AANEM Glossary of Terms in Neuromuscular and Electrodiagnostic Medicine

Compiled by the AANEM Nomenclature Committee

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Foreword

The field of neuromuscular and electrodiagnostic medicine requires a universal language to communicate effectively. This glossary is the cumulative effort of many individuals over the past several decades. With added knowledge gained through research and innovation, the need to update the extensive list will continue to occur periodically. The original glossary was produced in 1980 with updates in 1987 and 2001. Since the last glossary, the American Association of Electrodiagnostic Medicine (AAEM) has changed its name to the American Association of Neuromuscular and Electrodiagnostic Medicine (AANEM). Electrodiagnostic testing of muscle and nerve function has been enhanced by the addition of neuromuscular ultrasound imaging. Expanding research in this area has prompted the introduction of basic terms regarding ultrasound technology to this glossary. The number of articles with ultrasound in the title in *Muscle and Nerve* online was only 3 articles in the first six months of 2003 and expanded to 24 articles in a similar timeframe in 2013. Over 50 new terms have been added regarding ultrasound to this glossary with 7 original ultrasound images for illustration. The International Anatomical Terminology text entitled *Terminologia Anatomica* in 1998 introduced new anatomy terms that are gradually making their way into usage. Examples include the peroneal nerve also known as the fibular nerve and the peroneus brevis and longus muscles also known as the fibularis brevis and longus muscles. The fibular nerve is now added to this glossary. There were only a few terms deleted. The goal of providing educational outreach will be enhanced by adding the glossary to the AANEM website, (www.aanem.org).

The 2012-2013 AANEM Professional Practice Committee members who served as the Nomenclature Committee responsible for updating the glossary are acknowledged here:

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Lisa D. Hobson-Webb, MD and Andrea J. Boon, MD provided ultrasound terms and illustrations to introduce basic concepts in neuromuscular ultrasound imaging. A picture is worth a thousand words, especially for a glossary.

Francis O. Walker, MD and Michael S. Cartwright, MD, MS provided technical expertise with an additional review of the newly added neuromuscular ultrasound terms.

John C. Kincaid, MD provided a final review of the updates to electrodiagnostic medicine terms.

Elizabeth A. Conlin, BSEE, ME provided technical support.

Thank you to our families for their support allowing the committee members to spend so much time and so many days, nights, and weekends making sure this task was completed.
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SECTION I:
ALPHABETIC LIST OF TERMS WITH DEFINITIONS

*A wave A compound muscle action potential that follows the M wave, evoked consistently from a muscle by submaximal electric stimuli and frequently abolished by supramaximal stimuli. Its amplitude is similar to that of an F wave, but the latency is more constant. Usually occurs before the F wave, but may occur afterwards. Thought to be due to extra discharges in the nerve, ephapses, or axonal branching. This term is preferred over axon reflex, axon wave, or axon response. Compare with the F wave.

absolute refractory period See refractory period.

absorption The property of any material that transforms the acoustic energy of sound wave into another form, often heat. These sound waves are not reflected back to the transducer, leading to lower echogenicity on the produced image.

accommodation In neuronal physiology, a rise in the threshold transmembrane depolarization required to initiate a spike, when depolarization is slow or a subthreshold depolarization is maintained. In the older literature, the observation that the final intensity of current applied in a slowly rising fashion to stimulate a nerve was greater than the intensity of a pulse of current required to stimulate the same nerve. The latter may largely be an artifact of the nerve sheath and bears little relation to true accommodation as measured intracellularly.

accommodation curve See strength-duration curve.

acoustic attenuation The loss of echo amplitude as sounds waves travel through body tissues.

acoustic enhancement An ultrasound artifact in which the area behind anechoic structures (e.g. fluid-filled) appears brighter due to decreased attenuation in the overlying structures. The opposite of acoustic enhancement is acoustic shadowing.

acoustic impedance A measure of how easily sound waves pass through a tissue, dependent upon the tissue density and the velocity of sound wave propagation through the tissue.

acoustic myography The recording and analysis of sounds produced by contracting muscle. The muscle contraction may be produced by stimulation of the nerve supply to the muscle or by volitional activation of the muscle.

acoustic shadowing Sonographic appearance of reduced echo amplitude from regions lying beyond an attenuating object. It is important to distinguish between acoustic shadows and regions of low echogenicity. An acoustic shadow is one type of ultrasonographic artifact. The opposite of acoustic shadow is acoustic enhancement.

acoustic transmission gel A glycol-, glycerol-, or water-based acoustic coupling medium used to maintain contact between the skin and ultrasound transducer. Also known as ultrasound gel.

action potential (AP) The brief regenerative ionic potential that propagates along a single axon or muscle fiber membrane. An all-or-none phenomenon; whenever the stimulus is at or above threshold, the action potential generated has a constant size and configuration. See also compound action potential, motor unit action potential.

activation 1) In physiology, a general term for the initiation of a process. 2) The process of motor unit action potential firing. The force of muscle contraction is determined by the number of motor units and their firing rate.

