Neurology Cases
Discussion

Thomas K. Koch, MD
Professor of Pediatric Neurology
Medical Science University of South Carolina
Charleston, South Carolina
I have no relevant financial relationships with the manufacture of any commercial product and/or provider of commercial services discussed in this CME activity.

I do intend to discuss an unapproved / investigative use of a commercial product / device in my presentation.
Case 1: The Daydreamer

- 8 year old girl
- Referred to you for ADHD and inattention by teachers
- Parents notice her daydreaming even during dinner

What more do you want to know from history?

1. How often does it happen?
2. Gradual onset or “sudden pause”?
3. Can it be interrupted?
4. What is the best way to clinch the diagnosis quickly?
Case 2: Unusual Movements

- 4 year old male
- Normal development
- 6 month history of unusual movements & posturing

What more do you want to know from history?

1. What does it look like?
2. Does it always look the same?
3. Provoking factors?
4. Can it be suppressed?
Case 3: Floppy Baby

- 6 mo male with neonatal onset hypotonia
- Referred to ED for tachypnea evaluation
- ED exam:
  - RR 80-100, O2 sat 97% on RA
  - ECHO in ED: normal

What more do you want to know from history?

1. Can the infant oppose gravity?
2. Is there facial involvement?
3. Are all extremities equally involved?
4. Are there reflexes?
5. What is the next quickest test?
Case 4: Monthly Vomiting

- 7 year old girl
- 1 year history of episodic vomiting

What more do you want to know from history?

1. How often will she have vomiting?
2. How long will the vomiting last?
3. Is it associated with any dietary triggers?
4. Is there fever associated with it?
5. Is there headache associated with it?
6. What is the next step?
Case 5: Walking & Falling

- Otherwise normal boy without any prior gait problems
- One day onset
- Unsteady gait with frequent falls
- Recent viral illness

What more do you want to know from history?

1. Is there any pain?
2. Does he appear to be weak?
3. Does he always fall to one side?
4. Is there any vertigo?
5. What is the next step diagnostically?
Case 6: Progressive Leg Weakness

- 7 year old male
- 2 day history of progressive gait difficulty

What more do you want to know from history?

1. What was the onset?
2. Is there bowel / bladder dysfunction?
3. Any exposures / travel?
4. Preceding illness?
5. What are several key points on the examination?
Alternative Case

• Child refuses to walk and has back pain, with no ankle or patellar reflexes
  • He may be becoming weak in his arms and shoulders
• Sensation in legs is diminished slightly
• Catheterized with large amount of urine in his bladder
What test should you order first?

1. MRI of the spine
2. Lumbar puncture
3. Forced vital capacity
4. Nerve conduction velocity
NARRATIVES ARE PROVIDED AS A REFERENCE FOR THE CASE PRESENTATION SESSIONS.

IN ORDER FOR YOU TO ACHIEVE THE MOST BENEFIT FROM THESE SESSIONS, WE ASK THAT YOU DO NOT REFER TO THE NARRATIVES PRIOR TO ATTENDING THE CASE PRESENTATION SESSIONS
Neurology Cases

Faculty Disclosure Information

I have no relevant financial relationships with the manufacture of any commercial product and/or provider of commercial services discussed in this CME activity.

I do intend to discuss an unapproved / investigatory use of a commercial product / device in my presentation.

Presented by
Thomas Koch, MD
Case 1: The Daydreamer

- 8 year old girl
- Referred to you for ADHD and inattention by teachers
- Parents notice her daydreaming even during dinner and keeps wetting her lips
Differential of “staring episodes”

- Inattention
  - Normal daydreaming
  - ADHD

- Seizure
  - Absence seizure
  - Complex partial seizure
Case 1: More History

- PMHx:

- Family history:
  - Older brother with diagnosis of ADHD, dx at age 6

- Social history:
  - 2nd grade. Performing at grade level, but recent note of daydreaming interfering with class work

What more do you want to know from history?
3 KEY Questions

1. How often does it happen?
   - Multiple times per day

2. Gradual onset or “sudden pause”?
   - Sudden

3. Can it be interrupted?
   - No

Suspicious for seizure
Seizure Classification

- Categorization
  - Syndrome
    - Generalized
    - Localization-related
  - Seizure type
    - Generalized
      - Tonic-clonic
      - Tonic
      - Clonic
      - Absence
    - Atonic
    - Myotonic
    - Focal
      - Simple partial
      - Complex partial
      - Secondary Generalized

