UNUSUAL SENSORY CONDUCTION STUDIES
Workshop handouts are prepared as background didactic material to complement a hands-on workshop session. This workshop handout was originally prepared in May 1984, revised by Dr. Kraft in April 1992, and again in October 2007 by Susan L. Hubbell. The idea and opinions in this publication are solely those of the author(s) and do not necessarily represent those of the AANEM.
Unusual Sensory Conduction Studies
An AANEM Workshop

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INTRODUCTION

Sensory (cutaneous) nerve conduction studies were first described by Dawson in 1956. Since then they have become such an integral part of the electrodiagnostic examination that electro-myographers consider them indispensable for the adequate evaluation of a limb.

There are several reasons for this. First, some peripheral nerve lesions involve only sensory nerves (e.g., radial sensory mononeuropathies) or only the sensory fibers of mixed nerves (e.g., "pure" sensory polyneuropathies). Second, sensory conduction studies generally are more sensitive than their motor counterparts to pathophysiologic processes occurring along mixed nerves. Thus, sensory conduction latencies are typically affected before or more severely than the motor latencies by segmental demyelinating lesions producing focal slowing (e.g., carpal tunnel syndrome). Similarly, the sensory conduction amplitudes are the nerve conduction parameter most sensitive to axon loss. For any given degree of injury to a mixed nerve, they are characteristically more severely affected than the motor amplitudes. Using ulnar mono-neuropathies as an example, a moderate lesion would produce a low-amplitude ulnar sensory response at the time the motor amplitudes were still within the normal range; a more severe lesion would result in an absent sensory response with a low-motor response. Only if the axon loss were very severe would both the sensory and motor responses be unelicitable. Third, the sensory conduction amplitudes are very helpful in localizing proximal axon-loss injuries of moderate or greater severity; they are not affected by lesions located proximal to the dorsal root ganglia, within the intraspinal canal (e.g., mye-lopathies, radiculopathies), but are of low amplitude or unelicitable with lesions located at or distal to the dorsal root ganglia (e.g., plexopathies, peripheral mononeuropathies). Together with the presence or absence of fibrillation potentials in the paraspinal muscles, this is the major means the electromyographer has of differentiating root from plexus lesions.

The sensory conduction parameters are more sensitive to the various physical/physiologic variables than the motor parameters. The conduction velocities and distal latencies slow appreciably with both aging and limb cooling, while the amplitudes decrease with aging but increase with limb cooling. Each of these can be considerable sources of error if not considered. Also, the cutaneous nerves, being more superficial than the motor nerve fibers, are more susceptible to trauma and, consequently, the sensory responses may be absent or of low ampli-
tude due to coincidental nerve injury. In the lower extremity, various surgical procedures, particularly vein stripping and tendon lengthening, are notorious for producing such lesions. The elicitation of nerve action potentials can also be affected by a number of technical problems, including limb edema, thickened skin, gross obesity, and interference by activation of nearby muscle fibers, either due to poor relaxation or to simultaneously evoked compound action potentials.

Side-to-side comparison of the sensory responses can be helpful when evaluating unilateral abnormalities. In many laboratories, for example, the sensory amplitude is considered abnormal if it (1) is below normal values established for that laboratory and (2) is 50% or lower than the response obtained on the asymptomatic side.

It is not only important to perform sensory nerve conduction studies, but also to perform the ones most appropriate for the clinical situation. This requires knowledge of the anatomy of the peripheral nervous system and how the latter is affected by the various disease processes. For example, lower extremity sensory conduction studies show abnormalities much sooner than upper extremity studies do in patients with generalized peripheral polyneuropathies. Similarly, in patients with axon-loss brachial plexopathies involving the lower trunk fibers, the amplitudes of the ulnar sensory and medial antibrachial cutaneous sensory responses would be affected. In contrast, with such a lesion the median sensory responses, recording thumb and index fingers, and the lateral cutaneous nerve of forearm sensory conduction responses would be normal, since proximally the fibers subserving those conduction studies traverse the upper trunk of the plexus.

