EMG for OPAs
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Evaluation of Peripheral Nerve Injuries

- Exam has two parts:
  - Nerve Conduction Study
  - Needle EMG
Nerve Conduction Study

- Latency/NCV
- Amplitude

Needle EMG Study

- Expression of the physiological state of the muscles
- Three types of observations:
  - Spontaneous electrical activity in a relaxed muscle
  - Motor unit configuration with weak contraction
  - MUP recruitment with max contraction
NEURAPRAXIA
FIRST DEGREE

- A Temporary Conduction Block
- Preservation of the Axon
- Acute Transient Conduction Blocks are due to:
  - Compression
  - Ischemia
  - Ionic changes leading to decreased ATP production which NA pumps require
- Lasts Several Days to Weeks

NEUROPRAXIA
FIRST DEGREE

Preservation of:
- Axons
- Endoneurial Tubes
- Perineurium
- Epineurium
AXONOTMESIS
SECOND DEGREE

- Involves Axonal Damage
  - Results from Severe Compression
- There is subsequent disintegration & Wallerian degeneration of the damaged axons
- Endoneurial tubes are preserved
- Axonal regeneration is successful
- Prognosis is good

AXONOTMESIS
SECOND DEGREE

- Preservation of:
  - Endoneurial Tubes
  - Perineurium
  - Epineurium
NEUROTOMESIS
THIRD DEGREE

- Involves axonal disintegration & Wallerian degeneration
- Loss of endoneurial tubes
- Involves:
  - Hemorrhage
    - Edema
    - Inflammation
    - Fibrosis
- Epineurium & Perineurium are intact
- Prognosis for successful regeneration is POOR

NEUROTOMESIS
THIRD DEGREE

- Preservation of:
  - Perineurium
  - Epineurium
FOURTH DEGREE

- Involves axonal disintegration & Wallerian degeneration
- Loss of endoneurial tubes & perineurium
- Involves:
  - Hemorrhage
  - Edema
    - Inflammation
    - Fibrosis & scarring
- Epineurium is intact
- Prognosis for successful regeneration after nerve graft is POOR

FIFTH DEGREE

- Entire continuity of the trunk is lost
- Involves disintegration; Wallerian degeneration; loss of endoneurium, perineurium, & epineurium
- Prognosis for successful regeneration after nerve excision & grafting is POOR
FIFTH DEGREE

• Entire nerve trunk continuity is lost

DEMYELINATION

• Demyelination
  • A disturbance of the Schwann cells causing reduction in thickness of myelin
  • Na+ channel redistribution
  • Conduction changes from saltatory to eddy currents leading to decreased NCV
  • May be localized, uniform, or segmental
  • Chronic demyelination leads to decreased amplitudes but minimal, if any temporal dispersion
WALLERIAN DEGENERATION
(Axon Loss)

- Degeneration of the axon distal to the injury caused by loss of contact with the cell body (site of nutrient & energy production)
- Distal CMAP declines in 5-7 days
- Distal SNAP declines in 9-11 days
- Positive sharp waves may be seen in the 1st week, especially in proximal muscles
- Fibrillation potentials may be seen during the 2nd week in proximal muscles, are most prominent approximately 4-6 weeks after axonal injury

NERVE HEALING

- Remyelination
  - May occur under certain conditions
  - Schwann cells produce more myelin
  - Latencies & NCVs may either improve or return to normal
  - Occurs faster in inflammatory disorders than in compression injuries
  - If the compression force is removed, neurapraxic lesions may return to normal
NERVE HEALING

- Reinnervation of degenerated muscles occurs secondary to either:
  - Axonal Sprouting
  - Axonal Regeneration

AXONAL SPROUTING

- Must be some normal axons left
- Undamaged axons send out sprouts that reinnervate denervated muscle fibers
- Type II axons tend to sprout more quickly than Type I axons
- One terminal branch can send out 4-5 sprouts
- It takes 6-8 weeks for sprouting to be documented by EMG
AXONAL REGENERATION

- Regeneration may be successful if endoneurium is intact
- If cell body does not die, regeneration begins as early as 24 hrs post injury
- Optimal conditions grow @ 1mm per day or 1 inch per month
- It can take months to years, depending on the length of the nerve & site of injury
- Axonal regeneration is age related
- If the endoneurium has been damaged or surgically repaired, regeneration is much slower, especially through scar tissue

