Workshop handouts are prepared as background didactic material to complement a hands-on workshop session. This workshop handout was originally prepared in September 1994 and was revised in September 2003. The ideas and opinions in this publication are solely those of the author(s) and do not necessarily represent those of the AANEM.
The specific knowledge base required for performing an electrodiagnostic medicine consultation is broad, and includes anatomy, physiology, pathophysiology, diseases, techniques, electricity, and patient interaction. Conducting a successful needle examination requires attention to a number of specific issues in a series of steps:

- Clinical evaluation
- Preparing the patient
- Selecting the muscles to test
- Special considerations
- Locating the muscle
- Performing the examination

The clinical history and physical examination should be carefully reviewed before beginning the electrodiagnostic medicine consultation to develop your own clinical hypotheses. Keep in mind the questions you need to answer. Fill in details of the history during the needle examination. This approach has the added benefit of distracting the patient from the discomfort of the exam.

Note the distribution of muscle weakness; the needle examination will usually require assessment of weak muscles. For example, if an L5 radiculopathy is suspected and the extensor hallucis longus is the only weak muscle, it should be included in the study. Review the results of any previous studies to help design selection and order of the muscles to test. Plan the study to answer the questions as efficiently as possible with the least patient discomfort.

PREPARING THE PATIENT FOR THE STUDY

Most patients will have received information about the needle examination prior to the study and may have a few questions. It is still helpful to briefly explain that the needle will be inserted into a number of muscles and that there will be some discomfort, which is unavoidable. It is also helpful to point out that, although some pain is to be expected, the test is tolerated well by nearly everyone. Do not use statements such as, “A fine wire electrode will be placed...” Many will be caught unaware seconds later when they feel a needle stick, and their confidence in you might suffer. The patient will appreciate knowing approximately how long the study will take and how many muscles will be examined. Cleanse the skin over each muscle with alcohol or other appropriate agent before needle insertion. Patients appreciate your attention to issues related to possible infection. Prior to each needle insertion indicate to the patient the approximate location and alert them to an imminent “stick or poke.”
Selección de músculos para examen

The groups of muscles to be tested are initially selected on the basis of the clinical hypotheses, e.g., proximal for myopathy, single limb for radiculopathy, widespread for motor neuron disease, etc. The individual muscles selected for examination should ideally be superficial, easily palpated and readily identified. They should be located away from major vessels, nerve trunks, and viscera. Select muscles that are less uncomfortable for the patient. For example, the thenar and small foot muscles are often more uncomfortable, and should only be tested when the information is not available from other muscles. Since the appearance of motor unit action potentials (MUAPs) can vary greatly between different muscles, the muscles selected should be familiar to the examiner, both in how to test the muscle and the range of normal findings.

Localización anatómica del músculo

A needle electrodiagnostic medicine consultation (EMG) is intrinsically linked to human anatomy. This workshop is designed to facilitate the incorporation of anatomic principles into the practice of needle EMG. A thorough knowledge of musculoskeletal anatomy is essential to the successful practice of electrodiagnostic medicine. Above all else, the practitioner must always be certain of which muscle is being examined. Achieving that certainty is easily accomplished when the electrodiagnostic medicine consultant is confident of needle placement through a detailed knowledge of the pertinent anatomy (see appendix A).

Knowledge of anatomy is preferable to fixed distances for identifying the optimal point of insertion of the needle. Estimates of where to insert the needle based upon fixed distances from an anatomical landmark quickly fail in practice. A fixed distance will mean one thing in an infant, another in an obese adult and quite another in a tall adult. Apparent muscle locations vary with limb and joint position, with edema and with the atrophy or hypertrophy of disease. Only a detailed understanding of the three dimensional relationships that do not vary among patients makes it possible to develop confidence in needle placement. If sufficiently superficial, the muscle to be tested should be palpated during intermittent contraction to localize its borders with the thumb and index finger before needle insertion to optimally define the point of insertion. The location of end plate regions should also be taken into account.

Realizando la consulta de electrodiagnóstico

An electrodiagnostic medicine consultation includes a number of distinct skills that are described in detail below:

- Técnicas de EMG
- Control del dolor
- Recolección de datos
- Análisis de actividad EMG

Después del estudio

Forzar la sangre fría aplicada por el electrodiagnostic medicine consultant o el paciente unirán usualmente el sangrado. Un paquete de hielo es útil para minimizar la sangre si un hematoma pequeño ha formado. Asegúrese de que el paciente pueda vestirse sin ayuda o se asegure de que tengan ayuda. Algunos pacientes pueden preguntar si la inyección les causará dolor. Se les puede informar que sus músculos pueden doler por unos cuantos horas, pero esto desaparecerá durante la noche. Si es necesario, se pueden usar analgésicos blandos.

Técnicas de aguja EMG

The ability to record normal and abnormal electrical activity from muscle depends highly on skill in the use of the needle-recording electrode. Needle EMG requires a number of skills and knowledge. The needle placement and data recording that are absolutely necessary to obtain accurate and reliable waveforms, suffers from having the least attention devoted to it. A few simple guidelines allow this crucial aspect of electrodiagnostic medicine consultations to be performed correctly and efficiently. The following discussion outlines some of the considerations.

Electrodo de aguja

A variety of needle electrode lengths and types are available. Needle electrode selection depends on a number of patient and examiner considerations (Appendix B and C). Needle electrodes must be sterile. Disposable, standard electrodes are available at a reasonable cost and should be considered for each patient. Such electrodes are typically sharp and undistorted. Rarely they may not be sharp and will resist insertion. If an electrode penetrates the skin with difficulty, passing it through a sterile cotton or sponge to identify snags from bent tips can test it. To determine if a batch of electrodes are not well made they should be examined under a low power microscope.

