PREFACE

Welcome to the Electromyography Laboratory (EMG) and the Neuromuscular Program. In the following months you will be exposed to the anatomic, physiologic, clinical, and technical information necessary to perform electrodiagnostic studies. You will work closely with physician, nursing, and EMG technologist staff members who will guide you through the training process. The knowledge acquired during your training will be applicable to your clinical practice and enhance your understanding of neuromuscular pathophysiology. This knowledge will be acquired through direct teaching efforts of the staff and independent study. Opportunities are available to participate in research, although the major emphasis is clinical. We welcome and expect your active participation in the laboratory and sincerely hope you find the EMG training period productive and enjoyable.

INTRODUCTION TO THE EMG TRAINING PROGRAM MANUAL

The Electromyography Training Manual is a compilation of resident responsibilities, weekly lecture and clinic schedules, and didactic material. Residents and fellows should use this manual as a guide to learning the clinical and technical information necessary to perform electrodiagnostic studies. The manual defines the resident’s responsibilities and lecture schedules. The manual serves as a supplement to texts, journals, and didactic teaching sessions and should not be used in lieu of other sources of information. The manual will be updated from time to time. Please take time to familiarize yourself with this manual prior to beginning the training period or within the first day or two in the EMG Laboratory.

EMG LABORATORY STAFF

Faculty

James W. Teener, MD – Director, Neuromuscular Program
James K. Richardson, MD – Director, Physical Medicine and Rehabilitation

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LECTURES

Every Wednesday at 7:15 a.m. there is an EMG Conference dedicated to fundamentals of electromyography. The topics repeat every 3 to 4 months so you will be able to hear the majority of these basic lectures during a 3-month neuromuscular elective.

The residents also participate in the Wednesday 8:00 a.m. Neuromuscular Conference series. On the second Wednesday of every other month, the residents in the EMG Laboratory are responsible for organizing and presenting the conference. The Neuromuscular Fellows are responsible for the alternate Wednesday. You are free to choose any topic. We recommend avoiding esoteric topics.

In addition, the residents or fellows write protocols and present the assigned case and EMG findings for the Neuromuscular Pathology Conference on the fourth Wednesday each month. The resident should have an understanding of the case including the EMG and biopsy findings and develop a differential diagnosis based on these findings. Ideally, the resident should arrange to meet with Dr. Mila Blaivas, the neuromuscular pathologist, to review the biopsy prior to the conference. The case and EMG findings should be discussed with the staff person assigning the cases prior to presentation.

The residents attend all scheduled EMG/Neuromuscular Conferences and Neurology or PM&R Grand Rounds while in the EMG Laboratory. We welcome your attendance at all times throughout the rest of the year as well.

Every Wednesday afternoon, after the last case has been completed, there is an informal discussion of interesting or problematic cases.
EMG ROTATION OBJECTIVES

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University of Michigan
Updated 6/23/2010

General Objectives for the Rotation

I. KNOWLEDGE
   A. Peripheral nervous system anatomy
   B. Diseases and disorders of the peripheral nervous system
   C. Neuromuscular physiology
   D. Fundamentals of electromyography
   E. Normal values
   F. Ethics
   G. Infection control practices

II. PHYSICAL SKILLS
   A. Electrode placement for nerve conduction studies
   B. Muscle localization and needle EMG technique
   C. Operating the EMG machine
   D. Entering data and generating a report

III. INTERPRETATION SKILLS
   A. Interpretation of waveforms on nerve conduction studies and needle EMG
   B. Designing a logical approach to deciding which nerves and muscles to study
   C. Interpreting studies (localization, severity, pathophysiology, etc.)
   D. Using the interpretation to guide management of the patient

You are encouraged to take advantage of every opportunity to do nerve conduction studies and operate the computers under supervision during the first month of your rotation. You will not be allowed to do your own needle examinations until you have passed the following tests:

✓ Nerve Conduction Studies Test
✓ Machine Test
✓ Written Test

Please note:

All objectives written in black are key concepts that will be tested on the EMG multiple choice test at day 15-20 of the rotation.

