

ELECTRODIAGNOSTICS IN SPINAL RADICULAR DISORDERS

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ELECTRODIAGNOSTICS IN SPINAL RADICULAR DISORDERS: OVERVIEW

- What are Electrodiagnostic Studies?
- What information can we obtain from them?
- How is this information useful in the diagnosis and management of spinal radicular disorders?

ELECTRODIAGNOSTIC STUDIES: DEFINITION

Neurologic diagnostic studies in which the native electrophysiological properties of nerve and muscle are examined

ELECTRODIAGNOSTIC STUDIES: UNDERLYING PRINCIPLES

Nerve and Muscle are made up of electrically excitable cells

Electrically Excitable Cells alternate between:

Resting Potential and Action Potential

These 2 states have different levels of electrical charge

These electrical properties can be measured

ELECTRODIAGNOSTIC STUDIES: UNDERLYING BASICS

--Nerve and muscle demonstrate quantitative electrophysiological parameters in their normal states that differ from those that occur in states of disease and dysfunction--

ELECTRODIAGNOSTIC STUDIES: EXAMPLES

- ◉ Nerve conduction studies (NCS)
- ◉ Electromyography (EMG)
- ◉ Electroencephalography (EEG)
- ◉ Somatosensory evoked potentials (SEPs)
- ◉ Visual evoked potentials (VEPs)
- ◉ Brainstem auditory evoked potentials (BAERs)

All of these are studies that measure electrical properties of different parts of the nervous system

ELECTRODIAGNOSTIC STUDIES OF THE PERIPHERAL NERVOUS SYSTEM

- ◉ Nerve conduction studies (NCS)
- ◉ Electromyography (EMG)

Performed in conjunction, these studies provide examination of the electrical “wiring” of the entire peripheral nervous system, from spinal root to end organ

(end organ = muscle for motor nerves, sensory receptor for sensory nerves)

NCS AND EMG: SOME POINTS

- Tests of FUNCTION
- Serve as an extension of the clinical neurologic examination
- Complement imaging studies

- Triad of radiculopathy analysis:
 - Neurologic presentation (symptoms and signs)
 - NCS/EMG (electrodiagnostic studies)
 - Imaging (MRI, CT)

ELECTRODIAGNOSTIC STUDIES: PROCEDURE

- ⦿ NCS and EMG are almost invariably performed together
- ⦿ NCS are performed first, because findings will determine course of EMG
- ⦿ NCS can be performed by a physician, or by a technician under supervision of a physician
- ⦿ EMG is always performed by a physician
- ⦿ The test is done in “real time”: that is, the course of the test is determined by the findings as you go forward

NERVE CONDUCTION STUDIES

- Surface electrodes are placed on the patient's skin, which record either the underlying muscle or underlying sensory nerve
- An electrical stimulation is applied over the course of the nerve
- The response evoked by the stimulation is measured by the surface electrodes

ELECTROMYOGRAPHY

- A needle electrode is inserted through the skin into underlying muscle
- The native electrical activity of the muscle is recorded
- A series of muscles are studied in sequence
 - Muscle reacts in characteristic ways when its nerve supply is altered
 - Each muscle tested is supplied by different roots
 - By analyzing what muscles are involved and what muscles are spared, root injury can be localized

RESULTS

- ⊙ Diagnosis and Localization
 - Nerve root versus peripheral nerve, muscle, spinal cord
 - Which nerve root/roots are involved
- ⊙ Severity
 - Are nerve fibers dying or just irritated?
- ⊙ Chronicity
 - Chronic, subacute, acute

WHY?

The Role of the Neurologist:

--Accurately Diagnose

--Appropriately Triage

-Medical Management

-Interventional Procedures

-Surgery

Goals:

Preserve neurologic function

Control/eliminate pain

NEUROLOGIC CRITERIA FOR SURGICAL INTERVENTION OF RADICULAR DISORDERS

A) Surgical intervention is necessary to protect neurological function

OR

B) Pain cannot be controlled adequately by non-surgical treatments

AND

The surgical intervention is highly likely to alleviate the patient's problem

CASE EXAMPLE 1: CERVICAL RADICULOPATHY

60 year-old woman with 2 month history of severe pain in right arm, radiating from neck into medial hand.

Post evaluation by 2 different surgeons:

- 1) Need surgery ASAP
- 2) Surgery not indicated at all

(Based on symptoms and imaging)

CASE 1: IMAGING

○ MRI C-spine:

- Multilevel degenerative disease, with varying degrees of foraminal stenosis at most levels bilaterally
- Worst at C5/C6, where there is severe bilateral foraminal stenosis and moderate-severe central canal stenosis due to disc-osteophyte complex
- Normal cord signal throughout

CASE 1: NEUROLOGIC EXAM

General: Uncomfortable, splinting neck and RUE.

