Role of EMG for nerve injury and repair

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No disclosures
Learning Objectives

• At the conclusion of this activity, participants should be able to:
  – Describe the role of EMG in evaluating patients with peripheral nerve injuries,
  – Understand the similarities and differences in applying these same techniques to patients with central nervous system lesions.
Role of EMG for nerve injury and repair

• Part I  PNS injuries
• Part II  Using these same techniques for CNS lesions
Part I

PNS Injuries
Diagnostic EMG for PNS injuries

- EMG’ers are used to doing these studies in their own way in the safety of their own EMG labs.
Pre-op Studies

• Localization
Pre-op Studies

- Type of injury, Neurapraxia vs Axonal

![Neurapraxia vs Axonal Diagram]

**Neurapraxia**
- Normal nerve with intact myelin sheath and nodes of Ranvier.

**Axonal Injury**
- Focal demyelination with disrupted myelin at specific locations (A: Para-Nodal, B: Segmental).

**Nerve Crush**
- Wallerian Degeneration with complete loss of myelin sheath and axonal structure.

![Demyelination Waveforms]

- Normal waveform.
- Demyelinating waveform with decreased amplitude and distortion.

![Wallerian Degeneration Waveform]

- Further degraded waveform indicating complete axonal loss.
Pre-op Studies

- Extent of axonal injury, complete vs. partial
Pre-op Studies

- Root vs. plexus
Intra-op Studies

• Bring your EMG machine in to OR, try not to touch anything (important) and prepare for some detective work.
Exploring the brachial plexus
Exploring the brachial plexus
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Exploring the brachial plexus

Identify the spinal accessory nerve:

Spared in brachial plexus injuries.

Gets you oriented.

Important source for neurotization.
Exploring the brachial plexus
Exploring the brachial plexus
Time limit on success of nerve graft repair for peripheral nerve injuries

- Johnsson, 2013
- Delayed repair of rat sciatic nerve injuries.
Tendon Transfers

• Can be performed in patients with isolated PNS lesions with predictable results.
Tendon Transfers

• Can they activate the donor tendon?
• Is there another muscle working that will performs the same function after the donor muscle is diverted?
EMG to identify working (duplicate) muscle
Potential donor tendons

• Can the patient activate both muscles?
  – Upper vs. Lower Trapezius
  – Long vs. Short/Lateral Head Triceps
  – Teres Major vs. Latissimus Dorsi
  – Biceps vs. Brachioradialis
  – Pronator Teres vs. Pronator Quadratus
  – Flexor Digitorum Superficialis vs. Profundus
Part II

Applying these same techniques to patients with paresis from CNS lesions
PNS Regenerates, CNS Does Not
“Repairing” Central Lesions

• Apply the same concepts used in peripheral nerve injuries:
  – Neurotization
    • First converting a central into a peripheral lesion, then fixing it.
  – Tendon transfer
    • “Bypassing” a weak muscle using a diverted strong muscle.
Neurotization

- Spinal accessory nerve
- Intercostal nerves
- Phrenic nerve
Stroke pt, axillary neurotized from spinal accessory nerve
Tendon Transfer For Spastic Hand
“Repairing” Central Lesions vs. Peripheral Lesion

- Neurotization
  - First converting a central into a peripheral lesion, then fixing it.

- Tendon transfer
  - “Bypassing” a weak muscle using a diverted strong muscle.

No time limit
“Repairing” Central Lesions vs. Peripheral Lesion

- Neurotization
  - First converting a central into a peripheral lesion, then fixing it.
- Tendon transfer
  - “Bypassing” a weak muscle using a diverted strong muscle.

Dealing with more complicated motor control issues
Spasticity in Central Weakness

- Intact, disinhibited (and hence exaggerated) spinal reflex arc:
Loss of Reciprocal Inhibition
More Primitive Motor Pathways

Ready to go

Activate
Contracture
Evaluating Central Weakness
“Repairing” CNS Injuries

• More complicated than for PNS lesions
  – Must also consider:
    • Spasticity
    • Abnormal patterns of motor activity
    • Contractures
Evaluating Central Weakness with EMG

• Can the patient activate the “weak” muscle?
Evaluating Central Weakness
• Mayer, 1997
• Mayer, 1997
UMN Lesion, Arm “Weakness”
• Esquanazi et al, 2010, Open Rehab J
• Spastic limb, continuous activation of hamstrings during attempted knee extension

Fig. (2). Coactivation phenomenon between hamstrings and rectus femoris during active knee motion.
Another way to look at this

• Use EMG to decide is movement limited by:
  – Weakness?
  – Activation of an out of phase muscle?
  – Both?
Tendon Transfer for CNS Lesions
Potential donor tendons

- Can the patient activate both muscles?
  - Upper vs. Lower Trapezius
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But also ........

• Use multichannel recordings to measure concurrent activity in antagonistic muscles and synergistic muscles.
And .......

- Ideally muscles selected for transfer should be active during the same movement they are supposed to supplement - that transferred tendon will still want to be active during that same phase of movement post-op.
• Hoffer, 1992
• Patient with contracted hand and wrist,
• Grasp release improves after FCU to EDC tendon transfer.
FCU to EDC Transfer, Pre and Post-op.

- FCU remains active during grasp release phase
- Hoffer, 1990

Fig. 1. Pre-operative EMG of patient with difficulty in opening hand. Note activity of flexor carpi ulnaris in release (flat area on bottom indicator): there is relatively little activity in grasp.

Fig. 2. Postoperative EMG of same patient: note unchanged activity of flexor carpi ulnaris in release (elevated area on bottom indicator).
Identify Spasticity

- Esquanazi, 2010
- Multiple muscles active in this pt with fixed flexed elbow.
Spasticity must be addressed before considering any reconstructive procedures.

- Orthopedic Surgery
- Neurosurgery
- Intrathecal Baclofen Therapy
- Injection Therapy - Botox
- Oral Medications
- Rehabilitation Therapy
Treating Spasticity

Baseline

2 hrs after 50mcg ITB
We can use EMG to

• Localize and characterize PNS lesions.
• Identify donor muscles for tendon transfers.
• Demonstrate selective vs. synergistic muscle activation.
• Differentiate lack of muscle innervation from over-activity of antagonist muscle.
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Final Words

• Important to work closely with the surgeon, and know what they need/expect of you.
• Be flexible, be prepared to use what you know about nerve and muscle electrophysiology in unconventional ways.
• When selecting muscles for tendon transfer, be sure to use multi-channel recordings including synergistic and antagonistic groups.
References


• Holland NR, Belzberg AJ. Intraoperative electrodiagnostic testing during cross-chest C7 nerve root transfer. Muscle Nerve 1997; 20:903-095.


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