Objectives in red are concepts that you should learn by the end of the rotation, but will not be on the tests we give you.
NERVE CONDUCTION STUDIES TEST
(Goal – Day 5 of the rotation)

Be able to set up nerve conduction studies for the following studies:

1. Sensory studies
   A. Median at the wrist
   B. Ulnar at the wrist
   C. Median midpalmar
   D. Ulnar midpalmar
   E. Radial at the forearm
   F. Sural at the calf
   G. Superficial peroneal at the ankle

2. Motor studies
   A. Median at the wrist
   B. Ulnar at the wrist
   C. Musculocutaneous motor at the axilla
   D. Spinal accessory at the trapezius
   E. Peroneal at the ankle
   F. Tibial at the ankle

MACHINE TEST
(Goal – Day 10 of the rotation)

1. Know the following machine settings
   A. Sensory
      1. Gain
      2. Time Base
      3. Filters
   B. Motor
      1. Gain
      2. Time Base
      3. Filters
   C. F-response
      1. Gain
      2. Upper extremity time base
      3. Lower extremity time base
   D. Needle
      1. Filters

2. Be able to do the following nerve conduction studies
   A. Median sensory at the wrist (be able to recognize the amplitude, onset latency and peak latency)
   B. Ulnar motor at the wrist (be able to recognize amplitude and onset latency)
   C. Ulnar motor below the elbow (be able to recognize amplitude and onset latency, and calculate the conduction velocity in the forearm)
   D. Ulnar F-response
   E. Ulnar repetitive stimulation
I. Basic Concepts of Electricity and Electronics in Clinical EMG
   A. What is charge?
   B. What is voltage?
   C. What is current?
   D. What is impedance?
   E. What are filters?
   F. What are amplifiers?

II. Nerve Conduction Studies
   A. What is the difference between the anode and the cathode?
   B. What are the filter settings and gain settings for sensory and motor NCS?
   C. Where should G1 and G2 be placed?
D. What is the signal-to-noise ratio and when is this important? What can be done to improve the response?

E. Motor Amplitude
   1. What is the physiologic basis of the motor amplitude?
   2. What are the units used to measure it?
   3. Why do we record over the muscle motor point?
   4. What types of disorders cause a reduction of the CMAP amplitude and how can these be distinguished electrodiagnostically?

F. Sensory amplitude
   1. What is the physiologic basis of the sensory amplitude?
   2. What are the units used to measure it?
   3. What is the localization value of a normal versus abnormal sensory amplitude in the setting of both normal and abnormal motor amplitudes in the corresponding motor nerve?

G. Motor latency
   1. What is the significance of the motor latency?
   2. Do we look at the onset or peak?
   3. What are the units?

H. Sensory latency
   1. What is the significance of the sensory latency?
   2. Do we look at the onset or peak?
   3. What are the units?

I. Conduction velocity
   1. What is the physiologic basis of a slow conduction velocity?
   2. How do you calculate conduction velocity in a motor nerve?
   3. What are the units?
   4. Why do you need to stimulate at two different sites along the nerve for a motor conduction velocity but not for a sensory conduction velocity?

J. What is the difference between an orthodromic and an antidromic study?

K. Pitfalls
   1. How can you tell if you’re not over the motor point of the muscle?
   2. What will happen to the NCS responses if the patient’s skin is too cold (<32C)?
   3. What is the significance of supramaximal stimulation?
   4. What does 60 Hz interference look like and what can be done to eliminate it?

L. F-response
   1. What is the physiologic basis of the F-response?
   2. How is the F-response performed?
   3. Are the afferent and efferent arms of the F-response sensory or motor?
   4. Is there a synapse in an F-response?
   5. What disease states correlate with a prolonged F-response?
   6. Do F-responses detect radiculopathies not found on needle exam?
   7. Do you apply a supramaximal or submaximal stimulus in the F-response?