Las agujas deben estar rectas. Una aguja que ha sido doblada no se debe rectificar para un uso continuo, ya que una pequeña grieta puede formarse. Si una serie de electrodos no están bien hechos, deben ser examinados bajo un microscopio de baja potencia.

Muscules à examiner

Les groupes de muscles à tester sont initialement sélectionnés en fonction des hypothèses cliniques, e.g., proximal pour la myopathie, jambes isolées pour la radiculopathie, généralisé pour la maladie motoneuronale, etc. Les muscles individuels choisis pour l’examen devraient idéalement être superficiels, facilement palpables et facilement identifiés. Ils devraient être situés loin des vaisseaux majeurs, des troncs de nerf, et des organes. Sélectionnez des muscles qui sont moins inconfortables pour le patient. Par exemple, les muscles thenaires et les muscles des petits pieds sont souvent plus inconfortables, et devraient être testés uniquement lorsque l’information n’est pas disponible à partir d’autres muscles. Comme l’apparition des potentielles d’unité motoneuronale (MUAP) peuvent varier grandement entre différents muscles, les muscles sélectionnés devraient être familiers à l’examineur, tant en termes de méthode de test du muscle et de l’ensemble des résultats normaux.

Localisation anatômique du muscle

Un examen électromyographique (EMG) est intrinsèquement lié à l’anatomie humaine. Cette séance de travail est conçue pour faciliter l’inclusion des principes anatomiques dans la pratique de l’EMG par aiguille. Une connaissance approfondie de l’anatomie musculosquelettique est essentielle pour le bon exercice de l’EMG par aiguille. En premier lieu, le praticien doit toujours être certain de laquelle est le muscle examiné. Avoir cette certitude peut être facilement accompli lorsque le consultatif EMG par aiguille est confiant sur l’insertion de l’aiguille grâce à une connaissance détaillée de l’anatomie pertinente (voir annexe A).

La connaissance de l’anatomie est préférable aux distances fixes pour identifier le point d’insertion optimal de l’aiguille. Les estimations de l’endroit où insérer l’aiguille basées sur des distances fixes par rapport à un marqueur anatomique rapidement échouent en pratique. Une distance fixe signifie un seul chose chez un bébé, une autre chez un adulte obèse et une autre chez un adulte grand. Les localisations apparentes des muscles varient avec la position du membre et du joint, avec l’œdème et avec l’atrophie ou l’hypertrophie de la maladie. Seule une compréhension détaillée des relations dimensionnelles qui ne varient pas parmi les patients rend possible le développement de la confiance dans l’insertion de l’aiguille. Si suffisamment superficiel, le muscle à tester devrait être palpé pendant le contractile intermittent pour localiser ses limites avec le pouce et le doigt index avant l’insertion de l’aiguille pour optimalement définir le point d’insertion. La localisation des régions des plaques de finition devrait également être prise en compte.

Exécution de l’examen électromyographique

Un examen électromyographique comprend un certain nombre de compétences distinctes qui sont détaillées ci-dessous:

- Techniques EMG par aiguille
- Contrôle du douleur
- Collecte de données
- Analyse d’activité EMG

Après l’étude

Avant de quitter la pièce, vérifiez s’il n’y a pas de points de ponction humides ou bleutés. Si la saignée est toujours présente 1 à 2 minutes après un appui ferme sur le praticien EMG par aiguille ou le patient, il est généralement arrêté. Un pack de glace est utile pour minimiser la saignée si un hématome a formé. Assurez-vous que le patient peut se vêtir seul ou assurez-vous qu’ils ont de l’aide. Certains patients peuvent demander si le test leur causera du mal. Ils peuvent être informés que leurs muscles peuvent être douloureux pendant quelques heures, mais ils disparaîtront après la nuit. Si nécessaire, des analgésiques légers peuvent être utilisés.

Techniques EMG par aiguille

La capacité à enregistrer une activité électrique normale et anormale du muscle dépend fortement de la compétence de l’utilisation de l’électrode-recueilleur par aiguille. EMG par aiguille nécessite un certain nombre de compétences et de connaissances. L’insertion de l’aiguille et la collecte de données qui sont essentielles pour obtenir des ondes de potentielles d’unité motoneuronale fiables, souffrent d’avoir le moins d’attention consacrée à lui. Quelques simples directives permettent d’effectuer correctement et efficacement cette partie cruciale des consultations électromyographiques. Le présent exposé décrit quelques-unes des considérations.

Electrodes par aiguille


Aiguilles doivent être droites. Une aiguille qui a été pliée ne doit pas être rectifiée pour un usage continu en raison d’une petite brèche. Si une série d’aiguilles par aiguille ne sont pas bien faites, elles doivent être examinées sous un microscope à faible puissance.
insulation may cause a short circuit and needle EMG signal distortion. The recording surface must be the correct size and shape, and absolutely clean. Disposable, sterile needles from the manufacturer may rarely be left with a very thin, poorly conducting film on the surface that increases the impedance to cause a low-voltage, irregular, positive waveform (popping noise). This must be recognized since it may be mistaken for end plate noise or positive waveform fibrillation potentials. The film may be dispersed within a few seconds in the muscle. If not, the needle should be replaced. The shaft must be stable in the hub to prevent breaking off in a patient. The connections to the cable must be in tact. A poor connection can result in intermittent 60Hz or irregular interference. Electrical impedance should be checked if a break or short is suspected (correct impedance at 60Hz is 5-20 megohms).

NEEDLE INSERTION

The muscle to be tested should be palpated during intermittent contraction to localize its borders with the thumb and index finger. It is helpful to make the skin taut at the site of insertion, particularly where the skin is loose. The taut skin is best pulled a short distance distally over the muscle to reduce bleeding (when released, the skin will pull back over the needle site in the muscle).

