REVIEW OF RADICULOPATHY

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Overview
- Introduction
- Pathophysiology of Radiculopathy
- Electrophysiologic exam of Radiculopathy
- Cervical Radiculopathy
- Lumbar Radiculopathy
- Practice Questions

WHY DO WE PERFORM EMG FOR RADICULOPATHY?

Why do we perform EMG for radiculopathy?
A Tale of Three Foot Drops

A. 32-year old female with paresthesias after recent 50-lb weight loss when she joined a cross-fit gym
   - Fibular neuropathy ("slimmer’s palsy")

B. 60-year old male with HIV on antiretrovirals referred for frequent falls
   - ALS

C. 48-year old male with hemiparesis secondary to stroke, now with acute on chronic back pain
   - L5 radiculopathy

PATHOPHYSIOLOGY OF RADICULOPATHY

Why do we EMG?

- "Extend" the physical exam
- Confirm suspected clinical diagnosis
- Rule out competing diagnoses (peripheral neuropathy, plexopathy)
- Characterize the localization and pathologic mechanism of the disease process
- Assess extent/severity of disease process
- Assess for subclinical disease
- Assess for acuity/chronicity of disease process
- Assist with determining prognosis/response to specific treatment interventions

Nerve Root Anatomy

- Dorsal Root (Sensory)
  - Cell bodies for the sensory axons are in the dorsal root ganglion
- Ventral Root (Motor)
  - Cell bodies are the Anterior Horn Cells
- Ventral and Dorsal Root combine
  - Mixed spinal nerve
  - Exits through neuroforaminal space

PATHOPHYSIOLOGY OF RADICULOPATHY
**Spinal Nerve Anatomy**

- Spinal Nerve divides into:
  - Posterior primary (Dorsal) rami
    - Innervates the paraspinal muscles
    - Sensory to overlying skin
  - Anterior primary (Ventral) rami
    - To the trunk and limbs
    - Motor and sensory

**Pathophysiology of Radiculopathy**

- **Etiology**
  - Herniated Disc
    - 25% of Cervical
    - More common for lumbar
  - Foraminal stenosis
    - 75% of Cervical
  - Tumors
  - Infections
    - Lyme disease
    - Herpes-zoster
  - Age dependent
    - < 50 disc pathology
    - > 50 nerve compression secondary to DJD
    - Foraminal stenosis

**Pathophysiology of Nerve Injury**

- **Sensory vs. Motor**
  - Sensory fibers
    - Most commonly affected
    - Can not detect by needle EMG
  - Sensory and Motor
  - Rare motor only
- Demyelinating vs. Axonal
  - Mixed
  - Related to amount and duration of compression

**Key Point**

- Radiculopathy occurs proximal to DRG
Electrophysiologic evaluation of radiculopathy

- Nerve conduction studies
- Late responses
  - F waves
  - H reflex
- Somatosensory Evoked Potentials (SEP)
- Motor Evoked Potentials (MEP)
- Needle Electrode Exam (NEE)

Nerve conduction studies

- Purpose:
  - Assess for peripheral neuropathy
  - Assess severity of radiculopathy

- Recommendations (AANEM Practice Parameter):
  - 1 motor
  - 1 sensory

- What is the expected finding (if any) in a motor nerve conduction study in the setting of radiculopathy?

H-reflex

- Purpose:
  - Assess for peripheral neuropathy
  - Supplement an evaluation for S1 radiculopathy

- Latency or amplitude?
  - >1.0-1.8 ms side to side difference
  - >50% side to side amplitude difference or < 1mV
  - Caveat: studies of sensitivities vary from 33 to 100%
  - Absent in only 8% of healthy 60-88 year olds in one study
  - Benefit: assess sensory pathways that are neglected with needle electrode exam

- Downsides:
  - Only assess C6/7 and S1 roots
  - Can be normal in radiculopathy when fibers involved in the reflex are spared
  - Abnormal H reflex can reflect many other peripheral conditions
  - H reflex may not return following nerve root injury
**F-waves**