activation procedure A technique used to detect defects of neuromuscular transmission during repetitive nerve stimulation testing. Most commonly a sustained voluntary contraction is performed to elicit facilitation or postactivation depression. See also tetanic contraction.

active electrode Synonymous with recording electrode. See recording electrode.

acute inflammatory neuropathy An acute, monophasic polyneuropathy. Characterized by a time course of progression to maximum deficit within 4 weeks of onset of symptoms. Most common clinical presentation is an ascending sensorimotor neuropathy. Electrodiagnostic studies most commonly reveal evidence for demyelination, but axonal degeneration also occurs. Often termed acute inflammatory demyelinating polyradiculopathy (AIDP) when demyelination is present on electrodiagnostic

* Illustration in Section II & III

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studies. Distinguish from chronic inflammatory demyelinating polyradiculoneuropathy (CIDP). See also Guillain-Barré syndrome.

adaptation A decline in the frequency of the spike discharge as typically recorded from sensory axons in response to a maintained stimulus.

ADEMG Abbreviation for automatic decomposition electromyography.

AEP Abbreviation for auditory evoked potential.

afterdischarge 1) The continuation of action potentials in a neuron, axon or muscle fiber following the termination of an applied stimulus. 2) The continuation of firing of muscle action potentials after cessation of voluntary activation, for example in myotonia.

afterpotential The membrane potential between the end of the spike and the time when the membrane potential is restored to its resting value. The membrane during this period may be depolarized or hyperpolarized at different times.

akinesia Lack or marked delay of intended movement, often observed in patients with Parkinson’s disease. Often used synonymously with bradykinesia.

amplitude With reference to an action potential, the maximum voltage difference between two points, usually baseline-to-peak or peak-to-peak. By convention, the amplitude of potentials which have an initial negative deflection from the baseline, such as the compound muscle action potential and the antidromic sensory nerve action potential are measured from baseline to the most negative peak. In contrast, the amplitude of a compound sensory nerve action potential, motor unit potential, fibrillation potential, positive sharp wave, fasciculation potential, and most other action potentials is measured from the most positive peak to the most negative peak.

amplitude decay The percent change in the amplitude of the M wave or the compound sensory nerve action potential between two different stimulation points along the nerve. Decay = 100* (amplitude distal - amplitude proximal) / amplitude distal. Useful in the evaluation of conduction block. Abnormal decay without increased temporal dispersion may indicate a conduction block.

amplitude mode (A-mode) A single transducer scans a line through the body with the echoes plotted on screen as a function of depth.

amyotrophy Muscle atrophy or wasting.

anechoic See echogenicity.

anisotropy Change in sonographic appearance that is dependent upon the orientation of the ultrasound beam (i.e. directionally dependent). Also refers to change in reflective properties of tissue related to the incidence of the angle of the ultrasound beam relative to the tissue.

anodal block A local block of nerve conduction caused by membrane hyperpolarization under a stimulating anode. Does not occur in routine clinical studies as it is possible for the anode to routinely result in nerve depolarization if sufficient current intensities are used.

anode The positive terminal of an electric current source. See stimulating electrode.

antidromic Propagation of a nerve impulse in the direction opposite to physiologic conduction; e.g., conduction along motor nerve fibers away from the muscle and conduction along sensory fibers away from the spinal cord. Contrast with orthodromic.

AP Abbreviation for action potential.

artifact (also artefact) In EDX, a voltage change generated by a biologic or nonbiologic source other than the ones of interest. The stimulus artifact (or shock artifact) represents cutaneous spread of stimulating current to the recording electrode and the delay in return to baseline which is dependent on the ability of filters to respond to high voltage. Stimulus artifacts may precede or overlap the activity of interest. Movement artifact refers to a change in the recorded activity caused by movement of the recording electrodes. In NMUS, artifact refers to something seen on ultrasound that does not exist in reality. Artifact is an error inherent to ultrasound beam characteristics that can be a technical limitation to imaging, can be used to improve imaging, or can be due to improper imaging techniques. Examples include acoustic shadowing, acoustic enhancement, comet-tail artifact, reverberation, shadowing, increased through transmission, and anisotropy.

asterixis A quick involuntary movement caused by a brief lapse in tonic muscle activation. It can be appreciated only during voluntary movement. Is usually irregular, but can be rhythmic and confused with action tremor.

ataxia Clumsiness of movement. Specific features include dysmetria (incorrect distance moved) and dysdiadochokinesia (irregularity of attempted rhythmic movements). Most commonly due to a disorder of the cerebellum or proprioceptive sensory system. Referred to as cerebellar ataxia or sensory ataxia, respectively.

