent transfers, wheelchair propulsion, pressure relief, and upper and lower extremity dressing	No finger muscles Transfers to floor require moderate or maximum assistance Needs assist to right wheelchair
C8	Flexor carpi ulnaris Extensor carpi ulnaris Hand intrinsics	Same potential as individual at C7 Independent living Negotiation of 2- to 4-inch curbs in wheelchair Wheelies in wheelchair	Some intrinsic hand function Writing, fine-motor coordination activities can be difficult Assistance with floor transfers
T1–T8	Hand intrinsics Top half of intercostals Pectoralis major (sternal portion)	Independent in manual wheelchair propulsion on all levels and surfaces (6-inch curbs) Therapeutic ambulation with orthoses in parallel bars (T6–T8)	No lower abdominal muscle function Minimal assistance to independent with floor transfers and righting wheelchair

Physical therapy Intervention for SCI: Assessment

Functional Potential for Patients with SCI

T9–T11	Abdominals	Independent wheelchair mobility Therapeutic ambulation with orthoses and assistive devices T10 vital capacity 100%	No hip flexor function
T12–L2	Quadratus lumborum	Household ambulation Independent in coming to stand and ambulation with orthoses	No quadriceps function
L3–below	L3: Iliopsoas and rectus	Community ambulation with orthoses	No gluteus maximus function
L4–L5	Quadriceps, medial hamstrings	Community ambulation; may only need ankle-foot orthoses and canes for ambulation	
S1–S2	S1: Plantar flexors, gluteus maximus S2: Anal sphincter	Ambulation with articulated ankle-foot orthoses	Loss of bowel and bladder function

- **We will be focusing on complete injuries for this module.**

- **C5 Biceps: stabilize**
- **C6 Wrist extension: isolate**
- **C7 Triceps: watch for shoulder**
- **C8 Finger flexors: distal pip middle finger**
- **T1 Finger Abduction: little finger**

- **Specifically we will discuss complete injuries for C4, C6, and thoracic.**

- **Once you have triceps at C7 you merge into what some call the para-quad zone. But body type and the amount of trunk strength and sensation will determine how functional they can be.**

Level Of Injury	Muscle Innervation
C4	Trapezius, Sternocleidomastoid, cervical paraspinals, accessory muscles, diaphragm
C6	Above + deltoids, biceps, brachialis, brachioradialis, rhomboids, serratus, clavicular portion of pectoralis (C5,6), latissimus, supinator extensor carpi/radialis/brevis
Thoracic	Above + Sternal portion of pectoralis (C7,8,T1), triceps, hand musculature, and some trunk dependent on level of injury

GOALS

Level of Injury	Bed Mobility	Transfers	W/C Management and Propulsion
C4	**Total assistance Goal**: Able to instruct third party in all positioning (C5 some assist)	Dependent transfer or mechanical lift **Goal**: Able to instruct third party in safe transfers	**Mod I with power w/c and pressure relief with tilt/recline** Goal: Instruct third party in positioning in chair and w/c management
C6 **I = Independent**	Minimal assist and modified I in hospital bed	Potential to reach I transfers without board on even surface depending on body type.	**I driving power chair using hand-control** but I indoors with manual w/c. I in pressure reliefs
Thoracic	Independent	• **I even and uneven sit pivot.** • I floor to chair depending on body type	• **I indoors and outdoors on even and uneven surfaces**. Wheelies, curbs, and ramps. • Able to get chair in and out of car.

C1 THROUGH C3

- diaphragm is only minimally innervated by C3
- most patients require mechanical ventilation while others able to tolerate electric stimulation to the phrenic nerve (bilateral diaphragmatic nerve pacing).
- Pt should have adequate breath support or neck ROM(at least 30 degrees of active cervical motion) to operate a power wheelchair by a sip-and-puff mechanism or with a chin cup.

C4

- ❑ has some innervation of the diaphragm.
- ✓ means that a patient may not have to depend on a ventilator.
- ✓ The vital capacity of patients with diaphragmatic innervation is still markedly decreased.
- ✓ Individuals at this level should be able to operate a power wheelchair using a chin cup, chin control, or mouth stick.
- ✓ Individuals with C4 innervation continue to require full-time attendants because they arecompletely dependent in all transfers and ADLs.

A power wheelchair with a reclining feature will be needed to allow for pressure relief and rest

C5

- Patients with C5 innervation have some functional abilities.
- A patient with C5 innervation has deltoid, biceps, and rhomboid function.
- However, even though these muscles are innervated at this level, they may not have normal strength.
- **Because of innervation of these key muscles,** a patient with innervation at C5 should be able to
  - ✓ **flex and abduct the shoulders to 90 degree**
  - ✓ **flex the elbows,** and
  - ✓ **adduct the scapulae.**

- ✓ assist with rolling and can
- ✓ also bring her hand to mouth.
- ✓ operate a power wheelchair with a hand control.
- ✓ may be independent with some ADL

C6

- Because of innervation of **wrist extensors**, **pectoralis major**, **teres major**,

- ✓ patients at are able to be independent with **rolling**, **feeding**, and UL **dressing**.
- ✓ able to propel **a manual wheelchair** independently with rim projections
- ✓ Independent with sliding board transfers.
- ✓ need assistance for transfers,LL dressing.

Fig. 13.8 **Wrist-driven Flexor Hinge Orthosis.** A person with C6 tetraplegia holding a brush with the assistance of a wrist-driven flexor hinge orthosis. (From Webster JB, Murphy DP, editors: *Atlas of orthoses and assistive* devices, ed 5, Philadelphia, 2019, Elsevier, p 159.)

C7

- pt has the potential for living independently because patients at this level have innervation of the triceps.
- pt will be able to use her UL to:
  - wheelchair push-up for pressure relief.
  - Independence in self-care activities is possible, including UL and LL dressing.
  - independent in transferring from the wheelchair to the bed or mat, at first with a sliding board and eventually without the use of a board.

C8

- pt can live independently.
- pt is able to perform everything that a patient with innervation at **a C7** level is able to complete. With the addition of some increased finger control,
- the patient may also be able to perform wheelies and negotiate 2- to 4-inch curbs in the wheelchair

T1 THROUGH T9

We look at capabilities of individuals with T1 through T9 innervation as a group.

- With increased motor return in the thoracic region, the patient demonstrates improved trunk control and breathing capabilities,
- ✓ ability to clear secretions because of increasing innervation of the intercostal muscles.
- ✓ Individuals are able to operate a manual wheelchair on all levels and surfaces and should be able to transfer into and out of the wheelchair to the floor.
- ✓ may also be candidates for physiologic standing and limited therapeutic ambulation in the parallel bars *with physical assistance and orthoses.*

T10 THROUGH L2

- pt have abilities similar to those mentioned for individuals with T1 through T9 function.
- **Therapeutic ambulation** and **ambulation in the home with orthoses** and assistive devices may be possible, although
- manual wheelchair propulsion is the typical mode of functional mobility.

L3 THROUGH L5

- ❑ The quadriceps are partially innervated by L3.
- ✓LL innervation improves the patient's capacity for ambulation activities.
- ✓ independent in household ambulation and
- ✓may become independent in community ambulation at the L3 level.
- ❑ Patients with injuries at the L4 and L5 levels should be independent with all functional activities, including gait
- ✓ individuals can ambulate in the community with some type of orthoses and assistive device.

REHABILITATION APPROACHES

- physical therapists with a dilemma as to whether treatment should be directed at **compensation** or the **recovery of function**.
- **Compensation** is best thought of as a substitution or altered strategy to complete a task, whereas **recovery** is completing a task using the same or original processes.
- **compensation strategies** in which the patient utilizes *intact muscles, substitution, movement strategies (momentum, the head-hips relationship)*, *assistive devices*, and *bracing* to achieve functional movement and independence.

PHYSICAL THERAPY INTERVENTION: ACUTE CARE

PHYSICAL THERAPY INTERVENTION: ACUTE CARE

goals:

1. Prevention of joint contractures and deformities
2. Improvement of muscle and respiratory function
3. Acclimation of the patient to an upright position
4. Prevention of secondary complications
5. Pain management
6. Patient and family education

PHYSICAL THERAPY INTERVENTION: ACUTE CARE

patient's initial physical therapy examination

- patient's respiratory function,
- Muscle strength,
- muscle tone,
- reflex activity,
- skin status, cardiac function,
- functional mobility skills.

interventions should focus on :

- ✓ breathing exercises,
- ✓ selective strengthening and
- ✓ range-of-motion exercises,
- ✓ functional mobility training,
- ✓ activities to improve the patient's tolerance to upright,
- ✓ patient & family education.

PHYSICAL THERAPY INTERVENTION: ACUTE CARE

patients with spinal instability must be given medical clearance by their physician.

A patient with a cervical or thoracic injury **may not immediately undergo surgical stabilization**; therefore, the *PT may be involved in the care of the patient in the ICU*.

Breathing Exercises

BREATHING EXERCISES

- For those patients with innervation between **C4 and T1**, emphasis is on **increasing *diaphragm's strength and efficiency***.
- If the **diaphragm is weak**, ***use of accessory muscles***, such as the sternocleidomastoid & scalenes, may be evident.
- **A good way to assess respiratory function** is to **observe the epigastric area and to watch for epigastric rise,**
  - an exaggerated movement of the abdominal area indicates that the diaphragm is working.

BREATHING EXERCISES

- **The clinician can place a hand over this area to determine how much movement is actually occurring :**

- **If the patient is having difficulty,** *a quick stretch applied before the diaphragm contracts can help facilitate a response*.
- **If the patient is able to move the epigastric area at least two inches,** *the strength of the diaphragm is said to be fair .*

- **To strengthen this muscle even more,** *the therapist can apply manual resistance during the inspiratory phase of respiration.*
  - *If the patient is able to take resistance to the diaphragm during inspiration, the strength of the muscle is considered good.*

BREATHING EXERCISES

- **In addition, respiratory muscle fatigue may become evident.**

✓Observation of the neck area can provide the clinician with valuable information regarding **accessory muscle use.**

✓Patients often use accessory muscles extensively when the diaphragm is weak. Visible contraction of the sternocleidomastoids, scalenes, or platysma indicates accessory muscle use.

BREATHING EXERCISES

Glossopharyngeal Breathing

- Glossopharyngeal breathing is a technique that can be taught to patients with high-level tetraplegia.
- C1 through C3 level and some C4 injuries require mechanical ventilation.
- These patients need to be taught a technique to assist their ability to tolerate short periods of breathing while they are off the ventilator.

- patient takes a breath of air and closes the mouth.
- The patient raises the palate to trap the air. Saying the words “ah” or “oops” accomplishes this.
- The larynx is then opened as the tongue forces the air through the open larynx and into the lungs.

BREATHING EXERCISES

Lateral Expansion (basilar breathing)

- **For patients who have some intercostal innervation (T1 through T12)**

- Patients are encouraged to take deep breaths as they try to expand the chest wall laterally.
- Clinicians can place their hands on the patient's lateral chest wall and can palpate the amount of movement present.
- Manual resistance can eventually be applied as the patient gains strength in the intercostal muscles.
- Progression to a two-diaphragm, two chest breathing pattern is desirable if the patient has innervation through T12 (external intercostals).

BREATHING EXERCISES

Incentive Spirometry (inspiratory muscle trainers)

- ✓ A measurement of vital capacity.
- ✓ Vital capacity is the *maximal amount of air expelled after maximal inhalation.*
- ✓ Measurements of the patient's vital capacity can be taken throughout rehabilitation to document changes in ventilation.
- ✓ Patients can also be instructed to **vary their breathing rate** and to **hold their breath** *as a means to promote improved respiratory function.*

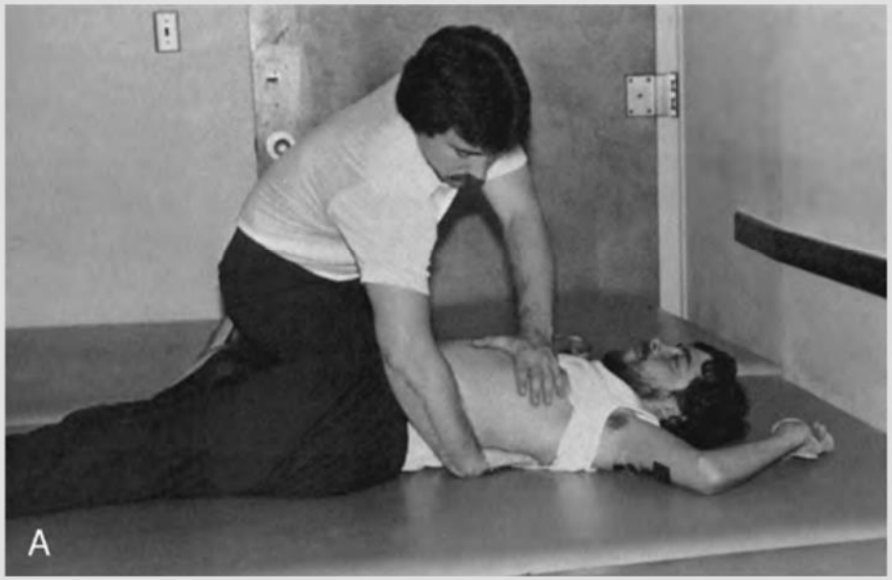
BREATHING EXERCISES

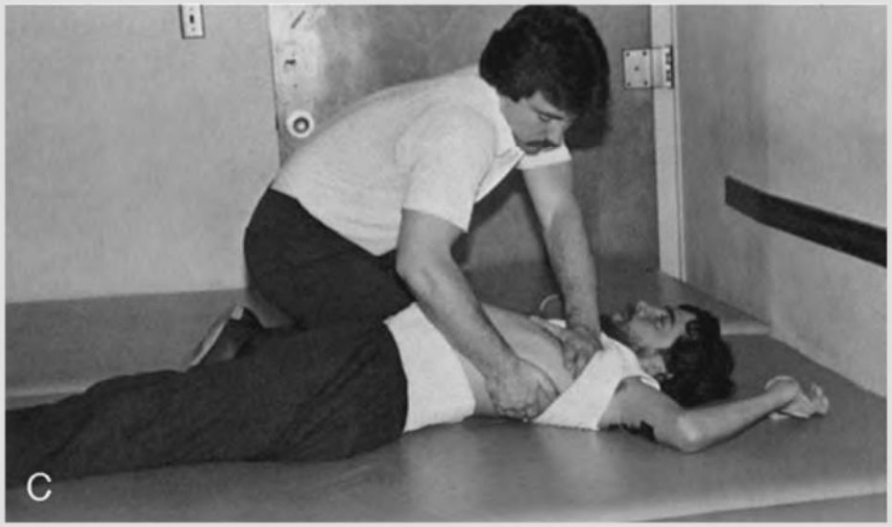
Chest Wall Stretching

- Spasticity and muscle tightness within the chest wall can develop. → Manual chest stretching indicated to increase chest expansion.
- This procedure, is contraindicated in the presence of rib fractures

- therapist places one hand under the patient's ribs and the other on top of the chest.
- The clinician then brings the hands together in a wringing type of motion, moving segmentally up the chest.