In this syllabus, a number of sensory nerve conduction studies are described. Some have much greater utility than others. The saphenous nerve conduction study has a limited applicability, usually being performed only whenever there is a question of a lumbar plexus or femoral nerve lesion. Yet each of the studies described, at one time or another, may prove helpful to the electromyographer. Hence, the ability to properly perform each one is well worth mastering.

Finally, it must be noted that sensory conduction studies, including the ones described here, are not performed in an identical fashion in all EMG laboratories. Variables include performing studies at fixed distances between the stimulating and recording electrodes versus performing them at variable distances, depending on anatomic landmarks; reporting the conduction times as latencies versus converting them to conduction velocities; measuring latency to the onset versus the peak of the response; and measuring amplitudes from peak-to-peak versus baseline-to-peak. Reflecting this variability, for some of the sensory nerve conduction studies, two techniques, rather than just one, are described here. For those electromyog-raphers who are not familiar with either one, probably the best course to follow is to choose one of the techniques, learn it well, and use it exclusively, rather than to alternate between the two.

*AANEM Glossary recommends peak-to-peak.

**TECHNICAL CONSIDERATIONS**

There are a number of technical points which will aid in performing sensory nerve conduction studies. In the normal subject, sensory responses are not difficult to obtain; however, in patients who have peripheral nerve lesions (focal or generalized), they may be very difficult or impossible to obtain using conventional techniques. It is especially in the patient with peripheral neuropathy that certain technical principles need to be employed to insure the best chance of obtaining useful data. Although ideally it is desirable to use an orthodromic conduction technique (because of the elimination of any possibility of obtaining a muscle artifact), in practice it may be easier to do antidromic conduction studies because it may be difficult to record a sensory nerve action potential (SNAP) where the nerve fibers run deep beneath the surface. On the other hand, by increasing the current, it is possible to stimulate a nerve at a considerable distance beneath the surface. Thus, antidromic techniques — which stimulate the nerve where it is deep and record the SNAP when the nerve is more superficial — generally result in larger amplitude potentials.

If no response is obtained using the standard distance, the examiner should try an antidromic technique using a shorter distance. Thus, for example, instead of stimulating a nerve at 14 cm, the examiner might try to stimulate 12 cm, 10 cm, or even 8 cm from the point of recording. The shorter the distance over which the impulse travels, the less the temporal dispersion and phase cancellation of the SNAP, and the larger the action potential which can be recorded. Also, the peripheral nerve may be more superficial distally, resulting in a greater possibility of obtaining an adequate depolarization current at the nerve.

Another principle is to reduce the shock artifact as much as possible. In general, this can best be done by putting the ground electrode between the stimulus and recording sites. The shock artifact can be reduced further by keeping the cathode over the nerve, while empirically rotating the anode until the electric field is oriented so that the shock artifact is minimal. To increase patient comfort, we have found that turning off the sound reduces the sensory input to the patient (by removing the auditory stimulus) and allows for more patient tolerance. When there is difficulty in obtaining a SNAP, the examiner should ask the patient where s/he feels the shock. If the shock is only felt under the stimulating electrodes when using the antidromic technique, the area being stimulated may not be correct and it is possible that the nerve is not being stimulated. When being
studied properly, the patient should feel the shock in the distribution of the sensory fibers stimulated.

Most new electromyographs have the capability for signal averaging. It is a common misassumption by electromyographers that if the response cannot be seen using single shocks, averaging will allow it to be recorded. This is erroneous; an averager does not create a signal out of nothing, but simply identifies the signal when it is approximately the same level as the system noise. In general, the electromyographer should remember that if the signal cannot be seen on single sweeps, it probably will not be obtained by averaging 10s, or 100s of sweeps.

It is generally easier to identify the negative peak of a SNAP than it is to accurately determine the onset. Most electromyographers, therefore, measure the "peak" latency, which is a widely-accepted manner of reporting sensory nerve conduction studies. However, "latency" is defined as the time between the onset of a stimulus and the onset of a response. Therefore, the true latency of the SNAP, when not otherwise specified, is the onset. The AAEE Glossary recommends specifying the latency measured (i.e., latency or peak latency) to avoid misinterpretation. If a nerve conduction velocity (NCV) is calculated by dividing the distance by the latency, the true latency (onset) should be used.*