- Evaluation/Etiology/Prognosis
  - **Focal features on history/exam or EEG → MRI

- AED selection
Complex Partial Seizures

- Clinical features
  - “Complex”
    - Altered consciousness
  - “Partial”
    - Localized to one part of the brain
  - Can be only staring
    - Not to be confused with absence seizures

- Evaluation
  - EEG
  - Neuroimaging (MRI)

- Treatment
  - Carbamazepine
  - Oxcarbazepine
  - Phenytoin
  - Lamotrigine
  - Levetiracetam
  - Other broad spectrum AEDs

<table>
<thead>
<tr>
<th></th>
<th>CP sz</th>
<th>Absence sz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>30 sec-min</td>
<td>5-10 seconds</td>
</tr>
<tr>
<td>Frequency</td>
<td>Daily-weekly</td>
<td>Many per day</td>
</tr>
<tr>
<td>Automatisms</td>
<td>-</td>
<td>+++</td>
</tr>
</tbody>
</table>
Absence Epilepsy

- Formerly known as petit mal
  - Must differentiate from daydreaming

- Clinical:
  - Most common age of onset 3-7
  - Often associated with automatisms
  - 30-50% will have GTC’s

- Evaluation:
  - EEG with 3/sec spike wave discharges
  - Hyperventilation can be helpful
  - MRI not necessary

**Treatment**

- **GOOD**
  - Ethosuximide
  - Valproate
  - Lamotrigine
    - Clonazepam
    - Topiramate
    - Zonisamide
    - Ketogenic diet
    - VNS

- **BAD**
  - Carbamazepine
  - Oxcarbazepine
  - Phenytoin
    - Gabapentin
    - Vigabatrin
    - Tiagabine
What is the best way to clinch the diagnosis of absence epilepsy quickly?

1. 30 minute EEG
2. Sleep-deprived EEG
3. 24-hour video EEG
4. MRI
5. None of the above
Childhood absence epilepsy

• Onset ages 3-7 years
• **Etiology**  - Genetic - complex
• Otherwise normal child
  • May have some intercurrent learning issues or behavioral abnormalities
• 30% with generalized tonic clonic seizures
• MRI is **not** needed
• EEG is “icing on the cake” – 3 Hz spike-wave
Prognosis & Treatment

- Most will outgrow by puberty...but can be pharmaco-resistant

- Drug of choice: **ethosuximide** 20 mg/kg/day divided BID (250 mg/5 cc solution)
  - CBC, LFT’s first
  - Can cause stomach upset

- If GTC’s (or no response): **valproate** 20-40 mg/kg/day divided BID (125mg sprinkle caps; 250 mg/5 cc solution)
  - CBC, LFT’s first
  - Can cause weight gain
Case 2: Unusual Movements

- 4 year old male
- Normal development
- 6 month history of unusual movements & posturing
Differential of “movements”

- Behavioral/self-stimulation
- Seizure
- Movement disorder
  - Ataxia*
  - Chorea
  - Athetosis
  - Dystonia
  - Stereotopy
  - Tic
  - Myoclonus
  - Tremor
Diagnosis?

1. Complex Partial Seizures
2. Stereotypies
3. Autism
4. Tourette’s Syndrome
Case 2: More History

• PMHx:
  • Birth at term. No complications. Normal development.

• Family history:
  • Parents and sibs healthy. Grandfather with Parkinson disease.

• Social history:
What more do you want to know from history?
3 KEY Questions

1. Does it always look the same?
   - Yes, since he was 2 years

2. Provoking factors?
   - Excitement, nervousness

3. Can it be suppressed?
   - He will stop when instructed to

Suspicious for stereotypy
Stereotypy

• **Clinical:**
  - Onset <3 years
  - Involuntary, repetitive, rhythmic
  - Fixed pattern
  - Last minutes-hours
  - Suppressible with distraction
  - Increased with excitement, stress, anxiety and when engrossed
  - Hand waving, arm flapping, head nodding, body rocking