INTERVENTION 13.1 **Chest Wall Stretching**





A. Starting position for manual chest stretching with one hand under the patient's ribs and the other on top of the patient's ribs.
B. Ending position of the clinician's hands after applying a wringing motion to the patient's chest for manual stretching.
C. The last hand position after the clinician progresses up the patient's chest for manual chest stretching with the clinician's top hand just inferior to the patient's clavicle.

(From Adkins HV, editor: *Spinal cord injury*, New York, 1985, Churchill Livingstone.)

BREATHING EXERCISES

Postural Drainage

- Postural drainage with percussion and vibration may be necessary to aid in clearing secretions.

BREATHING EXERCISES

Coughs

- For patients who lack abdominal innervation, it is imperative to identify ways in which the patient can expel secretions.

- **Coughs are classified into three different categories, :**

I. Functional coughs are those that *are strong enough to clear secretions.*

II. Weak functional coughs produce an *adequate amount of force to clear the upper airways.*

III. Nonfunctional coughs *are ineffective in clearing the airways of bronchial secretions.*

(Wetzel, 1985).

Assisted Cough Techniques

- Depending on the patient's medical status, these techniques can be initiated in the acute-care setting or during the early phases of rehabilitation:

Technique 1.

- pt inhales two or three times and, on the second or third inhalation, attempts to cough.
  - ✓ *Intrathoracic pressure increases, which allows the patient to generate a greater force to expel secretions.*

BREATHING EXERCISES

Technique 2.

- ❑ The patient places her forearms over the abdomen. As the patient tries to cough, the patient pulls downward with the upper extremities to assist with force production.
- ✓ This can be completed in either a supine or a sitting position.
- ✓ This technique can be modified by having the patient flex forward toward her knees as she attempts to cough.

BREATHING EXERCISES

Assisted Cough Techniques

Technique 3.

In a prone-on-elbows position, the patient raises her shoulders, extends her neck, and inhales. As the patient coughs, the patient flexes the neck downward and leans onto the elbows.

Technique 4.

- ❑ If the patient is unable to master any of the previously mentioned assistive cough techniques, a caregiver can assist the patient with secretion expulsion.
- ❑ A modified Heimlich maneuver can be performed by placing the caregiver's hands on the patient's abdomen, just below the rib cage, and providing resistance in a downward-and-upward direction as the patient coughs

INTERVENTION 13.2 **Assistive Cough Techniques**

A. Self-manual coughing by the patient.[a]
B. Assisted cough technique in long sitting.[a]
C. Assistive cough technique administered by the therapist.[b]

[a](From Sisto SA, Druin E, Sliwinski MM: *Spinal cord injury: management and rehabilitation*, St. Louis, 2009, Mosby.)
[b](From Adkins HV, editor: *Spinal cord injury*, New York, 1985, Churchill Livingstone.)

Range of Motion

ROM exercises are an important component of the early stage of rehabilitation.

- For patients with tetraplegia, stretching of the shoulders, elbows, wrists, and fingers is essential.
- **The halo vest sits over the patient's shoulders, thus:**

✓ **limiting** shoulder flexion & abduction to approximately 90 degrees.

✓ Approximately 60 degrees of shoulder extension *(supine to the long-sitting position)* and 90 degrees of shoulder external rotation (patient can perform the elbowlocking maneuver to assume a sitting position)**are desirable.**

- ✓ Full elbow extension is essential *(to ensure that the pt is able to use elbow locking for the long-sitting position & for transfers)*.

- ❖ **Patients who lack innervation of the triceps (patients with C5 and C6 tetraplegia)** *use the elbow-locking mechanism to improve their functional potentials.*

- ✓ Adequate forearm pronation is necessary for feeding.

✓ **Patients who lack finger function need 90 degrees of wrist extension.**

- ❑ When an individual extends the wrist, passive insufficiency causes a subsequent flexing of the finger flexors referred to as **tenodesis** (Fig. 13.10)
- ✓ Tenodesis can be used functionally to allow a patient to grip objects withbuilt-up handles using passive or active wrist extension.
- ✓ stretching of the extrinsic finger flexors in combination with wrist extension should be **avoided**.

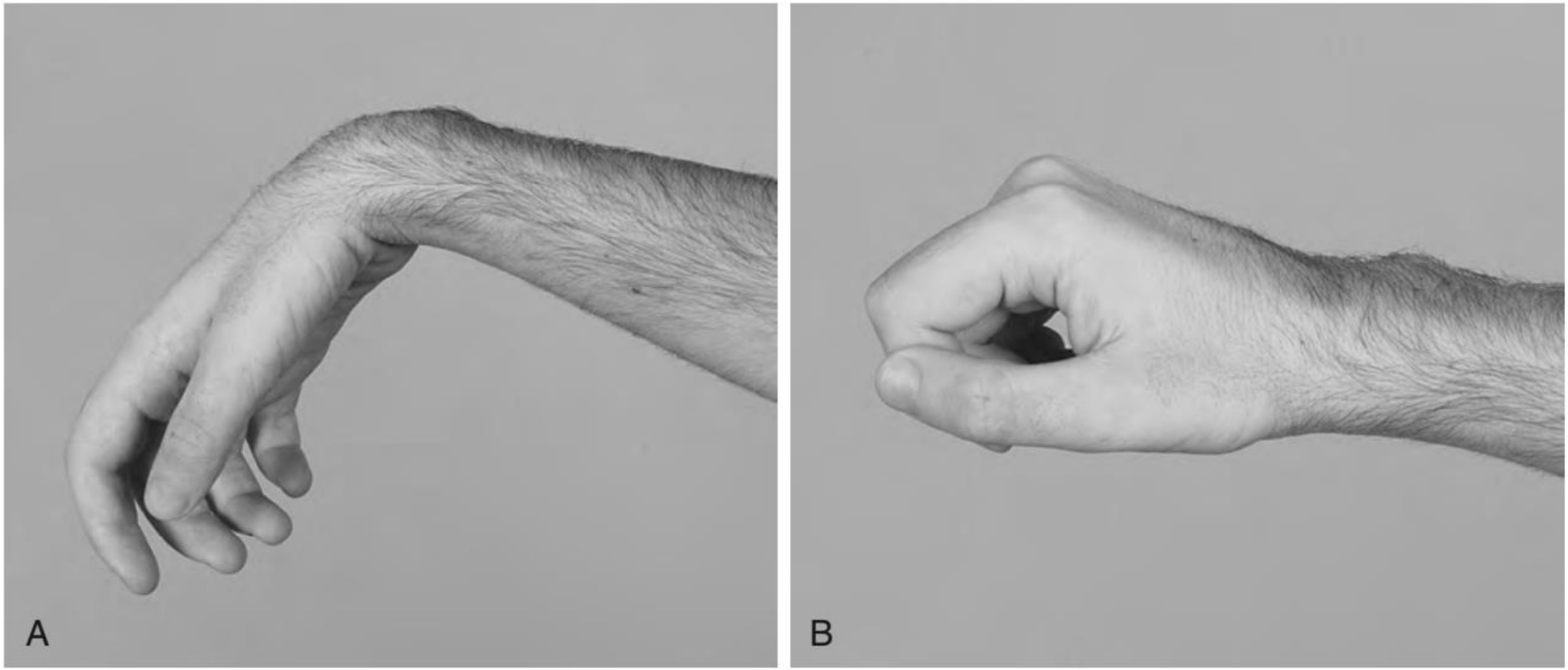


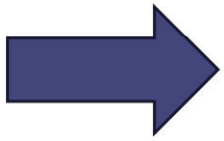
Fig. 13.10 Fundamental Principle of Tetraplegia Hand Function. A, With gravity-assisted WRIST flexion, the fingers and thumb passively open for grasp. **B,** With volitional WRIST extension, the thumb and fingers passively close for grasp. A tenodesis grasp provides hand function for the manipulation of light objects.

- Sitting on the mat with an open hand will overstretch the finger flexors; therefore, ***the patient should be encouraged to maintain the proximal interphalangeal joints and the distal interphalangeal joints in flexion***.

- **Overstretching of the thumb web space should also be avoided,**
  - ✓ as tightness in the thumb adductors and flexors allows the thumb to oppose the first and second fingers during tenodesis.
  - ✓ Patients are then able to **use the thumb as a hook** for completion of functional activities.

Special attention must be given to the hamstrings.

- **Once the halo is removed, clinicians should also avoid overstretching the cervical extensors.**
  - ✓ Stretching of the cervical extensors predisposes one to forward head posturing.



This head position interferes with the patient's sitting balance
&
can limit the patient's respiratory capabilities by inhibiting the use of accessory muscles.

Pssive
Range of Motion

Special attention must be given to the hamstrings.

- Passive ROM must be performed to the lower extremities when they are flaccid.
-

✓ The **desired** amount of passive hamstring flexibility needed to maintain a long-sitting position and to dress the lower extremities is **110 degrees,**

✓ although the amount of hamstring range required depends on the length of the patient's upper and lower extremities.

N.B.

When stretching the lower extremities, the therapist should make sure that the patient's pelvis is stabilized so movement is from the hamstrings and not from the low back.

Some tightness in the low-back musculature is desirable

- ✓ because this assists the patient with rolling, transfers, and maintenance of sitting positions.
- ✓ also provides the patient with a certain degree of passive trunk stability.
- ✓ In addition, maintenance of a "tight" back and the presence of adequate hamstring flexibility prevents the patient from developing a posterior pelvic tilt that can lead to **sacral sitting** and **pressure areas** *when sitting in the wheelchair.*

Stretching of the hip extensors, flexors, and rotators is necessary

- ❑ because **gravity** and **increased tone** may *predispose patients to contractures.*
- ✓ **Hip flexion range of 100 degrees** is needed to *perform transfers into and out of the wheelchair.*
- ✓ The patient needs **45 degrees of hip external rotation** for *dressing the lower extremities.*

✓ Early in rehabilitation it may not be possible to position the patient in prone to stretch the hip flexors because of respiratory compromise.
✓ The prone position can inhibit the diaphragm's ability to work.

Stretching of the ankle plantar flexors is necessary

- ✓ to provide passive stability of the feet during transfers,
- ✓ to allow proper positioning of the feet on the wheelchair footrests,
- ✓ to allow the use of orthoses if the patient will be ambulatory.

TABLE 13.7 Range-of-Motion Requirements

Movement	Range Needed
Shoulder extension	60°
Shoulder external rotation	90°
Elbow extension	Full elbow extension
Forearm pronation	Full forearm pronation
Forearm supination	Full forearm supination
Wrist extension	90°
Hip flexion	100°
Hip extension	10°
Hip external rotation	45°
Passive straight leg raising	110°
Knee extension	Full knee extension
Ankle dorsiflexion	To neutral

CAUTION

- **If the patient's cervical spine is unstable**, passive range-of-motion exercises to the shoulders should be limited to **90 degrees of flexion and abduction** to avoid possible movement of the cervical vertebrae.

- **Instability in the lumbar spine** requires that passive hip flexion be limited to **90 degrees with knee flexion** and **60 degrees with the knees straight** (Somers, 2010).

- Passive straight leg raises should be limited to ranges that do not produce movement (lifting of the pelvis).

- Once the spine is stabilized, more aggressive range-of-motion exercises can begin.

Strengthening Exercises

During the acute phase, certain muscles must be strengthened cautiously *to avoid stress at the fracture site and possible fatigue.*

- Initially, muscles may need to be exercised in **a gravity-neutralized (antigravity) position** secondary to weakness.

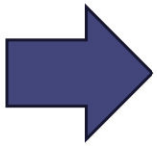
(Intervention 13.3, A and B, illustrates triceps strengthening in a gravity-neutralized position.)

- Application of resistance may be contraindicated in the muscles of the scapulae and shoulders in patients with tetraplegia and in the muscles of the hips and trunk in patients with paraplegia, depending on the stability of the fracture site.

(When the PT is designing the patient's plan of care, exercises that incorporate bilateral upper extremity movements are beneficial.)

During the acute phase, certain muscles must be strengthened cautiously *to avoid stress at the fracture site and possible fatigue.*

- For example,
  - **bilateral upper extremity exercises performed in a straight plane**
  - **proprioceptive neuromuscular facilitation patterns**



- ✓ *more efficiently performed* and
- ✓ *reduce the asymmetric forces applied to the spine* during upper extremity exercises.

Key muscles to be strengthened for patients with tetraplegia

- anterior deltoids,
- shoulder extensors, and
- biceps.

Key muscles to be emphasized for patients with paraplegia

- shoulder depressors,
- triceps, and
- latissimus dorsi.

During this early stage of rehabilitation, the clinician may use :

- ✓ manual resistance
- ✓ Velcro weights
- ✓ elastic bands (see Intervention 13.3, C and D).

  - ❑ Often, when a patient has decreased hand function, using one of these devices can be difficult.
  - ❑ Patients with paraplegia can perform more rigorous upper extremity strengthening. Barbells, exercise equipment, free weights, and elastic bands can be utilized for resistive exercise.

INTERVENTION 13.3 **Triceps and Upper Extremity Strengthening**

A. and **B.** Triceps strengthening. The patient's forearm must be carefully guarded. Weakness in the upper extremity may cause the patient's hand to flex toward her face.
C. Using a Velcro weight for additional resistance during triceps strengthening.
D. Using an elastic band for biceps strengthening.

Acclimation to Upright

- ✓ In addition to passive stretching and strengthening exercises, the patient *should also begin sitting activities*.
- ✓ Because of the initial trauma and secondary medical conditions, the patient may have been immobilized in a supine position for several days or weeks.
- ✓ As a consequence, the patient may experience **orthostatic hypotension**.

- Initially, nursing and physical therapy can work on **raising the head of the patient's bed.**

✓ One should monitor the patient's vital signs during the performance of upright activities. Baseline pulse, blood pressure, oxygen saturation, and respiration rates should be recorded.

As long as the patient's blood pressure does not drop below 80/50 mm Hg, kidney perfusion is adequate **(Finkbeiner and Russo, 1990).**

- If the patient can tolerate sitting with the head of the bed elevated, the patient can be progressed to **sitting in a reclining wheelchair with elevating leg rests.**

✓ Often, the patient is transferred to the wheelchair *with a draw sheet or mechanical lift initially.*

Fig. 13.11 The tilt table is used to help a patient gradually build up tolerance to the upright position. (From Fairchild SL: *Pierson and Fairchild's principles and techniques of patient care,* ed 5, St. Louis, 2013, Elsevier.)

- ✓ Transfers into and out of hospital beds are often difficult, based on the height of the bed and the presence of a halo.
- ✓ As the patient is better able to tolerate sitting, the time and degree of elevation can be increased.
- ✓ **The tilt table** can also be used to acclimate the patient to the upright position (Fig. 13.11).

❑ **Weight bearing on the lower extremities has many therapeutic benefits:**

- ✓ reducing the effects of osteoporosis,
- ✓ assisting with bowel and bladder function, and
- ✓ Decreasing abnormal muscle tone that may be present.

abdominal binder

- To assist the patient with blood pressure regulation during any of these upright activities, it may be necessary to have the patient wear an **abdominal binder**, **elastic stockings**, or **elastic wraps**.
- **abdominal binder:**

✓helps support the abdominal contents during upright activities by minimizing the effects of gravity.

✓ The top of the binder should cover the two lowest ribs, and

✓ the bottom portion should be placed over the patient's ASIS.

✓ binder should be tighter more distally.