* Illustration in Section II & III
auditory evoked potential (AEP) Electric waveforms of biologic origin elicited in response to sound stimuli. Classified by their latency as short-latency brainstem auditory evoked potential (BAEP) with a latency of up to 10 ms, middle-latency with a latency of 10 to 50 ms, and long-latency with a latency of over 50 ms. See brainstem auditory evoked potential.

automatic decomposition EMG (ADEMG) computerized method for extracting individual motor unit action potentials from an interference pattern.

autonomic neuropathy Disorder resulting from the dysfunction of peripheral autonomic nerves. See dysautonomia.

averager See signal averager.

averaging A method for extracting time-locked potentials from random background noise by sequentially adding traces and dividing by the total number of traces.

axon reflex Use of term discouraged as it is incorrect. No reflex is thought to be involved. See preferred term, A wave.

axon response See preferred term, A wave.

axon wave See A wave.

axonal degeneration Degeneration of the segment of a nerve distal to the cell body with preferential distal pathology.

axonotmesis Nerve injury characterized by axon and myelin sheath disruption with supporting connective tissue preservation, resulting in axonal degeneration distal to the injury site. Compare neuropaxxia, neurotmesis.

backaveraging Averaging a signal which occurs in a time epoch preceding a triggering event. Often used to extract a time-locked EEG signal preceding voluntary or involuntary movement, usually triggered by the onset of the EMG activity of the movement. An example is the Bereitschaftspotential.

backfiring Discharge of an antidromically activated motor neuron.

backscatter The scattered sound that travels back toward the source transducer. Analyzing this raw data can provide quantitative measures of ultrasound signal.

BAEP Abbreviation for brainstem auditory evoked potential.

BAER Abbreviation for brainstem auditory evoked response. See preferred term, brain stem auditory evoked potential.

baseline 1) The potential recorded from a biologic system while the system is at rest. 2) A flat trace on the recording instrument; an equivalent term, isoelectric line, may be used.

beam width artifact An artifact occurring when the ultrasound beam is wider that the area being scanned, so that adjacent tissues are included and their echogenicity is averaged into the image, thereby altering the tissue signal.

beam steering A process which directs the sound waves emitted by the transducer to a certain angle to enhance visualization of structures. This is often used to improve needle visualization or detection of blood flow.

benign fasciculation potential A firing pattern of fasciculation potentials occurring in association with a clinical syndrome of fasciculations and lack of other pathologic findings in an individual with a nonprogressive neuromuscular disorder. Use of term discouraged.

BER Abbreviation for brainstem auditory evoked responses. See preferred term, brainstem auditory evoked potentials.

Bereitschaftspotential (BP) A component of the movement-related cortical potential. The slowly rising negativity in the EEG preceding voluntary movement. The German term means “readiness potential.” Has two phases called BP1 and BP2 or BP and NS’ (negative slope). See backaveraging.

biphasic action potential An action potential with one baseline crossing, producing two phases.

biphasic end-plate activity See end-plate activity (biphasic).

*bipolar needle electrode Recording electrode that measures voltage between two insulated wires cemented side-by-side in a steel cannula. The bare tips of the electrodes are flush with the level of the cannula which may serve as a ground.

bipolar stimulating electrode See stimulating electrode.

bizarre high-frequency discharge See preferred term, complex repetitive discharge.

bizarre repetitive discharge See preferred term, complex repetitive discharge.

bizarre repetitive potential See preferred term, complex repetitive discharge.

blink reflex See blink responses.

*blink responses Compound muscle action potentials evoked from orbicularis oculi muscles as a result of brief electric or mechanical stimuli applied to the cutaneous area innervated by the supraorbital (or less commonly, the infraorbital) branch of the
trigeminal nerve. Typically, there is an early compound muscle action potential (R1 wave) ipsilateral to the stimulation site with a latency of about 10 ms and a bilateral late compound muscle action potential (R2 wave) with a latency of approximately 30 ms. Generally, only the R2 wave is associated with a visible contraction of the muscle. The configuration, amplitude, duration, and latency of the two components, along with the sites of recording and stimulation, should be specified. The R1 and R2 waves are oligosynaptic and polysynaptic brainstem reflexes, respectively. Together they are called the blink reflex. The afferent arc is provided by the sensory branches of the trigeminal nerve and the efferent arc is provided by facial nerve motor fibers.

blocking Term used in single fiber electromyography to describe dropout of one or more components of the potential during sequential firings. If more than one component drops out simultaneously it is described as concomitant blocking. Usually seen when jitter values exceed 80 to 100 µs. A sign of abnormal neuromuscular transmission, which may be due to primary neuromuscular transmission disorders such as myasthenia gravis and other myasthenic syndromes. Also seen as a result of degeneration and reinnervation in motor neuron disease, neuropathies or myopathies.

*B-Mode Brightness mode provides structural information using different shades of gray in a two dimensional image. The intensity of the image is represented by brightness of the image and the position relative to the transducer. Compare with M-mode.

BP Abbreviation for Bereitschaftspotential.

brachial plexus An anatomical structure which is formed by the spinal roots from C5 to T1, traverses the shoulder region, and culminates in the named peripheral nerves in the arm. It is composed of roots, trunks, divisions, cords, and terminal nerves.

brachial neuropathy Also called Parsonage-Turner syndrome, brachial neuritis, or neuralgic amyotrophy. An inflammatory brachial plexus disorder characterized by pain, muscle weakness, atrophy and sensory loss in the upper limbs.

bradykinesia Slowness of movement, often observed in patients with Parkinson’s disease. Often used synonymously with akinesia.