*The AAEE Glossary defines NCV as conduction of the fastest fibers. When calculating motor NCVs, the distal latency is subtracted from the proximal latency, so questions of myoneural junctions delay, latency of activation (utilization time), and other unknown values are subtracted out; NCV is determined by dividing the distance of a length of nerve by the actual time it takes an impulse to travel that distance. When calculating a sensory NCV from a single latency and distance, however, dividing the distance by the latency does not take into account the brief period of time between the onset of the stimulus and the time at which the depolarization wave starts to travel toward the recording electrodes: the latency of activation. Since this is unknown, it cannot accurately be subtracted from the latency; however, estimates suggest this time to be approximately 0.10 - 0.15 milliseconds. Reported sensory NCVs generally do not subtract this value from measured latencies, but its presence explains why sensory NCVs calculated in this manner may appear slower than might be anticipated.

**DORSAL CUTANEOUS BRANCH OF THE ULNAR NERVE**

The dorsal cutaneous branch of the ulnar nerve is a large sensory nerve which arises in the distal third of the forearm. It carries fibers from the C8, T1 roots via the medial cord of the brachial plexus. However, the fibers underlying both the stimulating and recording electrodes, and hence the only ones evaluated, are probably derived almost solely from the C8 root. It innervates the dorsal skin over the medial metacarpal region and the medial digits—but not the terminal phalanges. The latter is innervated via palmar branches of the ulnar nerve (more specifically, the superficial branch).

The course of the dorsal cutaneous nerve becomes superficial approximately 5 cm above the wrist, where it lies between the flexor carpi ulnaris and the ulna.

The dorsal cutaneous nerve is spared in lesions at the wrist, but may be involved with more proximal lesions, e.g., at the medial epicondyle or cubital tunnel.

(Clinically, sensory involvement of the dorsum of the digits implies a lesion above the wrist, involving the dorsal cutaneous branches that are given off in the forearm. Sensory abnormalities restricted to the skin of the hypothenar eminence and volar ulnar digits with some distal dorsal digital involvement suggest a wrist lesion implicating the superficial branch of the ulnar nerve).

**Stimulation Procedure: Setup (Figure 1)**

**Stimulation**

With the arm supinated, the nerve is stimulated using surface electrodes 5 cm above the ulnar styloid between the flexor carpi ulnaris tendon and the ulnar bone. (This is 8 cm proximal to the recording electrode).

**Ground**

This is placed between the stimulating and recording electrodes.

![Figure 1. Dorsal cutaneous branch of ulnar nerve.](image-url)
Recording

Surface electrodes are placed with the active recording electrode at the apex of the "V" between the fourth and fifth metacarpal bones. The reference electrode is placed distally, at the base of the fifth digit.

Stimulation Procedure: Values

Jabre data (Table 1). Temperature and gender were not mentioned.

<table>
<thead>
<tr>
<th>Table 1 - Dorsal Cutaneous Studies: Jabre Data*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latency</td>
</tr>
<tr>
<td>2.0±0.3</td>
</tr>
</tbody>
</table>

* n = 50  s = 30 (10-66 years old)

SUPERFICIAL RADIAL NERVE

The superficial radial nerve is the terminal sensory portion of the radial nerve. It is derived from the C6 and C7 roots, but the fibers underlying both the stimulating and recording electrodes, and hence the ones evaluated, are derived primarily, if not solely, from the C6 root. It supplies the dorsal skin of the lateral two thirds of the hand and lateral 2-1/2 digits and ball of the thumb (with variation in its area of supply).

It separates from the deep motor branch of the radial nerve in front of the lateral epicondyle of the humerus. Its course remains deep through the forearm until the lower third where it angles dorsally near the brachioradialis tendon and becomes superficial.

Branches can be palpated as they run over the tendons of the thumb extensors.

Stimulation Procedure: Setup (Figure 2)

Stimulation

Surface stimulation is performed on the dorsolateral aspect of the radius approximately 7 cm above the radial styloid process (or the junction of the middle and distal thirds of the forearm). The stimulating cathode should be 10 cm proximal to the active recording electrode.

Ground

This is placed over the dorsum of the hand.

