Spinal Cord Injury

Johns Hopkins Orthopaedic Surgery Review Course

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Spinal Cord Injury

- Often seen w/ MVAs, falls, diving accidents, sports, GSWs
- Young adult males most often
- Two Types
  1. Complete-- No function after spinal shock
  2. Incomplete-- Varying patterns w/ sacral sensory sparing

Miller, MD. Review of Orthopaedics, 3rd Edition, 2000.

Disclosures

Consultant/Teaching
Zimmer Spine
Kyphon, Inc./Medtronic
OrthoFix/Blackstone Medical

Speaker Bureau
AO Spine North America

Equity
New Era Orthopaedics, LLC

Initial Evaluation

- **ABCs!**

CTQ

- Hemodynamic stability
- Concomitant head and or neck injury
- Blunt thoracic or abdominal trauma
- Pelvic fracture
- Extremity injury

Key Points

1. Treatment of Incomplete vs. Complete Neurologic Injuries
2. Differentiate Spinal and Neurogenic Shock
3. Central Cord Syndrome– Most Common (U > L)
4. Anterior Cord Sydrome– Worst Prognosis (L > U)
5. Brown-Sequard Syndrome– Best Prognosis
6. Posterior Cord Syndrome– Rare
7. Assign a Spinal Cord Functional Level
8. Diagnosis and Treatment of Cauda Equina Syndrome
9. Understand Specific Principles of Surgery for Spinal Cord Injury

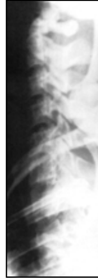
Physical Examination

- Most sensitive tool in diagnosis…
  -->initial neurologic examination
- Serial examinations are mandatory
- Motor Strength Grading

0	Total Paralysis
I	Palpable or Visible Contraction
II	Active FROM w/ Gravity Eliminated
III	Active FROM Against Gravity
IV	Active FROM Against Moderate Resistance
V	Active FROM against Full Resistance

Spinal Cord Injury: Diagnosis

- Initial--> C-Spine immobilization and good radiographs
- Must see C7-T1 CTQ
  -10% of C-Spine fractures are at C7-T1
- Lateral view detects 85% of C-Spine injuries



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Bulbocavernosus Reflex

- Easily tested distal reflex arc
- If a level of a reflex arc is physiologically and anatomically intact then it will function even if the cord above is severed
- May **not** recover if injury is at conus level

Neurologic Status: **Intact or Complete**

- Steroids of no use CTQ
- Urgent treatment

Spinal Shock

- Occurs immediately after spinal cord injury
- Spinal cord nervous tissue dysfunction due to physiologic reasons rather than structural damage
- Results in: flaccid paralysis, hypotonia, areflexia
- Bulbocavernosus reflex (BCR) absent during spinal shock CTQ
- When BCR returns--> spasticity, hyperreflexia, clonus

Neurologic Status: **Incomplete or Declining**

- Steroids best if within 3 hours CTQ
- Next best within 8 hours
- Emergent intervention

Neurogenic Shock

- Results from loss of autonomic reflexes
  -hypotension
  -bradycardia
- Attributed to sympathetic outflow disruption (T1 - L2) and unopposed vagal tone
- Treatment
  -invasive monitoring, fluids, vasopressors CTQ
- May coexist w/ hypovolemia

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Spinal Cord Injury: Autonomic Dysreflexia

- Sudden Hypertension, Pounding Headache, Flushing, Profuse Sweating, Blurred Vision, Nasal Congestion
- Potentially catastrophic hypertensive event
- Can occur w/ injuries above T5
- Usually caused by obstructed urinary catheter or fecal impaction

CTQ

Freedman MK, Fried GW. P&P of Spine Surgery, 2003.
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Frankel Classification

A - Absent motor and sensory

B - Sensation present motor absent

C - Sensation present motor present but not useful (grade 2-3)

D - Sensation present motor present and useful (grade 4)

E – Normal

REMEMBER: 1. Reverse Order
2. Motor Goes First, Then Sensory (Alphabetical)

Grading/Classification Systems

ASIA Classification

A – Complete
No Sensory or Motor Function Preserved in S4-5 Segments

B– Incomplete
Sensory but not Motor Function Preserved Below Neurologic Level and Includes S4-5 Segments

C– Incomplete
Motor Function Preserved Below Neurologic Level & More than Half of
Key Muscles Below Neurologic Level Have Muscle Grade < 3/5

D– Incomplete
Motor Function Preserved Below Neurologic Level & More than Half of \
Key Muscles Below Neurologic Level Have Muscle Grade > 3/5

E– Normal
Sensory and Motor Function Normal

REMEMBER: 1. Reverse Order

Maynard FM Jr. ASIA, 1996.