EMG Cheat Sheet

<table>
<thead>
<tr>
<th>Finding</th>
<th>Meaning</th>
<th>Significant When...</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NCV</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreased Amplitude</td>
<td>Axon loss</td>
<td>50% decrease above to below suspected lesion.</td>
</tr>
<tr>
<td>Increased Latency</td>
<td>Demyelination</td>
<td>Difference of: 1 ms for motor 0.5 ms for sensory</td>
</tr>
<tr>
<td>(median/ulnar comparsion)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreased Velocity</td>
<td>Demyelination</td>
<td>&lt; 50 m/s upper extremity &lt; 40 m/s lower extremity</td>
</tr>
<tr>
<td><strong>EMG</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive sharp waves</td>
<td>Axon loss</td>
<td>Present</td>
</tr>
<tr>
<td>Fibrillations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polyphasic Potentials</td>
<td>Reinnervation occurring</td>
<td>Present</td>
</tr>
<tr>
<td></td>
<td>Or chronicity of problem</td>
<td></td>
</tr>
<tr>
<td>Large amplitude</td>
<td>Reinnervation occurring</td>
<td>Present</td>
</tr>
<tr>
<td>potentials</td>
<td>And chronicity of problem</td>
<td></td>
</tr>
<tr>
<td>Fast firing motor units</td>
<td>Loss of motor units</td>
<td>Present</td>
</tr>
<tr>
<td>Decreased recruitment</td>
<td>Loss of motor units</td>
<td>Present</td>
</tr>
</tbody>
</table>
**EMG/NCV Can Help:**

- Localization of the site of injury
- Estimation of the extent of the injury
- Detection of evidence of progression or regeneration of injury
- Aid in medicolegal problems—baseline
- Rule out other possible causes

**EMG/NCV Can Help Diagnosis:**

- Neuropathy
- Myopathy
- Motor System Disease (e.g. ALS)
- Neuromuscular Junction Disorder (e.g. Myasthenia Gravis)
- Radiculopathy
- Plexopathy
- Local Mononeuropathy (e.g. Carpal Tunnel)
- Polyneuropathy (e.g. Diabetic, Alcoholic)
- Polyradiculopathy (e.g. Guillain-Barre syndrome)
Which Tests to use & When

- 3-4 days........EMG/NCV......Medicolegal, baseline
- 4th week........EMG/NCV......Localize, extent, hysteria
- 8th week........EMG..................Progression or regression
- q 4 months.....EMG..................Clinical improvement
- q 18 months..EMG/NCV.....Assess final recovery

BRACHIAL PLEXUS

<table>
<thead>
<tr>
<th>Branches</th>
<th>Cords</th>
<th>Divisions</th>
<th>Trunks</th>
<th>Rami</th>
</tr>
</thead>
<tbody>
<tr>
<td>Musculo</td>
<td></td>
<td></td>
<td></td>
<td>C5</td>
</tr>
<tr>
<td>Median</td>
<td></td>
<td>Radial</td>
<td>Upper</td>
<td>C6</td>
</tr>
<tr>
<td>Ulnar</td>
<td></td>
<td>Axillary</td>
<td>Middle</td>
<td>C7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
<td>C8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Long Thoracic</td>
</tr>
</tbody>
</table>
### SUPRASCAPULAR NERVE

**Pathophysiology & Clinical Signs**

- Entrapment in suprascapular or spinoglenoid notch
- Injury from shoulder pressure
- Stab wounds
- Improper crutch use
- Stretch or rupture of rotator cuff
- Upper trunk injury

- Muscle weakness & atrophy
- Pain

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### AXILLARY NERVE

**Pathophysiology & Clinical Signs**

- Degeneration due to brachial plexus neuritis
- Specific injury or trauma
- Humeral head fractures and/or dislocation
- Entrapment in the quadrilateral space

- Sensation loss in the lateral deltoid region
- Atrophy & weakness of deltoid
- Limited abduction after first 30 degrees
**MUSCULOCUTANEOUS NERVE**
Pathophysiology & Clinical Signs

- Humerus fracture and/or dislocation
- Gunshot or stab wounds
- Compression
- Entrapment by coracobrachialis
- Heavy exercise