Recording

Surface electrodes are used. The active electrode is placed over the main portion of the nerve, which can be palpated over an extended extensor pollicis longus tendon. The reference electrode is placed 3 cm distal to this, approximately midway between the first and second metacarpophalangeal joints.

Stimulation Procedure: Values

Ma and colleagues data (Table 2). Subjects were allowed to adjust to room temperature of 23°C to 26°C. Age was not significant. Gender was not significant except as detailed below.

<table>
<thead>
<tr>
<th>Table 2 - Superficial Radial Nerve Studies: Ma and Coleageus Data*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latency†  Conduction Velocity  Peak-to-Peak Amplitude (µV)</td>
</tr>
<tr>
<td>(ms)     (m/s)</td>
</tr>
<tr>
<td>1.58±0.12 63.53±4.94</td>
</tr>
<tr>
<td>(1.3-1.8) (55.6-76.9)</td>
</tr>
</tbody>
</table>

* n < 97  s < 53 (23-72 years old)  m = 47.7
† Onset latency.
‡ Male.
§ Female
Cleveland Clinic data, unpublished (Table 3). More than 600 normal persons were studied with more than 90 studied for each decade between 20 and 70 years. The set distance between cathode and G1 electrode was 10 cm.

| Table 3 - Superficial Radial Nerve Studies: Cleveland Clinic Data |
|-------------|-------------|-------------|----------|
| Age         | Peak-to-Peak Amplitude (µV) | Peak Latency (ms) |
|             | Range      | Average     | Range    | Average  |
| 10-19       | 18-50      | 30          | 1.8-2.7  | 2.2      |
| 20-29       | 18-60      | 34          | 1.8-2.7  | 2.2      |
| 30-39       | 18-60      | 32          | 1.8-2.7  | 2.2      |
| 40-49       | 18-56      | 30          | 1.9-2.7  | 2.2      |
| 50-59       | 14-56      | 30          | 1.9-2.7  | 2.3      |
| 60-69       | 10-42      | 24          | 1.9-2.7  | 2.4      |
| >70         | 10-30      | 18          | 2.0-2.8  | 2.4      |

MEDIAL ANTEBRACHIAL CUTANEOUS NERVE

The medial antebrachial cutaneous nerve carries fibers from the C8, T1 roots, via the medial cord of the brachial plexus. It separates from the latter before the cord gives off its medial head to the median nerve and continues as the ulnar nerve. The medial antebrachial cutaneous nerve is purely sensory in function, innervating the anterior upper arm and the medial forearm to the wrist.

Its course is anterior to the axillary artery, then on the ulnar aspect of the upper arm where it is medial to the brachial artery. A fascicle is given off to supply the skin over the biceps as distally as the elbow. In the lower third of the upper arm it divides into two branches. The larger is the anterior branch which supplies the ulnar half of the volar forearm to the wrist. The other branch is the ulnar branch which innervates the ulnar half of the dorsal forearm by traveling anterior to the medial epicondyle then passing dorsally. The entire sensory territory in the forearm extends to the midline (on both volar and dorsal surfaces) and as distally as the wrist.

Stimulation Procedure: Setup (Figure 3)

Stimulation

Surface stimulation is performed medial to the brachial artery, 4-5 cm proximal to the medial humeral epicondyle.

Ground

This is placed along the lateral portion of the elbow, between the stimulating and recording electrodes.

Figure 3. Medial antebrachial cutaneous nerve.

Recording

Surface electrodes are placed along a line connecting the point halfway between the medial epicondyle and the biceps brachii tendon — drawn to the ulnar styloid process. The active electrode is 7-8 cm distal to the epicondyle.

Stimulation Procedure: Values

Ma and Gibfried data (Table 4). Subjects were allowed to adjust to room temperature of 23˚C to 26˚C. Gender and age were not tested.

| Table 4 - Medial Antebrachial Cutaneous Nerve. MA/Gibfried Data* |
|------------------|------------------|------------------|
| Latency†         | Amplitude‡       | Conduction Velocity |
| (ms)             | (µV)             | (m/s)            |
| 1.9±0.2 (1.6-2.3)| 14.7±4.7 (8.0-24.0)| 64.5±6.4 (52-76.4)|
| [11.3-13.5 cm]   |                  |                  |

