RADICULOPATHY
AND ITS ELECTRODIAGNOSIS

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MUSCLES WITH UNUSUAL INNERVATION

- Pronator teres and ECRL are C 6-7
- Posterior tibial muscle is almost pure L-5, but NOT innervated by the peroneal nerve
- Gluteus medius is L-5, but NOT innervated by the sciatic
- Gluteus maximus is S-1, but not sciatically innervated
MUSCLES WITH UNUSUAL INNERVATION

- Rhomboid has only C-5 innervation
- Anterior tibial can be L-4, L-5 or both
  - Explains why some have foot drop with L-5 and some do not
- Biceps femoris
  - Long head is L-5 and medial division of sciatic
  - Short head is L-5 and lateral division of sciatic
Avoid false positive findings

- Avoid muscles that are commonly injected such as middle deltoid, and gluteus maximus (UOQ)

- Be wary of findings if bleeding occurs in the pin hole site
  - Don’t over sample a muscle
TIME SEQUENCE TO EDX FINDINGS IN RADICULOPATHY

What you find on electrodiagnostic studies of radiculopathy is usually a function of HOW LONG AFTER ONSET YOU STUDY THE PATIENT.
Progression from mild to severe:

- **Focal demyelination**
  - Reflex loss, slowed H reflex

- **Conduction block**
  - Decreased strength & sensation

- **Axonal loss**
  - Decreased strength
  - Muscle atrophy

From Wilbourn, Aminoff 1988
EDX FINDINGS WITH CONDUCTION BLOCK

Step IV:
- Reduced number of motor units firing
- Prolonged H reflex

These are the only changes regardless of when you study the patient...immediately or weeks later
EDX FINDINGS IN AXONAL LOSS

- Immediately
  - Step IV: Reduced number of motor units firing
  - Prolonged H reflex

- After 3 Days
  - Step IV: Reduced number of motor units firing
  - Prolonged H reflex
  - Positive waves in the paraspinals
EDX FINDINGS IN AXONAL LOSS

- After 3 Weeks
  - Step IV: Reduced number of motor units firing
  - Prolonged H reflex
  - Step II: Positive waves and fibrillations

- After 3 Months
  - Same as above, but
  - Fibs and positive waves are smaller
  - Complex Repetitive Discharges
  - Step III: Motor units neuropathic
Polyphasicity of motor units is by itself the least reliable sign of radiculopathy.

Be careful about making the diagnosis of radiculopathy on polyphasicity alone.
Are Paraspinals Always Positive?

- Conventional Wisdom: One-third of cases will have findings only in the paraspinals, one-third only in the extremity, and one-third in both.
  - Johnson & Melvin 1971 at Ohio State

- 40% of cervical and 20% of LS radiculopathies only had paraspinal findings
  - Czyrny and Lawrence 1996 in Buffalo
Are Paraspinals Always Positive?

- Haig says almost all radiculopathy cases have paraspinal findings on mapping
  - Haig et al 1993
  - They found in 50 patients that paraspinal mapping was more sensitive than peripheral EMG
Paraspinal Abnormalities in Normals?

- 15% of normals have positive waves and fibs in the LS paraspinals...and this rises with age
  - Date et al from Stanford 1996

- Using a paraspinal mapping technique, Haig found that normal subjects have “few, if any, electromyographic abnormalities in the paraspinal muscles.”
  - Score was 1.11 for normals, 12.18 for those with radiculopathy
  - Haig et al 1995 from Milwaukee
Paraspinals are Multisegmental

1966: Gough and Koepke (Arch PM&R)

Used SCI patients to compare lowest level
  - Sensation
  - Voluntary motor function
  - EMG MUAP’s in paraspinals

Cervical and Lumbar Paraspinals had innervation as much as 6 levels below the anatomic injury level
Localize Root with Paraspinals?

- Conventional Wisdom: You localize only with the limb muscles
  - Johnson of Ohio State and Kimura of Japan

- Multifidus muscle is always innervated by the nerve exiting below the spinous process from which they originate

- Rebuttal: Multifidus muscle is polysegmentally innervated.
  - [Wu PB, Date ES, Kingery WS. Electromyogr Clin Neurophysiol. 740 Dec;40(8):483-5].
Localize Root with Paraspinals?

- Needle techniques for the multifidus (lumbar)
  - Valencia and Munroe 1985
  - Haig et al 1991 from Vermont
  - Haig says multifidus muscles in the cervical spine are thin and hard to hit with EMG pin
But is the Multifidus segmentally innervated?