*brainstem auditory evoked potential (BAEP) Electric waveforms of biologic origin elicited in response to sound stimuli. Normally consists of a sequence of up to seven waves, designated I to VII, which occur during the first 10 ms after the onset of the stimulus and have positive polarity at the vertex of the head.

brainstem auditory evoked response (BAER, BER) See preferred term, brainstem auditory evoked potential.

brightness mode (B-mode) The generation of a two-dimensional image by simultaneous scanning of body tissues using a linear array of transducers. Also known as 2D mode.

BSAP Abbreviation for brief, small, abundant potential. (See BSAPP). Use of term is discouraged.

BSAPP Abbreviation for brief, small, abundant, polyphasic potential. Used to describe a recruitment pattern of brief duration, small amplitude, overly abundant, polyphasic motor unit action potentials, with respect to the amount of force generated; usually a minimal contraction. Use of term discouraged.

carpal tunnel syndrome A mononeuropathy affecting the median nerve at the wrist. As the nerve passes through the carpal tunnel, a space bounded dorsally by the bones of the wrist, laterally by the forearm flexor tendons, and volarly by the transverse carpal ligament, it is subject to compression by any of these structures. Repetitive hand and wrist movement is thought to contribute to the compression.

C reflex An abnormal reflex response representing the electrophysiologic correlate of sensory evoked myoclonus. The term “C” was chosen to indicate that the reflex might be mediated in the cerebral cortex. This is sometimes, but not always, true.

c/s (also cps) Abbreviation for cycles per second. See preferred term, Hertz (Hz).

cathode The negative terminal of an electric current source. See stimulating electrode.

center frequency The mean or median frequency of a waveform decomposed by frequency analysis. Employed in the study of muscle fatigue.

central electromyography Use of electrodiagnostic recording techniques to study reflexes and the control of movement by the spinal cord and brain. See electrodagnosis.

central motor conduction The time taken for conduction of action potentials in the central nervous system from motor cortex to alpha motoneurons in the spinal cord or brainstem. Calculated from the latencies of the motor evoked potentials produced by transcranial magnetic stimulation or transcranial electrical stimulation, subtracting the time for peripheral conduction.
channelopathy Disorders resulting from abnormal ion channel function. Can be congenital or autoimmune. Often causes skeletal muscle hyperexcitability and weakness. Cardiac muscle or electrical conduction system can be affected.

chorea Clinical term used to describe irregular, random, brief, abrupt, involuntary movements of the head or limbs often due to a disorder of the basal ganglia. Most commonly observed in patients with Huntington’s disease and Sydenham’s chorea.

chronaxie (also chronaxy) See strength-duration curve.

chronic inflammatory demyelinating polyradiculoneuropathy (CIDP) A polyneuropathy or polyradiculoneuropathy characterized by generalized demyelination of the peripheral nervous system. In most cases there is also a component of axonal degeneration. Some cases are associated with a monoclonal gammopathy of undetermined significance (MGUS). Distinguish from acute inflammatory neuropathy.

clinical electromyography Term used commonly to describe the scientific methods of recording and analysis of biologic electrical potentials from human peripheral nerve and muscle. See preferred term, electrodiagnostic medicine.

CMAP Abbreviation for compound muscle action potential.

coaixile needle electrode See synonym, concentric needle electrode.

collision When used with reference to nerve conduction studies, the interaction of two action potentials propagated toward each other from opposite directions on the same nerve fiber so that the refractory periods of the two potentials prevent propagation past each other.

color flow imaging (CFI) The merging of gray-scale and motion-detection processing to produce an image that depicts soft tissue in gray scale and blood flow in color.

complex motor unit action potential A motor unit action potential that is polyphasic or serrated. See preferred terms, polyphasic action potential or serrated action potential.

*complex repetitive discharge A type of spontaneous activity. Consists of a regularly repeating series of complex polyphasic or serrated potentials that begin abruptly after needle electrode movement or spontaneously. The potentials have a uniform shape, amplitude, and discharge frequency ranging from 5 to 100 Hz. The discharge typically terminates abruptly. May be seen in both myopathic and neurogenic disorders, usually chronic. Thought to be due to ephaptic excitation of adjacent muscle fibers in a cyclic fashion. This term is preferred to bizarre high frequency discharge, bizarre repetitive discharge, bizarre repetitive potential, pseudomyotonic discharge, and synchronized fibrillation. See also ephapse and ephaptic transmission.

compound action potential A potential or waveform resulting from the summation of multiple individual axon or muscle fiber action potentials. See compound mixed nerve action potential, compound motor nerve action potential, compound nerve action potential, compound sensory nerve action potential, and compound muscle action potential.

compound mixed nerve action potential A compound nerve action potential recorded from a mixed nerve when an electric stimulus is applied to a segment of the nerve that contains both afferent and efferent fibers. The amplitude, latency, duration, and phases should be noted.