M. H-Reflex
   1. Are the afferent and efferent arms of the H-reflex sensory or motor?
   2. Is there a synapse in the H-reflex?
   3. What is the best nerve to study the H-reflex?
   4. Do you apply a supramaximal or submaximal stimulus in the H-reflex?
   5. What disease states correlate with a prolonged H-reflex?
6. Do H-reflexes detect radiculopathies not found on needle exam?

N. Physical Skills. How do you set up each of these nerve conduction studies?
   
   1. Sensory nerves
      a. Median at the wrist
      b. Ulnar at the wrist
      c. Median midpalmar
      d. Ulnar midpalmar
      e. Radial at the forearm
      f. Sural at the calf
      g. Medial and lateral antebrachial cutaneous
      h. Lateral femoral cutaneous
      i. Superficial peroneal
      j. Medial plantar
      k. Lateral plantar
   
   2. Motor nerves
      a. Ulnar
      b. Median
      c. Peroneal
      d. Tibial
      e. Musculocutaneous
      f. Radial
      g. Facial
      h. Spinal accessory
      i. Femoral
      j. Phrenic

III. Normal Values

   A. Sensory nerves. What are the normal amplitudes and latencies for each of these nerves?
      1. Median
      2. Ulnar
      3. Median midpalmar
      4. Ulnar midpalmar
      5. Radial
      6. Sural
   
   B. Motor nerves. What are the normal amplitudes and latencies for each of these nerves?
      1. Ulnar
      2. Median
      3. Peroneal
      4. Tibial
      5. Facial
   
   C. What is a normal upper extremity motor conduction velocity?
   
   D. What is a normal lower extremity conduction velocity?
   
   E. F-responses.
      1. What is a normal median/ulnar F-wave value?
      2. What is a normal tibial/peroneal F-wave value?
   
   F. What is a normal tibial/soleus H-reflex value?
G. How are normal values affected by
   1. Height
   2. Age
   3. Lower extremities vs. upper extremities
   4. Proximal vs. distal segments of the same nerve

IV. Repetitive Stimulation
   A. Which nerves are typically studied with repetitive simulation?
   B. What is the rate of stimulation that is given?
   C. Regarding the physiology of the neuromuscular junction
      1. How is Ach synthesized?
      2. What are quanta?
      3. What is a mini-endplate potential (MEPP)?
      4. What is an end-plate potential (EPP)?
      5. What is a muscle fiber action potential (MFAP)?
   D. Explain the significance of primary, secondary, and tertiary stores of acetylcholine in neuromuscular transmission, and the ramifications of these various stores on repetitive stimulation testing.
   E. Describe the exercise protocol with repetitive stimulation.
   F. What is post-exercise facilitation and in which disorders is this a prominent finding?
   G. What are the expected findings with repetitive stimulation in each of the following disorders:
      1. Myasthenia gravis
      2. Lambert Eaton Myasthenic Syndrome
      3. Botulinum intoxication

V. Needle EMG - Resting Muscle
   A. How many locations should be evaluated in each muscle?
   B. What sweep speed and sensitivity are best for observing spontaneous activity?
   C. What sweep speed and sensitivity are best for observing voluntary motor units?
   D. Insertional activity
      1. What causes increased insertional activity?
      2. What causes decreased insertional activity?
   E. Endplate noise
      1. What is endplate noise?
      2. Are endplate spikes regular or irregular?
      3. Is the initial deflection positive or negative?
   F. Fibrillation potentials and positive sharp waves
      1. What is the physiologic basis of fibrillations and positive sharp waves?
      2. How fast do fibrillations fire? (0.5-10Hz) How does this compare to normal motor units? (5-50 Hz)
      3. Are fibrillations generally regular or irregular?
      4. Is the initial deflection positive or negative?
      5. What is the significance of tiny fibrillation potentials?
      6. How long after nerve injury do positive waves and fibrillations appear?
      7. What disease states other than nerve injury can produce positive waves and fibrillations?
8. Fibrillations are graded on a scale of 0-4+. What is the difference between 1+, 2+, 3+, and 4+ fibrillations?
9. Which myopathies can cause fibrillations?
10. Which myopathies generally do not cause fibrillations?
11. After denervation, please note that fibrillations may continue until complete reinnervation has occurred.