Elastic wraps or elastic stockings:

❑ Elastic wraps or elastic stockings:

✓ assist the lower extremities with venous return in the absence of skeletal muscle action in the lower extremities.

The patient should also be carefully monitored for possible autonomic dysreflexia during these early attempts at upright positioning.

PHYSICAL THERAPY INTERVENTION: INPATIENT REHABILITATION

- Once the patient is medically stable, the patient will likely be transferred to **a comprehensive rehabilitation center**.
- Most patients spend approximately **11 days** in an acute-care center.
- During the inpatient rehabilitation phase of the patient's recovery, the emphasis is on maximizing functional potential.
- The average length of stay for inpatient rehabilitation is approximately **31 days.**

(National Spinal Cord Injury Statistical Center, 2019).

- **Activities that were initiated during the acute phase of recovery continue.** Interventions should focus on maximizing **respiratory function**, **range of motion**, **positioning**, and **strength of innervated muscles**.

- **Additional interventions** are incorporated to assist the patient in the development of **motor control**, **acquisition of self-care and functional activities**, including

✓ gait (if appropriate),

✓ therapeutic exercises to improve flexibility & overall fitness,

✓ patient/family education and training, and

✓ recommendations for adaptive equipment.

PHYSICAL THERAPY GOALS

- Much depends on the **patient's level of innervation** and **resultant muscle capabilities.**
- Additionally, goals developed must incorporate **what is important and meaningful to the patient.**
- **Examples of goals for this stage of the patient's recovery include the following:**

1. Increased strength of key muscle groups
2. Independence in skin inspection and pressure relief
3. Increased passive range of motion of the hamstrings and shoulder extensors
4. Increased vital capacity

PHYSICAL THERAPY GOALS

5. Increased tolerance to upright positioning in *bed* and the *wheelchair.*

6. Independence in transfers or independence directing a caregiver.

7. Independence in bed and mat mobility or independence directing a caregiver.

8. Independence in wheelchair propulsion on level surfaces

9. Independence in the operation of a motor vehicle (if appropriate).

10. Return to home and school or work.

11. Independence in a home exercise and fitness program.

12. Patient and family education and instruction.

DEVELOPMENT OF THE PLAN OF CARE

- **treatment interventions selected to achieve patient goals an be separated into two different approaches:**

- **compensatory approach :**

patient will *learn new motor skills through the use of compensatory strategies*, including strengthening intact muscles; using :

- **muscle substitution,**
- **momentum**, and
- principles, such as the **head-hips relationship**; and
- the incorporation of **adaptive equipment** and **environmental modifications**.

recovery approach:

- the focus is on the *patient's ability to use normal movement patterns in the acquisition of functional skills*.
- Relearning previous motor skills and limiting the use of compensatory strategies form the basis of the recovery approach.

In addition to mastery of functional skills, the **PT will want to promote certain behaviors in the patient:**

- ✓ SCIs pt must become active problem solvers.
- ✓ patient needs to determine how to move using her remaining innervated muscles.
- ✓ The patient also needs to know what to do in emergency situations.

For example, the patient must be able to direct someone if she should fall out of the wheelchair and is unable to transfer back into it.

- ✓ During the treatment session, **tasks should be broken down into component parts,** and *the therapist should allow the patient to find solutions to the movement problems presented*.

In addition to mastery of functional skills, the **PT will want to promote certain behaviors in the patient:**

- ✓ Patients should practice the activity in its entirety but must also work on the steps leading up to the completed activity.

An example is practicing the transition from a supine-on-elbows position to long sitting.

- ✓ Pt should also be taught to work in reverse.
- ✓ pt must also experience success during rehabilitation. Activities to be selected should provide the patient with the opportunity to succeed.
- ✓ Treatment activities selected should help the patient to develop a balance of skills between different postures and stages of motor control.

In addition to mastery of functional skills, the PT will want to promote certain behaviors in the patient:

- ✓ The patient does not need to perfect movement in one postural set before attempting something more challenging.
- ✓ **interventions within the plan of care should be varied:**
  - pool therapy,
  - mat programs,
  - functional mobility activities,
  - group activities, and
  - strengthening exercises.

Early Treatment Interventions
I- Mat Activities

Early in treatment, the patient should work on **rolling**.

- ✓ can assist with the *prevention of pressure ulcers*.

Clinician an also work on the patient's achievement of the **prone position**.

- ✓ excellent position for *pressure relief* and *stretching hip flexors*.

ROLLING

If the patient is wearing a halo,

- it will often be necessary for the therapist to **help** the patient **with rolling**.

- Prepositioning **a wedge under the patient's chest** is desirable when the patient is **prone**.

ROLLING

If the patient does not have a halo, rolling can be facilitated in the following way:

Step 1. The patient should flex the head and neck and rotate the head from right to left.

Step 2. Both upper extremities should be extended above the head (in approximately 80 degrees of shoulder flexion). For patients at C5 and C6, care should be taken to limit the amount of shoulder flexion to less than 90 degrees to prevent the elbows from flexing toward the patient's face as triceps innervation is not present. the patient should move the upper extremities together from side to side.

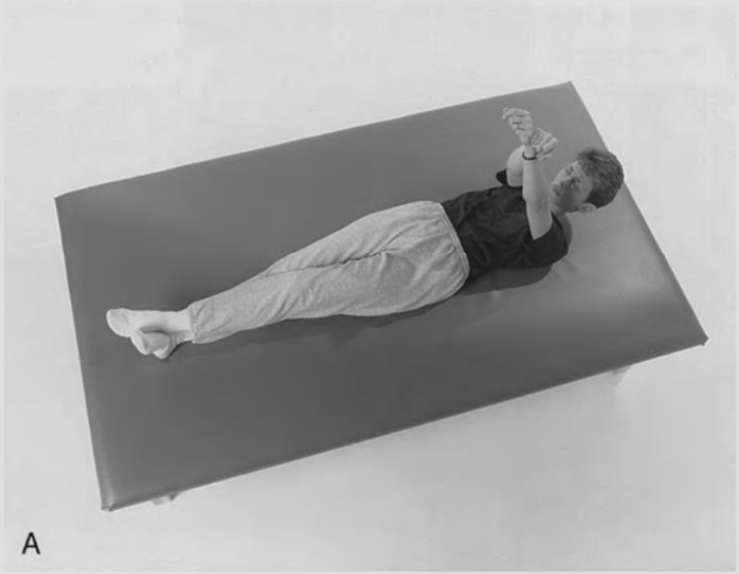
Step 3. With momentum and on the count of three, the patient should flex and turn the head in the direction she wishes to roll while moving the arms in the same direction.

ROLLING

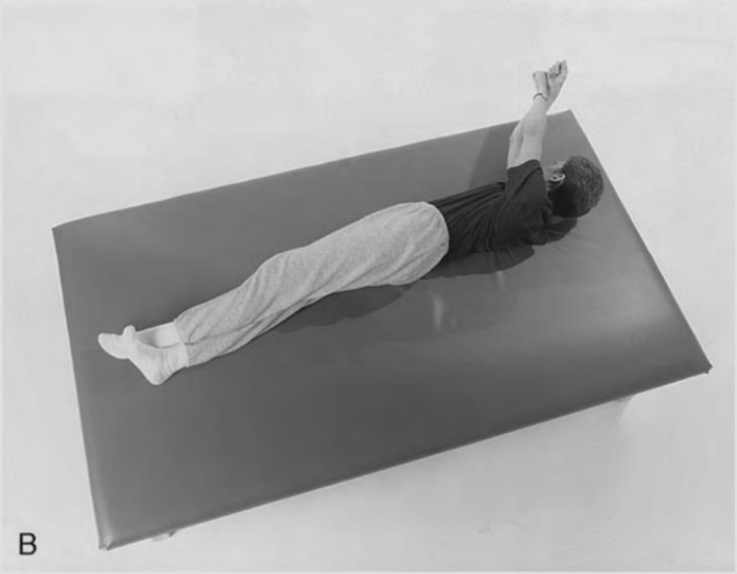
If the patient does not have a halo, rolling can be facilitated in the following way:

Step 4. To make it easier for the patient, the patient's ankles can be crossed at the start of the activity. This prepositioning allows the patient's lower extremities to move more easily. To roll to the left, you would cross the patient's right ankle over the left. Intervention 13.4 illustrates a patient who is completing the rolling sequence. Cuff weights applied to the patient's wrists can add momentum and facilitate rolling.

INTERVENTION 13.4 **Rolling from Supine to Prone**



A



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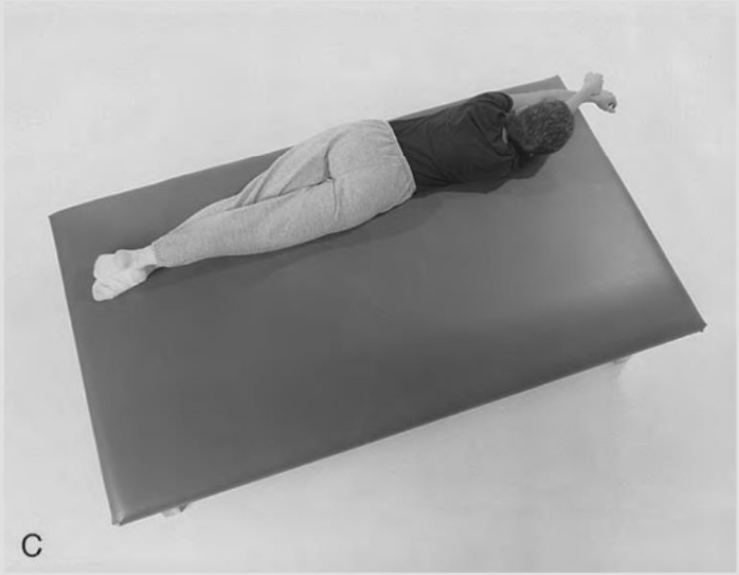


C

A. Rolling from supine to prone can be facilitated by having the patient flex her head and use upper extremity horizontal adduction for momentum. The upper extremities must remain in less than 90 degrees of shoulder flexion to prevent elbow flexion. The patient's lower extremities should be crossed to unweight the hip to assist with rolling.

B. and **C.** With momentum and on the count of three, the patient should flex and turn her head in the direction she wishes to roll while throwing her arms in the same direction.

strengthening exercises for the scapular muscles

- Once the patient has rolled from supine to prone, strengthening exercises for the scapular muscles can also be performed:

Shoulder extension,

shoulder adduction, and

shoulder depression with adduction

- Theses are three common exercises that can be performed to strengthen the scapular stabilizers. Intervention 13.5 shows a patient performing these types of exercises.

INTERVENTION 13.5 **Scapular Strengthening**

A. and **B.** Scapular-strengthening exercises can be performed in a prone position.

PRONE

Prone to prone on elbows

a beneficial position because it :

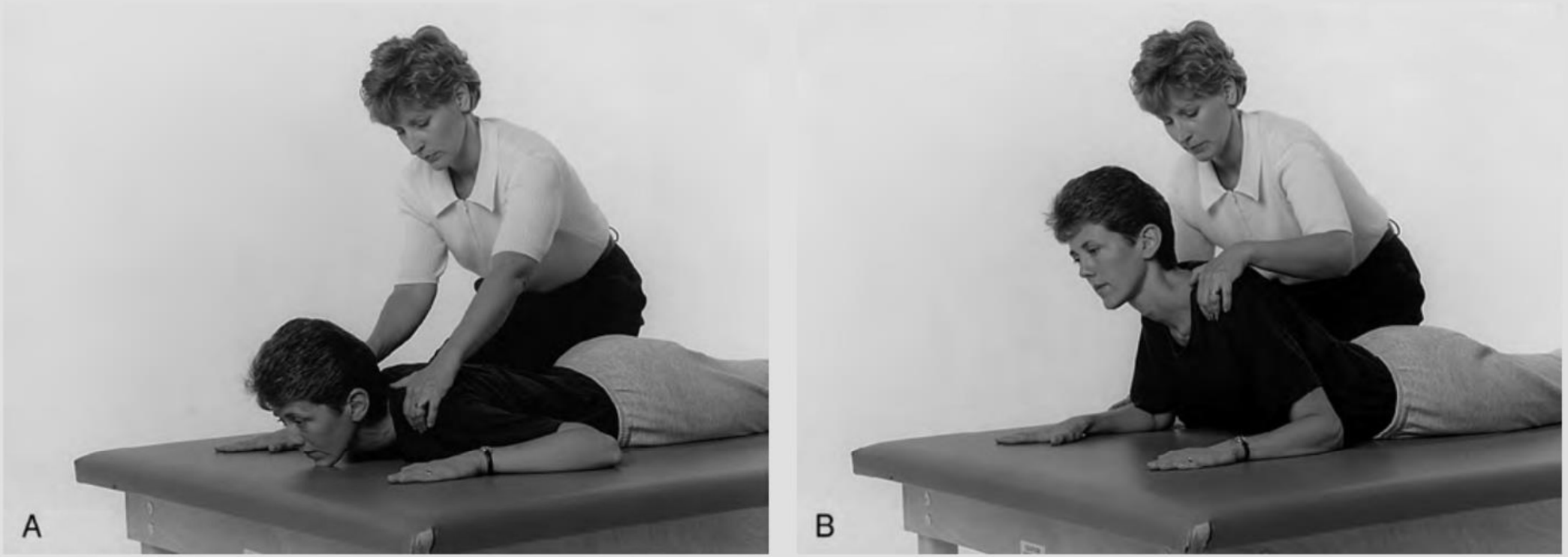
- ✓ *facilitates head and neck control*, as well as
- ✓ *requiring proximal stability of the glenohumeral joint and scapular muscles*.

- ❑ patient may need assistance:

therapist can place her hands under the patient's shoulders anteriorly and lift up (Intervention 13.6, A).

As the patient's chest is lifted, the PT should move herhands posteriorly to the patient's shoulder or scapular region.

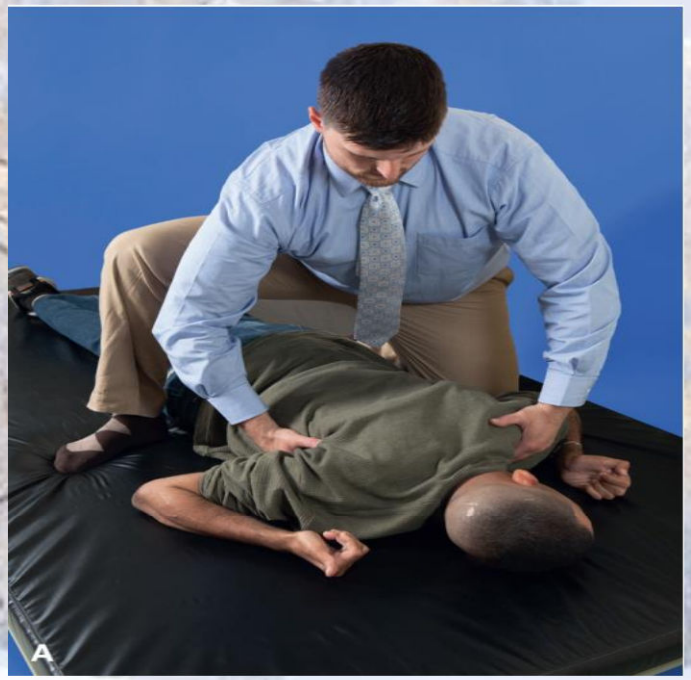
INTERVENTION 13.6 **Prone to Prone on Elbows**



A. The therapist may need to help the patient achieve the prone-on-elbows position.
B. Weight shifting from one side to the other allows the patient to move her elbows into correct alignment.