compound motor nerve action potential (compound motor NAP) A compound nerve action potential recorded from efferent fibers of a motor nerve or a motor branch of a mixed nerve. Elicited by stimulation of a motor nerve, a motor branch of a mixed nerve, or a ventral nerve root. The amplitude, latency, duration, and phases should be noted. Distinguish from compound muscle action potential.

compound muscle action potential (CMAP) The summation of nearly synchronous muscle fiber action potentials recorded from a muscle, commonly produced by stimulation of the nerve supplying the muscle either directly or indirectly. Baseline-to-peak amplitude, duration, and latency of the negative phase should be noted, along with details of the method of stimulation and recording. Use of specific named potentials is recommended, e.g., M wave, F wave, H wave, T wave, A wave, and R1 or R2 wave (blink responses).

compound nerve action potential (compound NAP) The summation of nearly synchronous nerve fiber action potentials recorded from a nerve trunk, commonly produced by stimulation of the nerve directly or indirectly. Details of the method of stimulation and recording should be specified, together with the fiber type (sensory, motor, or mixed nerve).

* Illustration in Section II & III
**compound sensory nerve action potential (compound SNAP)** A compound nerve action potential recorded from the afferent fibers of a sensory nerve, a sensory branch of a mixed nerve or in response to stimulation of a sensory nerve or a dorsal nerve root. May also be elicited when an adequate stimulus is applied synchronously to sensory receptors. The amplitude, latency, duration, and configuration should be noted. Generally, the amplitude is measured as the maximum peak-to-peak voltage when there is an initial positive deflection or from baseline-to-peak when there is an initial negative deflection. The latency is measured as either the time to the initial deflection or the negative peak, and the duration as the interval from the first deflection of the waveform from the baseline to its final return to the baseline. Also referred to by the less preferred terms sensory response, sensory potential, or SNAP.

**compression of dynamic range** A reduction of the total amplitude range of echo signals. This is an adjustable setting on most ultrasound systems for image optimization.

**concentric needle electrode** Recording electrode that measures an electric potential difference between a centrally insulated wire and the cannula of the needle through which it runs.

**concomitant blocking** Concomitant blocking may be generated by a split muscle fiber or failure of conduction at an axon branch serving several muscle fibers.

**conditioning stimulus** See paired stimuli.

**conduction block** Failure of an action potential to propagate past a particular point in the nervous system whereas conduction is possible below the point of the block. Documented by demonstration of a reduction in the area of a compound muscle action potential greater than that normally seen with stimulation at two different points on a nerve trunk; anatomic variations of nerve pathways and technical factors related to nerve stimulation must be excluded as the cause of the reduction in area.

**conduction distance** The length of nerve or muscle over which conduction is determined, customarily measured in centimeters or millimeters.

**conduction time** See conduction velocity.

**conduction velocity (CV)** Speed of propagation of an action potential along a nerve or muscle fiber. The nerve fibers studied (motor, sensory, autonomic, or mixed nerve) should be specified. For a nerve trunk, the maximum conduction velocity is calculated from the latency of the evoked potential (muscle or nerve) at maximal or supramaximal intensity of stimulation at two different points. The distance between the two points (conduction distance) is divided by the difference between the corresponding latencies (conduction time). The calculated result is the conduction velocity of the fastest fibers and is usually expressed as meters per second (m/s). As commonly used, refers to the maximum conduction velocity. By specialized techniques, the conduction velocity of other fibers can also be determined and should be specified, e.g., minimum conduction velocity.

**congenital myasthenia** See preferred term myasthenic syndrome, congenital.

**contraction** A voluntary or involuntary reversible muscle shortening that may or may not be accompanied by action potentials from muscle. Contrast the term contracture.

**contraction fasciculation** Clinical term for visible twitching of a muscle with weak voluntary or postural contraction which has the appearance of a fasciculation. More likely to occur in neuromuscular disorders in which the motor unit territory is enlarged and the tissue covering the muscle is thin, but may also be observed in normal individuals.

**contracture** 1) Fixed resistance to stretch of a shortened muscle due to fibrous connective tissue changes and loss of sarcomeres in the muscle. Limited movement of a joint may be due to muscle contracture or to fibrous connective tissue changes in the joint. Contrast with contraction, which is a rapidly reversible painless shortening of the muscle. 2) The prolonged, painful, electrically silent, and involuntary state of temporary muscle shortening seen in some myopathies (e.g., muscle phosphorylase deficiency).

**coronal plane** A vertical imaging plane that divides the structure of interest into anterior and posterior sections.

**coupled discharge** See preferred term, satellite potential.

**cps (also c/s)** Abbreviation for cycles per second. See preferred term, Hertz (Hz).

**cramp discharge** Involuntary repetitive firing of motor unit action potentials at a high frequency (up to 150 Hz) in a large area of a muscle usually associated with painful muscle contraction. Both discharge frequency and number of motor unit action potentials activated increase gradually during development, and both subside gradually with cessation. See muscle cramp.