Motor Exam : Grading

0 Total Paralysis
I Palpable or Visible Contraction
II Active FROM w/ Gravity Eliminated
III Active FROM Against Gravity
IV Active FROM Against Moderate Resistance
V Active FROM against Full Resistance

Spinal Cord Injury

Functional Level Determined By:

1. Most Distal Intact Functional Dermatome (Sensory Level)
2. Most Distal Intact Motor Level > Grade 3-4/5 provided that next rostral level is 5/5

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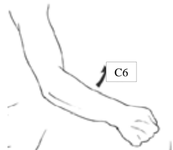
Example

- Motor
  - Deltoid 5/5
  - Biceps 4/5
  - Triceps 2/5
- Sensation
  - Thumb Intact (C6)
  - Middle Finger Absent (C7)



LEVEL: C6

C7	Independent in transfer to bed, car, and toilet Independent in dressing with equipment Propel manual and/or power wheelchair Independent with feeding Independent with bathing and other self-care activities Bowel/bladder program with some assistance
C8 to T4	Independent in all transfers Push wheelchair Independent with self-care skills Homemaking activities with assistance Independent with bowel/bladder program
T5 to T12	Independent in all self-care Able to do all of above more easily than with above levels of injury T12: Walk with walker and long leg braces (difficult and time consuming)
L1 to L5	Independent in all self-care Walking with short or long leg braces and crutches more easily than with T5- to T12-level injuries Independent with bowel and bladder program
S1 to S5	Able to walk if able to push off ground (may need brace) Independent in all activities Bowel/bladder and sexual functioning might still be impaired

(Reproduced with permission from Maynard FM Jr: International Standards for Neurological and Functional Classification of Spinal Cord Injury. Atlanta, GA, American Spinal Injury Association, 1996.)

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Spinal Cord Injury: Mobility

- Spinal cord injury level determines degree of mobility
- C4 and higher---> high back and head support
- C5---> mouth-driven accessories can control motorized WC
- C6---> manual wheelchair
  -and flexor hinge wrist and hand orthoses
- Transfers
  -C4--> Dependent
  -C5--> Assisted
  -C6--> Independent

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Spinal Cord Injury Syndromes

Spinal Cord Level/ Spinal Nerve	Possible Goals
C3 to C4	Control power wheelchair with sip-and-puff (mouth) or chin/head control Locomotion with modified independence Verbalize care Communicate through adaptive equipment
C5	Dress upper body (time consuming) Feed self with equipment Brush teeth, wash face with assistance Operate power wheelchair
C6	Dress upper body Dress lower body with assistance (time consuming) Groom self with equipment Perform bowel/bladder program with assistance Feed self with splints (hand or tenodesis splints) Transfer to/from wheelchair to bed, car, and toilet with some assistance Able to drive Propel power wheelchair May be able to push manual wheelchair if strength in shoulder permits

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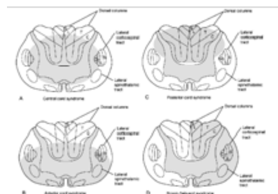
Incomplete Syndromes

- Maintain some level of function and potential for partial recovery

1. Central
2. Anterior
3. Brown-Sequard
4. Posterior
5. Single root



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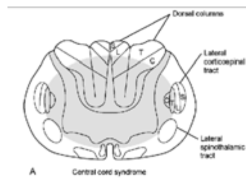
Central Cord Syndrome

- Most common
- Usually secondary to C-Spine extension in elderly w/ pre-existing stenosis
- Upper extremities more affected than lower
- Motor and sensory loss
- Perianal sensation preserved



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Posterior Cord Syndrome

- Rare
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- Loss of sensory function
  - -joint position
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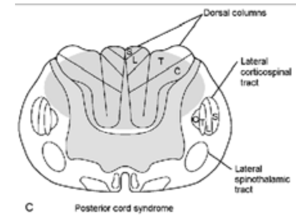
- Ambulation possible only with visual feedback



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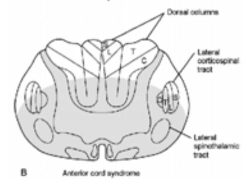
Anterior Cord Syndrome

- Less common
- Usually flexion-compression mechanism
- Lower extremities more affected than upper
- Posterior column sensory pathways preserved
- Worst prognosis
  (16% have neuro improvement)