- **prone-on-elbows**

✓ can be assumed from either prone or side-lying.



shoulders initially abducted and weight shifting.

PRONE

Prone to prone on elbows

- If the patient is to attempt achievement of the position independently,

✓ pt should be instructed to place her elbows close to the trunk, hands near her shoulders. The patient is then instructed to push the elbows down into the mat while lifting her head and upper trunk.

✓ **To position the elbows under the shoulders**, the patient needs to shift weight from one side to the other to move the elbows into correct alignment.

This is accomplished by movement of the head to the right or the left. The PT can also facilitate weight shifts in the appropriate direction during these activities (see Intervention 13.6, B).

PRONE

Prone on Elbows

- **Before beginning activities in the prone-on-elbows position, the patient needs to assume the correct alignment, as shown in Fig. 13.12.**

Fig. 13.12 The elbows should be positioned directly under the shoulders when the patient is prone on elbows. The physical therapist assistant is applying a downward force (approximation) through the shoulder to promote tonic holding and stabilization of the shoulder musculature. To preventing overstretching of the finger flexors, the patient's fingers may remain flexed.

PRONE

Prone on Elbows

- **pt try to keep the scapulae slightly adducted and downwardly rotated** to counteract the natural tendency to hang on the shoulder ligaments.

(therapist may need to provide the patient with manual cues on the scapulae to maintain the correct position.)

- **Downward approximation** applied through the shoulders or **tapping to the rhomboids** is often necessary to increase scapular stability.

(Approximation promotes tonic holding of the muscles.)

- patient should practice **weight shifting to the right, left, forward, and back**.

(encouraged to maintain good alignment and to avoid shoulder sagging)

activities that can be performed in a prone-on-elbows position

- Once the patient can maintain the position, she can progress to other exercises that will increase proximal control and stability.

alternating isometrics,
the patient should be instructed to *hold the desired position as the PT or PTA applies manual resistance* to the right or left, forward or backward. **Intervention 13.7, A**

Rhythemic stablization,
patient performs *simultaneous isometric contractions of agonist and antagonist* patterns as the therapist provides a rotational force. **Intervention 13.7, B**

INTERVENTION 13.7 **Alternating Isometrics and Rhythmic Stabilization**

A. The clinician is performing alternating isometrics with the patient in a prone-on-elbows position. Force is applied in a posterior direction as the patient is asked to hold the position.

B. Rhythmic stabilization performed in a prone-on-elbows position. The therapist is applying simultaneous isometric contractions to both agonists and antagonists. As the patient holds the position, a gradual counterrotational force is applied.

PRONE

activities that can be performed in a prone-on-elbows position

lifting one arm,

unilateral reaching activities,

(Intervention 13.8, A).

serratus strengthening

patient is instructed to push her elbows down into the mat and to tuck the chin while lifting and rounding the shoulders.

- For patients with paraplegia, instruction in prone push-ups, as depicted in Intervention 13.8, B, can be provided.

INTERVENTION 13.8 **Other Scapular-Strengthening Exercises**

A. The patient reaches for a functional object. The therapist stabilizes the weight-bearing shoulder to prevent collapse.
B. The patient with paraplegia performs a prone press-up.

PRONE TO SUPINE

From a prone-on-elbows position, the patient can transition back to supine.

1) pt shifts weight onto one elbow and extends and rotates her head in the same direction.

2) As she does this, the patient "throws" the unweighted upper extremity behind.

3) The momentum created by this maneuver facilitates rolling back to a supine position.

SUPINE

Supine on Elbows

a beneficial position because it :

- ✓ *assist the patient with bed mobility and to prepare her for the attainment,*
- ✓ *prepare her for the attainment of long sitting.*

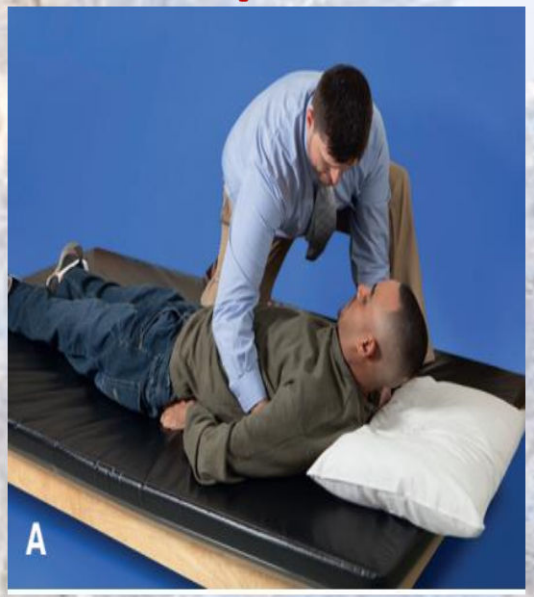
Supine on Elbows C5 and C6 levels may need assistance :

- Several different techniques as A pillow or bolster placed under the upper back can assist the patient with this activity.
- *helps acclimate the patient to the position* and
- *assists the patient with stretching the anterior shoulder capsule*.

INTERVENTION 13.9 **Supine to Supine on Elbows**

A. The patient flexes her head to initiate the activity.
B. With her hands on the patient's shoulders, the therapist helps to lift the patient's upper trunk.
C. The head is used to initiate a weight shift to the right so that the left elbow can be unweighted and brought back.
D. The final position.

- **supine-on-elbows**



Patient transitioning from supine (A) to supine-on-elbows (B) by stabilizing hands under pelvis, forcefully pulling up by contracting the biceps, weight shifting side to side, and placing elbows farther underneath the shoulder joints (C).

With more independence with the transition from a supine position to supine on elbows

- ✓ patient hook her thumbs into her pockets or belt loops or position the hands under the buttocks. **Intervention 13.10**
- ✓ As the patient does this, she stabilizes with one arm as she pulls back with the other, using the reverse action of the biceps.
- ✓ pt may need to reposition the patient's arms at the end of the movement.

INTERVENTION 13.10 **Independent Supine to Supine on Elbows**

A

B

C

D

E

A. The patient prepositions her hands under her buttocks.
B. The patient flexes her neck.
C. and D. Using her head to initiate the weight shift, the patient pulls one elbow and then the other elbow back.
E. The final position.

Activities of supine-on-elbows position:

1) **weight shifting in the position,**
2) **transitioning back to prone, and**
3) **progressing to long sitting.**
4) **Supine pull-ups**
5) While the patient is in a supine position, the clinician holds the patient's supinated forearms in front of the body and has the patient pull up into **a modified sit-up position.**

(helps strengthen both the shoulder flexors and the biceps.)

Activities of supine-on-elbows position:

6) From supine on elbows, **the patient can roll to prone** by shifting weight onto one elbow, looking in the same direction, and reaching across the body with the other upper extremity.

(This maneuver provides the patient with another option to achieve the prone position.)

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LONG SITTING

- It can also be achieved from a supine-on-elbows position.
- Long sitting is sitting with both upper and lower extremities extended and is **a functional posture for patients with tetraplegia**.
- This position allows patients with C7 innervation a position in which they can perform lower extremity dressing, skin inspection, and self-range of motion.

LONG SITTING

The technique to assume long sitting is as:

Step 1. In the supine-on-elbows position, the patient shifts her weight to one side. The patient's head should follow the movement (Intervention 13.11, A and B).

Step 2. With the weight on one elbow, the patient throws her other upper extremity behind the buttocks into shoulder extension and external rotation (see Intervention 13.11, C). Once the hand makes contact with the surface, the shoulder is quickly elevated and then depressed to maintain the elbow in extension. The elbow is locked biomechanically (see Intervention 13.11, D and E).

Step 3. The patient shifts her weight back to the midline see Intervention 13.11, E).

Step 4. Once the patient has the elbow locked on one side, she repeats the motion with the other upper extremity (see Intervention 13.11, F and G).

INTERVENTION 13.11 **Supine on Elbows to the Long-Sitting Position**


A


B


C


D

Continued

INTERVENTION 13.11 **Supine on Elbows to the Long-Sitting Position—cont'd**

A. and **B.** Supine on her elbows, the patient shifts her weight to one side by moving the head in that direction.

C. With her weight on one elbow, the patient throws her other upper extremity behind her buttocks into extension and external rotation.

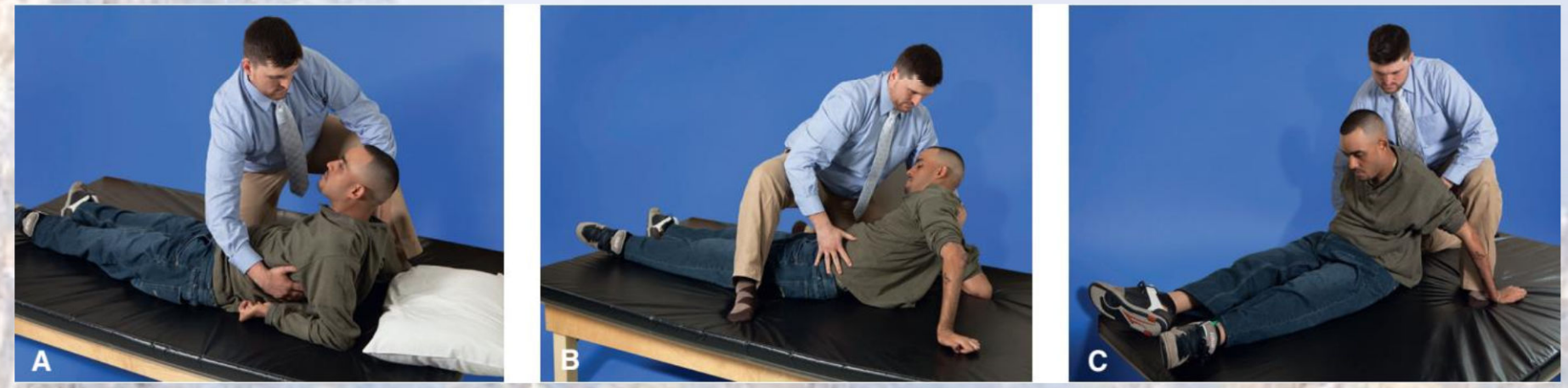
D. Once the weight is shifted onto the extremity, the elbow is biomechanically locked into extension because of the bony alignment of the joint when it is positioned in shoulder external rotation and then depressed.

E. The patient shifts her weight back to the midline.

F. Once the patient has the elbow locked on one side, she repeats the motion with the other upper extremity.

G. The final position.

- long sitting from supine-on-elbows



Bears weight on one elbow while the other UE is thrown back into shoulder extension with the elbow extended to bear weight on the other UE (B); then weight shifts onto the other UE and throws other UE back into shoulder extension with elbow extended to come into long sitting (C).

- **Coming Straight to Long Sitting From Supine**

Patient transitioning from prone-on-elbows (A) to long sitting(B), walks into a "C" position (C), pulls trunk up to long sitting position (D).

LONG SITTING:

difficulty in achieving the long-sitting position::

- ✓ lack the necessary ROM in their shoulders
- ✓ elbow flexion contractures
- ✓ Patients who do not possess at least 90 to 100 degrees of passive straight leg raising

(Failure to possess adequate hamstring range of motion causes patients to overstretch the low back musculature and ultimately decrease their functional abilities.)

LONG SITTING

Patients with injuries at C7 and below also use the long sitting position.

✓ it is **easier for these patients** because they *possess triceps innervation and may be able to maintain active elbow extension.*

Once the patient has achieved the long-sitting position with the elbows anatomically locked and is comfortable in the position, additional treatment activities can be practiced:

1) **Manual resistance** can be applied to the shoulders to foster cocontraction around the shoulder joint and to promote scapular stability.
2) **Rhythmic stabilization** and **alternating isometrics** are also useful to improve stability.

LONG SITTING

If the patient has triceps innervation, the clinician will want to work with the patient on the ability to sit in a long-sitting position without upper extremity support

(Fig. 13.13).

- The **patient moves her hands from 1)*behind the hips***, 2)***to the hips***, and finally to 3)***forward at the knees***.
- ✓**Hamstring range of motion is essential** for the patient to be able to perform this transition safely.
- ✓Once the patient can place her hands in front of the hips and close to the knees, she can try maintaining the position with 4) ***only one hand for support*** and eventually 5)***with no hands***.
- ✓ In this position, the patient learns to perform self-range of motion and self-care activities.

Fig. 13.13 Balance activities should always be emphasized in the long-sitting position to prepare the patient for numerous functional activities. (From Buchanan LE, Nawoczenski DA: *Spinal cord injury and management approaches*, Baltimore, 1987, Williams & Wilkins.)

A GOAL FOR THE PATIENT WITH TRICEPS FUNCTION IS TO DO A **PUSH-UP WITH THE UPPER EXTREMITIES IN A LONG-SITTING POSITION** (INTERVENTION 13.12).

- requires that the patient have at least **fair-plus strength in the triceps.**
- **Intervention :**

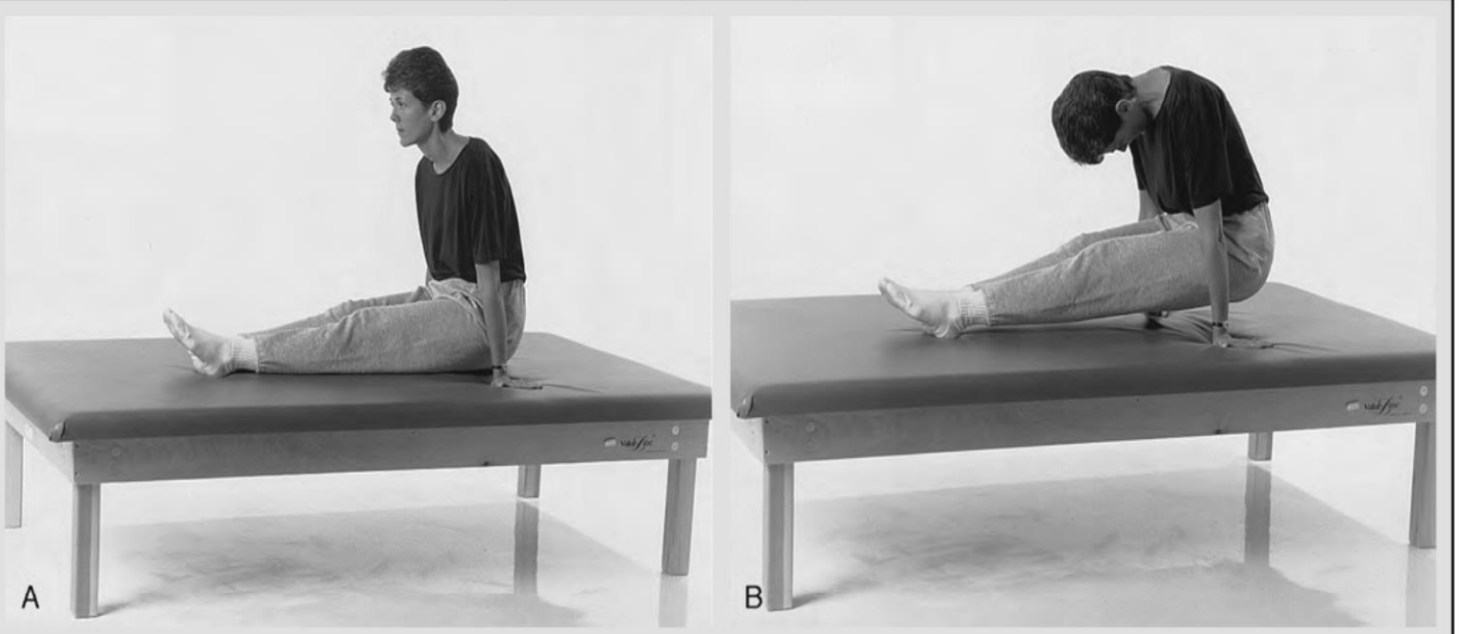
the patient straightens the elbows and depresses the shoulders to lift the buttocks. The patient flexes the head and upper trunk to facilitate a greater rise of the buttocks. Tightness in the low back also allows this to occur.