**crossed leg palsy** See preferred term fibular neuropathy at the knee.

**cross-sectional plane** The plane observed and described when the ultrasound transducer is perpendicular.
relative to the underlying structure. Also referred to as short axis or transverse plane.

**cross-sectional area (CSA)** Standard measure of peripheral nerve size, made in millimeters square (mm²). Measured while viewing the nerve in cross-section and typically excluding the nerve’s hyperechoic rim.

cross talk 1) A general term for abnormal communication between excitable membranes. See ephapse and ephaptic transmission. 2) Term used in kinesiologic EMG for signals picked up from adjacent muscles.

cubital tunnel syndrome A mononeuropathy involving the ulnar nerve in the region of the elbow. An entrapment neuropathy caused by compression of the nerve as it passes through the aponeurosis (the cubital tunnel) of the two heads of the flexor carpi ulnaris approximately 1.5 to 3.5 cm distal to the medial epicondyle of the elbow. The mechanism of entrapment is presumably narrowing of the cubital tunnel during elbow flexion. See also tardy ulnar palsy and ulnar neuropathy at the elbow.

curvilinear transducer An ultrasound transducer with a convex surface, permitting a wider field of view. Often used in the scanning of deeper structures.

cutaneous reflex A reflex produced by cutaneous stimulation. There are several phases to cutaneous reflexes, and, if the muscle has a background contraction, the phases can be seen to be inhibitory as well as excitatory.

**CV** Abbreviation for conduction velocity.

cycles per second (c/s, cps) Unit of frequency. See preferred term hertz (Hz).

decomposition EMG Synonym for automatic decomposition EMG.

decremental response See preferred term, decrementing response.

*decrementing response* A reproducible decline in the amplitude and/or area of the M wave of successive responses to repetitive nerve stimulation. The rate of stimulation and the total number of stimuli should be specified. Decrementing responses with disorders of neuromuscular transmission are most reliably seen with slow rates (2 to 5 Hz) of nerve stimulation. A decrementing response with repetitive nerve stimulation commonly occurs in disorders of neuromuscular transmission, but can also be seen in some neuropathies, myopathies, and motor neuron disease. An artifact resembling a decrementing response can result from movement of the stimulating or recording electrodes during repetitive nerve stimulation (see pseudodecrement). Contrast with incrementing response.

delay 1) The time between the beginning of the horizontal sweep of the oscilloscope and the onset of an applied stimulus. 2) A synonym for an information storage device (delay line) used to display events occurring before a trigger signal.

delay line An information storage device used to display events which occur before a trigger signal. A method for displaying a waveform at the same point on a sweep from a free-running electromyogram.

demyelination Disease process affecting the myelin sheath of central or peripheral nerve fibers, manifested by conduction velocity slowing, conduction block, or both.

denervation potential Sometimes used as a synonym for fibrillation potential. Use of this term is discouraged, since fibrillation potentials can occur in the absence of denervation. See preferred term, fibrillation potential.

depolarization A change in the existing membrane potential to a less negative value. Depolarizing an excitable cell from its resting level to threshold typically generates an action potential.

depolarization block Failure of an excitable cell to respond to a stimulus due to pre-existing depolarization of the cell membrane.

depth electrodes Electrodes which are inserted into the substance of the brain for electrophysiological recording. Most often inserted using stereotactic techniques.

depth of field The range around the focal length in which targets remain in focus.

depth of focus See depth of field.

dermatomal somatosensory evoked potential (DSEP) Scalp recorded waveforms generated from repeated stimulation of a specific dermatome. Different from typical somatosensory evoked potentials that are recorded in response to stimulation of a named peripheral nerve.

discharge The firing of one or more excitable elements (neurons, axons, or muscle fibers); as conventionally used, refers to all-or-none potentials only. Synonymous with action potential.

discharge frequency The rate at which a potential discharges repetitively. When potentials occur in groups, the rate of recurrence of the group and rate of repetition of the individual components in the groups should be specified. See also firing rate.

discrete activity See interference pattern.

distal latency The interval between the delivery of a stimulus to the most distal point of stimulation on a nerve and the onset of a response. A measure of the conduction properties of the distal most portion of motor or sensory nerves. See motor latency and sensory latency.
doppler effect The change in frequency of a sound wave based on movement towards or away from the transducer.

double discharge Two sequential firings of a motor unit action potential of the same form and nearly the same amplitude, occurring consistently in the same relationship to one another at intervals of 2 to 20 ms. See also multiple discharge, triple discharge.

doublet Synonym for the preferred term, double discharge.

