1935 Big Ten Championships
Jesse Owens set
Four World Records in
One hour during the finals.
Then went on to Berlin in ’36.

Jesse Owens Memorial Plaza
The Ohio State University

EDX of Lumbosacral
Radiculopathy and
Plexopathy

William S. Pease, M.D.

Several slides are from the
Ernest W. Johnson, MD Collection

Ultra EMG
May 10 – 13, 2017
Nationwide Conference Center
Lewis Center, Ohio
First examine the patient!
To plan the EMG.

First examine the patient!
Moderate weakness in a muscle
gives best EMG information.
Lumbar Radiculopathy

- EDX diagnosis Matters!
- Forero study
- 21 EDX+ LS Radic
- 17 EDX- LS Radic
- Conservative PMR Tx
- No ESI or surgery
- 81% improved
- 41% improved

Forero J. Archives of Physical Medicine and Rehabilitation 2013;94:1287-92

Lumbar Radiculopathy

- Annaswamy 2012
- 70=n
- All received ESI (1 or 2)
- EDX+ n=41
- EDX- n=19
- Others uncertain or not in F/U
- Mean improvement pain Function
  - 2.2/10  7.65
  - 0.78/10  3.2
- Both p<0.001

Lumbar Radiculopathy

• Annaswamy 2012

Chronology of L/S radiculopathy

• When radicular pain begins:
  – Recruitment will be reduced (if significant weakness)
  – H reflex latency will be prolonged
  – Early “polyphasic MUP’s” will appear
Muscles to explore

• Paraspinals
• Same root but 2 different nerves
• One proximal muscle
• One distal muscle
• One muscle ABOVE suspected root level
• One muscle BELOW suspected root level

Must verify that it is a FOCAL injury by surrounding abnormal with normal

Contralateral limb relating to those most abnormal
Polyphasic MUP’s

• Definition – those more than 4 phases
• Collateral innervation
  – Begins by 3-4 weeks
• Repetitive discharge polyphasic MU’s
  – Relative refractory period is shortened
  – Hyperventilation; tetanus; alkalosis
• Ephaptic co-activation of motor units

Motor unit in Radiculopathy

• As collateral reinnervation proceeds:
  – Begins at 3-4 weeks
  – Long duration polyphasic MUP (w/satellite)
  – 6-9 months MUP simplifies and increases in amplitude
  – Recruitment pattern would be difficult to evaluate if only minor weakness
Collateral reinnervation polyphasic MUP

Anterior Tibial M.

Collateral reinnervation polyphasic MUP
Needle EMG Abnormalities - chronology

- 1st week – recruitment frequency will be increased
- By 7-8 days – positive waves in paraspinals
  \(\textit{Caution}\) – a train will result if in end plate area!
- 3rd week – abnormal irritability in paraspinals and proximal limb muscles
- 4th week all findings
- Sensory nerve responses NOT affected

Chronology of Motor unit

- Collateral re-innervation begins at 3-4 weeks
- Continues for several months
- MUP’s grow larger as sprouts mature
- At 1 year most spontaneous activity is gone and recruitment will be larger MUP’s and mild reduced RF
“Early polyphasic”

• LAMBERT IN 1968 (EEG.CL NEUROPHYSIOL 25:404):
  – A polyphasic MUP can be:

  • A SYNCHRONOUS BUT NOT SIMULTANEOUS ACTIVATION OF 2 OR MORE MUP’S

KATZ & SCHMITT

Ephaptic activation between two nerve axon fibers
J.Physiol.1940.97:471
Case Y at FMC (prison) April ’13

• Left lower limb weakness and cramping 6-8 weeks ago. Began with acute pain then weakness, some paresthesias.
• Now pain, weakness and paresthesias have resolved (6 weeks to get to EMG lab).
• No back pain.
• Strength, sensation and reflexes normal.
• He still wanted to know what happened and if it could return.

Case Y at FMC April ‘13

• Sensory NCS

<table>
<thead>
<tr>
<th>Site</th>
<th>Unit</th>
<th>Peak (μV)</th>
<th>Norm Peak (μV)</th>
<th>P-T (m/s)</th>
<th>Norm P-T (m/s)</th>
<th>Site</th>
<th>Unit</th>
<th>Peak (μV)</th>
<th>Norm Peak (μV)</th>
<th>P-T (m/s)</th>
<th>Norm P-T (m/s)</th>
<th>Dist (cm)</th>
<th>Vel (m/s)</th>
<th>Norm Vel (m/s)</th>
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</thead>
<tbody>
<tr>
<td>Left Sural Anti Sensory (Lat Mall)</td>
<td>T:29.4</td>
<td>3.4</td>
<td>&lt;4.0</td>
<td>11.2</td>
<td>&gt;6.0</td>
<td>Calf</td>
<td>Lat Mall</td>
<td>3.4</td>
<td>14.0</td>
<td>41</td>
<td>&gt;35</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>P:2.5</td>
<td>13.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12.2</td>
<td></td>
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</tr>
</tbody>
</table>