G. Complex repetitive discharges
1. What causes complex repetitive discharges?
2. What is the appearance of a complex repetitive discharge on needle EMG?

H. Myotonia
1. What is myotonia?
2. What are the features of a myotonic discharge on EMG?
3. What disease states are associated with myotonic discharges?
4. How can complex repetitive discharges be distinguished from myotonic discharges?

I. Fasciculations
1. What is the physiologic difference between a fasciculation and a fibrillation?
2. Are fasciculations regular or irregular?
3. At what rate do fasciculations fire?
4. What conditions or disease states are associated with fasciculations?

J. Myokymia
1. How can myokymia be distinguished from complex repetitive discharges?
2. How can myokymia be distinguished from tremor?
3. What disease states cause myokymia?

K. What is the difference between cramp and neuromyotonia?

VI. Needle EMG – Motor Unit Activity
A. How do you know you are recording directly over a motor unit action potential?
B. Duration
1. What does the duration of a motor unit action potential (MUAP) reflect?
2. What is the physiologic basis for prolonged duration in neurogenic disease?
3. What does a long duration MUAP sound like?
4. What is the importance of MUAP rise time?
C. Polyphasia
1. How do you calculate the number of phases in a MUAP?
2. In normals, what percent of MUAPs have 3 or 4 phases?
3. What is the morphological difference between phases and serrations?
4. What is the physiologic basis for increased polyphasia in neurogenic disease?
5. What is the physiologic basis for increased polyphasia in myopathic disease?
D. Satellite potential
1. What does a satellite potential look like?
2. What is the physiologic basis for a satellite potential?
E. Amplitude
1. What is the upper limit of normal for the amplitude of a MUAP?
2. What does the amplitude of a MUAP reflect?
3. What is the physiologic basis for high amplitude MUAPs in neurogenic disease?
4. What is the physiologic basis for low amplitude MUAPs in myopathic disorders?
5. What does a high-amplitude MUAP sound like?
F. Recruitment
   1. What is the slowest frequency at which a voluntary motor unit can fire?
   2. In a normal recruitment pattern, what is the ratio of firing frequency (in Hertz) of the fastest motor unit to number of units firing?
   3. What is the difference between reduced recruitment and reduced activation?

VII. Electrodiagnostic Findings in Common Clinical Scenarios
   A. In each of the following conditions, describe what would be expected on nerve conduction studies (sensory, motor and F-responses) and needle EMG (including the pattern of abnormal spontaneous activity, MUAP duration, amplitude, polyphasia, and recruitment)
      1. Axonal loss
         a. Hyperacute axonal loss (<3d)
         b. Acute axonal loss (>1 week, <3-6 weeks)
         c. Subacute axonal loss (>3-6 weeks, <2-3 months)
         d. Subacute to chronic axonal loss (>2-3 months, <many months/years)
         e. Chronic axonal loss (>many months/years)
      2. Demyelinating disease
         a. Acquired demyelinating polyneuropathy
         b. Hereditary demyelinating polyneuropathy
         c. Focal demyelination (a single distal lesion)
      3. Myopathy producing muscle fiber necrosis
      4. Myopathy not producing muscle fiber necrosis (metabolic myopathy)
      5. Neuromuscular Junction Lesions (excluding abnormalities seen on repetitive stimulation and single fiber EMG)
      6. Central nervous system disease
   B. What is the electrodiagnostic approach to the diagnosis of:
      1. Painless weakness
      2. Unsteady gait
      3. Rhabdomyolysis
      4. Elevated serum CK levels
      5. Muscle cramps
      6. Foot drop
      7. Wrist drop/hand weakness

VIII. Pathophysiology of Peripheral Neuropathies
   A. What is neurapraxia?
   B. What is neurotmesis?
   C. What is axonotmesis?
   D. What is Wallerian degeneration and how does it occur?
   E. Describe the histology of normal nerves and connective tissue.
   F. What are the effects on conduction of an axonopathy?