The needle electrode should be held firmly in the fingers like a pen and inserted smoothly and quickly through the skin into the subcutaneous tissue or superficial layers of the muscle at approximately a 45° angle. This minimizes the force necessary to achieve penetration, and also may distract the patient prior skin puncture. Rest the hand holding the needle on the skin to make needle movement comfortable and precise, while your opposite hand is on the boundaries of the muscle for assistance in localization during needle movement.

During needle insertion and the study of insertional activity, the study is best served if the patient is not asked to do anything more than relax. There are many pertinent reasons to avoid relying on patient input for your localization of a muscle. No voluntary contractions should be required to confirm needle placement, for the following reasons: (1) Some patients are not capable of activating one or any muscle, e.g. with nerve palsy, hemiparesis, coma, upper motor neuron disorders, hysteria, etc. (2) Some muscles are not palpable from the surface in any patient, e.g. posterior tibial, and fewer still in the obese patient. (3) Voluntary contractions can be misleading. If the needle, for example, is mistakenly placed in the flexor carpi radialis rather than the targeted pronator teres, testing localization with forearm pronation will not reveal the error, as both muscles carry this function. (4) Patients tend to become less comfortable with needle EMG consultations as time passes. The sequence of palpation, contraction, repalpation, needle insertion, and recontraction takes time, extending the length of the examination. (5) The patient’s confidence in you might waver if you spend as much time searching for each muscle as examining it. (6) Above all, you must be completely confident that you are examining the muscle you intend to study.

NEEDLE MOVEMENT

The muscle is examined by moving the needle along a straight line into the muscle in short steps (0.5 - 1 mm). Large movements are more painful and endplate areas may not be recognized. The needle should not be released between movements. The pace of needle movement should not be rushed. A brief pause (1 second or more) between each step movement is needed to listen and watch for slow abnormal activity. The needle is advanced 5 to 30 such steps depending on muscle diameter. After traversing the diameter, the needle is withdrawn from the muscle, but not from the skin, and then reinserted at a different angle in the same location. Two to four such passes through the muscle are made until an adequate number of sites in the muscle have been examined.

DATA COLLECTION

The muscle should be examined at multiple sites both at rest and during contraction using the methods described above. Either resting or contracting muscle may be tested initially. Resting muscle is preferred first since it is sometimes more difficult to obtain full relaxation than a contraction. However, if a muscle is already contracting at the desired level on insertion, it should be tested in that position. Do not intermittently relax and contract a muscle at one site. That leads to more local muscle damage, bleeding, and subsequent pain.

Resting Muscle

The resting muscle is tested for spontaneous activity at a gain of 50 µv/cm. When the needle is well within the muscle it should be left undisturbed for a number of seconds to listen for fasciculations. It is not always easy to obtain muscle relaxation. In tense patients or during a painful examination, relaxation can be enhanced by:

- carefully positioning the patient at the beginning to provide the best relaxation and save time overall.
- adequately supporting the limb and, at times, passively manipulating the limb.
- contraction of antagonist.
• distraction with conversation.
• reassurance.
• changing needles.

Once you have the needle under the skin, a more gentle movement of the needle can be used to pierce the superficial fascia. As the fascia is approached, listen for the rumbling of “distant” motor units. The muscle might not be relaxed enough to proceed, and pushing the needle into a moderately or strongly contracting muscle is unnecessarily painful. Give specific directions about how to relax, especially at increasingly higher volumes on your part. The typical responses are, “I thought I was relaxed,” or, “I’m as relaxed as I can be with you sticking that needle in me.”

Tonic pressure should be kept on the needle hub while studying insertional activity. If you do not, particularly with concentric needle electrodes, there will be a tendency for the electrode to “bounce” back out of the muscle the same distance you just moved it in. Insertions should be smooth, firm, and small amplitude forward movements of 0.5 mm or so. There is no advantage in using hard jabbing motions and they cause undue pain.

**Contracting Muscle**

The contracting muscle is examined using the same needle methods as for resting muscle. The contracting muscle is best examined with the muscle held at a level of contraction that activates a few motor units (low to moderate effort). Selective activation of the muscle of interest and adjacent muscles is needed to determine needle position when examining deep muscles, muscles that are difficult to palpate, or small muscles. Steps in testing contracting muscle include:

• withdrawing the needle to a subcutaneous position before asking for muscle contraction.

• positioning the limb and muscle and initiating contraction before moving the needle into the muscle. Advance the needle until you encounter MUAPs with a rapid rise time and sharp, clicking sound

• positioning the joints across which the muscle acts to limit the activity of synergistic and adjacent muscles.

• asking the patient to perform a movement that requires activation only of the muscle being examined.

• palpating the contracting muscle to help guide the needle movement.

**Special problems**

Small muscles are best tested with an oblique needle course through the muscle to lengthen the needle’s path. Deep muscles and obese patients require a needle of adequate length. If the needle were to break off at its weakest point, the hub, while inserted to a depth greater than its length, the needle would be difficult to remove. Some muscles, such as the deep paraspinal muscles, may be difficult to reach, even in average-sized patients, without a long needle. Needles of up to 120 mm length should be available.

**Pain Control**

Most patients are able to tolerate the discomfort of the needle examination without difficulty, but a few need special approaches. Pain minimization requires attention to all interactions with the patient, in particular the techniques of the needle examination itself. Approaches that can be helpful in all patients are described in Appendix C.

A number of special problems presented by a few patients must be considered before initiating the needle examination. These are detailed in Appendix D and include:

• anticoagulants and bleeding disorders

• infection

• cardiac valvular disease

• obesity

• skin conditions
APPENDIX A: TESTING SPECIFIC MUSCLES

UPPER EXTREMITY MUSCLES

Note: In the arm, “lateral” refers to the thumb side of the arm, while “medial” refers to the ulnar side of the arm.