- **What:**
  - Antidromic stimulation of motor nerves
- **What assessed:** motor nerve patency
- **What is measured:**
  - Minimal latency
  - Mean latency
  - Chronodispersion
  - Size
  - Persistence

**Purpose:**
- Screen for polyneuropathy
- Supplement radiculopathy eval (controversial)

**Caveat:** Low sensitivity for radiculopathy (13-69%) → Abnormal segment "dilated" in normal axon.

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**Somatosensory Evoked Potentials**

- **What:**
  - Stimulation over mixed or cutaneous nerve or dermatome
  - Record over peripheral nerve, spine, scalp
  - Generally, not used for radiculopathy evaluations

**Motor Evoked Potentials**

- **Nerve root stimulation**
- **Transcranial magnetic stimulation**

- Essentially, nerve conduction studies with proximal stimulation over spine or nerve roots
- Not in wide clinical use
Needle Electrode Exam: Spontaneous Activity

- Abnormal Spontaneous Activity
  - Positive sharp waves
  - Fibrillation potentials
  - Complex repetitive discharges
  - Fasciculations
- Timecourse of presentation:
  - Paraspinals: ~7 days
  - Limbs: 3 weeks
  - Resolve: proximal -> distal

Needle electrode Exam: MUAP analysis

- What is normal?
  - Buchthal studies defined normal ranges of amplitudes and duration
- Polyphasia
  - <20% polyphasics considered normal
- Amplitude
  - Dependent on type of needle electrode (monopolar/concentric)
- Recruitment
  - Reduced recruitment

Needle Electrode Exam: Sensitivity

- How many muscles?

<table>
<thead>
<tr>
<th>Source</th>
<th># muscles</th>
<th>Sensitivity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AANEM, 1999</td>
<td></td>
<td>50-71%</td>
</tr>
<tr>
<td>Dillingham, 2000</td>
<td>4 w/o PSP</td>
<td>35-75</td>
</tr>
<tr>
<td></td>
<td>4 w/PSP</td>
<td>77-90</td>
</tr>
<tr>
<td></td>
<td>5 w/o PSP</td>
<td>50-77</td>
</tr>
<tr>
<td></td>
<td>5 w/ PSP</td>
<td>84-91</td>
</tr>
<tr>
<td></td>
<td>6 w/o PSP</td>
<td>62-79</td>
</tr>
<tr>
<td></td>
<td>6 w/ PSP</td>
<td>67-93</td>
</tr>
<tr>
<td></td>
<td>8 w/o PSP</td>
<td>73-80</td>
</tr>
</tbody>
</table>

Needle electrode exam

- How many muscles?
  - 6, including paraspinals
  - “In order to avoid harm, 6 in the leg and 6 in the arm” - Dillingham
- Which muscles?
  - In the suspected root:
    - One proximal
    - One distal
    - Two different peripheral nerves
  - In the nerve root above suspected level
  - In the nerve root below suspected level
  - Paraspinals
Needle electrode exam: Specificity

- Needle EMG in asymptomatic subjects (Tong et al., 2006)
- 30 patients
- ages 55-79
- Specificity depends on criteria set
  - Abnormalities in 2 limb plus PSP’s, two limbs or one limb plus PSP’s
    - If fibs/PSW’s required than 100% specificity
    - If only polyphasia > 30% required than specificity > 67-97
    - If only polyphasia > 20% required than specificity > 60-77
- So if you require fibs/PSW’s for diagnosis you will have very few false positives

Paraspinal Muscle Examination

- Fibs/PSW’s indicate axonal lesion near the interspinal canal
  - Helps to rule out a plexus injury
  - Most paraspinals have multilevel innervation so difficult to localize
  - Multifidus has monosegmental innervation

Paraspinal Muscle Examination

- Radiculopathy occurs proximally
  - PSP’s should be affected
- Plexopathy occurs distally
  - PSP’s should be normal

Paraspinal Muscle Exam- Caveats

- Abnormal Paraspinals ≠ Radiculopathy
  - Myopathy
  - Neuropathy
  - Motor Neuron Disease