IX. Normal Anatomy
   A. What are the nerve, nerve root, and trunk innervations of the following upper extremity muscles?
      1. Rhomboids
      2. Supraspinatus
3. Infraspinatus  
4. Deltoid  
5. Biceps Brachii  
6. Serratus Anterior  
7. Pectoralis Major – clavicular  
8. Pectoralis Major – sternocostal  
9. Brachioradialis  
10. Ext carpi radialis longus  
11. Triceps  
12. Extensor carpi Ulnaris  
13. Extensor digitorum communis  
14. Extensor indicis  
15. Extensor pollicis longus  
16. Supinator  
17. Pronator teres  
18. Flexor carpi radialis  
19. Flexor pollicis longus  
20. Flexor digitorum profundus 1&2  
21. Flexor digitorum superficialis  
22. Abductor pollicis brevis  
23. Opponens pollicis  
24. Flexor carpi ulnaris  
25. Flexor digitorum profundus 4&5  
26. First dorsal interosseus of the hand  
27. Abdductor digiti quinti of the hand  

B. What are the nerve and nerve root innervations of the following lower extremity muscles?  
1. Iliopsoas  
2. Sartorius  
3. Rectus femoris  
4. Vastus lateralis  
5. Vastus medialis  
6. Adductor longus  
7. Gluteus medius  
8. Gluteus maximus  
9. Quadratus femoris  
10. Peroneus longus  
11. Peroneus brevis  
12. Anterior tibialis  
13. Extensor digitorum longus  
14. Extensor hallucis  
15. Extensor digitorum brevis  
16. Internal hamstrings  
17. External hamstrings  
18. Short head of the biceps femoris  
19. Posterior tibialis  
20. Medial gastrocnemius  
21. Lateral gastrocnemius
22. Abductor hallucis  
23. Abductor digitorum (Ped)  
24. First dorsal interosseus pedis

X. Compressive Neuropathies 1: Median Nerve
A. What is the difference between compressive neuropathy and entrapment neuropathy? 
B. What are the signs and symptoms of carpal tunnel syndrome? 
C. What are the risk factors for carpal tunnel syndrome? 
D. What are the AANEM electrodiagnostic criteria for carpal tunnel syndrome (sensory, midpalmar sensory, and motor)? 
E. What are our criteria for carpal tunnel syndrome? Note that these relative differences are not considered absolute or diagnostic. 
F. Proximal Median mononeuropathy  
   1. The pronator syndrome  
      a. What is it and what are the symptoms? 
      b. What are the expected nerve conduction and EMG findings? 
   2. Compression at the ligament of Struthers  
      a. What are the signs and symptoms? 
      b. What are the expected nerve conduction study and EMG findings? 
G. The anterior interosseous syndrome:  
   1. Which muscles are innervated by the anterior interosseous nerve? 
   2. What are the signs and symptoms? 
   3. What are the expected nerve conduction study and EMG findings?

XI. Compressive Neuropathies 2: Ulnar Nerve
A. What muscles are supplied by the ulnar nerve? 
B. Ulnar mononeuropathy at the elbow  
   1. What are the clinical features of ulnar mononeuropathy at the elbow? 
   2. What are risk factors for ulnar mononeuropathy at the elbow? 
   3. What are the expected nerve conduction study and EMG findings in ulnar mononeuropathy at the elbow? 
   4. How are the flexor carpi ulnaris and flexor digitorum profundus 4&5 useful localizing an ulnar mononeuropathy? 
   5. How can an ulnar mononeuropathy at the elbow be distinguished from ulnar mononeuropathy proximal to the elbow? 
C. Ulnar mononeuropathy at the wrist  
   1. What are the various branches of the ulnar nerve that can be affected at the wrist? 
   2. How do the clinical presentations vary? 
   3. What are the nerve conduction study findings associated with these? 
   4. How does evaluation of the dorsal ulnar cutaneous branch help differentiate ulnar neuropathy at the wrist from ulnar neuropathy at the elbow?