- Numbness in lateral aspect of forearm
- Weakness & atrophy of muscle
- Paralysis of biceps
- Absent biceps MSR

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**RADIAL NERVE**

- Radial Nerve
- Posterior Interosseus Nerve
RADIAL NERVE
Pathophysiology & Clinical Signs

- Focal injury due to crush or twisting
- Repetitious pronation/supination at work
- Trauma to spiral groove
  - Fracture
  - Saturday night palsy

- Pain
- Loss of sensation
- Muscle weakness & atrophy

POSTERIOR INTEROSSEUS NERVE
Pathophysiology & Clinical Signs

- Terminal motor branch of the radial nerve
- Entrapment at the Arcade of Frohse, between heads of supinator
  - Supinator is spared

- Wrist & digit extensor weakness
- Normal strength of supinator
- Lateral elbow pain
- No sensory loss
MEDIAN NERVE

- Pronator Teres Syndrome
- Anterior Interosseus Syndrome
- Carpal Tunnel Syndrome
- Digital Nerve Entrapment

PRONATOR TERES SYNDROME
Pathophysiology & Clinical Signs

- Trauma, muscle hypertrophy, fracture, anomalous fibrous band
- Entrapment occurs between heads of pronator teres
- Pronator teres is spared
- If entrapment is by ligament of Struthers, then pronator teres is not spared

- Weakness of flexor pollicis longus, abductor pollicis
- Pronation is spared
- Pain
- Loss of sensation over thenar eminence
ANTERIOR INTEROSSEUS NERVE
Pathophysiology & Clinical Signs

- Kiloh-Nevin Syndrome
- The AIN branches off the median nerve just distal to the pronator teres
- The AIN is a purely motor nerve
- Injury is usually by compression
- No distinct sensory abnormalities
- Elbow and/or forearm pain
- Unable to make “OK” sign
- Weakness of FPL, pronator quadratus, & FDP I&II

CARPAL TUNNEL SYNDROME
Pathophysiology

- Entrapment of median nerve by a thickened distal transverse carpal ligament
- Most common entrapment syndrome
- Affects women > men
- May accompany other nerve pathology
  - Double Crush
CARPAL TUNNEL SYNDROME

CLINICAL SIGNS

• Hand paresthesias, especially at night
• Hand pain, frequently up to the elbow & shoulder
• Pain is alleviated by movement
• Muscle weakness & atrophy
• Positive Tinel’s sign & Phalen’s sign at the wrist
• Raynaud’s Phenomenon may occur

ULNAR NERVE

• Tardy ulnar palsy & cubital tunnel syndrome
• Compression at Guyon’s Canal
• Involvement of the deep palmar branch
• Digital nerve entrapment
CUBITAL TUNNEL SYNDROME
Pathophysiology & Clinical Signs

- TARDY ULNAR PALSY
- Elbow trauma
- Immobilization
- Repetitive overuse
- Compression
- Entrapment by aponeurosis of FCU

- Fifth digit sensation changes
- Wasting & weakness of ulnar hand intrinsics
- Pain

LUMBOSACRAL PLEXUS
LATERAL FEMORAL CUTANEOUS NERVE
Pathophysiology & Clinical Signs

- Meraglia Paresthetica
- Entrapment of purely sensory nerve by Inguinal ligament
- Compression by:
  - Tight belts/corsets
- Inability to flex hip or extend the knee
- Absent or diminished knee jerk reflexes
- Sensation loss
- Anterior thigh pain

OBTURATOR NERVE
Pathophysiology & Clinical Signs

- Pressure during pregnancy or labor
- Pelvic fracture
- Surgical injuries
- Entrapment in Obturator canal by intraabdominal pressure
- Weakness of hip adductors & internal/external rotators
- Pain in groin that radiates to medial aspect of thigh
- Hyperesthesias of dysesthesias of medial aspect of upper thigh
SUP & INF GLUTEAL NERVES
Pathophysiology & Clinical Signs

- Fractures of upper femur
- Intramuscular injections
- Piriformis syndrome
- Buttock pain
- Weakness & muscle atrophy