Motor: Mild (4+/5) R triceps weakness, mild (4/5) weakness of right intrinsic hand muscles

Sensory: Mix of hypesthesia and hyperesthesia medial right hand

Reflexes: Absent right triceps, otherwise 2+ and symmetrical throughout. Plantar reflex flexor bilaterally. Negative Hoffman sign bilaterally.

Coordination and Gait: Normal

Clinically = C8

FEATURES OF CERVICAL RADICULOPATHY

	C3-4	C5	C6	C7	C8	T1
Pain Radiation	Parasp muscles	Neck, shoulder, anterior arm	Neck, shoulder, anterior arm extending to antecubital fossa	Neck, shoulder, dorsum of forearm	Neck, shoulder, ulnar forearm	Neck, shoulder, ulnar forearm
Sensory Impairment	Neck	Shoulder	Thumb, index finger, radial forearm	Middle finger	4 th ,5 th fingers hypothenar eminence	Ulnar forearm
Weakness	Diaphragm, nuchal muscles, strap muscles	Deltoid, supra/infraspinatus, rhomboid, biceps, brachiorad	Deltoid, supra/infraspinatus, rhomboid, biceps, brachioradialis pronator teres, FCR, ECR	Triceps, Latissimus dorsi, pronator teres, FCR, ECR	Intrinsic hand muscles, finger extensors, finger flexors	Intrinsic hand muscles (Horner's syndrome)
Hypo/Areflex	None	Biceps, Brachiorad	Biceps, Brachiorad	Triceps	Triceps	None

CASE 1: ELECTRODIAGNOSTICS

- NCS/EMG of upper extremities
 - Evaluate C8 root (distribution of sx/signs)
 - Evaluate for ulnar neuropathy (superimposed?)
 - Evaluate C5/6 roots (where pics look the worst)

Root Innervation of Upper Extremity Muscles

Proximal Nerves

C5 C6 C7 C8 T1

		C5	C6	C7	C8	T1
Serratus Anterior	(Long Thoracic Nerve)	■	■	■	■	
Rhomboids	(Dorsal Scapular Nerve)	■	■			
Supraspinatus	(Suprascapular Nerve)	■	■			
Infraspinatus	(Suprascapular Nerve)	■	■			
Latissimus Dorsi	(Thoracodorsal Nerve)	■	■	■	■	
Deltoid	(Axillary Nerve)	■	■			
Biceps	(Musculocutaneous Nerve)	■	■			

Radial Nerve

C5 C6 C7 C8 T1

		C5	C6	C7	C8	T1
Triceps			■	■	■	
Anconeus			■	■	■	
Brachioradialis		■	■	■	■	
Extensor Carpi Radialis		■	■	■	■	
Supinator	(Posterior Interosseous Nerve)	■	■	■	■	
Extensor Digitorum Communis	(Posterior Interosseous Nerve)			■	■	■
Extensor Digiti Minimi	(Posterior Interosseous Nerve)			■	■	■
Extensor Carpi Ulnaris	(Posterior Interosseous Nerve)			■	■	■
Abductor Pollicis Longus	(Posterior Interosseous Nerve)			■	■	■
Extensor Pollicis Longus	(Posterior Interosseous Nerve)			■	■	■
Extensor Pollicis Brevis	(Posterior Interosseous Nerve)			■	■	■
Extensor Indicis Proprius	(Posterior Interosseous Nerve)			■	■	■

Median Nerve

C5 C6 C7 C8 T1

		C5	C6	C7	C8	T1
Pronator Teres			■	■	■	
Flexor Carpi Radialis			■	■	■	
Flexor Digitorum Superficialis			■	■	■	■
Flexor Digitorum Profundus I, II	(Anterior Interosseous Nerve)			■	■	■
Flexor Pollicis Longus	(Anterior Interosseous Nerve)			■	■	■
Pronator Quadratus	(Anterior Interosseous Nerve)			■	■	■
Abductor Pollicis Brevis					■	■
Opponens Pollicis					■	■
Flexor Pollicis Brevis (superficial head)					■	■
Lumbricals I & II					■	■

Ulnar Nerve

C5 C6 C7 C8 T1

		C5	C6	C7	C8	T1
Flexor Carpi Ulnaris				■	■	■
Flexor Digitorum Profundus III, IV					■	■
Abductor Digiti Minimi					■	■
Palmar/Dorsal Interossei					■	■
Lumbricals III & IV					■	■
Adductor Pollicis					■	■
Flexor Pollicis Brevis (deep head)					■	■

CASE 1: NCS/EMG RESULTS

- 1) Evidence of acute, severe, right C8 radiculopathy
 - Active denervation of muscles sharing C8 innervation on right
- 2) Evidence of mild, chronic bilateral C6 radiculopathy
- 1) NO evidence of focal right ulnar neuropathy

CASE 1: RESOLUTION

Minimally invasive decompression of R C8

Expectant management of C5/6

CASE 2: LUMBOSACRAL RADICULOPATHY

- ◉ 60 year-old woman with severe osteoarthritis, s/p bilateral total hip replacement and left total knee replacement
- ◉ Developed pain radiating from left buttock posteriorly down left leg into foot
- ◉ About 1-2 months later, developed gait difficulty, found to have left foot drop