XII. Compressive Neuropathies 3: Peroneal Nerve (fibular nerve) 
A. What muscle is supplied directly by the common peroneal branch of the sciatic nerve above the fibular head? 
B. What muscles are supplied by the deep peroneal nerve? 
C. What muscles are supplied by the superficial peroneal nerve?
D. Which of branch or branches of the peroneal nerve are usually involved in an entrapment neuropathy at the fibular head?
E. What are the expected nerve conduction studies and EMG findings in peroneal mononeuropathy at the fibular head?

XIII. Compressive Neuropathies 4: Radial Nerve
A. What muscles are supplied by the radial nerve before the spiral groove? Which is the last one?
B. What muscles are supplied by the radial nerve after the spiral groove but before the branch to the posterior interosseus? Which is the first one?
C. What muscles are supplied by the posterior interosseus nerve?
D. What is the first muscle innervated by the posterior interosseus nerve as it emerges from the supinator?
E. What are the expected nerve conduction study and EMG findings in a radial neuropathy at the spiral groove?
F. What are the expected nerve conduction study findings and needle EMG findings in a posterior interosseus syndrome?
G. What is the arcade of Frohse?

XIV. Compressive Neuropathies 5: Uncommon Compressive Neuropathies
A. What is the difference between vascular and neurogenic thoracic outlet syndrome?
B. What are the expected nerve conduction study and EMG findings in neurogenic thoracic outlet syndrome?
C. What are the features of digital nerve entrapment of the hand?
D. Sciatic neuropathy:
   1. What muscles are supplied by the sciatic nerve?
   2. What etiologic factors may contribute to sciatic mononeuropathy?
   3. What are the expected nerve conduction and EMG findings?
E. Tarsal Tunnel Syndrome:
   1. What are the clinical features of tarsal tunnel syndrome?
   2. What etiologic factors may contribute to tarsal tunnel syndrome?
   3. What are the expected nerve conduction study and EMG findings?
F. Femoral Neuropathy:
   1. What are the sensory branches of the femoral nerve?
   2. What is the clinical presentation of lateral femoral cutaneous neuropathy?
   3. What muscles are innervated by the femoral nerve?
G. What are the findings in long thoracic neuropathy?
H. What are the findings in dorsal scapular neuropathy?
I. What are the findings in suprascapular neuropathy?
J. What are the findings in musculocutaneous neuropathy?
K. What are the findings in ilioinguinal, genitofemoral, and saphenous neuropathies?
L. What are the findings in obturator neuropathy?

XV. Anomalous Innervation
A. What are the three types of median-ulnar anastomoses?
B. Which is the most common type of median-ulnar anastomosis?
   1. What nerve conduction study finding suggests the presence of this anastomosis?
   2. How would this anomaly be confirmed?
C. What are the findings in a patient with a median-to-ulnar anastomosis and carpal tunnel syndrome?
D. What muscle may be innervated by an accessory peroneal nerve?
E. How is an accessory peroneal nerve identified on nerve conduction studies?

XVI. Axonal vs. Demyelinating Neuropathy

A. What types of nerve fibers are involved in conveying pain:
   1. Pain
   2. Temperature
   3. Pressure
   4. Vibration
   5. Two-point discrimination
   6. Proprioception
B. What physical exam findings may be present in patients with peripheral neuropathy?
C. What electrodiagnostic findings differentiate peripheral neuropathy from polyradiculopathy?
D. What electrodiagnostic findings are suggestive of an axonal peripheral neuropathy?
E. Demyelinating peripheral neuropathy
   a. What electrodiagnostic findings are suggestive of an acquired demyelinating peripheral neuropathy?
   b. What conditions cause an acquired demyelinating peripheral neuropathy?
   c. What electrodiagnostic findings are suggestive of a hereditary demyelinating peripheral neuropathy?
   d. What conditions cause a hereditary demyelinating peripheral neuropathy?
   e. How can cool skin temperature be misleading in determining whether a peripheral neuropathy is axonal or demyelinating?
   f. What percentage of patients over 70 years old will have a sural sensory response?