• 25% positive family history

• **Prognosis:**
  - Complex stereotypies can persist
  - 18% develop tics*

Harris, KM., Pediatric Neurology, 2008;38:267-272
## Tics vs. Stereotypies

<table>
<thead>
<tr>
<th></th>
<th>Tics</th>
<th>Stereotypies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age Onset</strong></td>
<td>6-7 yrs</td>
<td>&lt; 3 yrs</td>
</tr>
<tr>
<td><strong>Pattern/type</strong></td>
<td>Variable</td>
<td>Fixed</td>
</tr>
<tr>
<td><strong>Movements</strong></td>
<td>Blinks, grimace, shrug</td>
<td>Flapping, waving</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>Brief</td>
<td>Prolonged</td>
</tr>
<tr>
<td><strong>Premonitory urge</strong></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>Precipitant</strong></td>
<td>Stress, anxiety</td>
<td>Excitement</td>
</tr>
<tr>
<td><strong>Suppression</strong></td>
<td>Brief</td>
<td>With distraction</td>
</tr>
<tr>
<td><strong>Family Hx</strong></td>
<td>Frequent</td>
<td>Rare</td>
</tr>
<tr>
<td><strong>Treatment</strong></td>
<td>Neuroleptics</td>
<td>Not indicated</td>
</tr>
</tbody>
</table>
Case 3: Floppy Baby

- 6 mo male with neonatal onset hypotonia
- Referred to ED for tachypnea evaluation
- ED exam:
  - RR 80-100, O2 sat 97% on RA
  - ECHO in ED: normal
Case 3: More History

• Birth history:
  • 38 6/7 wk by C/S for fetal distress, nuchal cord
  • Apgars 5 & 8
  • Meconium aspiration w/intubation x 24-48 hours
  • Birth weight 5 lbs 9 oz (5th percentile)
  • 2 ½ weeks in NICU
• Bilateral equinovarus deformity
• Hypotonia since birth
  • Evaluated with MRI and EEG in NICU
  • MRI: “small, scattered lesions in white matter” thought to be hemorrhage
  • Improving w/PT

• Family History:
  • First child to non-consanguineous parents
  • Mother 37 yrs, Father 42 yrs
  • No known neurologic disease

• Developmental History:
  • Does not lift head in prone, roll over or sit
  • Fixes/follows, grasps objects
  • Smiles, alerts to sounds, coos

• ROS:
  • Tires with feeds
  • Coughs with liquids>solids
  • Tachypnea since birth per parents
Case 3: Physical Exam

- Weight 6kg (3-5\textsuperscript{th}%), Length 63cm (10-25\textsuperscript{th}%)
- General: Alert, NAD
- Head:
  - 40cm (<3%), AF open, soft
  - Non-dysmorphic, high arched palate
- Respiratory:
  - Pectus excavatum
  - Tachypneic but not distressed
- CV/Abd/GU: Normal
- Skin: Normal
Case 3: Neurological Exam

• Mental Status:
  • Alert, interactive, smiles, coos

• Cranial Nerves:
  • PERRL, EOMI, fixes/follows, blinks to threat, face symmetric, tongue midline w/o fasciculation

• Motor:
  • Hypotonic, head lag
  • Some spontaneous, anti-gravity movement of distal extremities, no proximal movement

• Reflexes:
  • 2/4 bilaterally

• Sensory:
  • Responds to touch all extremities
Differential of Hypotonia

- Cerebral
- Spinal cord (very rare)
- Anterior horn cell
- Peripheral nerve (rare)
- Neuromuscular junction
- Muscle
Cerebral Hypotonia

• **Clinical Features:**
  • Hypotonia > weakness
  • Other features suggesting CNS involvement:
    • Seizures
    • Altered level of consciousness
    • Micro/macrocephaly
    • Dysmorphisms

• **Etiologies:**
  • Central Nervous System Malformations
    • Lissencephaly/holoprosencephaly
  • Diffuse CNS dysfunction/encephalopathy
    • HIE
  • Metabolic disorders
    • Amino/Organic acidemias
    • Mucopolysaccharidoses
    • Hypothyrioidism
  • Chromosomai disorders
    • Down syndrome
    • Fragile X
  • Single gene disorders
    • Prader-Willi
Spinal Cord Disorders

- Clinical Features:
  - Quadriplegia with facial sparing
  - Sensory impairment
  - Impaired sphincter function