FLEXOR DIGITORUM PROFUNDUS

ULNAR (MEDIAL) HEADS

**Innervation:** Ulnar nerve; lower trunk; medial cord; C8, T1

**Localization:** In the proximal one-third of the forearm, immediately ventral to the ulnar shaft. Here, the muscle lies just below the thin aponeurosis of flexor carpi ulnaris (see cross section 1 below). It is too deep to be readily palpated. Insert needle to a depth of 1 to 2 cm, unless there is more than the usual overlying subcutaneous tissue.

**Activation:** Flexion of the distal phalanges of digits 4 and 5.

OPPONENTS POLLICIS

**Innervation:** Median nerve; lateral cord; lower trunk; C8, T1

**Localization:** At the midpoint of the first metacarpal shaft, in the groove between the metacarpal bone and abductor pollicis brevis (see cross section 1 below). The muscle is studied where it attaches to the medial side of the bone. In most patients, no other muscle overlies the opponents at this point.

**Activation:** Opposition of thumb across the palm.

BRACHIALIS

**Innervation:** Musculocutaneous nerve; lateral cord; upper trunk; C5, C6

**Localization:** In the distal one-third of the arm, push the biceps (see cross section 1 below) medially and insert the electrode in the groove between biceps and triceps (see cross section 2 below). Direct it down and medially, toward the anterior aspect of the humeral shaft.

**Activation:** Elbow flexion; the degree of forearm pronation-supination is irrelevant.
SERRATUS ANTERIOR

**Innervation:** Long thoracic nerve; C5, C6, C7

**Localization:** In the mid or anterior axillary line, isolate one rib by placing two fingers in the adjacent interspaces, anterior to the bulk of the latissimus dorsi (see cross section 1 below), but posterior to the breast tissue in a woman. Needle electrode insertion is directly between your fingers, as serratus anterior is the only muscle between the skin and the rib.

**Activation:** Elevation and reaching forward with the arm, i.e., scapular protraction. Providing resistance is sometimes necessary.

RHOMBOID

**Innervation:** Dorsal scapular, C4, C5

**Localization:** Beneath the trapezius. Origin from lateral mass of upper thoracic vertebrae. Insertion on lower third of medial scapular border. Can be palpated during activation in some muscular patients.

**Activation:** Hand in the small of the back with palm pushing posterior against the examiner. Posterior (dorsal) pressure against resistance of the elbow on the hip can be used in patients unable to make this first maneuver. Caution is required since penetration too deeply could enter the pleural cavity.

FLEXOR POLLCIS LONGUS

**Innervation:** Anterior interosseous branch, median nerve, medial cord, lower trunk, C8, T1 (C7)

**Localization:** Superficial on the ventral surface of the distal fifth of the forearm, immediately lateral to the extensor carpi ulnaris and medial to the thumb extensors. Follow the line of the index extensor tendon to just proximal to the wrist where the muscle can often be palpated.

EXTENSOR INDICIS PROPRIUS

**Innervation:** Posterior interosseous branch, radial nerve, posterior cord, lower (middle) trunk, C8 (C7)

**Localization:** Superficial on the dorsal surface of the distal fourth of the forearm, just beneath the radial artery. The muscle can often be palpated with contraction. Needle placement is usually best just medial to the artery; if the artery is more medially located, place it just lateral.

**Activation:** Flexion of the distal phalanx of the thumb.
EXTENSOR DIGITORUM COMMUNIS

**Innervation:** C7, C8, middle and lower trunks, posterior cord, radial nerve, posterior interosseous.

**Localization:** Superficial, readily palpable muscle that is bordered laterally by muscles innervated directly from the radial nerve, rather than from the posterior interosseous. Localization is best obtained by palpation of the active muscle in the center of the proximal third of the forearm dorsum, during selective extension of digit III. It is important to distinguish the radial innervated wrist extensors supplied by the posterior interosseous nerve from the EDC. These groups are easily separable by a groove between them and the EDC. The former are just lateral to the groove, the latter just medial to it. The muscles lateral to the groove are easily movable (anatomists label them the “movable wad”). The EDC and the extensor carpi ulnaris just medial to it are fixed to the underlying tissues.

**Activation:** Extension of 3rd digit.

LOWER EXTREMITY MUSCLES

EXTENSOR HALLUCIS LONGUS (EHL)

**Innervation:** Deep branch of peroneal (fibular) nerve; peroneal (fibular) division of sciatic nerve; sacral plexus; L5, S1

**Localization:** At the junction of the middle and lower thirds of the leg, one-third of the distance from the tibial shaft to the lateral border of the leg. The electrode is directed deep and medially. The anterior tibial (AT) is just lateral to the shaft of the tibia. Insert the electrode one-third the distance laterally around that quadrant to avoid piercing the thick AT tendon. Also, angle the needle from lateral to medial, rather than aiming it straight down, because the belly of EHL is thin and vertically oriented.

**Activation:** Great toe extension; be certain the needle is pulled back into the subcutaneous tissue before the patient contracts this muscle.

GLUTEUS MEDIUS

**Innervation:** Superior gluteal nerve; sacral plexus; furcal nerve; L4, L5, S1

**Localization:** The anterior border of gluteus medius is defined by the line joining the anterior superior iliac spine (ASIS) and greater trochanter. The electrode is inserted parallel to this line, at its midpoint and just posterior to it.