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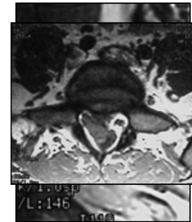
Cauda Equina Syndrome

- Severe low back pain
- Unilateral or bilateral sciatica
- Saddle Anesthesia
- Motor Weakness
- Loss or reduction in LE reflexes
- Varying degrees of bladder or rectal dysfunction

- Relatively rare
- Often missed



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Brown-Sequard Syndrome

- Penetrating injury
- Ipsilateral motor loss
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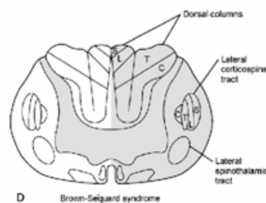
- Best prognosis for segmental recovery
  (90% of Patients)



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Rectal Exam

- **Orthopaedic**
- Tone
- Volitional control
- Sensory
  - light touch and pin prick (anal wink)

- **Trauma**
- Heme
- High riding prostate
- Mass or tumor
- Open pelvis

Cauda Equina Syndrome

- Immediate MRI or CT myelography for evaluation
- May consider urodynamic studies
- Emergent/urgent surgery for decompression
  - No minimally invasive procedures
  - Standard mid-line incision and wide decompression
- Outcomes better with surgery <48 hours than >48 hours

Lemma et al. P&P of Spine Surgery, 2003.
Ahn UM et al. Spine, 2000.
Kostuik JP, et al. JBJS, 1986.

Spinal Cord Injury: Surgery

- Spinal fusion in the Complete Patient
  -to expedite rehab and prevent late pain or deformity at fracture level
- Anterior and/or posterior fusion w/ instrumentation

Spinal Cord Injury: Treatment

- When traction is needed…
  -initial= 5-10 pounds w/ F/U radiograph
  -if no overdistraction present, additional weight = 5 pounds/level
- Unstable injuries
  -decompression, reduction and stabilization

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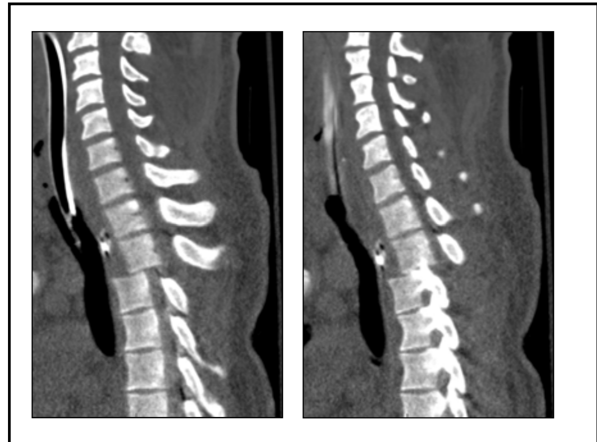

Spinal Cord Injury: Treatment

- Anterior decompression for incomplete SCI can improve neurologic outcome as late as one year after surgery
- Acute management
- Methylprednisolone
  -30 mg/kg bolus AND
  -5.4 mg/kg/hr x 23 hours if within 3 hours
  -5.4 mg/kg/hr x 47 hours if within 8 hours

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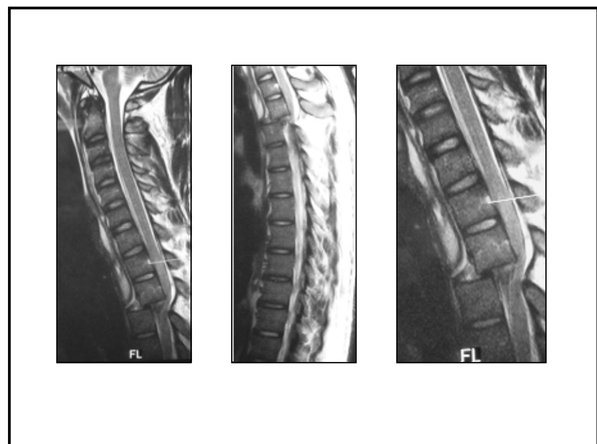