- Etiologies:
  - Hypoxic-ischemic myelopathy
  - Trauma
  - Congenital malformations

Rare!
Motor Neuronopathies
(Anterior Horn Cell)

- Clinical Features:
  - Weakness of legs > arms (distal)
  - Absent reflexes
  - Sparing of the face
  - Normal sphincter tone
  - Paradoxical breathing
    - Strong diaphragm and weak chest/abdominal wall

- Etiologies:
  - Spinal muscular atrophy
  - Poliomyelitis
Peripheral Neuropathies

• **Clinical Features:**
  - Distal weakness and sensory loss
  - Absent deep tendon reflexes

• **Etiologies:**
  - Congenital hypomyelinating polyneuropathy
  - Hereditary motor sensory polyneuropathies
    - Dejerine-Sottas syndrome (CMT III)
  - Acquired polyneuropathy
    - Acute inflammatory demyelinating polyneuropathy
Neuromuscular Junction Disorders

• Clinical Features:
  • Weakness of bulbar, facial and extraocular muscles
  • +/- limb weakness
  • Fatigability

• Etiologies:
  • Myasthenic syndromes
    • Congenital myasthenia
    • Neonatal transient myasthenia gravis
    • Autoimmune myasthenia
  • Infantile botulism
Primary Muscle Disorders

- Clinical features:
  - Generalized weakness

- Specific features:
  - Dystrophy:
    - Markedly elevated CK
    - +/- Eye/Brain defects

- Myopathy
  - Congenital myopathies
    - Central core disease
    - Myotubular myopathy
    - Nemaline myopathy
    - Congenital fiber type disproportion

  - Metabolic myopathies
    - Acid maltase deficiency
    - Phosphofructokinase deficiency
    - Cytochrome-c-oxidase deficiency
    - Carnitine dependency
    - Mitochondrial myopathies

- Muscular Dystrophy
  - Congenital muscular dystrophy
  - Myotonic muscular dystrophy
  - Fascioscapulohumeral (FSH) dystrophy
Case 3: Evaluations

- CBC: normal
- CMP: ALT 85, AST 131
- CK: 54,000 (DOL#2)

Congenital muscular dystrophy ↓
Muscle biopsy / Gene Testing
Muscle Biopsy

H&E 20X

Normal
laminin α2

α-dystroglycan

G.R.
Case 4: Monthly Vomiting

- 7 year old girl
- 1 year history of episodic vomiting

Courtesy of the late Dr. Don Lewis
Differential of recurrent vomiting

- Food allergy
- GI disease
- Endocrine disorders
- Metabolic disease
- Neurologic disease
  - Increased ICP
  - Migraine/migraine variants
    - Cyclic vomiting syndrome
    - Abdominal migraine
    - Including catamenial migraine
  - Autonomic dysfunction
  - Seizure-- Panayiotopoulos syndrome
Cyclic Vomiting Syndrome

- First described in 1806
- Girls:Boys
  - 55%:45%
- Age of onset – 5.5 yrs
  - Diagnosis – 7.8 yrs
  - Resolution – 9.8 yrs
- Periodicity
  - 2-4 weeks
- Duration of attacks
  - 1-5 days

- Stereotyped episodes
  - Pernicious vomiting
  - Early morning onset
  - Prodrome: pallor, anorexia, nausea, abdominal pain
  - Intervals of wellness
- Migraine Variant
  - Headache – 40%
  - Photo/phonophobia
  - Vertigo
- 80% family history of migraine
- 75% develop classic migraine
Cyclic Vomiting Syndrome
ICHDI I

• > 5 attacks
• Episodic attacks of nausea and vomiting
• 1-5 days in duration
• Vomiting > 5 times/hr for at least 1 hr
• Symptom-free between attacks
• Not attributed to another disorder
  • GI
  • Metabolic
  • Renal
# Cyclic Vomiting Syndrome

## Treatment of Acute Attacks

- IV rehydration
- Sedation
  - Lorazepam
  - Diphenhydramine
- Anti-emetics
  - Ondansetron
    - IV: 0.3-0.4 mg/kg q 4-6h
    - PO: 4-8 mg q 4-6h
- Triptans

## Preventative Treatment

- Amitriptyline
- Cyproheptadine
- Beta Blockers
- Topiramate
- Flunarizine
Case 5: Walking & Falling