**Activation:** Internal rotation of the thigh. Needle insertion as described above places it in the anterior fibers of gluteus medius, allowing internal rotation to be used for activation. If more posterior locations, the gluteus medius can be readily activated with the patient lying on the contra lateral side and the foot resting on the bed while the knee is gently raised toward the ceiling.
**ADDUCTOR LONGUS**

*Innervation:* L2, L3, lumbar plexus, obturator nerve

*Localization:* Both borders are readily palpable for needle placement in the proximal 20% of the medial thigh with the knee flexed to 90 degrees and abducted. If the needle is placed too distal, approaching the adductor canal of Hunter, it could easily enter the adductor magnus, part of which is supplied by the sciatic nerve. Investigation of a possible obturator neuropathy could thereby be compromised.

*Activation:* With the patient lying on the back with the knee flexed and externally rotated, minimal elevation of the knee readily activates a number of motor unit potentials without the examiner needing to resist the motion.

**BICEPS FEMORIS**

**SHORT HEAD**

*Innervation:* Peroneal (fibular) division of sciatic nerve, sacral plexus, L5, S1

*Localization:* The needle is inserted just lateral or just medial to the lateral hamstring tendon, at the proximal popliteal crease, then directed to underneath the tendon. If the muscle is studied more proximally, the short and long heads cannot be distinguished. At the more distal point only short head muscle fibers will be encountered, to better exclude proximal damage to the peronal nerve.

*Activation:* Partial knee flexion with the heel resting on the bed.

**PERONEUS LONGUS**

*Innervation:* Superficial peroneal, peroneal nerve, peroneal division of sciatic nerve, sacral plexus, L5, S1

*Localization:* Readily palpable, immediately lateral to the anterior tibial muscle, in the proximal third of the leg.

*Activation:* Plantar flexion of the foot with a minimum of eversion.

**FLEXOR DIGITORUM LONGUS**

*Innervation:* Tibial nerve, sciatic nerve, sacral plexus, L5 (S1)

*Localization:* Distal third of the leg, immediately posterior to the tibia at a depth of 2 - 3 cm. Needle insertion just behind the ventral (posterior) surface of the tibia usually passes through some of the soleus which can be distinguished by selective activation. Occasionally the posterior tibial is entered first.

*Activation:* Toe flexion with the ankle slightly dorsiflexed. The posterior tibial can be distinguished by slight plantar flexion and inversion with no toe flexion.

**TENSOR FASCIA LATA**

*Innervation:* Superior gluteal, sacral plexus, (furcal nerve), (L4), L5

*Localization:* One-half the distance between the anterior iliac spine and the greater trochanter. Vertical entry is needed, since the muscle is often deep.

*Activation:* Most patients can provide excellent MUP control with gentle internal hip rotation, and full relaxation with external rotation.

**FIRST DORSAL INTEROSSEOUS, PEDIS**

*Innervation:* Deep branch peroneal (fibular) nerve, sciatic nerve, sacral plexus, L5, S1.

*Localization:* The index finger of one hand is placed in the notch between metatarsal heads I and II. The needle is inserted just distal to your finger, and directed slightly toward digit II upon which this muscle acts. This muscle is less painful, is less subject to trauma than other intrinsic foot muscles, and is the most distal muscle in the body. This muscle is therefore very sensitive to even mild, distal motor axon loss.
CRANIAL MUSCLES

TONGUE (GENIOGLOSSUS)

**Innervation:** Hypoglossal nerve; Cranial nerve XII

**Localization:** Midpoint between tip of chin and the angle of the jaw, medial to the mandible. The tongue is found deep here, after the electrode passes through mylohyoid (see cross section 1 below) and geniohyoid (see cross section 2 below) muscles.

**Activation:** Protrusion of the tongue. Ask the patient to stick out the tongue.

APPENDIX B. REDUCING THE DISCOMFORT OF THE NEEDLE EXAMINATION

**NEEDLE HANDLING TECHNIQUES**

While needle movement in short can minimize the pain, and in some patients give a painless needle EMG, a few patients will be unable to tolerate the discomfort. Below are steps that are required to gain patient tolerance of the discomfort that does occur.

- Tell the patient that some areas of the muscle may be uncomfortable (near small nerves).
- Tell the patient that you will move away from such areas if they tell you about the pain.
- Quickly move a short distance away from an area where the patient has increased pain.
- Penetrate through dorsal rather than ventral skin if possible, e.g. opponens rather than abductor pollicis brevis, and brachialis rather than biceps.
- Whenever feasible, the needle should follow a path nearly parallel to the muscle fibers, rather than perpendicular to them. While there will be no difference in the appearance of the wave forms observed, normal or abnormal, the tangential approach is less painful.
- Use a secondary muscle function for contraction, e.g. the pronation of the pronator teres can be quite painful as the muscle torques around the electrode. The secondary function of elbow flexion instead pulls the needle along in a linear path that is generally much more easily tolerated.
- Use a one-joint muscle if possible. For example, the gastrocnemius is an extremely strong muscle and obtaining its contraction using pressure against your hand can be difficult if not impossible. The soleus has the same S1 innervation, and can be much more readily activated by plantar flexion.
- Select muscle testing in which nothing of importance lies between the skin and the targeted muscle except perhaps subcutaneous tissue. Some muscle approaches require piercing other structures first, which may add discomfort, greater risk and uncertainty about needle location. Examples are: (1) the distal approaches to the flexor pollicis longus, flexor digitorum longus and extensor indicis; (2) the medial approaches to the flexor digitorum profundus and the pronator quadratus; and (3) the lateral chest approach to the serratus anterior.

Pain is most common if the needle is in the endplate region. As the needle is moved through the muscle, endplate noise will be recognized as the needle tip approaches. When this is apparent from the presence of end plate noise or spikes, the needle should be quickly moved to another area. Sometimes movement in every direction is plagued by endplate activity. In this situation the needle should be completely withdrawn and reinserted a short distance away. Localized burning pain occurs if the needle is inserted in the immediate region of pain nerve ter-
minals in the skin, and also requires withdrawing and reinserting the needle through the skin.