CASE 2:

- Imaging of lumbosacral spine:
 - Multilevel degenerative disease throughout including moderate-severe foraminal stenosis at L4/5 and L5/S1 bilaterally.
- Based on combination of pain, foot drop, and MRI findings, underwent decompression and fusion L4-S1
- Following procedure, pain continued to worsen, as did weakness.
- Repeat L/S MRI was performed: good surgical decompression

CASE 2: NEUROLOGIC EXAM

General: Uncomfortable, multifocal joint pain

Motor: LLE: 3/5 dorsiflexion, 3/5 eversion, 4/5 inversion, 5-/5 plantarflexion, 4+/5 knee flexion. Cannot walk on toes or heels with left foot

Sensory: Hypesthesia entire left foot (dorsal and plantar), lateral leg. Sparing of medial leg.

Reflexes: Absent at left ankle, 2+ at right ankle, 2+ and symmetrical at knees, normal in UEs. Plantar reflex flexor bilaterally.

Clinically=L5 and S1, ?

FEATURES OF LUMBOSACRAL RADICULOPATHY

	S1	L5	L4	L2/3
Pain Radiation	Buttock, posterior thigh and leg, lateral foot	Buttock, lateral thigh and leg, dorsal foot	Hip, anterior thigh, knee, medial leg	Groin, anteromedial thigh
Sensory Impairment	Posterior thigh, lateral foot, little toe	Lateral leg, dorsal foot, big toe	Anterior thigh, medial leg	Groin, medial thigh
Weakness	Plantarflexion, toe flexion	Toe and ankle dorsiflexion, inversion and eversion	Knee extension and ankle dorsiflexion	Hip flexion and knee extension
Hypo/Areflexia	Ankle jerk	None	Knee jerk	Knee jerk

CASE 2: ELECTRODIAGNOSTICS

- NCS/EMG of bilateral lower extremities
 - Evaluate left L5 root
 - Evaluate for other potential neuropathic causes of foot drop (eg peroneal neuropathy)
 - Is something else going on?

Root Innervation of Lower Extremity Muscles

Femoral Nerve

	L2	L3	L4	L5	S1	S2
Iliacus	■	■				
Rectus Femoris		■	■			
Vastus Lateralis		■	■			
Vastus Medialis		■	■			

Obturator Nerve

	L2	L3	L4	L5	S1	S2
Adductor Longus		■	■			
Adductor Magnus (Also has Sciatic Nerve Innervation)	■	■	■			

Superior Gluteal Nerve

	L2	L3	L4	L5	S1	S2
Gluteus Medius				■	■	
Tensor Fascia Lata				■	■	

Inferior Gluteal Nerve

	L2	L3	L4	L5	S1	S2
Gluteus Maximus				■	■	

Sciatic Nerve

	L2	L3	L4	L5	S1	S2
Semitendinosus (Tibial Nerve Division)				■		
Semimembranosus (Tibial Nerve Division)				■		
Biceps Femoris, Long Head (Tibial Nerve Division)				■	■	■
Biceps Femoris, Short Head (Peroneal Nerve Division)				■	■	■

Peroneal Nerve

	L2	L3	L4	L5	S1	S2
Tibialis Anterior (Deep Peroneal Nerve)			■	■		
Extensor Digitorum Longus (Deep Peroneal Nerve)			■	■		
Extensor Hallucis Longus (Deep Peroneal Nerve)			■	■		
Peroneus Longus (Superficial Peroneal Nerve)				■		
Peroneus Brevis (Superficial Peroneal Nerve)				■		
Extensor Digitorum Brevis (Deep Peroneal Nerve)				■	■	

Tibial Nerve

	L2	L3	L4	L5	S1	S2
Tibialis Posterior				■	■	
Flexor Digitorum Longus				■	■	
Gastrocnemius (lateral head)				■	■	
Gastrocnemius (medial head)					■	■
Soleus					■	■
Abductor Hallucis					■	■
Abductor Digiti Quinti Pedis					■	■

CASE 2: NCS/EMG RESULTS

- ◉ Evidence of left sciatic neuropathy, with peroneal division more severely affected than tibial division

- ◉ Acute and chronic features

CASE 2: RESOLUTION

- Hip MRI: found to have extensive inflammation and adhesions from metal-on-metal hip prosthetic encasing and compressing sciatic nerve
- Total hip revision, peripheral nerve decompression
- Pain resolved, had some improvement in LE strength, but it did not recover to normal.

ELECTRODIAGNOSTICS IN SPINAL RADICULAR DISORDERS: CONCLUSIONS

NCS/EMG are studies of FUNCTION that provide information regarding the status of the neurological wiring

Structural lesions do not always correlate with the pathology that is problematic for the patient

Should always be considered, and should definitely be performed when there is doubt or a disconnect between clinical findings and imaging