F. How do you define peripheral neuropathy in the geriatric population?

G. Hereditary neuropathies
   1. What are the most common hereditary neuropathies and how are they classified?
   2. What genetic tests are available for hereditary neuropathies?
   3. In approximately what fraction of hereditary demyelinating neuropathies is there no known family history?

H. What is multifocal motor neuropathy and what are the findings on nerve conduction studies?

XVII. Radiculopathies and Plexopathies

A. Radiculopathy
   1. What are the expected findings on motor nerve conduction studies in a radiculopathy?
   2. What are the expected findings on sensory nerve conduction studies in a radiculopathy?
   3. After an acute radiculopathy, which muscles (proximal or distal) will show abnormal spontaneous activity first? Which muscles will show changes of reinnervation first?
   4. What are the most common cervical and lumbar radiculopathies?
5. What are the electrodagnostic findings in lumbar spinal stenosis?
6. What is the minimum number of muscles that should be tested to screen for radiculopathy in an upper extremity?
7. What is the minimum number of muscles that should be tested to screen for radiculopathy in a lower extremity?
8. What abnormalities do you expect on needle exam in each of the following radiculopathies?
   a. L4 radiculopathy
   b. L5 radiculopathy
   c. S1 radiculopathy
   d. C5 radiculopathy
   e. C6 radiculopathy
   f. C7 radiculopathy
   g. C8 radiculopathy

B. Plexopathy
1. How can you differentiate plexopathy from radiculopathy on the basis of nerve conduction studies?
2. What are the clinical features of an upper trunk brachial plexopathy?
3. What are the clinical features of a lower trunk brachial plexopathy?
4. Which nerves are supplied by the posterior cord?
5. Which nerves are supplied by the lateral cord?
6. Which nerves are supplied by the medial cord?
7. Draw the brachial plexus.
8. In an upper trunk plexopathy, which of the following sensory nerve action potentials will be affected?
   a. Median at D1
   b. Median at D3
   c. Ulnar
   d. Radial
   e. Medial antebrachial cutaneous
   f. Lateral antebrachial cutaneous
9. In a lower trunk plexopathy, which of the following sensory nerve action potentials will be affected?
   a. Median at D1
   b. Median at D3
   c. Ulnar
   d. Radial
   e. Medial antebrachial cutaneous
   f. Lateral antebrachial cutaneous
10. In a middle trunk plexopathy, which of the following sensory nerve action potentials will be affected?
   a. Median at D1
   b. Median at D3
   c. Ulnar
   d. Radial
   e. Medial antebrachial cutaneous
   f. Lateral antebrachial cutaneous
11. In a lateral cord plexopathy, which of the following sensory nerve action potentials will be affected?
   a. Median at D1
   b. Median at D3
   c. Ulnar
   d. Radial
   e. Medial antebrachial cutaneous
   f. Lateral antebrachial cutaneous

12. In a medial cord plexopathy, which of the following sensory nerve action potentials will be affected?
   a. Median at D1
   b. Median at D3
   c. Ulnar
   d. Radial
   e. Medial antebrachial cutaneous
   f. Lateral antebrachial cutaneous

13. In a posterior cord plexopathy, which of the following sensory nerve action potentials will be affected?
   a. Median at D1
   b. Median at D3
   c. Ulnar
   d. Radial
   e. Medial antebrachial cutaneous
   f. Lateral antebrachial cutaneous

14. What is diabetic amyotrophy?
15. What is brachial plexitis (Parsonage-Turner Syndrome?)
16. Are paraspinal muscles affected in plexopathy?

C. Paraspinal Mapping
   1. How much paraspinal denervation can one expect in the low back muscles of asymptomatic persons?
   2. What is the specificity of needle EMG in differentiating clinically and radiographically apparent spinal stenosis from low back pain or no symptoms?
   3. How does one place an EMG needle in the L5-innervated paraspinal muscles?

XVIII. Cranial Nerve Studies
   A. For what clinical situations is a facial motor response a useful study?
   B. In the blink reflex, what pathway does the R1 represent?
   C. In the blink reflex, what pathway does the ipsilateral R2 represent?
   D. In the blink reflex, what pathway does the contralateral R2 represent?