- Controversy- Is paraspinal denervation seen in normals?
  - Gilad et al (2006): up to 92% of persons >40 had denervation in C-spine
  - Date et al (2006): 12% of normals had C-spine denervation, 14.5% had L-spine denervation
  - Dumitru (2001): 4% prevalence in lumbar paraspinals
Electrophysiologic evaluation of radiculopathy- timing of study

- Week 1:
  - Reduced recruitment
  - Prolonged or absent H-reflex
  - Prolonged or absent F-waves
  - Prolonged or absent SEP
  - "early polyphasic"

- Week 2:
  - Positive waves in paraspinals
  - Possibly decreased CMAP amplitude

- Week 3:
  - Abnormal findings in limb muscles

Differential Diagnosis for Cervical Radiculopathy

- Cervical myelopathy
- Motor neuron disease (Monomelic amyotrophy/Hirayama disease)
- Brachial plexopathy/ amyotrophy (Parsonage-Turner)
- Peripheral neuropathy
Cervical Radiculopathy

- C7 > C6 > C8 > C5
- H reflex: FCR (C6/7 root)
- CMAPs for prognosis:

<table>
<thead>
<tr>
<th>Root</th>
<th>Nerve conduction Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>C6</td>
<td>Infraspinatus</td>
</tr>
<tr>
<td>C7</td>
<td>Lateral head triceps</td>
</tr>
<tr>
<td>C8</td>
<td>Pronator quadratus</td>
</tr>
<tr>
<td>T1</td>
<td>Abductor digit minimi</td>
</tr>
</tbody>
</table>

Upper extremity myotomal chart

Differential Diagnosis for Lumbar Radiculopathy

- Lumbar spinal stenosis
- Motor neuron disease
- Lumbar plexopathy
- Peripheral neuropathy
  - Tibial neuropathy
  - Peroneal neuropathy
  - Meralgia paresthetica
  - Peripheral polyneuropathy

LUMBAR RADICULOPATHY
Lumbar Radiculopathy

- L5 > S1 > L4
- H-reflex: gastroc/soleus

Lumbar Disc Herniation Pattern

- L4-L5 disc herniation affecting L5 Root
- L5-S1 disc herniation affecting both L5 and S1 roots
- Large central disc at L4-L5 causing cauda equina

Lower extremity myotomal chart

High-Yield Muscles
Practice Question #1

- A 35-year-old gentleman presents to your clinic with pain radiating from the right low back to the right lateral leg and dorsal foot. Physical exam reveals weakness in right great toe extension. Which needle electrode study would be most appropriate?

1. RFEM, ATIB, PTIB, MGAS
2. ATIB, PTIB, MGAS, RFEM, SHBF, LGAS
3. ATIB, PTIB, MGAS, VMED, TFL, PSP
4. RFEM, ADD, ATIB, PTIB, MGAS, LGAS, SHBF

Practice Question #2

- Your favorite local football hero presents to your office with a stinger sustained on the field over the weekend (4 days ago). He has persistent pain in a C5 distribution. His coach requests urgent Edx evaluation. What finding may yield helpful information at this point?

1. CMAP amplitude
2. H reflex latency
3. Recruitment in limb muscles
4. Spontaneous denervation in the paraspinals

Summary

- EMG is the most useful tool for diagnosis of radiculopathy
  - Moderate sensitivity
  - High specificity
  - “In order to avoid harm...”

- Nerve conduction studies should be included in the electrophysiologic eval of suspected radiculopathy
  - Help exclude competing diagnosis
  - In radiculopathy, decreased amplitude of CMAP or SNAP uncommon but do occur, should prompt additional evaluation
“Surround the abnormal with normal”

Thank you!

Resources

- AAEM Minimongraph #32: The Electrodiagnostic Examination in Patients with Radiculopathies

Other works cited

- "Brachial Plexus Logical Schematic" by Chris Talbot - Own work. Licensed under CC BY-SA 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Brachial_Plexus_Logical_Schematic.svg#mediaviewer/File:Brachial_Plexus_Logical_Schematic.svg
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