DSEP Abbreviation for dermatomal somatosensory evoked potential.

duplex ultrasound The common name for the simultaneous presentation of 2D and (usually) power Doppler information.

duration The time during which something exists or acts. 1) The interval from the beginning of the first deflection from the baseline to its final return to the baseline of an action potential or waveform, unless otherwise specified. If only part of the waveform is measured, the points of the measurement should be specified. For example, the duration of the M wave may be measured as the negative phase duration and refers to the interval from the deflection of the first negative phase from the baseline to its return to the baseline. 2) The interval of the applied current or voltage of a single electric stimulus. 3) The interval from the beginning to the end of a series of recurring stimuli or action potentials.

dynamic EMG See kinesiologic EMG.

dysautonomia Dysfunction of all or portions of the autonomic nervous system such as cardiac, vasculature, sweat gland, digestive or genitourinary systems. Dysautonomia may result from peripheral autonomic neuropathy or central nervous system dysfunction.

dyskinesia An abnormal involuntary movement of a choreic or dystonic type. The term is nonspecific and is often used in association with a modifier that describes its etiology, e.g. tardive dyskinesia or LDOPA dyskinesia.

dystonia A disorder characterized by involuntary movements caused by sustained muscle contraction, producing prolonged movements or abnormal postures.

E-1 Synonymous with input terminal 1. See recording electrode.

E-2 Synonymous with input terminal 2. See recording electrode.

E:I ratio In autonomic testing, the ratio of the longest electrocardiographic R-R interval during expiration to the shortest during inspiration. Primarily a measure of parasympathetic control of heart rate.

early recruitment A recruitment pattern which occurs in association with a reduction in the number of muscle fibers per motor unit or when the force generated by the fibers is reduced. At low levels of muscle contraction more motor unit action potentials are recorded than expected, and a full interference pattern may be recorded at relatively low levels of muscle contraction. Most often encountered in myopathy.

earth electrode Synonymous with ground electrode.

*echogenicity The ability to create an echo (ie. return a signal to the transducer). Tissues that return more signal create a relatively brighter image and are referred to as hyperechogenic or hyperechoic. Conversely, those tissues that absorb and do not return most of the signal appear darker on imaging and are called hypoechogenic or hypoechoic. The absence of an echoic image is termed anechoic.

EDX Abbreviation for electrodiagnosis. Can also be used for electrodiagnostic and electrodiagnostic medicine.

elastography An ultrasonographic technique measuring the stiffness of body tissues through analysis of displacement and deformation in response to a known load.

electric inactivity See preferred term, electric silence.

electric silence The absence of measurable electric activity due to biologic or nonbiologic sources. The sensitivity and signal-to-noise level of the recording system should be specified.

electrocochleography Electrophysiologic recording directly from the surface of the brain. In the intraoperative setting, recordings are made of ongoing spontaneous electroencephalogram activity, or potentials evoked by stimulation of peripheral sensory pathways.

electrode A conducting device used to record an electric potential (recording electrode) or to deliver an electric current (stimulating electrode). In addition to the ground electrode used in clinical recordings, two electrodes are always required either to record an electric potential or to deliver a stimulus. See ground electrode, recording electrode, and stimulating electrode. Also see specific needle electrode configurations: monopolar, bipolar, concentric, bifilar recording, bipolar stimulating, multilead, single fiber, and macro-EMG needle electrodes.

electrodiagnosis (EDX) The scientific methods of recording and analyzing biologic electrical potentials from the central, peripheral, and autonomic nervous systems and muscles. See also clinical electromyography, electromyography, electroneurography, electroneuromyography, evoked potentials, electrodiagnostic medicine, electrodiagnostic medicine consultation, and electrodiagnostic medicine consultant.

electrodiagnostic medicine A specific area of medical practice in which a physician integrates information obtained from the clinical history, observations from

* Illustration in Section II & III

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physical examination, and scientific data acquired by recording electrical potentials from the nervous system and muscle to diagnose, or diagnose and treat diseases of the central, peripheral, and autonomic nervous systems, neuromuscular junctions, and muscle. See also electrodiagnosis, electrodiagnostic medicine consultation, and electrodiagnostic medicine consultant.

electrodiagnostic medicine consultant A physician specially trained to obtain a medical history, perform a physical examination, and to record and analyze data acquired by recording electrical potentials from the nervous system and muscle to diagnose and/or treat diseases of the central, peripheral, and autonomic nervous systems, neuromuscular junction, and muscle. See also electrodiagnosis, electrodiagnostic medicine, and electrodiagnostic medicine consultation.

electrodiagnostic medicine consultation The medical evaluation in which a specially trained physician (electrodiagnostic medicine consultant) obtains a medical history, performs a physical examination, and integrates scientific data acquired by recording electrical potentials from the nervous system and muscle to diagnose and/or treat diseases of the central, peripheral, and autonomic nervous systems, neuromuscular junction, and muscle. See also electrodiagnosis, electrodiagnostic medicine, and electrodiagnostic medicine consultation.

electromyogram The record obtained by electromyography.

electromyograph Equipment used to activate, record, process, and display electrical potentials for the purpose of evaluating the function of the central, peripheral, and autonomic nervous systems, neuromuscular junction, and muscles.

electromyographer See preferred term, electrodiagnostic medicine consultant.

electromyography (EMG) Strictly defined, the recording and study of insertion, spontaneous, and voluntary activity of muscle with a recording electrode (either a needle electrode for invasive EMG or a surface electrode for kinesiologic studies). The term is also commonly used to refer to an electrodiagnostic medicine consultation, but its use in this context is discouraged.

electroneurography (ENG) The recording and study of the action potentials of peripheral nerve. Synonymous with nerve conduction studies.

electroneuromyography (ENMG) The combined studies of electromyography and electroneurography. Synonymous with clinical electromyography. See preferred term electrodiagnostic medicine consultation.