* n = 50  s = 25 (22-49 years old)  m = 34  † Onset latency  ‡ Peak-to-peak amplitude.
**LATERAL ANTEBRACHIAL CUTANEOUS NERVE**

The lateral antebrachial cutaneous nerve is the terminal sensory continuation of the musculocutaneous nerve. Its root supply is C5 and C6 whose fibers travel through the lateral cord of the brachial plexus. Since clinically C5 radiculopathies do not produce paresthesias distal to the elbow, however, it is probable that only fibers derived from the C6 root are being evaluated by this procedure. For this reason the amplitudes recorded with this technique tend to decrease proportionally with those recorded from the thumb, while stimulating median nerve, in the presence of axon-loss upper trunk brachial plexopathies. The lateral antebrachial cutaneous nerve provides the sensory supply of the lateral volar forearm to the wrist. A dorsal branch supplies the lateral dorsal aspect of the forearm almost to the wrist.

Its course commences at the lateral margin of the biceps brachii tendon where it becomes superficial. An anterior branch continues distally along the lateral volar forearm. A dorsal branch separates at the elbow joint supplying the lateral dorsal aspect of the forearm.

**Stimulation Procedure: Setup (Figure 4)**

**: Stimulation**

Antidromic surface stimulation is applied at the level of the elbow, just lateral to the biceps brachii tendon.

**: Ground**

This is placed between the stimulating and recording electrodes.

**: Recording**

Surface recording electrodes are placed along a line connecting the stimulation point to the radial artery or to the radial styloid process at the wrist. The active recording electrode is placed 12 cm distal to the stimulating cathode. The reference electrode is placed approximately 3 cm more distally.

**Stimulation Procedure: Values**

*Spindler and Felsenthal data (Table 5).* Room temperature was 23.9°C. Age was not significant. Gender was not mentioned.

<table>
<thead>
<tr>
<th>Latency (ms)</th>
<th>Conduction Velocity (m/s)</th>
<th>Peak-to-Peak Amplitude (µV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.8±0.1 (1.6-2.1)†</td>
<td>65±3.6 (57-75)</td>
<td>24±7.2 (12-50)</td>
</tr>
<tr>
<td>2.3±0.1 (2.2-2.6)§</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* n = 60  s = 30 (20-84 years old)  m = 35
† Calculated using onset latency.
‡ Onset latency.
§ Peak latency.

**POSTERIOR ANTEBRACHIAL CUTANEOUS NERVE**

The posterior antebrachial cutaneous nerve is a sensory branch which separates from the radial nerve in the spiral groove. Its fibers pass through the C5 through C8 roots, then the posterior cord of the brachial plexus, and the radial nerve. The nerve provides sensation to the skin of the lateral arm and elbow, and the dorsal forearm as distal as the wrist.

At its origin it pierces the lateral head of the triceps brachii and separates into two branches. The proximal branch innervates the skin of the distal upper arm. The distal branch travels along the lateral upper arm and dorsal forearm.

Its surface course can be visualized as passing between the lateral epicondyle and olecranon from a point at the junction of...
the middle and distal thirds of the lateral upper arm. It is superficial in this region.

**Stimulation Procedure: Setup (Figure 5)**

**Stimulation**

Surface stimulation is performed at the elbow, just above the lateral epicondyle, between the biceps brachii and triceps brachii. The stimulation site is closer to the latter, at the medial border of the lateral head of the triceps brachii.

**Ground**

This is placed between the stimulating and recording electrodes.

**Recording**

Surface electrodes are placed along a line extended from the stimulation point to mid-dorsum of the wrist (midway between the ulnar and radial styloid processes). The active recording electrode is placed approximately 12 cm distal to the stimulating cathode, with the reference electrode 3 cm more distal.

**Stimulation Procedure: Values**

Ma, Kim and Liveson data (Table 6). Subjects were allowed to adjust to room temperature of 23°C to 26°C. Gender was not significant. Age was not studied.

<table>
<thead>
<tr>
<th>Latency†</th>
<th>Amplitude‡</th>
<th>Conduction Velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.9±0.3 (1.5-2.4)</td>
<td>8.6±3.9 (5.0-20.0)</td>
<td>64.0±7.4 (51.3-73.7)</td>
</tr>
</tbody>
</table>

* n = 40  s = 22 (19-48 years old)  m = 31
† Onset latency.
‡ Peak-to-peak amplitude.