NCS [Left Sural Anti Sensory]

Normal

20 µV/div
2 ms/div
Case Y at FMC April ‘13

• Motor NCS

<table>
<thead>
<tr>
<th>Site</th>
<th>NR</th>
<th>Onset (ms)</th>
<th>Norm Onset (ms)</th>
<th>O-P Amp (mV)</th>
<th>Norm O-P Amp</th>
<th>Site1</th>
<th>Site2</th>
<th>Delta-0 (ms)</th>
<th>Dist (cm)</th>
<th>Vel (m/s)</th>
<th>Norm Vel (m/s)</th>
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<tbody>
<tr>
<td>Left Peroneal Motor (Ext Dig Brev)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ankle</td>
<td></td>
<td>4.1</td>
<td>&lt;6.1</td>
<td>1.1</td>
<td>&gt;2.0</td>
<td>B Fib</td>
<td>Ankle</td>
<td>6.2</td>
<td>26.5</td>
<td>43</td>
<td>&gt;40</td>
</tr>
<tr>
<td>B Fib</td>
<td></td>
<td>10.3</td>
<td>0.6</td>
<td></td>
<td>0.6</td>
<td>Poplt</td>
<td>B Fib</td>
<td>1.9</td>
<td>8.0</td>
<td>42</td>
<td>&gt;40</td>
</tr>
<tr>
<td>Poplt</td>
<td></td>
<td>12.2</td>
<td>0.6</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Distal stim gives small response with normal latency time, and this suggests Axon loss. Proximal stim shows further loss of amplitude and increased duration = Temporal dispersion, and this suggests myelin disruption. ie, both conduction block and dispersion are likely present. NCV slowing is not seen at the knee, no entrapment there.

• Needle EMG

<table>
<thead>
<tr>
<th>Side</th>
<th>Muscles</th>
<th>Nerve</th>
<th>Root</th>
<th>Inn Act</th>
<th>Fibs</th>
<th>Psw</th>
<th>Amp</th>
<th>Dur</th>
<th>Poly</th>
<th>Recrt</th>
<th>Int Pat</th>
<th>Comme nt</th>
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<tbody>
<tr>
<td>Left</td>
<td>Vastus Med</td>
<td>Femoral</td>
<td>L2-4</td>
<td>Nml</td>
<td>Nml</td>
<td>Incr</td>
<td>Nml</td>
<td>1+</td>
<td>Reduced</td>
<td>50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>Ant Tibialis</td>
<td>Dip Br Peron</td>
<td>L4-5</td>
<td>Nml</td>
<td>1+</td>
<td>3+</td>
<td>Incr</td>
<td>Nml</td>
<td>0</td>
<td>Reduced</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>Gastroc</td>
<td>Tibial</td>
<td>S1-2</td>
<td>Nml</td>
<td>Nml</td>
<td>Incr</td>
<td>Nml</td>
<td>0</td>
<td>Reduced</td>
<td>Nml</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>L4</td>
<td>Rami</td>
<td>L4</td>
<td>Nml</td>
<td>Nml</td>
<td>Incr</td>
<td>Nml</td>
<td>0</td>
<td>Reduced</td>
<td>Nml</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>L5</td>
<td>Rami</td>
<td>L5</td>
<td>Nml</td>
<td>Nml</td>
<td></td>
<td>Nml</td>
<td>0</td>
<td>Reduced</td>
<td>Nml</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>Ext Hal L</td>
<td>Dip Br Peron</td>
<td>L5, S1</td>
<td>Nml</td>
<td>Nml</td>
<td>Incr</td>
<td>Nml</td>
<td>0</td>
<td>Reduced</td>
<td>Nml</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>Adductor Lon</td>
<td>Obturator</td>
<td>L2-4</td>
<td>Nml</td>
<td>Nml</td>
<td>Nml</td>
<td>Nml</td>
<td>0</td>
<td>Nml</td>
<td>Nml</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>Biceps Femoral</td>
<td>Femoral</td>
<td>L2-3</td>
<td>Nml</td>
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<td>Nml</td>
<td>0</td>
<td>Nml</td>
<td>Nml</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Summary

- Mild Lumbar Radiculoplexopathy can present like LS radiculopathy, NEMG abnormalities can be limited to paraspinal muscles only.
- Most recover adequate function to walk.
- Autoimmune/inflammatory cause is suggested by pathology. Myelin destruction playing a role, and leading to good prognosis.
- Treatment by immune suppression is often given, methylpred or IVIG is w/o strong evidence support in this infrequent problem.