- The patient uses this technique **(the head-hips relationship)**

1) to move around on the mat. This strategy is illustrated when a patient moves the head in one direction and the hips move directly opposite (Somers, 2010).

A GOAL FOR THE PATIENT WITH TRICEPS FUNCTION IS TO DO A PUSH-UP WITH THE UPPER EXTREMITIES IN A LONG-SITTING POSITION (INTERVENTION 13.12).

INTERVENTION 13.12 **Push-Up in the Long-Sitting Position**



A. and B. The patient uses the head-hips relationship to assist with lifting the buttocks.

2) Upper extremity push-ups are also used for transfers in and out of the wheelchair and as a means for the patient to perform independent pressure relief.

- Considered a compensatory strategy, the head-hips relationship assists patients in performing functional activities.

Early Treatment Interventions
II-Transfers

Patients with high cervical injuries (C1 through C4 level) are completely dependent in their transfers.

A two-person lift

a dependent sit-pivot transfer

a mechanical lift

Preparation phase.

(Before the transfer, the patient and the wheelchair must be positioned in the correct place.)

- ✓The wheelchair should be positioned parallel to the mat or the bed.
- ✓ The brakes must be locked and the wheelchair leg rests removed.
- ✓ A gait belt must be applied to the patient before the therapist begins the activity.

INTERVENTION 13.13 **Two-Person Lift**

A. and **B.** Care must be taken so that the patient's buttocks clear the wheel during the two-person lift. Good body mechanics are equally important for the individuals assisting with this type of transfer.

(From Buchanan LE, Nawoczenski DA: *Spinal cord injury and management approaches*, Baltimore, 1987, Williams & Wilkins.)

I. SIT-PIVOT TRANSFER.

Step 1.

- ✓The patient must be forward in the wheelchair to perform the transfer safely.
- ✓The PT shifts the patient's weight from side to side to move the patient forward. Often, placing one's hands under the patient's buttocks in the area of the ischial tuberosities is the best way to assist the patient with weight shifting. The clinician must monitor the position of the patient's trunk carefully as she performs this maneuver owing to a lack of trunk control necessary to maintain the trunk upright.
- ✓Once the patient is forward in the wheelchair, the armrest closest to the mat or bed should be removed.

SIT-PIVOT TRANSFER.

Step 2.

✓The therapist then flexes the patient's trunk over the patient's feet.

The clinician brings the patient forward over her hip that is farther away from the wheelchair. This maneuver allows the PT to be close to the area where most individuals carry the greatest amount of body weight.

✓ Guarding of the patient's knees is also necessary.

Step 3.

A second person should be positioned on the mat table or behind the patient to assist with moving the patient's posterior hips and trunk.

SIT-PIVOT TRANSFER.

Step 4.

- ✓ **On a specified count,** the therapist positioned in front of the patient shifts the patient's weight forward and moves the patient's hips and buttocks to the transfer surface.
- ✓ The position of the patient's feet must also be monitored to avoid possible injury. Generally, prepositioning the feet in the direction that the patient will assume at the end of the transfer is beneficial.

Step 5.

- ✓ **Once the patient is on the mat,** the therapist in front of the patient aligns the patient to an upright position.
- ✓ The therapist does not, however, take her hands off the patient because of the patient's lack of trunk control. Without necessary physical assistance, a patient with tetraplegia could lose balance and fall.

Intervention 13.14 demonstrates a sit-pivot transfer with a patient.

INTERVENTION 13.14 **Sit-Pivot Transfer**


A


B


C

A. The clinician helps the patient scoot forward in the wheelchair.
B. The patient is flexed forward over the therapist's hip.
C. The patient's hips and buttocks are moved to the transfer surface.

II- MODIFIED STAND-PIVOT TRANSFER

- used with some patients who have:

1) **incomplete injuries and lower extremity innervation.**
2) **lower extremity extensor tone** may be able to perform a modified stand-pivot transfer.

The steps in completion of this transfer are similar to the ones described earlier. Intervention 13.15 illustrates this type of transfer.

INTERVENTION 13.15 **Modified Stand-Pivot Transfer**

A. and **B.** Leverage principles and good body mechanics facilitate this stand-pivot transfer. The patient may assist with this transfer by holding his arms around the person who is completing the transfer.

(From Buchanan LE, Nawoczenski DA: *Spinal cord injury and management approaches*, Baltimore, 1987, Williams & Wilkins.)

III- AIRLIFT.

preferred type of transfer for patients with significant lower extremity extensor tone. because it **prevents shear forces on the buttocks**.

- ✓The patient's legs are flexed and rest on the clinician's thighs.
- ✓The patient is then rocked out of the wheelchair and moved to the transfer surface.
- ✓ The therapist must maintain proper body mechanics and initiate the patient lift with her legs to avoid possible injury to the therapist's low back.

Intervention 13.16

INTERVENTION 13.16 **Airlift Transfer**

In the airlift transfer, the patient's flexed legs rest on or between the therapist's thighs. The patient can be "rocked" out of the chair and lifted onto the bed or mat. The patient's weight is carried through the therapist's legs and not the back.

(From Buchanan LE, Nawoczenski DA: *Spinal cord injury and management approaches*, Baltimore, 1987, Williams & Wilkins.)

IV- SLIDING BOARD TRANSFERS.

chair should be prepositioned as close as possible to the transfer surface and at approximately a 30-degree angle.

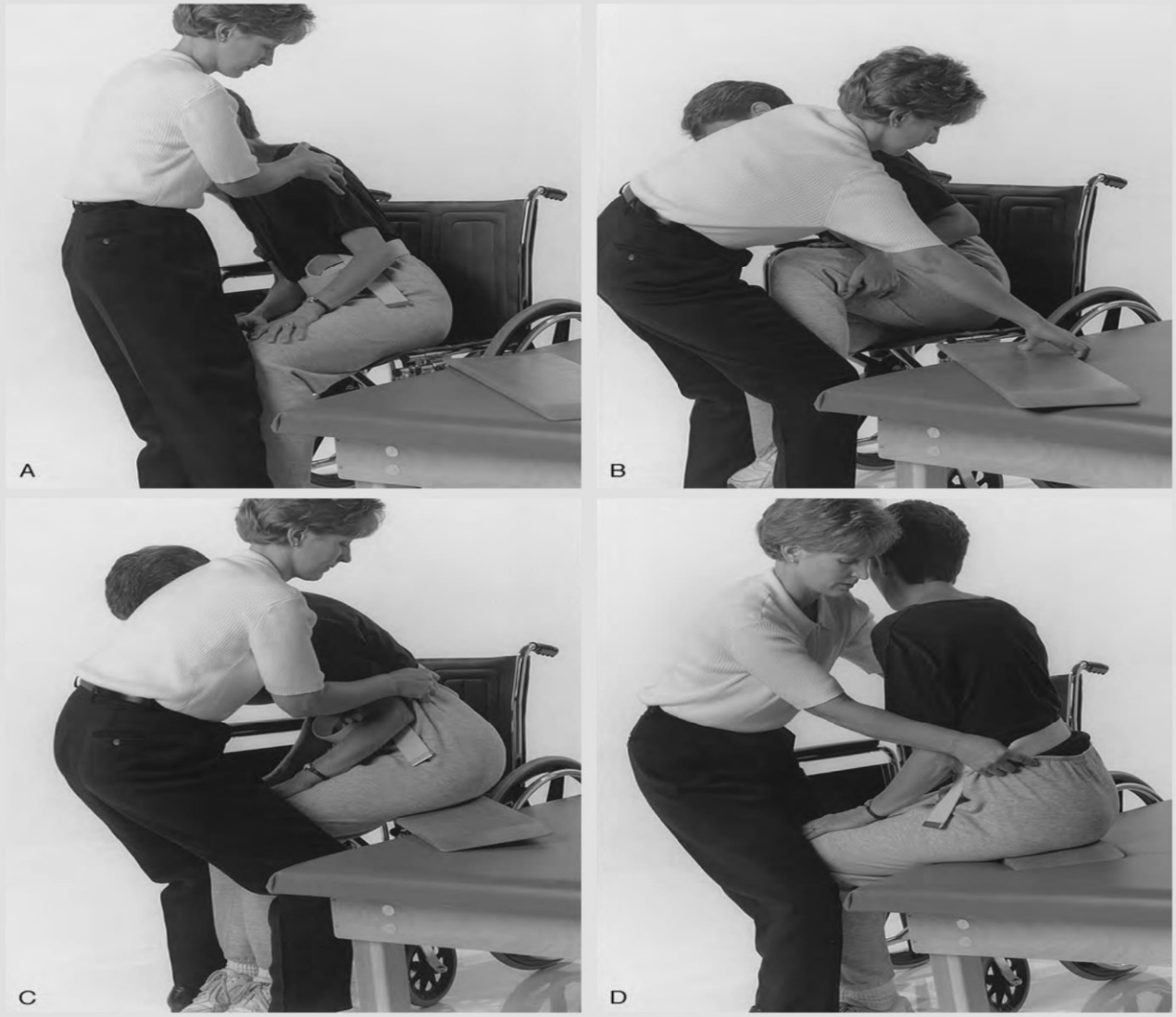
- As the patient's trunk is flexed forward over her knees, the PT places the sliding board under the patient's hip that is closer to the mat table.

(The clinician may need to lift up the patient's buttocks to assist with board placement.)

- Clinicians must be aware of the patient's active trunk control. Many individuals with SCIs are not able to maintain their trunks in an upright position.
- Once the board is in the proper position, it helps support the patient's body weight during the transfer.

Intervention 13.17

INTERVENTION 13.17 **Sliding Board Transfer**



A. The patient's weight is shifted to the side farther away from the transfer surface.
B. The patient's thigh is lifted to position the board. The therapist remains in front of the patient, blocking the patient's lower extremities and trunk.
C. and **D.** The patient is transferred over to the support surface.

V- SLIDING BOARD TRANSFERS

A patient with **C6** tetraplegia has the potential to transfer independently using a sliding board.

- often use the assistance of a caregiver or a family member because of the time and energy involved with transfers.
- To be independent , the patient must be able to manipulate the wheelchair parts and position the sliding board. ***Extensions applied to the wheelchair's brakes are common and allow the patient to use wrist movements to maneuver these wheelchair parts***.
- To position the board, the patient can use tightness in the finger flexors to move the board to the proper location. The patient can also place her wrist at the end of the board and use wrist extension for board positioning. Placement of the sliding board under the buttocks is facilitated by lifting up the leg. Loops can be sewn onto the patient's pants to make this easier. Once the board is in position, the patient can reposition the lower extremities (Intervention 13.18).

V- SLIDING BOARD TRANSFERS

A patient with C6 tetraplegia has the potential to transfer independently using a sliding board.

In an effort to prevent the development of **upper extremity overuse injuries,** patients should be instructed to

- ✓ limit the numbers of transfers they perform each day and
- ✓ avoid extremes of joint range (Somers, 2010).

INTERVENTION 13.18 **Independent Sliding Board Transfer**

Continued

INTERVENTION 13.18 **Independent Sliding Board Transfer—cont'd**

A. and B. The patient prepares to position the sliding board by moving the leg closest to the mat table over the other leg.

C. The patient positions the sliding board under the buttock of the leg closest to the mat table. The patient can uncross the lower extremities if it makes the transfer easier.

D. Pushing with the forearm closest to the wheelchair armrest and pushing down against the sliding board, the patient slides herself off of the wheelchair seat.

E. The patient then slides her buttocks down the length of the board until she is on the table.

F. Continuing to push off the wheelchair arm and using the other arm on the mat table, the patient scoots off the board and onto the table itself.

V1A- PRONE-ON-ELBOWS TRANSFER.

- **used also for patient with C6 tetraplegia:**

1) rotates her head and trunk to the opposite direction of the transfer while still in the wheelchair.
2) Then, she flexes both elbows and places them on the wheelchair armrest.
3) Then, flexes her trunk forward and pushes down on the upper extremities, thus scooting over onto the mat or bed. (Some patients may also use the head to assist with the transfer. The patient can place her forehead on the armrest to provide additional trunk stability while attempting to move from the wheelchair.)
4) **Once the patient is on the mat table,** the patient hooks her arm under her knee and uses the sternal fibers of the pectoralis major to extend her trunk.

V1B- ROLLING OUT OF THE WHEELCHAIR.

- **After removing the wheelchair armrest,**

✓ the patient rotates the trunk to the mat table.

✓The patient then positions the lower extremities onto the support surface.

✓The patient can use the back of her hand or Velcro loops attached to her pants to lift the lower extremities up and onto the support surface.