**MEDIAL PLANTAR NERVE**

The medial plantar nerve is the larger of the two terminal branches of the tibial nerve, which divides under the flexor retinaculum; the other branch is the lateral plantar nerve. The nerve is analogous to the median nerve in the hand, supplying the medial muscles (abductor hallucis, flexor digitorum brevis, flexor hallucis brevis and first lumbrical muscles) and sensation over the plantar surface of the first 3-1/2 toes.

**Stimulation Procedure: Setup (Figure 6)**

**Stimulation**

Orthodromic surface stimulation is performed using ring electrodes placed around the first toe, with the cathode proximal to the anode.

**Ground**

This is placed between the stimulating and recording electrodes.

**Recording**

Surface electrodes are located behind the medial malleolus, proximal to the flexor retinaculum.

**Stimulation Procedure: Values**

Oh, Sarala, Kuba and Elmore data (1979), Table 7. Computer averaging was performed with 32 to 256 responses. Velocity was calculated from the peak latency. Skin temperature was 29.5°C-33.5°C. Gender and age were not mentioned.
LATERAL PLANTAR NERVE

The lateral plantar nerve is the smaller of the two terminal branches of the tibial nerve, which divides under the flexor retinaculum. The nerve passes obliquely forward across the foot, passing under the abductor hallucis to run between the flexor digitorum brevis and the abductor digiti minimi.

The nerve is analogous to the ulnar nerve in the hand, supplying all the intrinsic muscles of the foot except for the extensor digitorum brevis and the muscles innervated by the medial plantar nerve, and sensation over the plantar surface of the lateral 1-1/2 toes.

Stimulation Procedure: Setup (Figure 6)

Stimulation

Orthodromic surface stimulation is performed using ring electrodes placed around the fifth toe, the cathode proximal to the anode.

Ground

This is placed between the stimulating and recording electrodes.

Recording

Surface electrodes are located behind the medial malleolus, proximal to the flexor retinaculum.

Stimulation Procedure: Values

Oh, Sarala, Kuba and Elmore data (1979), Table 8. Computer averaging was performed with 32 to 256 responses. Velocity was calculated from the peak latency. Skin temperature was 29.5°C-33.5°C. Gender and age were not mentioned.

Table 7 - Medial Plantar Nerve (Sensory): OH/SARALA/KUBA/Elmore Data*

<table>
<thead>
<tr>
<th>Amplitude (mV)</th>
<th>Conduction Velocity (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.61 (2-6)</td>
<td>35.22±3.63</td>
</tr>
</tbody>
</table>

* s = 20 (19-50 years old)

Table 8 - Lateral Plantar Nerve (Sensory): OH/SARALA/KUBA/Elmore Data*

<table>
<thead>
<tr>
<th>Amplitude (mV)</th>
<th>Conduction Velocity (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.89 (1-5)</td>
<td>31.68±4.39</td>
</tr>
</tbody>
</table>

* s = 20 (19-50 years old)

MEDIAL/LATERAL PLANTAR COMPOUND NERVE ACTION POTENTIALS

Evaluating the sensor nerve distribution of the medical and lateral plantar nerves can be challenging as the responses may be small and are inconsistently obtained. This technique evaluated the mixed nerve action potential of the medial and lateral plantar nerves.

Stimulation Procedure: Setup

Stimulation

Medical Plantar. Measure 10 cm from the recording electrode (point A) to the interspace between the first and second metatarsals on the plantar aspect of the foot. The measure an additional 4 cm toward the digits on the inter-metatarsal line. Lateral Plantar. Stimulation occurs 4 cm beyond the 10 cm site (point D) in the interspace between the fourth and fifth metatarsals.

Ground

Placed between the stimulating and recording electrodes.

Figure 6. Medial and lateral plantar nerves.
A bar electrode is positioned just proximal to the superior edge of the flexor retinaculum over the tibial nerve (point A).

**Instrument Setting**

The mixed nerve response is similar to the SNAP so typical sensory settings are used.