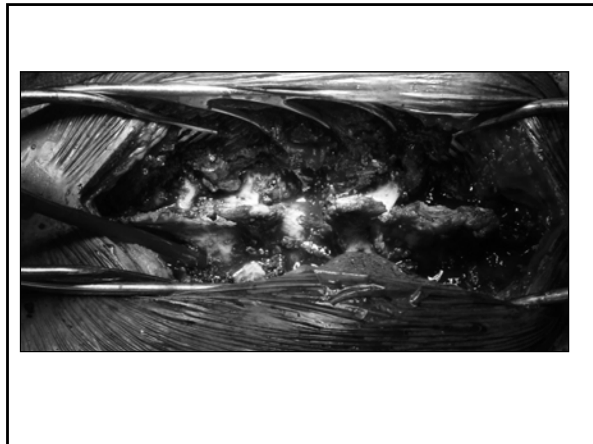

Spasticity & Contracture

- Can produce problems w/ hygiene or pressure ulcers
- Treatment Options
  1. Percutaneous or open motor nerve blocks w/ phenol
  2. Static Contracture:
     -Consider muscle release or disarticulation to improve
     sitting or transfer potential
  3. Tendon transfers in upper extremity

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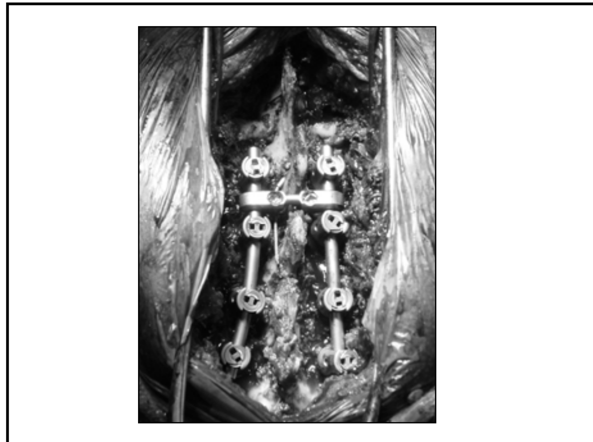

GSW to Spinal Cord/Spine

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- Nonoperative treatment unless direct passage through esophagus or colon
- Or progressive neurologic deterioration w/ proven neurologic compression w/ bullet, bony fragments or hematoma

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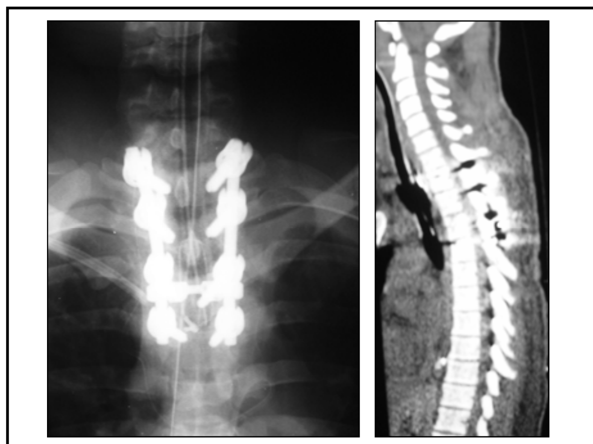

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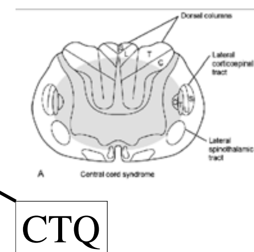

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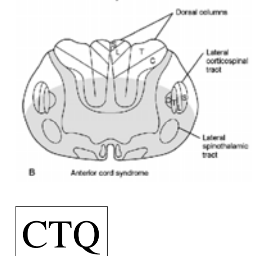
- Posterior column sensory pathways preserved
- Worst prognosis
  (16% have neuro improvement)



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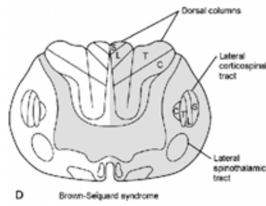

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  - Thumb Absent (C6)
  - Middle Finger Absent (C7)

LEVEL: C5

Posterior Cord Syndrome

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  - -joint position
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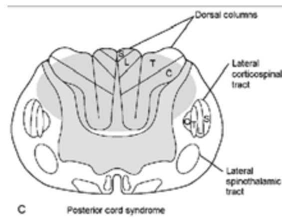
  - -deep pressure
- Ambulation possible only with visual feedback



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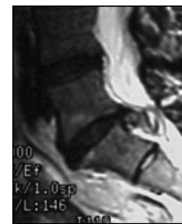

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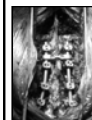

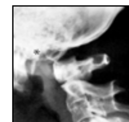

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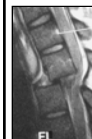

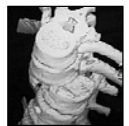

212. A 42-year-old man has severe low back pain, urinary retention, and saddle anesthesia. His medical history is unremarkable. What is the most likely diagnosis?