XIX. Motor Neuron Disease
   A. What are the different motor neuron diseases that affect adults and children and how are they can be distinguished clinically?
   B. What is the differential diagnosis for weakness with normal sensation?
   C. What are the clinical features of amyotrophic lateral sclerosis?
   D. In motor neuron disease:
      1. What are the expected sensory and motor nerve conduction study findings?
      2. What findings may be noted on repetitive stimulation?
3. What findings are expected on needle examination and what is the distribution of involvement?
E. A cervical lesion may cause polyradiculopathy (wasting and weakness of the upper limbs) and myelopathy (spasticity in the lower limbs). How can this be distinguished from ALS?
F. What are the Escorial definitions of definite, probable, and possible motor neuron disease? What are the four body segments that can be tested to meet these criteria?
G. What does muscle biopsy show in motor neuron disease?
H. Why are thoracic paraspinal muscles useful in the EMG evaluation of ALS?

XX. Introduction to Muscle Pathology
A. Be able to identify each of the following in muscle tissue, and describe the clinical significance of the findings that are abnormal:
   1. Normal H&E
   2. Atrophic muscle fibers
   3. Fiber type grouping
   4. Increased glycogen storage
   5. Split fibers
   6. Central nuclei
   7. Vacuoles
   8. Z band, I band, and A band
B. What are the features of Type I muscle fibers?
C. What are the features of Type II muscle fibers?
D. How do the following relate to each other: Muscle fibers, myofibrils, sarcomeres?

XXI. The Muscular Dystrophies
A. What are the clinical features, mode of inheritance, and EMG findings in:
   1. Duchenne muscular dystrophy
   2. Becker muscular dystrophy
   3. Limb Girdle muscular dystrophy
   4. Fascioscapulohumeral muscular dystrophy
   5. Oculopharyngeal muscular dystrophy
   6. Myotonic dystrophy
B. How are muscular dystrophies classified?
C. For which muscular dystrophies is a gene test available?

XXII. Inflammatory/Metabolic Myopathies
A. What are the clinical features and EMG characteristics of:
   1. Dermatomyositis
   2. Polymyositis
   3. Steroid myopathy
   4. Inclusion body myositis
   5. Hypokalemic periodic paralysis
   6. Hyperkalemic periodic paralysis
   7. Statin myopathy
B. What are the limitations of EMG in the diagnosis of steroid myopathy?
C. What are the EMG findings in an incompletely treated inflammatory myopathy?
XXIII. Congenital/Storage Myopathies
   A. What are the clinical features and muscle biopsy findings in:
      1. Central core myopathy
      2. Nemaline myopathy
      3. Myotubular (centronuclear) myopathy
      4. Mitochondrial myopathy
   B. What are the clinical features and muscle biopsy findings in:
      1. Acid maltase deficiency (Pompe’s disease)
      2. Myophosphorylase deficiency (McArdle’s disease)
      3. Carnitine palmitoyltransferase deficiency

XXIV. Myotonia
   A. What are the clinical features of myotonic dystrophy?
   B. What are the clinical features of myotonia congenita?
   C. What are the clinical features of paramyotonia congenita?
   D. What ion channels are involved in each of the myotonic disorders?

XXV. Neuromuscular Complications of Cancer 8.18
   A. What conditions can cause facial myokymia?
   B. Describe the clinical picture in the various paraneoplastic syndromes of the peripheral nervous system.
   C. How can radiation plexopathy be differentiated from plexopathy caused by metastatic tumor?

XXVI. An Approach to the Diagnosis of Neuromuscular Disease in the Floppy Infant 8.19
   A. How do the nerve conduction study findings differ between normal infants and adults?
   B. What is the most likely diagnosis in a floppy infant with neuropathic motor unit changes on EMG?
   C. What is neonatal myasthenia gravis?

XXVII. SFEMG 8.21
   A. What is jitter and how is it measured?
   B. What is the significance of increased jitter?
## Physical Medicine and Rehabilitation
### EMG Rotation Skills List

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