SCIATIC NERVE
Pathophysiology

- Neoplasm
- Abscess
- Pregnancy
- Pelvic, hip, or femoral fractures
- Endometriosis
- Misdirected injections
- Penetrating wounds
- Hip surgery
- Piriformis syndrome
- Affects peroneal division > tibial division
SCIATIC NERVE
Clinical Signs

- Muscle atrophy & weakness
- Foot drop
- Pain
- Sensory deficits
- Diminished or absent ankle jerk reflexes

COMMON PERONEAL NERVE
Pathophysiology & Clinical Signs

- Compression at fibular head (deep)
- Ganglion cyst
- Fibular head dislocation or fracture
- Compression by muscle
- Anterior Tarsal Tunnel syndrome (deep)
- Deep branch
  - Weakness of toe & foot dorsiflexors
  - Sensory changes in web space between 1st & 2nd toes
- Superficial branch
  - Weakness of everters
  - Sensory changes over dorsum of foot
- Ankle jerk reflex is preserved
TIBIAL NERVE
Pathophysiology & Clinical Signs

- Rarely injured in thigh due to its deep location
- Commonly entrapped by flexor retinaculum behind medial malleolus
  - Tarsal Tunnel syndrome
- Trauma
- Tenosynovitis
- Venous stasis
- Tumor
- Weakness of intrinsic foot muscles
- Sensory loss in toes & sole of foot
- Painful dysesthesias

SURAL NERVE
Pathophysiology & Clinical Signs

- Compression & trauma is rare
- Ganglion cyst
- Baker’s cyst
- Combat boot compression
- Stretch injury
- Surgical biopsy
- Sensory abnormalities in posterolateral aspect of lower third of leg & lateral aspect of dorsum of foot
- Pain
What is Normal???

- Dependent on technique
- Dependent on temperature
- Dependent on age
- Each EMG lab has its own norms

Normative Data

- Motor latency delta < 1.0 ms
- Motor amplitude delta < 20%
- Sensory latency delta < 0.5 ms
- Sensory amplitude delta < 50%
- H-reflex per nonogram, delta < 1.2 ms
- F-wave < 1.2 ms
- Temperatures should be maintained at > 32°C for UE, > 29°C for LE
- All delta differences are for side to side comparisons
## Sensory Nerves

<table>
<thead>
<tr>
<th>Nerve</th>
<th>Dist (cm)</th>
<th>Latency (ms)</th>
<th>NCV (m/s)</th>
<th>Amp (µV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median D3</td>
<td>14</td>
<td>3.6</td>
<td>38</td>
<td>15</td>
</tr>
<tr>
<td>Palmar</td>
<td>7</td>
<td>1.7</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>Ulnar</td>
<td>14</td>
<td>3.7</td>
<td>38</td>
<td>15</td>
</tr>
<tr>
<td>Radial D1</td>
<td>12</td>
<td>3.5</td>
<td>38</td>
<td>15</td>
</tr>
<tr>
<td>Radial EPL</td>
<td>12</td>
<td>3.0</td>
<td>40</td>
<td>15</td>
</tr>
<tr>
<td>MAC</td>
<td>14</td>
<td>3.5</td>
<td>40</td>
<td>3</td>
</tr>
<tr>
<td>LAC</td>
<td>14</td>
<td>3.5</td>
<td>40</td>
<td>3</td>
</tr>
<tr>
<td>Sural</td>
<td>14</td>
<td>4</td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td>Sup peron</td>
<td>14</td>
<td>4.2</td>
<td>33</td>
<td>2</td>
</tr>
<tr>
<td>Saphenous</td>
<td>14</td>
<td>4.4</td>
<td>32</td>
<td>2</td>
</tr>
</tbody>
</table>

## Motor Nerves

<table>
<thead>
<tr>
<th>Median</th>
<th>Dist (cm)</th>
<th>Lat (ms)</th>
<th>NCV (m/s)</th>
<th>Amp (mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median wrist</td>
<td>8</td>
<td>4.0</td>
<td>50</td>
<td>4</td>
</tr>
<tr>
<td>Ulnar wrist</td>
<td>8</td>
<td>4.0</td>
<td>50</td>
<td>4</td>
</tr>
<tr>
<td>Segments from BE, AX-AE, Erb's</td>
<td>8-10</td>
<td>7-10</td>
<td>39-40</td>
<td>3.5-40</td>
</tr>
</tbody>
</table>