1- Spondylolisthesis
2- Cauda equina syndrome
3- Peripheral neuropathy
4- Herpes zoster infection
5- Cervical myelopathy

OITE, 2003

264. A 27-year-old man injures his neck in a motor vehicle accident. Neurologic examination reveals intact light touch and pinprick sensation. His deltoids and biceps are 5/5, and he has 3/5 strength in his left hand and 2/5 strength in the right hand. He has 4/5 strength throughout his left lower extremity and 4+/5 on the right side. His neurologic status could most accurately be classified as

1- complete cord injury.
2- posterior cord syndrome.
3- anterior cord syndrome.
4- central cord syndrome.
5- Brown-Sequard syndrome.

Preferred Response: 4

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Preferred Response: 2

OITE, 2003

250. An 18-year-old man sustained a transcolonic gunshot wound to the lumbar spine 2 hours ago. Examination reveals that the bullet passed through the L2 vertebral body and is lodged in the spinal canal. He has an incomplete sensory motor deficit at the L2 level. What is the best course of action?

Strict bed rest for 6 weeks
Excision of the bullet to improve motor recovery
Broad-spectrum antibiotics for no more than 48 to 72 hours
Anterior debridement of the involved vertebral body alone
High-dose IV methylprednisolone for 48 hours

OITE, 2004

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OITE, 2004

Radiographs of the cervical spine of a 73-year-old-man who fell down stairs reveal cervical spondylosis without evidence of fracture or dislocation. MRI and CT scans are consistent with the plain radiographs. After 72 hours, neurologic evaluation reveals intact sensation; however, weakness of the upper extremities is greater than that of the lower extremities. What is the most likely diagnosis?

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Preferred Response: 1

A 19-year-old man sustains a complete spinal cord injury at the C7 level as a result of diving into a lake. He has a blood pressure of 90/60 mm Hg, a pulse of 60/min, and respirations of 20/min. These values most likely signify

1- spinal shock.
2- neurogenic shock.
3- hypovolemic shock.
4- pulmonary embolism.
5- fat embolus syndrome.

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Preferred Response: 2

In which of the following anatomic sites will a patient with an early central cord syndrome resulting from a cervical fracture-dislocation have more neurologic dysfunction?

1- Central torso
2- Bowel and bladder
3- Upper extremities
4- Lower extremities
5- Sympathetic nervous system

In which of the following anatomic sites will a patient with an early central cord syndrome resulting from a cervical fracture-dislocation have more neurologic dysfunction?

1- Central torso
2- Bowel and bladder
3- Upper extremities
4- Lower extremities
5- Sympathetic nervous system

Preferred Response: 3

The end of spinal cord shock is signaled by the return of

1- normal bowel sounds.
2- spontaneous respirations.
3- the Hoffman reflex
4- the bulbocavernosus reflex
5- a bilateral Babinski reflex

Which of the following types of neural dysfunction is present with a cervical fracture-dislocation resulting in a Brown-Sequard neurologic injury?

1- Ipsilateral loss of pain and temperature recognition and contralateral loss of motor function
2- Ipsilateral loss of motor function and contralateral loss of pain and temperature recognition
3- Bilateral loss of pain and temperature recognition and unilateral loss of motor function
4- Bilateral loss of motor function and unilateral loss of pain and temperature recognition
5- Bilateral upper extremity loss of motr function and unilateral lower extremity loss of pain and temperature recognition

Preferred Response: 2

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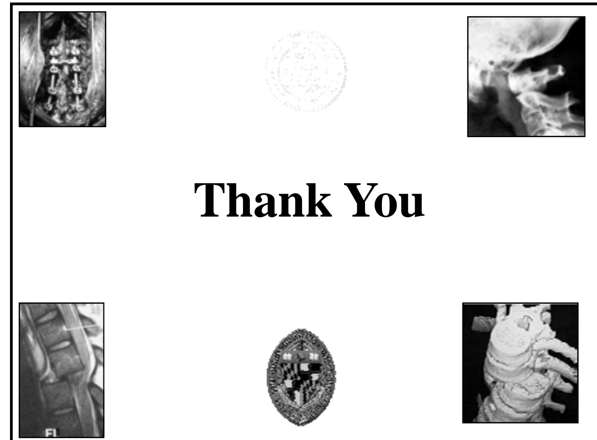
1- normal bowel sounds.
2- spontaneous respirations.
3- the Hoffman reflex
4- the bulbocavernosus reflex
5- a bilateral Babinski reflex

Preferred Response: 4



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