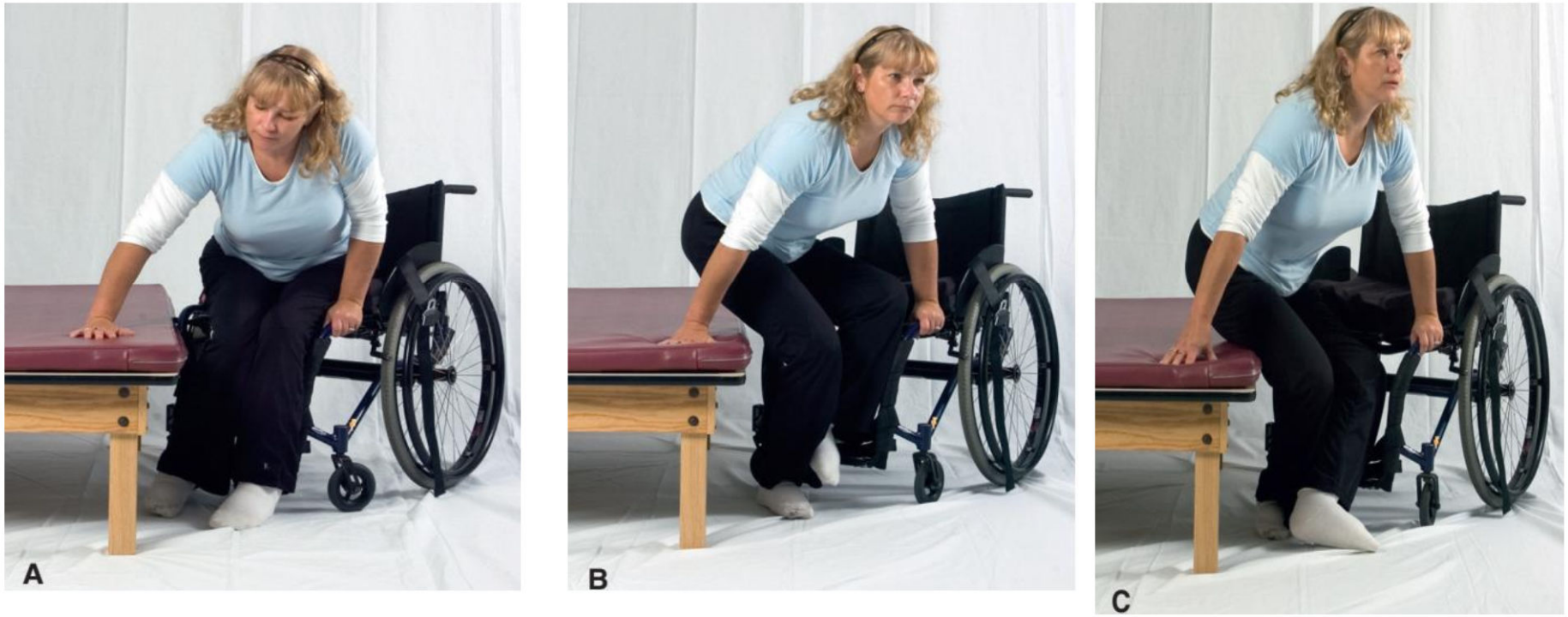
✓Once the patient's lower extremities are up on the bed, *the patient actually rolls out of the wheelchair.*

✓The patient can move to a side-lying position or can roll all the way over to a prone-on-elbows position.

V2A- LATERAL PUSH-UP TRANSFER.

If the patient possesses triceps function(a C7 injury), the potential for independent transfers with and without the sliding board is greatly enhanced.

- Initially, when instructing a patient in this type of transfer, the therapist **should use a sliding board.**
- ✓ patient positions the board under the posterior thigh.
- ✓ With both upper extremities in a relatively extended position, the patient pushes down with her arms and lifts the buttocks up off the sliding board.
- ✓ The patient's feet and lower extremities should be prepositioned before the start of the transfer. Both feet should be placed on the floor and rotated away from the direction of the transfer.
- ✓ The patient moves slowly, using the board as a place to rest if necessary.



(A) Preparatory phase of the transfer; trunk is flexed forward and laterally away from surface transferring to. (B) Lift phase; buttocks are lifted off the seating surface as the trunk rotates. (C) End of the descent phase when the buttocks are on the other sitting surface.

LATERAL PUSH-UP TRANSFER

As the strength in the patient's upper extremities improves, the patient will be able to complete the transfer faster and will not need to use the sliding board.

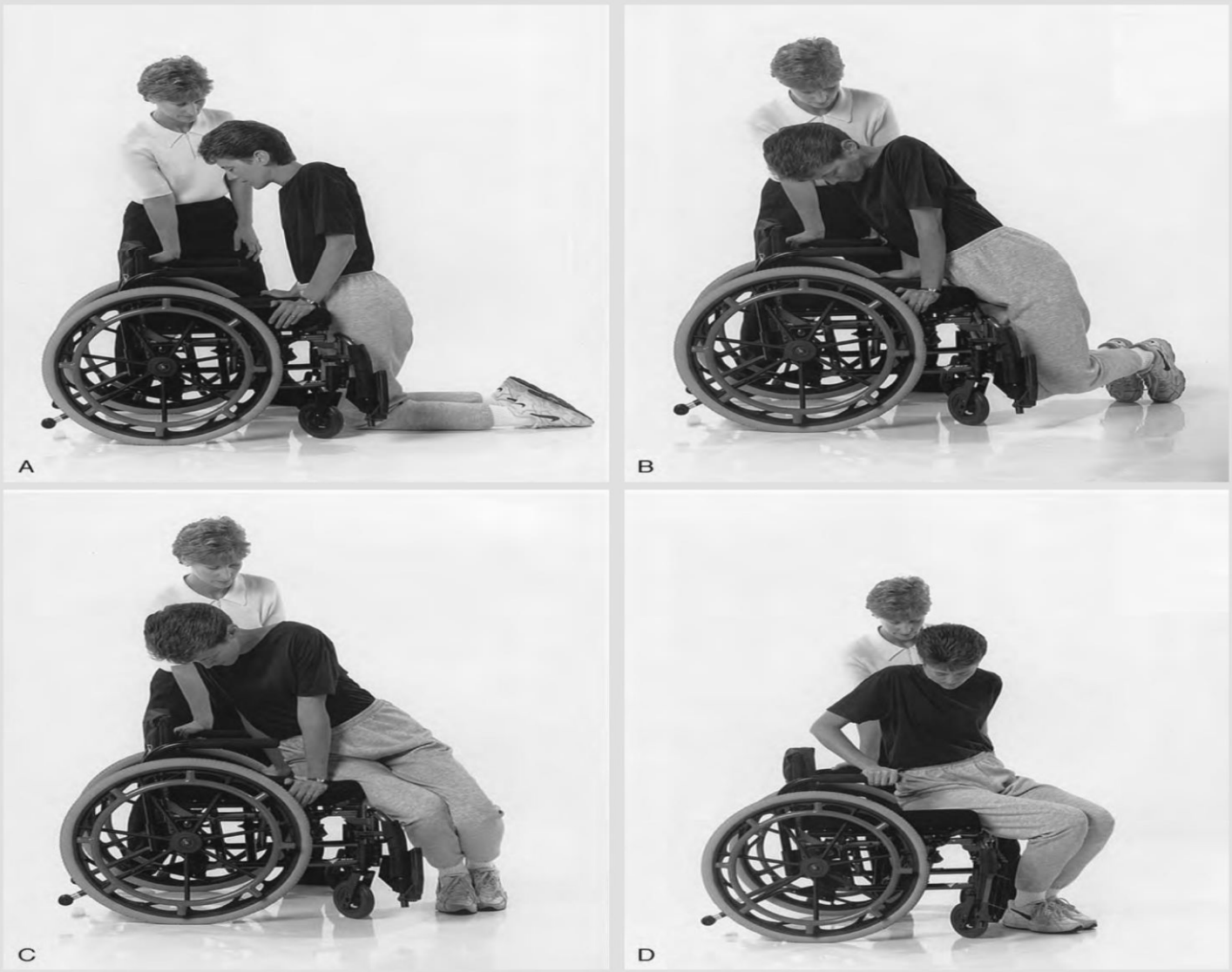
high-level paraplegia also perform lateral push-up transfers. Not until a patient **possesses fair strength in the lower extremities** are stand-pivot transfers possible.

WHEELCHAIR-TO-FLOOR TRANSFERS.

- ✓ **3 interventions**

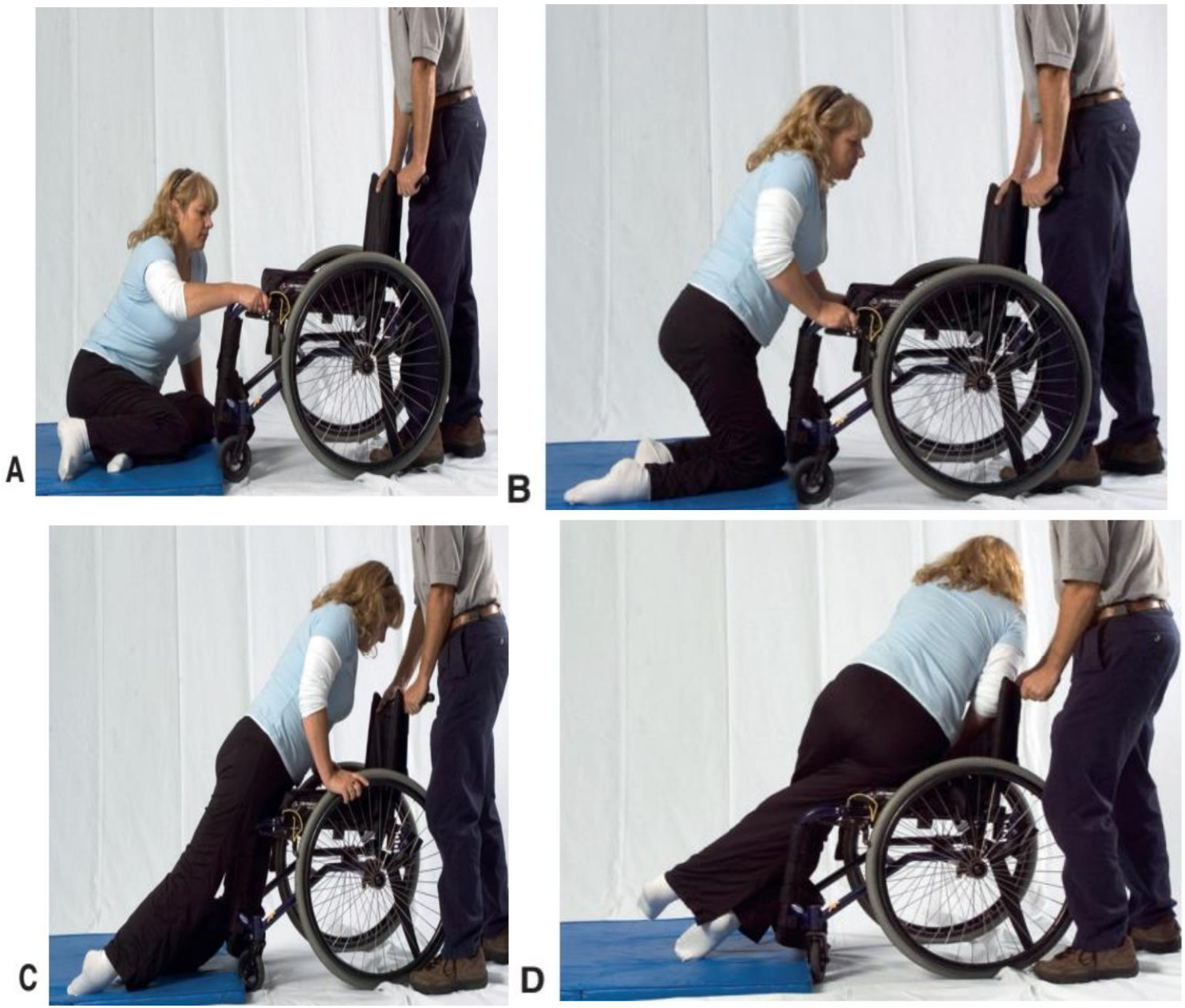
If the patient can position herself in a supported kneeling position in front of the wheelchair,

INTERVENTION 13.23 **Transfer to Wheelchair From Tall Kneeling**



A. The patient assumes a tall-kneeling position and pulls herself into the wheelchair.
B. to D. The patient must rotate over her hips to assume a sitting position. The sequence can be reversed to transfer out of the wheelchair.

vention 13.23.



(A–D) Floor to wheelchair transfer using a frontward approach.

If the patient possesses adequate upper extremity strength and range of motion,

- ✓ she can back up to the wheelchair in **a long-sitting position**, depress her shoulders, and lift her buttocks back into the wheelchair.
- ✓ The patient's hands are positioned near the buttocks. Flexion of the neck while attempting this maneuver aids in elevating the buttocks through the head-hips relationship.
- ✓ one can practice this by using a small step stool or several mats.

INTERVENTION 13.24 **Transfer to Wheelchair From Long-Sitting Position**


A


B


C


D


E

Transfers from the floor to the wheelchair can be practiced in the clinic with a small step stool.

A. to **C.** The patient first transfers from the floor to the stool. The patient uses the head-hips relationship to lift the buttocks.

D. to **E.** From the stool, the patient depresses her shoulders and lifts herself back into the wheelchair.

(A–C) Floor to wheelchair transfer using a sideways approach.

AMBULATION TRAINING (COMPENSATORY APPROACH)

One of the first questions that patients with SCIs often askn is whether they will be able to walk again.

- This question is frequently posed in the acute-care center immediately following the injury.
  - Early on, it may be **difficult** to determine the patient's ambulation potential secondary to spinal shock and the depression of reflex activity; *however, once this condition resolves, many patients expect an answer to this question*.
  -

A CLINICAL PREDICTION RULE FOR AMBULATION

a study by van Middendorp et al. (2011)

- based on a patient's age and her results on four neurologic tests:

I. motor scores for the quadriceps and gastrocsoleus and

II. light touch sensation in dermatomes L3 and SI.

AMBULATION TRAINING

- Other health care professionals believe that **a patient should possess strength in the hip-flexor musculature before ambulation** is attempted because of the high-energy costs, time, and financial resources associated with gait training.

- Most patients with **higher-level *injuries*** ***choose wheelchair mobility as their preferred method of locomotion after trying ambulation with orthoses and assistive devices*** because of the energy expenditure and decreased speed associated with the activity
- The use of orthoses, assistive devices, functional electrical stimulation, and robotic exoskeletons are examples of ***compensatory strategies*** that can be employed to assist patients with ambulation on level surfaces.
- Locomotor training through partial body-weight-supported treadmill ambulation provides an excellent example of the ***recovery approach*** to patient care.

BENEFITS OF STANDING AND WALKING

- prevents the development of osteoporosis and also
- helps decrease the patient's risk for bladder and kidney stones.
- Self-reported improvements in spasticity, bladder and bowel management, and
- psychological benefits

FACTORS TO CONSIDER FOR SUCCESS WITH AMBULATION.

1) **patient's motivation to walk** and to continue with ambulation once discharged from rehabilitation (given the opportunity to try assisted ambulation with orthoses, some patients decide it is too difficult a task and prefer not to continue with the training);

2) the **patient's weight and body build** (the heavier the patient is, the more difficult it will be for the patient to walk, and taller patients usually find it more challenging to ambulate with orthoses);

3) the **passive range of motion** present at the hips, knees, and ankles (hip, knee, or ankle plantar flexion contractures limit the patient's ability to ambulate with orthoses and crutches; in addition, patients need approximately **110 degrees of passive hamstring range of motion** to *be able to don their orthoses and transfer from the floor if they fall);*

4) **amount of spasticity present** (lower extremity or trunk spasticity can make wearing orthoses difficult);

5) the **cardiopulmonary status** of the patient (patients with better pulmonary function have an easier time meeting the energy demands of walking); and (6) status of the integumentary system.

FACTORS TO CONSIDER FOR SUCCESS WITH AMBULATION.

- **For patients with T2 through T11 injuries,** therapeutic standing or ambulation may be possible.

✓ patient is able to stand or ambulate in the physical therapy department with assistance. However, functional ambulation is not possible.

- **Patients with injuries at the T12 through L2 level** have the potential to be household ambulators,

- **patients with innervation at L3** can achieve functional community ambulation

FACTORS TO CONSIDER FOR SUCCESS WITH AMBULATION.

- **energy cost for ambulation in patients with complete injuries above T12 :**
  (above the anaerobic threshold and cannot be maintained for an extended period)

✓ **gait velocities** for patients with paraplegia were significantly slower than normal walking, and

✓ gait required a **50% increase in oxygen consumption** and a **28% increase in heart rate.**

Consequently, individuals with paraplegia
- ✓ discontinue ambulation with their orthoses and assistive devices
- ✓ use their wheelchairs for environmental negotiation .