**Stimulation Procedure: Values**

Medial plantar mixed nerve negative peak latency 3.2 ± 0.3 ms (2.6-3.7 ms) and amplitude greater than 10 micro volts (10-30 micro volts). Lateral plantar peak latency 3. ± 0.3 ms (2.7 - 3.7 ms) with amplitude greater than 8 micro volts (8 - 20 micro voltes).

**SUPERFICIAL PERONEAL NERVE**

The superficial peroneal nerve is a branch of the common peroneal nerve. It is formed from L4, L5, and S1 roots. The fibers underlying both the stimulating and recording electrodes, and thus the ones evaluated by this technique, are essentially all derived from the L5 root. Its motor innervation is to the foot evertors. It also provides cutaneous innervation to the distal anterolateral foreleg and to most of the dorsum of the foot.

Its course becomes superficial in the groove between the peroneus longus and extensor digitorum longus at the junction of the middle and distal thirds of the foreleg. It passes in front of the extensor retinaculum at the ankle (in contrast to the deep peroneal nerve) to reach the dorsum of the foot.

Motor branches are given to the peroneus longus and brevis in the foreleg. Sensation is provided to the anterolateral foreleg via fibers above the ankle. Below the ankle, sensation of the dorsum of the foot is provided (except of the adjacent surfaces of digits 1 and 2 which are innervated via the deep peroneal nerve).

This nerve is commonly involved by lesions of the common peroneal nerve; however, the responses obtained with this technique will be low amplitude or absent only with those lesions causing axon loss. In contrast, if conduction block (neuropaxia) is occurring at the fibular head or more proximally, the response will be normal since both the stimulation and recording points are distal to the lesion site. Also, this response may be unelicitable bilaterally in a few normal persons under the age of 60 (16%) and in many over the age of 60 years.

**Stimulation Procedure: Setup (Figure 8)**

**Stimulation**

Antidromic surface stimulation is performed 10 to 15 cm proximal to the upper edge of the lateral malleolus, anterior to the peroneus longus.

**Ground**

This is placed between the stimulating and recording electrodes.
**Recording**

Surface recording is used. The active electrode is placed just above the junction of the lateral third of a line connecting the malleoli. The reference electrode is parallel and 3 cm distal to this.

**Stimulation Procedure: Values**

*Ma, Kim and Liveson data* (Table 11). Subjects were allowed to adjust to room temperature of 23°C to 26°C. Gender was not significant. Age was not significant except as detailed in Table 11.

<table>
<thead>
<tr>
<th>Table 11 - Superficial Peroneal Studies: MA/KIM/Liveson Data*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conduction Age</strong></td>
</tr>
<tr>
<td><strong>Velocity (m/s)</strong>†</td>
</tr>
<tr>
<td>53.32±5.68 (40-68)</td>
</tr>
<tr>
<td>[9.0-17.0 cm]</td>
</tr>
</tbody>
</table>

* n < 91 s < 79 (23-73 years old) m = 43.8
† Latency to initial point of negative deflection was used to calculate conduction velocity.

*Cleveland Clinic data, unpublished* (Table 12). Ninety-nine normal persons were studied, ranging from three in the over-70 age group to 25 in the 50-59 age group. A set distance of 10 cm was used between cathode and G1 electrode.

<table>
<thead>
<tr>
<th>Table 12 - Superficial Peroneal Studies: Cleveland Clinic Data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
</tr>
<tr>
<td><strong>Studies</strong></td>
</tr>
<tr>
<td>10-19</td>
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<tr>
<td>20-29</td>
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<tr>
<td>30-39*</td>
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<td>40-49†</td>
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<tr>
<td>50-59</td>
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<tr>
<td>60-69†</td>
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<tr>
<td>&gt;70†</td>
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</tbody>
</table>

* No responses in two.
† No responses in one.

**SAPHENOUS NERVE**

The saphenous nerve branches from the femoral nerve 4-5 cm distal to the inguinal ligament (where it is part of the posterior division of the femoral nerve which also supplies the quadriceps muscle). It travels deep to the sartorius muscle in the adductor canal in the anteromedial thigh. Its course remains anterior to the femoral artery, but it crosses from a lateral to a medial position in the middle third of the thigh.