A number of methods can help a patient tolerate a full evaluation: Reassure the patient that everyone experiences some discomfort during the test, but almost all are able to tolerate it.

• Reassurance and continued verbal sympathy for the patient throughout the study.
• Reassure the patient that the discomfort of the test is not long lasting.
• Move the needle gently and slowly.
• Begin with the most important muscle (e.g. paraspinal muscles in suspected radiculopathy).
• Avoid hyperventilation.
• Patients can take analgesics prior to the test if they are concerned about the pain.
• Change needles if there is increased resistance to needle movement.
• Rarely, but if all else fails, it may be necessary to use a narcotic such as Fentanyl by injection at the start of the test.

Under most circumstances thorough explanation of the procedure and a kind, understanding, and sympathetic manner with adult patients will be sufficient to complete the needle examination. Some patients inquire if they can take acetaminophen with codeine or Darvon before the examination; this is quite acceptable but probably of limited benefit. On rare occasions it may be necessary to use a short-term parenteral analgesic such as Fentanyl. Chloral hydrate may be helpful in children. Some institutions now require conscious sedation by an anesthetist.

**PATIENT INTERACTIONS TO OPTIMIZE COOPERATION ON CLINICAL EMG**

Introductions in the examining room:

• Greet patient, introducing yourself
• Confirm patient’s name and test
• Confirm clinical problem requiring EMG
• Briefly describe purpose of test

• Briefly describe test components and time
• Reassure patient about test
• Ask about possible contraindications or confounding factors
  - Medications such as anticoagulants, and anticholinesterases
  - Allergies and reactions such as alcohol or iodine
  - Pertinent medical problems such as SBE
• Reassures patient about absence of significant risk

Discussion of the discomfort of test by physician

• Review specific components of test
• Provide understanding of need for discomfort
• Describe options for dealing with discomfort
  - Patient choice on how to proceed
  - Tolerate as best as possible
  - Move needle or stimulating electrodes to different sites
  - Change needle type
  - IM medication if needed
• Discontinue individual muscle or entire test if necessary

During needle EMG

• Describe nature and purpose of needle examination
• Explain cleansing with alcohol and use of gloves
• Describe use of disposable electrodes
• Describe need to record at rest and with voluntary contraction
• Use as small needle movements as possible (0.5 mm)
• Do not change level of voluntary contraction with needle in muscle
• Do not move the joint with needle in muscle
• Move needle only in straight lines through muscle.
• Redirect needle only in subcutaneous tissue
• Ask patient frequently how they are doing
• Respond to each clue that they are having discomfort by a change in technique
• Warn before each new needle insertion
• Describe need for and nature of any unusual or particularly uncomfortable recordings
• Reassure patient about quality of cooperation and recordings frequently
• Maintain local pressure on each site to stop all bleeding after testing
• Ask for a chaperone when examining intimate areas for both men and women
• Keep patient covered at all times everywhere except the area being tested

After the test
• Reassure patient about their cooperation
• Sympathize with their discomfort
• Indicate that useful data was recorded
• Describe results to the extent appropriate.
• Ask if they have questions or concerns before they leave.

APPENDIX C: NEEDLE ELECTRODE TYPES

<table>
<thead>
<tr>
<th>CONCENTRIC</th>
<th>MONOPOLAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recording area</td>
<td>Smaller (stable)</td>
</tr>
<tr>
<td>Recording properties</td>
<td>Stable</td>
</tr>
<tr>
<td>Background</td>
<td>Less noise (better common mode rejection)</td>
</tr>
<tr>
<td>Reference electrodes</td>
<td>Needle shaft</td>
</tr>
<tr>
<td>Motor unit potentials</td>
<td>Smaller</td>
</tr>
<tr>
<td>Motor unit quantitation</td>
<td>More reliable</td>
</tr>
<tr>
<td>Discomfort</td>
<td>No difference if disposable</td>
</tr>
<tr>
<td>Cost</td>
<td>More expensive</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MONOPOLAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Larger (variable)</td>
</tr>
<tr>
<td>Variable; may polarize</td>
</tr>
<tr>
<td>Noise from surrounding muscles</td>
</tr>
<tr>
<td>Separate surface electrode</td>
</tr>
<tr>
<td>Larger</td>
</tr>
<tr>
<td>Less reliable</td>
</tr>
<tr>
<td>Less than non-disposable</td>
</tr>
<tr>
<td>Less expensive</td>
</tr>
</tbody>
</table>

COMPARISON OF MONOPOLAR AND CONCENTRIC NEEDLE ELECTRODES

CONCENTRIC NEEDLE ELECTRODES (CNE)

CNE are made of a bare needle shaft (reference) and a central platinum wire (active) insulated from the shaft. All standard concentric electrodes are beveled to a fine tip with an exposed central core 125 by 500 micra. There are four common sizes of needles available: 37 mm (26 gauge), 50 mm (26 gauge), and 75 mm (20 gauge). The needle is a detachable electrode connected to the preamplifier by a cable. Because of the narrow gauge electrodes are particularly delicate and need careful handling, CNE are most fragile at the junction of the shaft and the hub and may bend or break at that location.

MONOPOLAR ELECTRODES

A Teflon coated fine needle electrode, usually made of stainless steel, can have a very fine gauge and an extremely sharp point. The recording surface is usually somewhat larger than a standard concentric electrode, resulting in different characteristics of the recorded potentials. The area of the exposed surface may change as the Teflon insulation near the tip is damaged or pulled back from repeated needle insertions. Monopolar electrodes, if used repeatedly, should be examined under the mi-
croscope after at least every third use and discarded if their Teflon is ragged.