ORTHOSES

- **Knee ankle-foot orthoses** may be recommended for patients with paraplegia.
- These orthoses typically have :

✓ a thigh cuff and

✓ an external knee joint with a locking mechanism

✓ a calf band and

✓ an adjustable locked ankle joint.

ORTHOSES

- **ScottCraig knee-ankle-foot orthoses** are frequently prescribed for patients with paraplegia.
- These orthoses consist of
  - ✓ a single thigh and pretibial band, a bail lock at the knee joint, and modified footplates.
  - The design of this orthosis provides built-in stability at the knee and ankle while passively positioning the hip in extension. "An extension moment is created at the hips that prevents the individual from folding forward" while the Y ligaments in the hip maintain the hip in extension. This provides the patient with inherent stability while standing.

ORTHOSES

hip-knee-ankle-foot orthosis (HKAFO)

- ✓ used with patients with limited trunk control.
- ✓ The reciprocating gait orthosis has an external hip joint that is operated by a cable mechanism.
- ✓ When the patient shifts weight forward and laterally onto one lower extremity, the cable system advances the opposite leg.
- ✓ Individuals using reciprocating gait orthoses **often use a walker** *instead of Lofstrand crutches as their preferred assistive device*.

ORTHOSES

New orthotic systems are also being developed that utilize robotic exoskeletons and electric stimulation.

- These systems may decrease some of the physiologic demands of ambulation with orthotics; however, barriers to use include **cost**, **donning and doffing**, and the **ability to use the device when in one's wheelchair.**

Fig. 13.18 **A,** Combination plastic and metal knee-ankle-foot orthoses. **B,** The Scott-Craig knee-ankle-foot orthosis is a special design for spinal cord injury. The orthosis consists of double uprights, offset knee joints with locks and bail control, one posterior thigh band, a hinged anterior tibial band, an ankle joint with anterior and posterior adjustable pin stops, a cushion heel, and specially designed footplates made of steel. **C,** The reciprocating gait orthosis, although generally used with children, is also used with adults. Its main components are a molded pelvic band, thoracic extensions, bilateral hip and knee joints, polypropylene posterior thigh shells, ankle-foot orthosis sections, and cables connecting the two hip joint mechanisms. **D,** Electronic knee-ankle-foot orthosis. (**A–C,** From Umphred DA, editor: *Umphred's neurological rehabilitation*, ed 6, St. Louis, 2013, Elsevier; **D,** From Webster JB, Murphy DP, editors: *Atlas of orthoses and assistive devices*, ed 5, St. Louis, 2019, Elsevier, p 253.)

- patients with motor complete, **AIS A,** have *very limited abilities to achieve functional ambulation.*

- **AIS B,** motor complete and sensory incomplete, *the ability to ambulate is approximately 33%,* whereas in

- patients with **AIS C** the *recovery of walking is about 75%.* Age does appear to be a prognostic factor in patients with AIS C because individuals **younger than 50 have** a significantly improved chance of walking (80% to 90%) as compared with older adults (30% to 40%).

- *Independent ambulation* is possible for all patients who are classified as **AIS D**

STANDING IN THE PARALLEL BARS

- It is easiest to have the patient hold on to the parallel bars and pull forward.
- In preparation for this transition, the patient needs to move forward in the wheelchair. Having the patient push up and lift the buttocks forward is best to prevent shearing of the patient's skin.
- Once the patient is forward in the chair, the therapist will want to make sure the patient's orthoses are locked.
- If this is the patient's first time to stand up, it will be safest to have two individuals assist. While the patient is wearing the safety belt, one person is positioned in front of the patient and the other person is at the side or the back of the patient. On the count of three, the patient pulls herself forward on the bars.
- The individuals assisting the patient also provide the patient with the needed strength and momentum to complete the transfer.

STANDING IN THE PARALLEL BARS

- **Once upright, the patient must work to find her balance point:**
  - The patient's lower extremities should be slightly apart;
  - the low back should be in hyperextension;
  - the shoulders are toward the back; and
  - the hands must be forward of the hips and holding on to the parallel bars.
- Once the patient is able to find her balance point, **she will eventually be able to stand and maintain balance without the use of the upper extremities.**
- **To guard the patient during this activity,** the therapist will be **behind the patient** or off to the side. The therapist holds on to the **gait belt** and should **avoid holding on to the patient's upper arms**. The therapist may place a supporting hand on the patient's anterior shoulder as long as the therapist does not provide a counterbalancing or rotational force.

During practice of achievement of the balance point,

- ❑ initially have both hands on the parallel bars.
- ✓ encouraged to hold the bars lightly and should avoid grabbing or pulling on them.
- ❑ patient to balance with one hand, and finally with no hands.
- ✓ The patient should ultimately be able to stand in the orthoses without any upper extremity support.
- ❑ she can begin to practice **push-ups in the bars.**
- ✓ With the hands in a forward position, the patient pushes down on the bars by depressing the shoulders and tucking the head.
- ✓ Depending on the *type of lower extremity orthosis* and the *presence or absence of a spreader bar,*

STANDING IN THE PARALLEL BARS

Performing a push-up is a prerequisite activity for the patient to ambulate in a forward direction.

STANDING IN THE PARALLEL BARS

practice jack-knifing.

- Jack-knife can be described as movement of the patient's upper body and head forward of the pelvis.
- Although jack-knifing is an **undesirable occurrence**, the activity should be practiced in the parallel bars during early gait training sessions.
- With the hands forward, the patient bends forward at the waist and lowers the trunk down toward the parallel bars. The patient then pushes back up to an upright position by extending her elbows.
- Once the patient feels comfortable with this activity, she can practice falling into a jack-knife position.
- The pa**tient can initiate this fall either by moving the hands posterior to the hips** or by **flexing the head forward**. The **therapist can also assist the patient with the achievement of the jack-knife position by gently pulling the patient's hips and pelvis in a posterior direction.**

If jack-knifing position should occur during gait, the patient will want to **straighten her elbows** while **extending the head and trunk.**

Once the patient can maintain her balance point and can perform a push-up to clear her feet from the floor, she is ready to begin **forward ambulation in the parallel bars**.

GAIT PROGRESSION

- Normally, you will want to progress the patient to taking a few steps on the first standing and ambulation attempt.
- the clinician has to monitor the patient's responses closely during standing and ambulation. The effects of fatigue, orthostatic hypotension, decreased cardiopulmonary endurance, and the anxiety associated with standing and walking can easily overwhelm the patient.

1) therapist should instruct the patient to find her balance point before advancing forward in the parallel bars.
2) The patient's head should be held upright, looking forward.
3) The patient then flexes her head, pushes down on the hands, depresses the shoulders, and lifts the lower extremities off the ground.
4) As the patient depresses her shoulders and straightens the elbows, she must extend the head and neck and return them to a neutral position.
5) To maintain balance, the patient needs to move her hands forward of the hips immediately. If the patient were to maintain her hands in the same place after completing the lift, she would jack-knife.

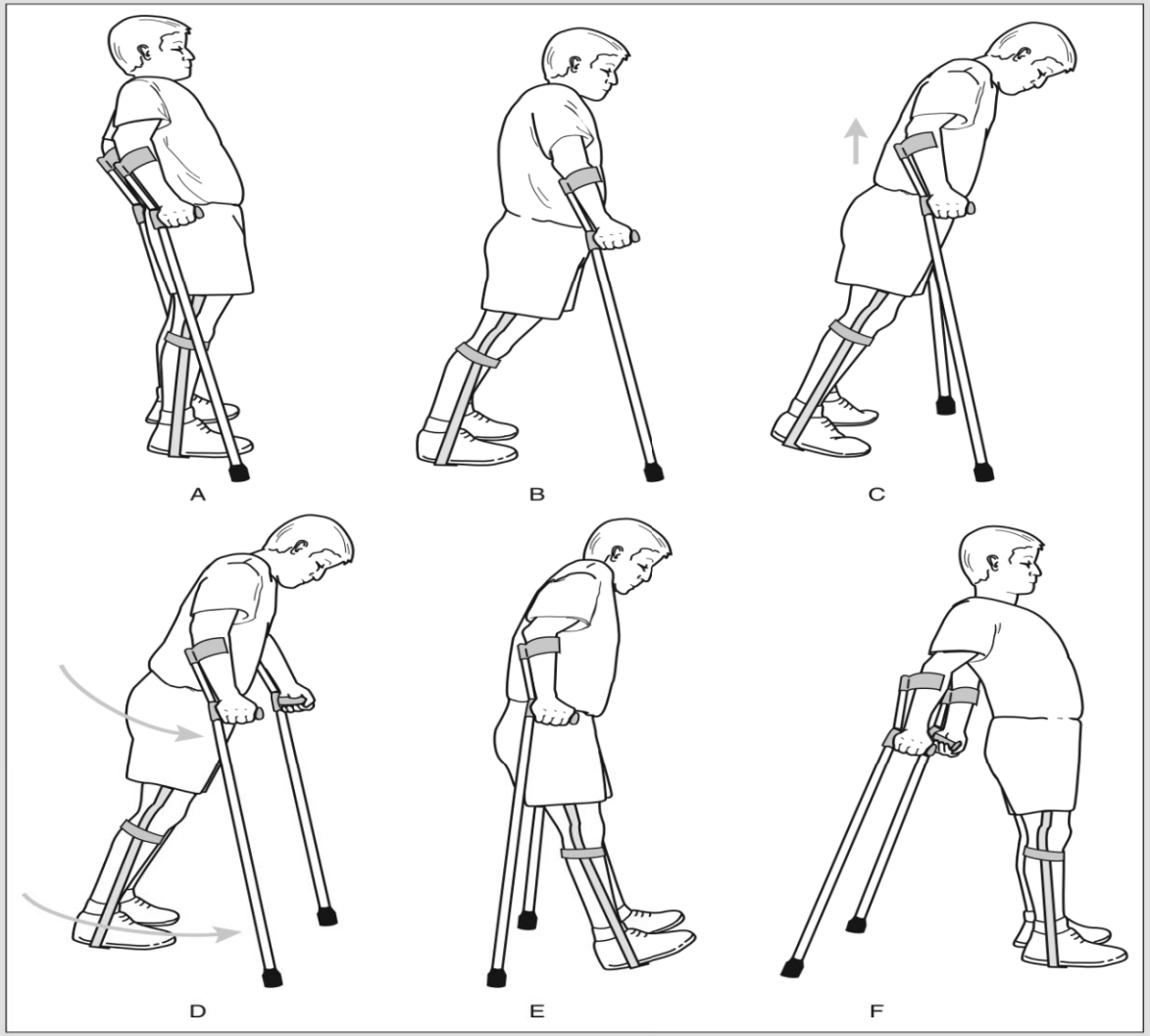
6) **After the patient's feet make contact with the floor,** she must retract the scapula and move the upper trunk and head posteriorly. This type of gait pattern is known as **a swing-to pattern** because the patient is *moving the feet the same distance as her hands*.

7) The patient should repeat the steps just described

8) Using the **verbal instructions** "Lean, lift, and land" is helpful.

9) At this point, someone can pull the wheelchair up behind the patient, or the patient can be instructed in performing a quarter-turn.

INTERVENTION 13.27 **Gait Progression**



A. The patient finds his balance point.
B. He advances the crutches forward.
C. The patient tucks his head and pushes down on the crutches.
D. His pelvis and lower extremities swing forward.
E. His feet strike the floor.
F. The patient lifts his head and resumes a lordotic posture.

QUARTER-TURNS

- the patient depresses her shoulders and lifts the legs while rotating the trunk and changing her hand position on the parallel bars.
- In essence, she is completing two quarter-turns to turn around.
- The patient must practice turning in both directions.

SITTING

- Remember, the patient transfers from standing to sitting with the lower extremity orthoses locked in extension.

✓ For this reason, the chair should be at least **12 inches** from the patient so she will be able to land in the wheelchair seat.

✓ The PT hold have the patient keep both of her hands on the parallel bars during the descent.

✓ In time, the patient will be instructed in other methods to perform transfers from sitting to standing and from standing to sitting without the use of the parallel bars.

SWING-THROUGH GAIT PATTERN

- Once the patient feels comfortable with the swing-to gait pattern, the patient can progress to a swing-through pattern.
- The technique is the same as the swing-to pattern, except the patient advances her legs a little farther forward instead of stopping between steps. This gait pattern allows the patient to move forward a little faster and is more energy-efficient.

OTHER GAIT PATTERNS

- If the patient possesses lower extremity innervation, specifically hip flexion, the patient may have the potential to use a four-point or two-point gait pattern.
- Both patterns more closely resemble normal reciprocal gait patterns with upper and lower extremity movement.

BACKING UP يرجع للخلف

- Initially, backing up should be practiced in the parallel bars.
- The patient tucks the head, depresses the shoulders, and extends the elbows. This position causes the patient to **perform a mini–jack-knife** and allows the patient's legs to move backward by virtue of the head-hips relationship.
- The patient repeats this sequence several times to move the desired distance backward.

PROGRESSING THE PATIENT

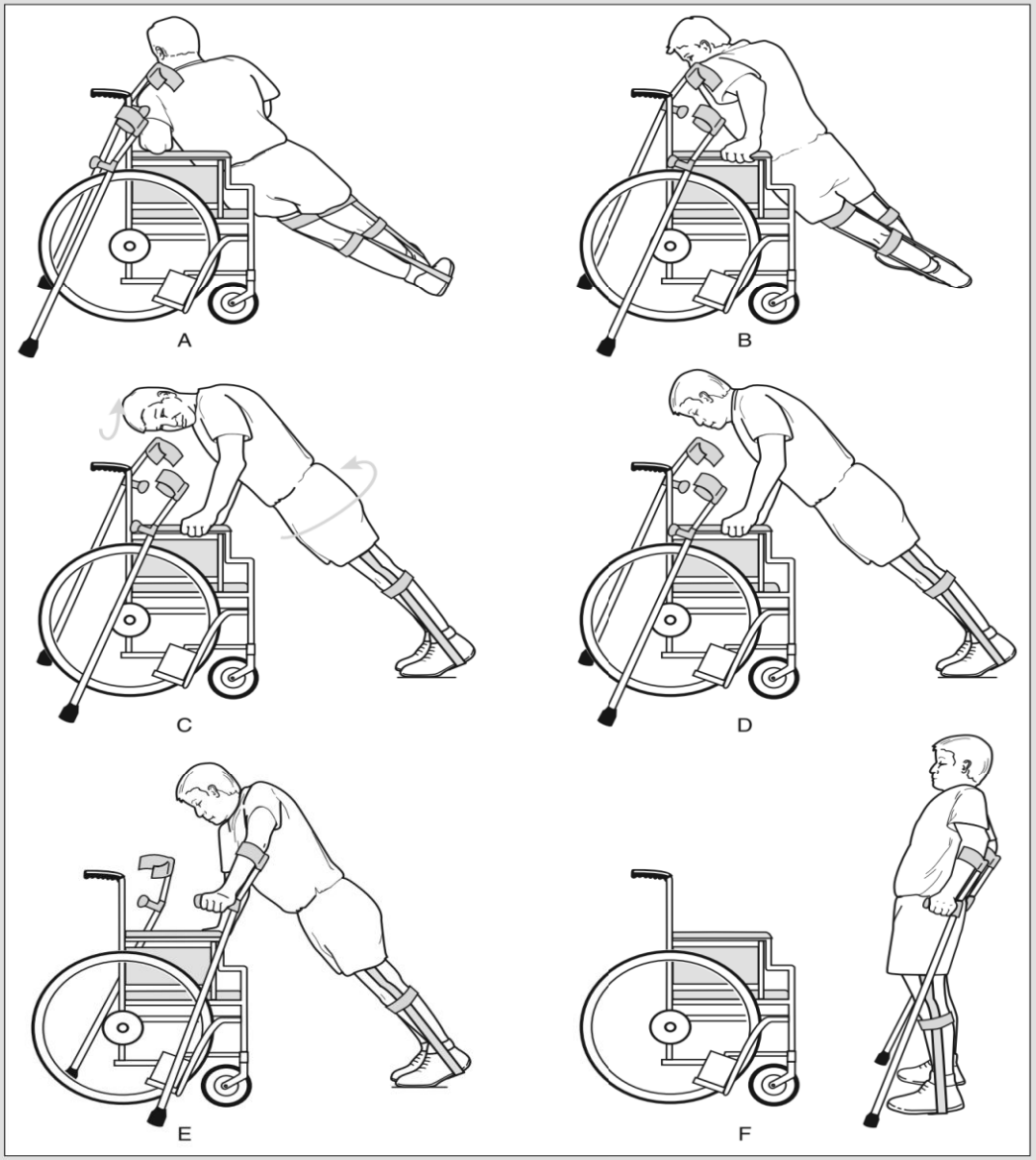
- ❑ After the patient has practiced ambulation in the parallel bars several times, it is time to progress to ambulation outside of them.
- ❑ To assist with this transition, the clinician may elect to introduce **Lofstrand (Canadian or forearm) crutches** while the patient is still ambulating in the parallel bars.
- ✓ **Care must be** exercised when practicing transitions into and out of the wheelchair. These techniques are best practiced with ***the back of the wheelchair positioned next to a wall*** **for greater safety.** In addition, the patient should check to make sure the ***wheelchair brakes are locked.***

STANDING FROM THE WHEELCHAIR

The first method described is probably the easiest.