- Multifidus muscle is polysegmentally innervated.
  - [Wu PB, Date ES, Kingery WS. Electromyogr Clin Neurophysiol. 740 Dec;40(8):483-5].
  - Series of L5 and S1 radiculopathies – found EMG paraspinal muscle abnormalities at multiple levels
PROBLEMS WITH EMG IN RADICULOPATHY

- Transient Radiculopathy
  - Nerve is under pressure too short a time to have changes necessary for EMG abnormalities
  - Commonly seen in Lumbar spinal stenosis syndrome

- Pure Sensory Radiculopathy
  - Some radiculopathies give no motor root changes
  - Braddom estimates about 10% are sensory
Problem of Widespread Paraspinal Abnormalities in Radiculopathy

- Due to multisegmental innervation of roots?
- Chemical irritation of a number of roots by a single herniated disc?
  - Kang et al 1995 showed that excised herniated discs showed metalloproteinase activity, nitric oxide, prostaglandin E2 and interleukin-6
  - Presumably some or all of these could chemically irritate nerve roots, giving abnormal muscle membrane irritability
Problem of Previous Surgery Scar

- Scars cause abnormal muscle membrane irritability

- Wilbourn said no universally accepted way of circumventing this

- Ernie Johnson says you’re OK if more than 3 cm. away from the scar
  - But other studies have not confirmed this

- Look at the amplitude of the fibrillations…old ones are small, new ones are large (Kraft)
One Root

- Odom found that 80% of radiculopathies involve only one nerve root...and Honet found that 2/3rds of cervical were C-7
- Try to make a one nerve root radiculopathy diagnosis
- Since having more than one root abnormal is unusual, if the pattern of EMG abnormalities covers more than one root:
  - Consider brachial plexopathy or other causes of abnormalities
EMG is still the most popular study for radiculopathy diagnosis

- Survey by Braddom (unpublished) of 10 recognized EDX experts about their favorite study for radiculopathy (1997)
  - All preferred standard needle EMG…even those who have written about other techniques for radiculopathy
  - Most studies have shown EMG to be the most sensitive electrodiagnostic study
EMG vs MRI in Radiculopathy DX

- MRI has many false positives
- MRI is anatomy, EMG is physiology

Example: EMG vs MRI for acute L5 radic

- 26 consecutive EMG proven unilateral L5
- Only 9 had isolated MRI L5 root compression
  - 14 had multi-root compression on MRI
  - 3 normal MRI
- Study excluded those with neuropathy, etc.

This can occur but:
- Usually only in severe lesions or
- When more than one root is involved
- Most muscles have dual innervation

Braune and Wunderlich (Germany) found no amplitude differences in 57 LS radiculopathy patients (1997)
Nerve Root Stimulation Techniques

- Most studies used the technique of MacLean
  - Berger 1987 100% abnormal in cervical radiculopathy
  - Tsai 1994 78% abnormal in cervical radiculopathy
  - Chang 1990 94% abnormal in LS radiculopathy

- But a number of authors have shown that the stimulation is of peripheral nerves, not nerve roots
  - Evans, Daube, Litchy 1990
  - Mills and Murray 1986
Magnetic Stimulation of Nerve Roots

- Cervical region normals by MacLean 1994
- LS region normals by Chokroverty et al 1989
- Banerjee et al 1993 found abnormal latency in all with motor deficit from LS radiculopathy, and in 36% of those with sensory deficit only.
- Cauda equina stimulation studies by Maccabee et al (Brooklyn) 1997 have shown correlation with EMG in radiculopathy...using latencies.
Nerve Root Stimulation not accepted

“With the commercial stimulators that are presently available in the United States, neither needle or magnetic stimulation of nerve roots is accepted as sufficiently reliable in producing supramaximal stimulation of demyelinated nerve roots to be included in these criteria.

SNAP IS SPARED

- Compression or injury in radiculopathy is usually proximal to the dorsal root ganglion (sensory ganglion)
- SNAP is spared, even if the patient has complete numbness clinically
SEP’s in Radiculopathy?

- Most experts feel that major nerve SEP’s are **not** helpful in radiculopathy, mainly because peripheral nerves are multisegmental.

- Sensory nerve (dermatomal) SEP’s utility for radiculopathy diagnosis is also controversial:
  - Various studies have reported dermatomal SEP’s to be from 25-95% sensitive in radiculopathy diagnosis.
  - Wilbourn only 7 of 28 obvious L5 and S1 radiculopathies had an abnormal DSEP.
ARE DSEP’S HELPFUL IN RADICULOPATHY?

- Report of the AAN Therapeutics and Technology Assessments Subcommittee
- “At present, there is no evidence that DSEP findings provide any reliable information beyond the routine clinical examination and there is no evidence to suggest DSEPs are superior to already established neurophysiologic techniques.”
- Neurology 1997;49:1127-1130
Randy’s Rule of Thumb

- Avoid False Positive EMG Reports
- Your referring physicians don’t mind false negatives (no study or test is 100% sensitive)
- They will be bothered by false positives
ELECTRODIAGNOSIS IN RADICULOPATHY

- Safe
- Relatively Inexpensive
- Accurate
- Studies actual nerve root physiology
- Few false positives or negatives
- Relatively pain-free
- Tells type of pathology
- Gives prognostic information