- Otherwise normal boy without any prior gait problems
- One day onset
- Unsteady gait with frequent falls
- Recent viral illness
Differential of unsteady gait

- Acute cerebellar ataxia
- Guillain Barre syndrome
- Transverse myelitis or spinal trauma
- Viral myositis
- Cauda equina syndrome (injury, tumor)
- Opsoclonus myoclonus syndrome
- Non-neurologic etiology
  - Drug/Toxic exposure
  - Conversion Disorder
  - Orthopedic – toxic synovitis, osteo, hip disease
  - Labyrinthitis
  - Tick Paralysis

What more do you want to know from history?
3 KEY Questions

1. Is there any pain?
   - No

2. Does he appear to be weak?
   - No

3. Does he always fall to one side?
   - Yes, to the right

Suspicious for primary vestibular/cerebellar etiology
# Neurologic Signs

<table>
<thead>
<tr>
<th>Sign</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absent reflexes</td>
<td>Guillain Barre syndrome</td>
</tr>
<tr>
<td>Sensory level, urinary retention</td>
<td>Transverse myelitis or spinal trauma</td>
</tr>
<tr>
<td>Reproduced calf pain</td>
<td>Viral myositis</td>
</tr>
<tr>
<td>Saddle anesthesia, urinary retention or fecal incontinence</td>
<td>Cauda equina syndrome (injury, tumor)</td>
</tr>
<tr>
<td>Ataxia</td>
<td>Acute cerebellar ataxia</td>
</tr>
<tr>
<td>Darting eye movements</td>
<td>Opsoclonus myoclonus syndrome</td>
</tr>
<tr>
<td>Astasia abasis</td>
<td>Conversion</td>
</tr>
</tbody>
</table>
Vertigo

Environment is rotating relative to the patient
- Localizes to the vestibular system
- Both peripheral and central nervous system components

- **Etiology**
  - Otitis media
    - Mastoiditis, cholesteatoma
  - Migraine headache
    - 19% of children have vertigo as part of aura
  - Benign paroxysmal vertigo of childhood
    - Brief (<1 min) recurrent episodes
    - Occur in clusters over several days
    - Usually remits by 5 years of age
    - Frequently family history of migraine → may evolve to migraine
  - Trauma/Toxic
  - CNS infection
Labyrinthitis

• Dizziness, vertigo
• Loss of balance with falling to one side
• Nystagmus
• Hearing loss
• Tinnitus
• Nausea, vomiting

**Treatment**

• Improves in days to weeks
• Symptomatic
• Antihistamines
• Medicines such as compazine to control nausea and vomiting
• Medicines to relieve dizziness, such as meclizine or scopalamine
• Sedative-hypnotics such as Valium
Case 6: Progressive Leg Weakness

- 7 year old male
- 2 day history of progressive gait difficulty
Case 6: More History

- Previously healthy, normal development
- Minor head trauma 2 days prior to presentation, no LOC, returned to baseline
- Unsteady gait noted by neighbor → ED
  - HCT normal
  - D/C home
- Awoke from sleep with bilateral leg pain
  - Difficulty walking independently
- Seen by PCP
  - Refusal to walk
  - Reflexes present but possibly diminished at the ankle
  - Referred to ED

What more do you want to know from history?
3 KEY Questions

1. Is there bowel/bladder dysfunction?
   - Yes

2. Any exposures/travel?
   - No

3. Preceding illness?
   - Yes, gastroenteritis 1 week ago

Can we narrow our differential?
Differential diagnosis of weakness

- Brain
  - Brain stem stroke
  - Encephalitis
- Spinal cord
  - Compressive lesion
  - Transverse myelitis
- Anterior horn cell
  - Poliomyelitis
  - West Nile virus
- Peripheral nerve
  - Guillain-Barré syndrome
  - Diphtheria
  - Acute intermittent porphyria
  - Vasculitis
  - Heavy metal intoxication
  - Tick paralysis
- Neuromuscular junction
  - Myasthenia gravis
  - Botulism
- Muscle
  - Periodic paralysis
  - Hypokalemia
  - Acute myopathy