- **Step 1.** The patient places the wheelchair against the wall and locks the brakes.
- **Step 2.** The patient places her crutches behind the wheelchair to rest on the push handles.
- **Step 3.** The patient moves to the edge of the wheelchair. The patient needs to complete mini–push-ups as she does this. Scooting forward can cause unnecessary shearing to the patient's skin.
- **Step 4.** With the orthoses locked, the patient crosses one leg over the other.
- **Step 5.** The patient then pivots over the fixed foot and pushes up to standing.
- **Step 6.** Holding on to the wheelchair armrest, the patient secures one crutch, positions it, and then secures the second crutch.
- **Step 7.** Once the crutches are in place, the patient backs up from the wheelchair, taking two or three steps backward. Intervention 13.28 shows the steps needed to transfer from sitting to standing with lower extremity orthoses and Lofstrand crutches.

INTERVENTION 13.28 **Sit-to-Stand Transfer With Orthoses**



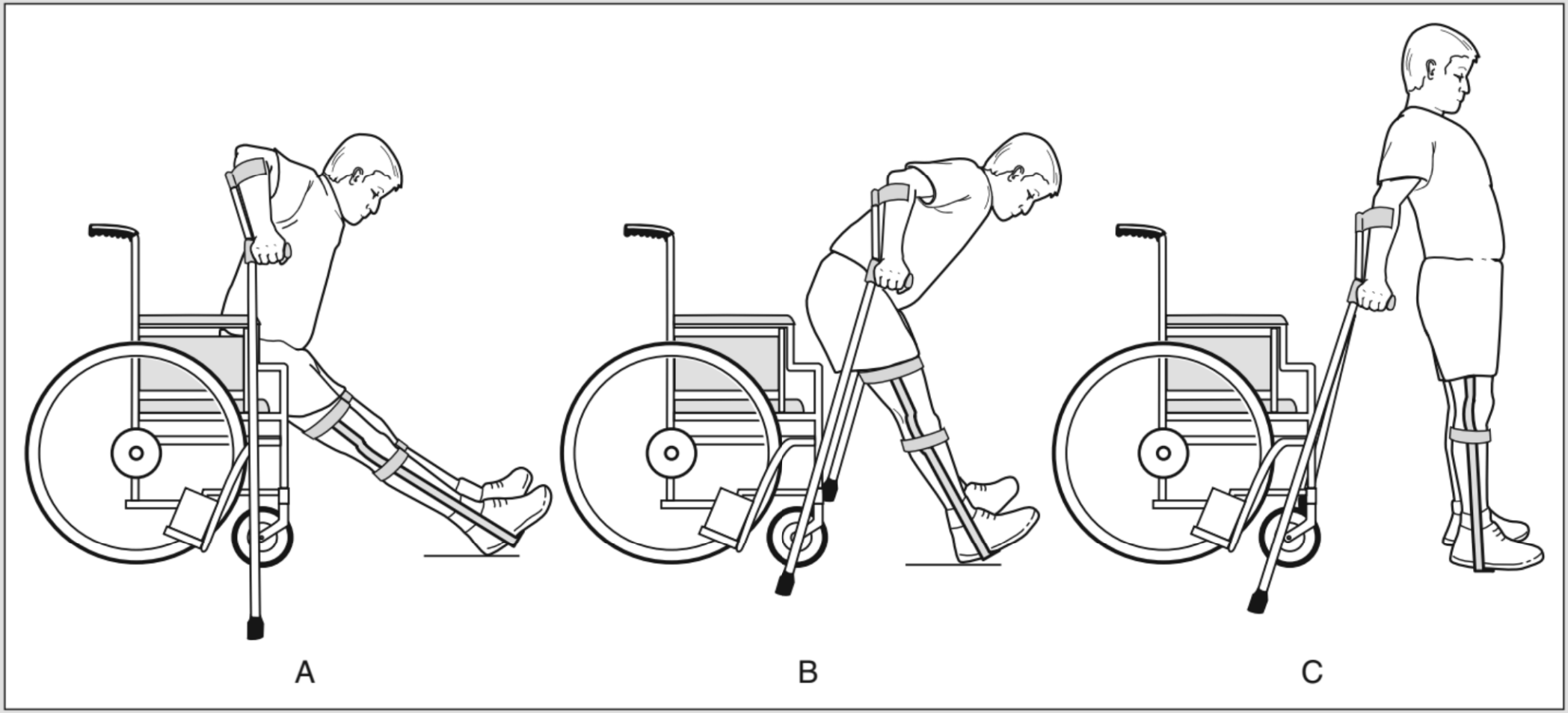
The sequence for transferring from sit to stand with lower extremity orthoses. (See text description on steps 1 through 7.)

AN ALTERNATIVE WAY OF STANDING FROM THE WHEELCHAIR

This technique can be less stressful to the hip joint than the one previously described.

- **Step 1.** The patient moves forward to the edge of the chair.
- **Step 2.** With the arms in the crutches, the patient places the crutches flat on the floor, slightly behind the front wheels.
- **Step 3.** The patient flexes his head and pushes down on the crutches to propel out of the wheelchair.
- **Step 4.** Once standing, the patient must quickly extend the head and trunk to regain the lumbar lordosis necessary for standing stability.
- **Step 5.** The patient's upper extremities remain behind until the patient feels he has regained balance. Then he can move the arms and crutches forward. Intervention 13.29 shows a patient completing this activity.

INTERVENTION 13.29 **Coming to Stand From the Wheelchair**



A. The patient flexes his head and upper trunk.
B. The patient uses the head-hips relationship and muscle action from the latissimus dorsi and triceps to push himself upright.
C. Upright standing.

ONCE THE PATIENT IS STANDING AND HAS REGAINED BALANCE, HE CAN BEGIN TO AMBULATE USING A SWING-THROUGH GAIT PATTERN, AS DESCRIBED PREVIOUSLY.

- **The clinician guards the patient from behind,** with **one hand** *on the gait belt* and the **other** on *the patient's posterior shoulder*, as depicted in Fig. 13.19.
- The clinician must be careful to avoid the tendency to apply *excessive tactile cues to the patient.*
- **Pulling on the gait belt** or i**mpeding the movement of the patient's upper trunk** may, in fact, cause the *patient to experience balance disturbances*.

Fig. 13.19 Patient with an injury at the T12 level ambulating with crutches and bilateral knee-ankle-foot orthoses for balance and lower extremity advancement.
(From Adkins HV, editor: *Spinal cord injury*, New York, 1985, Churchill Livingstone.)

TO REGAIN A SITTING POSITION AFTER WALKING,

- the following is recommended:
- **Step 1.** The patient faces the wheelchair initially.
- **Step 2.** The patient places the crutches behind the chair.
- **Step 3.** The patient unlocks one of the knee joints and rotates over that knee to assume a sitting position.

❑ **Patients can return to sitting using a straight-back method.**

This technique is difficult, however, and may best be used when:
a second person is present to assist with the transition to stabilize the wheelchair.

GAIT TRAINING WITH CRUTCHES

- As the patient begins ambulation training on level surfaces with the crutches, she once again needs to find her balance point.
- The patient must maintain the hands forward of the hips to prevent jack-knifing.
- Initially, the clinician may elect to perform **a swing-to gait pattern** with the patient.
- The clinician should guard the patient from behind by holding on to the gait belt as necessary.
- Some clinicians may find it easier to guard the patient from the side initially by holding on to the gait belt and placing the other hand on the patient's shoulder.
- Verbal and tactile cueing may be necessary to assist the patient with head positioning and the hyperlordotic posture.

GAIT TRAINING WITH CRUTCHES

Should the patient lose her balance and begin to jack-knife,
the clinician will push the patient's pelvis forward
+
bring the shoulders back to resume the hyperextended posture.

Because the patient will be moving relatively quickly,
the clinician will need to take bigger steps. As the patient becomes more proficient,
the patient can begin a swing-through gait pattern.

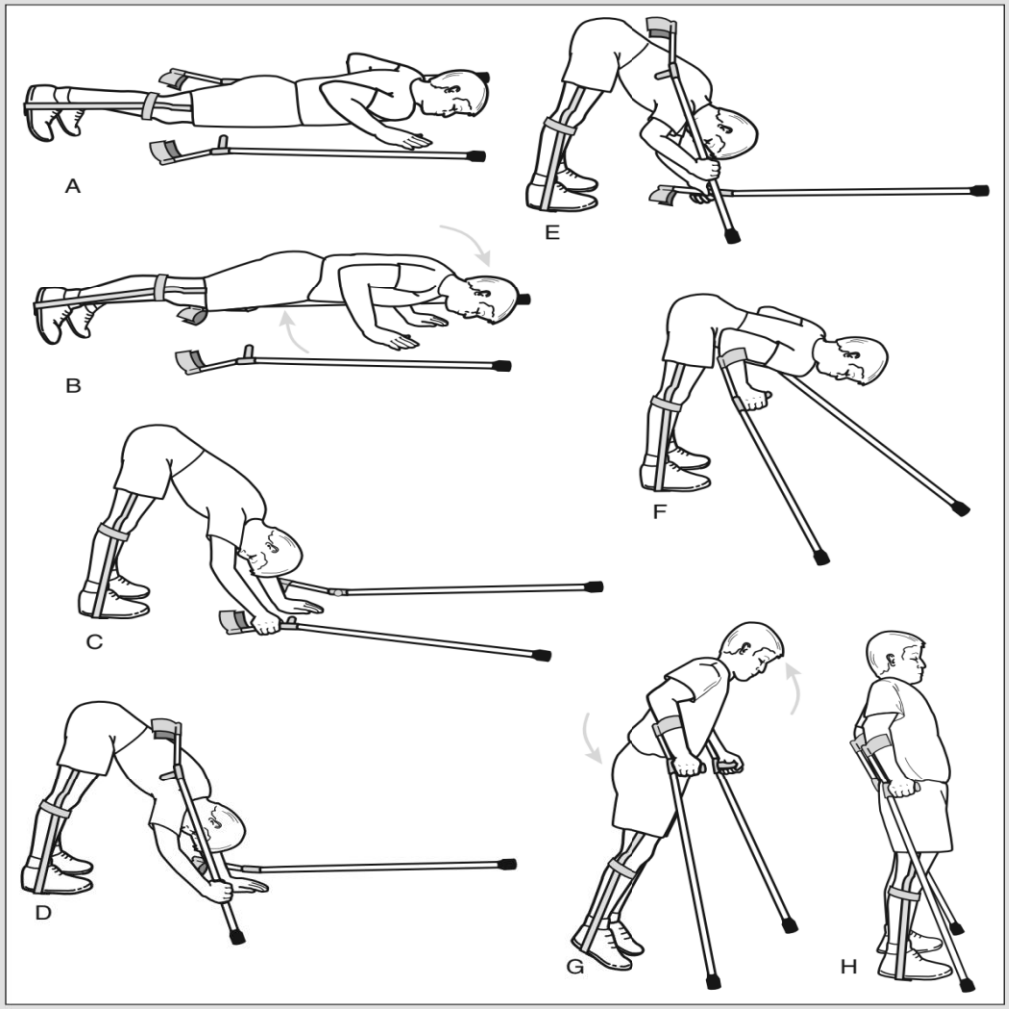
FALLING.

- ❑ You will want to have the patient fall onto a floor mat.
- ❑ **The patient is instructed to:**
- ✓ let go of the crutches and remove the hands from the handgrips.
- ✓ The patient then reaches toward the ground and flexes the elbows to avoid trauma to the wrist.
- ✓ Holding onto the gait belt, the therapist slowly helps to lower the patient to the floor.
- ✓ If the facility has a crash mat (these mats are higher and softer), having the patient fall onto it is an easier starting point for the patient.

GETTING UP FROM THE FLOOR.

- **Step 1.** The patient is instructed to assume a prone position on the floor.
- **Step 2.** The patient positions the crutches with the tips pointing toward the head and the hand gripping at the hips.
- **Step 3.** The patient pushes up to a plantigrade position. (The patient ensures that both orthoses are locked before attempting this maneuver.)
- **Step 4.** The patient reaches for one of his crutches and puts the crutch tip on the floor to assist in the transition to an upright position. The patient's hand is on the crutch handle, and the crutch rests against the shoulder.
- **Step 5.** The patient uses the crutch on the floor as a point of stability as he reaches for the other crutch and positions it on the forearm.
- **Step 6.** The patient turns the opposite crutch around and places the forearm cuff at his elbow region.
- **Step 7.** The patient regains balance with the crutches. Intervention 13.30 depicts this sequence.

INTERVENTION 13.30 **Getting Up From the Floor**



A. Instruct the patient to assume a prone position on the floor. Have the patient position the crutches with the tips pointing toward his head and the handgrips at the patient's hips.

B. The patient pushes up to a plantigrade position. (The patient will want to make sure that both orthoses are locked before attempting this.)

C. and **D.** The patient reaches for one of his crutches, using it for balance. The crutch rests against his shoulder.

E. and **F.** The patient uses the crutch on the floor as a point of stability as he reaches for the other crutch and positions it on his forearm.

G. and **H.** The patient regains his balance with the crutches.