**SINGLE FIBER ELECTRODES**

Single fiber electrodes have a fine 25 micron wire exposed on the lateral surface of the shaft of a needle as the active electrode. These electrodes may also develop barbs or bent tips, but can be readily sharpened without damage to the active electrode. Microscopic examination is needed, since a damaged tip will result in damage to muscle fibers, and prevent reliable recording from single fibers; they should be examined after every use.

The impedance of the small surface of a single fiber electrode is much higher than that of a monopolar or a standard concentric electrode and cannot be reduced by cleaning or etching. These electrodes should be examined at regular intervals for pitting or local damage to the surface of the active electrode which, if present, are best corrected by sanding with fine emery paper. These electrodes are much more susceptible to noise if the electrode surface is dirty (high impedance) or if improperly seated in the connecting cable.

**APPENDIX D: SPECIAL PROBLEMS TO CONSIDER PRIOR TO NEEDLE EMG**

**ANTICOAGULANTS AND BLEEDING DISORDERS**

Patients with a variety of bleeding disorders may be referred for an electrodiagnostic medicine consultation. The electrodiagnostic medicine consultant must examine each case individually, carefully weighing the potential risks and benefits. Aspirin poses no significant risk of bleeding, however heparin and coumadin anticoagulants do. Ideally the anticoagulant should be discontinued before the study. It may be difficult to interrupt anticoagulant because of the disease or delay in testing. If the prothrombin time is in the therapeutic range, particularly the low range, the needle EMG can be safely performed in most instances. If the patient is on therapeutic doses of heparin, the needle EMG may need to be deferred.

The performance of the needle EMG in a patient on therapeutic doses of anticoagulants can be performed, but requires special judgments. The anticoagulation should be tested just prior to the study to accurately assess the level of risk. A needle EMG should be avoided if the anticoagulation is beyond the therapeutic range. If the needle EMG is performed it is prudent to examine the minimum number of muscles, to avoid deep muscles, to study each muscle briefly, and to avoid tight fascial spaces. After each muscle is examined, place firm pressure on the needle puncture site for 1 to 5 minutes to stop bleeding or bruising. It is often possible to proceed to another muscle while maintaining local pressure on the previous puncture site. There have been rare reports of local hematoma and compartment syndromes after EMG. More serious problems have not occurred as a result of examining anticoagulated patients, some electrodiagnostic medicine consultants do not feel it is worth the risk.

Thrombocytopenia may be encountered in some patients. If the count is above 30,000/mm2 the study can usually be performed. The needle EMG should be avoided in patients with hemophilia who have inhibitors. For these and more uncommon bleeding diatheses it may be necessary to consult with a hematologist before proceeding.

**INFECTION**

Special precautions are needed in the use of needle electrodes in patients who are demented, who have a history of viral hepatitis, Acute Immune Deficiency Syndrome (AIDS) patients and other potentially transmittable diseases. These needles should always be discarded after use in specially designed containers. The use of gloves by the physician is strongly recommended when performing the needle examination not only for patients who have a potentially transmissible disease, but to protect the electrodiagnostic medicine consultant from unrecognized agents.

**CARDIAC VALVULAR DISEASE**

Patients with rheumatic or other types of valvular disease and patients with prosthetic valves are at risk of developing endocarditis as a result of transient bacteremias. However, the risk from needle EMG is similar to the risk from repeated venipunctures in which prophylactic antibiotics are not used. Prophylactic antibiotics for such patients undergoing an electrodiagnostic medicine consultation are therefore not required.

**OBESITY**

Grossly overweight patients present problems of locating and palpating muscles you wish to study. For example, it may be difficult to palpate the spinous processes used as a landmark for paraspinal muscle insertion. Usually with extra palpation and ballotment, landmarks can be distinguished. If landmarks cannot be appreciated muscles near structures are at risk, e.g., serratus anterior, may have to be eliminated from the study. For
obese patients the standard 50mm needle will not be long enough to reach some muscles, and a 75mm or 120 mm needle should be chosen at the start of the study.

SKIN CONSIDERATIONS

Inspect the skin over the muscle to be examined before inserting the needle to avoid superficial veins or varicosities. Tortuous arteries or anomalous vessels can be detected by palpation. Avoid areas of infection, ulceration, dermatitis and venous stasis. Scars should also be avoided since there may have been associated damage to the underlying muscle. If the lower extremity is ischemic the small foot muscles or even leg muscles may need to be avoided. Severely swollen lower extremities will make the examination difficult; edema fluid may leak after the needle puncture. If the edematous limb has macerated or has very thin skin, a judgment will have to be made about the safety of the needle EMG. Diabetic patients with such problems need special attention.

OUTLINE OF TECHNIQUES OF NEEDLE EMG

EMG TEST PLANNING

CLINICAL EVALUATION

Review clinical history and examination from record. Repeat focused (yet thorough) neuromuscular history and examination.

Define the question / hypothesis. What is the differential diagnosis?

PLAN THE STUDY

Review nerve conduction studies. Do they support your hypothesis or suggest a different etiology?

Decide which muscle to test.

a) Test most likely involved muscles. If normal, test other muscles with similar supply or distribution. If abnormal, confirm in another muscle.

b) Superficial muscles are preferable to deep muscles.

c) Palpable muscles are preferable.

d) Familiar muscles are preferable. Should attempt to become familiar with as many muscles as possible.

e) Stay away from dangerous areas (pleura, arteries).

f) Have a reason for each muscle examined. If you think about doing a muscle, you probably should do it.

g) Other considerations:

- myopathy - do one side only

- paraspinal muscles - if abnormal, consider other side

- define upper limit of abnormality in paraspinals

PREPARE THE PATIENT

1) Greet patient; identify yourself.