EDX of Lumbar radiculopathy

- Prone position is best for relaxation of spine extensors
- Land marks
  - Mark L-4 spinous process at level of iliac crest
  - Mark L-5 – next caudal spinous process
  - Mark S-1 – next caudal spinous process
  - Draw diagonal line from post. sup. iliac spine to midline
L5 root is most often affected by L4-L5 disc in lateral gutter
Lacks mobility

Recruitment frequency

- In normal muscles the 2d MU will appear when the 1st MU is firing 10-12 hz
- Compare with contralateral muscle

- Easiest – a **single** joint muscle
  - (ie, soleus rather than gastrocnemius)
Recruitment frequency

- Increased in radiculopathy
  - EG. L-5 radiculopathy (EXT Dig long)
    - Normal – 10-12 Hz
    - \( \text{RI} = \frac{1000 \text{ ms}}{10 \text{ Hz}} = 100 \text{ ms} \)
    - Abnormal – 16-20 Hz
    - \( \text{RI} = \frac{1000 \text{ ms}}{16 \text{ Hz}} = 62 \text{ ms} \)
EDX for prognosis

- Stimulate nerve to weak muscle and note CMAP amplitude
- Compare with ‘normals’
- Compare with contralateral if asymmetric weakness

PROGNOSIS

- FOR L-5 – record CMAP of ext dig long
- FOR S-1 - record CMAP of soleus or medial head of gastrosoleus
- FOR L-4 – record CMAP of ant tib or vastus lat
CLINICAL WEAKNESS
BUT...
NORMAL AMPLITUDE "M"
H-REFLEX OF PAUL HOFFMANN, M.D., 1918

IA AFFERENT SENSORY
From Muscle Spindle

DORSAL ROOT GANGLION

SPINAL NERVE

α MOTOR FIBERS
To Muscle Fibers

5/3/2017
‘H’ REFLEX LATENCY IN LUMBAR RADICULOPATHY

- Will be prolonged in S-1 radiculopathy from the onset of radiculopathic pain
- Difference in latency, side-to-side, ≤ 1 ms is significant
  - Original study (1974) mean .8 +/- S.D. 0.4 ms
  - More recent series (better instruments) difference side-to-side mean =0.3 ms
Formula to calculate Predicted H latency

- 0.46 x distance (cm) from stimulation to medial malleolus
- + 0.1 x age in years
- + constant of 9.14
- Range of individual normal is +/- 2.5 ms
- Difference side to side > 1.0 ms

\[ \text{Predicted H-Reflex Latency} = 0.46L + 0.1A + 9.1 \]

Where
- \(L\) = Leg length in cm
- \(A\) = Age in years
We are recording from SOLEUS

This is a large muscle and one can record it from any position around leg
H reflex - Influences

- Facilitate –
  - Slight contraction of agonist
- Depress –
  - Contraction of antagonists
  - Strong co-contraction
  - Unreliable parameter in unconscious person

- Ref: McHugh, Reeser, Johnson: Am J PM&R 1994
Use of H reflex latency

- Early in course of L/S radiculopathy
- When abnormal irritability is only in paraspinals
- Underlying peripheral neuropathy (diabetic)
- If muscle exploration is confusing
- Post laminectomy with recurrent symptoms

Use of H reflex latency when positive waves are only in paraspinals

- Especially useful in first two weeks after onset
- 90 – 95% of all first appearing radiculopathies are L-5 or S-1
- Ratio of frequency – L-5:S-1 = 2:1
- H latency is prolonged – S1; if normal L5
Case: Is it S1 Radic?

- 49 yo F LBP and distal paresthesia
- Prior study included Bilateral Peroneal and Tibial motor nerve conduction with F waves
- Left sural was normal
- Dx of S1 radic was based upon asymmetric delay of left tibial F wave

Is it S1 Radic?

Left tibial F wave mean of 45.2ms is reported compared to 43.0ms on the right
Is it S1 Radic?

Left tibial Fwave mean of 45.2ms is reported
compared to 43.0ms on the right
Fastest F latency is not reported!
Motor NCV is not reported!

My study 5 mon later, no change in symptoms per patient,
Shows normal H reflex to soleus bilateral
And mild delay of sural latency on left
Suggesting peripheral neuropathy
(recall that sensory responses not usually affected by radic)

Signs of Abuse

- Duplicate data
- Nonsense math
  - Both suggest contrived results
- Excessive testing
  - Often protocol driven
  - Rather than patient-specific
Radiculopathy L/S Summary

- EDX is essential for DX radiculopathy
- Chronology is important:
  - 1st few days – reduced recruitment frequency; prolonged H latency
  - >7 days – positive waves in paraspinals
  - >14 days – abnormal irritability in proximal muscles
  - >21 days – all abnormalities

Back surgery
Cochrane review: Lumbar disc disease surgery

- any positive or negative effects on the lifetime natural history of the underlying disc disease are unclear. Microdiscectomy gives broadly comparable results to standard discectomy. There is insufficient evidence on other surgical techniques to draw firm conclusions.

- Trials showed that discectomy produced better outcomes than chemonucleolysis, which in turn was better than placebo. For various reasons including concerns about safety, chemonucleolysis is not commonly used today to treat prolapsed disc.
References


References

- Annaswamy TM, et al. NEEDLE ELECTROMYOGRAPHY PREDICTS OUTCOME AFTER LUMBAR EPIDURAL STEROID INJECTION. Muscle Nerve 2012; 45: 346–355,
References

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Thank You!
william.pease@osumc.edu

Ultra EMG  Lewis Center
2017