Where does this localize?
Differential Diagnosis

- Brain
  - Brain stem stroke
  - Encephalitis
- Spinal cord
  - Compressive lesion
  - Transverse myelitis
- Anterior horn cell
  - Poliomyelitis
  - West Nile virus
- Peripheral nerve
  - Guillain-Barré syndrome
  - Diphtheria
  - Acute intermittent porphyria
  - Vasculitis
  - Heavy metal intoxication
  - Tick paralysis
- Neuromuscular junction
  - Myasthenia gravis
  - Botulism
- Muscle
  - Periodic paralysis
  - Hypokalemia
  - Acute myopathy

Exam?
Case 6: Physical Exam

- VS: Temp 36.6°C, BP 109/63, HR 33 RR 18 SpO2 98%
- General
  - Thin male, moaning in bed, neck supple
- Neurologic:
  - MS: alert and responsive young boy in moderate distress due to generalized pain. Intact orientation, attention, language and memory.
  - CN: normal
  - Motor:
    - Difficult secondary to diffuse pain and poor effort, but tone appeared decreased throughout
    - At least 3/5 strength in all extremities and is able to sit independently for 1-2 seconds
  - Sensation:
    - Intact to light touch, temperature and vibration in the toes bilaterally
  - Reflexes:
    - 2/4 in UE, 1/4 at knees and trace at the ankles bilaterally
  - Toes are mute
- Coordination:
  - No evidence of ataxia

Few key exam pieces missing...
### Key exam items...
**often forgotten or deferred**

<table>
<thead>
<tr>
<th>Item</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spinal level?</td>
<td>No</td>
</tr>
<tr>
<td>Peri-anal sensation?</td>
<td>Intact</td>
</tr>
<tr>
<td>Rectal tone?</td>
<td>Normal</td>
</tr>
</tbody>
</table>

- **Spinal cord lesion**
  - Infarct
  - Compressive lesion

- **Peripheral nerve**
  - **Guillian-Barre**
  - Tick paralysis
  - Toxic
Guillain-Barré Syndrome

Clinical Presentation

• Main features:
  • Acute/subacute symmetric ascending paralysis
    • Progression over days-weeks, peak by 4 weeks
  • Motor > sensory
  • Weakness both proximal and distal
  • Globally depressed/absent reflexes

• Other features:
  • Pain (more common in children)
  • Cranial nerve or bulbar involvement
    • Facial nerves often affected
  • Autonomic involvement
    • Urinary retention, ileus, tachycardia, hyper- or hypotension, arrhythmias

• Epidemiology:
  • 2/3-3/4 have infection in preceding 6 weeks

• Vaccines:
  • Slight increase in number of cases following 1976 swine flu vaccination
  • No significant risk with current influenza vaccine (1992-1994 1 case/million vaccines)
Guillain-Barré Syndrome

Neurologic Examination

**Clinical:**
- Motor weakness >>> sensory loss
- Weakness out of proportion to atrophy
- Areflexia
- Note: Ataxia is a frequent presentation in children

**CSF:** “cytoalbuminologic dissociation”
- Elevated protein (80%)
  - May be normal early in disease
- Normal WBCs

**EMG/Nerve conduction:**
- Demyelinating
  - Slow conduction velocities
  - Prolonged F-wave latency

**MRI:** enhancement of lumbar nerve roots

**Other serologic evaluation:**
- Electrolytes, HIV, ESR, CK, heavy metals, AChR, urine porphobilinogen, stool/serology for C. jejuni
Guillain-Barré Syndrome
Treatment/Outcome

• Treatment:
  • AAN Practice Parameter
    • Plasmapheresis and IVIG effective
    • Steroids are NOT effective (6 trials)
  • What about ambulatory patients:
    • Plasmapheresis helpful in 1 study in adults

• Outcome:
  • 4-15% mortality in adults (very rare in children)
  • 20% have residual disability (much better in children)
  • Severity and rapid onset are predictive factors of worse outcome
  • 8-16% relapse
Alternative Case

- Child refuses to walk and has back pain, with no ankle or patellar reflexes
  - He may be becoming weak in his arms and shoulders
- Sensation in legs is diminished slightly
- Catheterized with large amount of urine in his bladder
What test should you order first?

1. MRI of the spine
2. Lumbar puncture
3. Forced vital capacity
4. Nerve conduction velocity
Transverse myelitis

Tumor

Disc herniation - injury