2) Confirm understanding of their problem

3) Explain the purpose of the study (identify disease and severity)

4) Explain the test (muscle recording, test muscles, no shocks or electricity)

5) Some discomfort, but minimized (pain averages a 3 on a scale of 1-10)

6) Advise - can’t be done without their consent. If too painful, will stop.

NEEDLE EMG TECHNIQUE

Identify muscle by palpation of selective activation.

Wipe muscle with alcohol.

Set parameters (50 μV / div for spontaneous, 200 μV / div for voluntary). On the Nicolet Viking™, sweep speeds can be varied to preference (QEMG).

Upper or left screen

Sweep can be set at half (10 divisions) or full screen (20 divisions)

Sweep speed can be varied:

10 msec / division reproduces what is seen on oscilloscope with a 100 msec (half) or 200 msec (full) sweep time

50 msec / division at full screen width

- Full 1 second sweep - easier analysis of firing frequency and pattern
- Evaluation of duration of insertional activity
- Evaluation of slow initial and terminal component so long duration waveforms

**Right or lower screen**
Superimposition or rastering of multiple traces of the same triggered MUAP. (standard number of traces is five)
Sweep speed can be varied (5 msec / division is standard)

**Filters**
- **Low frequency** - 30 Hz
- **High frequency** - 20 kHz

If quantification of MUAPS is done, set filters similar to Buchthal (LLF at 2 Hz, HLF at 10 kHz)
Support muscle by hand.
Warn patient.
Pull skin taut, quick stick through skin. Hold needle like pen and insert needle at an angle. Brace hand on muscle.

**Evaluating Insertional and Spontaneous Activity**
Move needle in short steps (0.5 to 1 mm) - large movements are more painful
Move in straight line from insertion through muscle.
Don’t release between steps.
Pause at least 1-2 seconds to listen for slow fibs
Rest hand on muscle - brace for stability.
Make 3 - 4 passes of 5-10 steps in a straight line through muscle
a) Explore different areas of muscle with each pass
b) Move obliquely through muscle with each pass
c) Withdraw needle from muscle, but not skin between passes. Sometimes need to look at completely different area of same muscle (e.g., inflammatory myopathies)
Don’t contract muscle with needle in muscle (painful, tears muscle, bends needle).

Remember the following: Careful positioning of the patient at the beginning, adequate support and passive manipulation of the limb, contraction of antagonist muscles, distraction with conversation, and reassurance are all methods to improve relaxation during evaluation of spontaneous activity.

**EVALUATING VOLUNTARY ACTIVITY**
Same needle methods as for resting muscle.
Withdraw needle to a subcutaneous position before initiating muscle contraction.
Best examined with weak muscle contraction, with only 1-3 motor units firing at a time. Too strong of a contraction will firing too many MUAPs at once, making it more difficult to analyze.
Advance needle until you reach MUAPs with a rapid rise time (0.5 ms) and sharp clicking sound. Only assess MUAPs with short rise time.

Know duration of MUAPs for various muscles. Units in some muscles always look long and large.
Avoid MUAPs at edge of muscle.
Move from one site to another site quickly. Look at units in onsite and decide what the characteristics are, then move to another site. “Spend a little time looking at a lot of units.”
Be objective. Avoid seeing what you expect to see.

**SPECIAL PROBLEMS**

1) Anticoagulants and Bleeding Disorders
Examine each case individually, weighing risks and benefits
Anticoagulation (INR) should be tested before the study to determine the level of risk.
If the prothrombin time is in the therapeutic range (especially low range) the study can be performed safely in most instances.
If it is above therapeutic range, may need to defer needle examination.

If needle EMG is performed, examine minimal number of muscles, avoid deep muscles (e.g. paraspinals), avoid tight fascial spaces (e.g. tibialis anterior - anterior compartment).
Place pressure on the puncture site for 1-2 minutes after examined.
In patients with thrombocytopenia, if the platelet count is above 30,000/mm2, the study can be performed safely. For uncommon bleeding disorders, consult hematologist.

2) Infection precautions
Special precautions in patients with dementia, history of viral hepatitis, AIDS, and other potentially transmittable diseases.
Always discard needles in specially designed containers.
Always use gloves (for any patient).

3) Cardiac Valvular Disease
Risk of needle EMG in patients with rheumatic or other type of valvular disease or with prosthetic valves is similar to that of repeated venipuncture. Prophylactic antibiotics are not necessary.

4) Obesity
May present problems of locating and palpating muscle.

If landmarks cannot be appreciated, certain muscles may need to be eliminated from the study (e.g. serratus anterior, diaphragm).

Standard 50-mm needle may not be long enough. Use a 75-mm or 120-mm needle for sum muscles.

Skin considerations
Examine skin over the muscle before inserting needle.
Avoid superficial veins or varicosities.
Avoid areas of infection (cellulitis), dermatitis, and venous stasis.
Avoid areas of lymphedema (persistent leak of fluid, risk of development of infection)
Special care with this, brittle skin (e.g. patients on steroids)

Reducing the Discomfort of the Needle EMG
Needle handling techniques
Short movements

Tell patients that some areas of the muscle may be more uncomfortable. Tell them that you will move away from them if they tell you about the pain.

Watch / listen for end plate activity and move away from it.

Patient rapport
1) Reassure the patient that everyone experiences some discomfort.
2) Reassurance and continued verbal sympathy throughout the study.
3) Reassure the patient that the discomfort is not long lasting.
4) Move needle gently and slowly.
5) Begin with most important muscles.
6) Patients can take analgesics prior to test.
7) Change needles in increased resistance.

REFERENCES