The nerve becomes superficial at the posterior border of the sartorius above the medial condyle of the femur. Here it pierces the fascia and travels between the tendons of the sartorius and gracilis. Its course in the foreleg is along the medial surface of the tibia, immediately behind its posterior border. Approximately 7 cm above the medial malleolus it turns forward and passes diagonally across it. It extends along the medial border of the foot as far as the head of the first metatarsal.

Entrapment has been reported of the infrapatellar portion between the tendon of the sartorius and the medial epicondyle.

**Stimulation Procedure: Setup (Figure 9)**

**Stimulation**

Antidromic surface stimulation is performed on the medial aspect of the slightly flexed knee. The stimulation point is between the tendons of the sartorius and gracilis, approximately 1 cm above the inferior border of the patella.

**Ground**

This is placed between the stimulating and recording electrodes.

**Recording**

Surface recording electrodes are used. A line is drawn from the stimulation point directly 15 cm to the medial border of the tibia. The active electrode is placed at this point with the reference electrode 3 cm distal to this.

**Stimulation Procedure: Values**

*Ma, Kim and Liveson data* (Table 13). Subjects were allowed to adjust to room temperature of 23°C to 26°C. Gender was not significant. Significance of age was not tested.

**LATERAL FEMORAL CUTANEOUS NERVE**

The lateral femoral cutaneous nerve is formed (along with the femoral nerve) from the dorsal portions of the ventral primary divisions of the L2.3 roots. It is a purely sensory nerve.
Its course remains deep intra-abdominally where it emerges from the lateral border of the psoas muscle to travel across the iliacus to the anterior superior iliac spine. It emerges under the lateral portion of the inguinal ligament and travels subcutaneously over or through the origin of the sartorius muscle. Distal to the inguinal ligament it divides into two branches. The anterior branch provides cutaneous innervation of the anterolateral thigh as distal as the knee. The posterior branch innervates the skin of the lower lateral quadrant of the buttocks to the mid-thigh.

**Stimulation Procedure: Setup (Figure 10)**

**Stimulation**

Antidromic surface stimulation is performed above the inguinal ligament (S1) 1 cm medial to the anterior superior iliac spine (ASIS), and/or below the inguinal ligament over the origin of the sartorius muscle (S2).

**Ground**

This is placed between the stimulating and recording electrodes.

**Recording**

Surface electrodes are placed along a line connecting the anterior superior iliac spine to the lateral border of the patella. The active electrode is placed 17-20 cm distal to the anterior superior iliac spine, with the reference electrode 3 cm more distal.

**Stimulation Procedures: Values**

*Ma and Liveson data (Table 14).* Subjects were allowed to adjust to room temperature of 23˚C to 26˚C. Gender was not significant. Significance of age not tested.

<table>
<thead>
<tr>
<th>Table 13 - Saphenous Nerve: MA/KIM/Liveson Data*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latency† (ms)</td>
</tr>
<tr>
<td>2.5±0.19 (2.2-2.8)</td>
</tr>
<tr>
<td>[13-16 cm]</td>
</tr>
</tbody>
</table>

* n = 35  s = 28 (20-56 years old)  m = 35
† Onset latency.
‡ Peak-to-peak amplitude.

Figure 9. Saphenous nerve.

Figure 10. Lateral femoral cutaneous nerve.
Table 14 - Lateral Femoral Cutaneous Nerve: MA/Liveson Data

<table>
<thead>
<tr>
<th></th>
<th>Latency (ms)</th>
<th>Amplitude (µV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above ligament</td>
<td>2.8±0.4 (2.3-3.2) [17-20 cm]</td>
<td>6.0±1.5 (3-10)</td>
</tr>
<tr>
<td>Below ligament</td>
<td>2.5±0.2 (2.2-2.8) [14-18 cm]</td>
<td>7.0±1.8 (4-11)</td>
</tr>
</tbody>
</table>

* n = 40  s = 20 (25-44 years old)  m = 33
† Latency to initial point of negative deflection.
‡ Peak-to-peak amplitude.

REFERENCES

1. AANEM glossary of terms in electrodiagnostic medicine, Muscle, Nerve 2001 (suppl. 10).


UNUSUAL SENSORY CONDUCTION STUDIES

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