EMG Abbreviation for electromyography.

*end-plate activity Spontaneous electric activity recorded with a needle electrode close to muscle end plates. These potentials may have several different morphologies.

1. Monophasic: Low-amplitude (10 to 20 µV), short-duration (0.5 to 1.0 ms), negative potentials occurring in a dense, steady pattern, the exact frequency of which cannot be defined. These nonpropagated potentials are probably miniature end-plate potentials recorded extracellularly. Referred to as end-plate noise or sea-shell sound (sea shell roar or noise).

2. Biphasic: Moderate-amplitude (100 to 300 µV), short-duration (2 to 4 ms), initially negative spike potentials occurring irregularly in short bursts with a high frequency (50 to 100 Hz). These propagated potentials are generated by muscle fibers excited by activity in nerve terminals. These potentials have been referred to as biphasic spike potentials, end-plate spikes, and, incorrectly, nerve potentials. May also have a biphasic initially positive morphology.

3. Triphasic: Similar to biphasic potentials, but the waveforms have three phases with an initial positive deflection. Fire in an irregular fashion; contrast with fibrillation potential.

end-plate noise See end-plate activity (monophasic).

end-plate potential (EPP) The graded nonpropagated membrane potential induced in the postsynaptic membrane of a muscle fiber by release of acetylcholine from the presynaptic axon terminal in response to an action potential.

electroneurography (ENG) The recording and study of insertion, spontaneous, and voluntary activity of muscle with a recording electrode (either a needle electrode for invasive EMG or a surface electrode for kinesiologic studies). The term is also commonly used to refer to an electrodiagnostic medicine consultation, but its use in this context is discouraged.

ephapse A point of abnormal communication where an action potential in one muscle fiber or axon can cause depolarization of an adjacent muscle fiber or axon to generate an action potential.

ephaptic transmission The generation of a nerve fiber action potential from one muscle fiber or axon to another through an Ephapse. Postulated to be the basis for complex repetitive discharges, myokymic discharges, and hemifacial spasm.

EPSP Abbreviation for excitatory postsynaptic potential.

Erb’s point The site at the anterolateral base of the neck where percutaneous nerve stimulation activates the axons comprising the upper trunk of the brachial plexus.
Erb’s point stimulation  Percutaneous supraclavicular nerve stimulation during which the upper trunk of the brachial plexus is activated. See the more general and preferred term, supraclavicular nerve stimulation.

evoked potential  Electric waveform elicited by and temporally related to a stimulus, most commonly an electric stimulus delivered to a sensory receptor or nerve, or applied directly to a discrete area of the brain, spinal cord, or muscle. See auditory evoked potential, brainstem auditory evoked potential, spinal evoked potential, somatosensory evoked potential, visual evoked potential, compound muscle action potential, and compound sensory nerve action potential.

evoked potential studies  Recording and analysis of electric waveforms of biologic origin elicited in response to electrical, magnetic, or physiological stimuli. Stimuli are applied to specific motor or sensory receptors, and the resulting waveforms are recorded along their anatomic pathways in the peripheral and central nervous system. A single motor or sensory modality is typically tested in a study, and the modality studied is used to define the type of study performed. See auditory evoked potentials, brainstem auditory evoked potentials, visual evoked potentials, and somatosensory evoked potentials.

evoked response  Tautology. Use of term discouraged. See preferred term, evoked potential.

excitability  Capacity to be activated by or react to a stimulus.

excitatory postsynaptic potential (EPSP)  A local, graded depolarization of a neuron in response to activation by a nerve terminal. Contrast with inhibitory postsynaptic potential.

F reflex  An incorrect term for F wave.

F response  Synonymous with F wave. See preferred term, F wave.

*F wave  An action potential evoked intermittently from a muscle by a supramaximal electric stimulus to the nerve due to antidromic activation of motor neurons. When compared with the maximal amplitude of the M wave, it is smaller (1 to 5% of the M wave) and has a variable configuration. Its latency is longer than the M wave and is variable. It can be evoked in many muscles of the upper and lower extremities, and the latency is longer with more distal sites of stimulation. Named “F” wave by Magladery and McDougall in 1950, because it was first recorded from foot muscles. Compare with the H wave and the A wave. One of the late responses.

facial neuropathy  Clinical diagnosis of facial weakness or paralysis due to pathology affecting the seventh cranial nerve (facial nerve). Bell’s palsy refers to a facial neuropathy due to inflammation of the facial nerve.

*facilitation  An increase in an electrically measured response following identical stimuli. Occurs in a variety of circumstances: 1) Improvement of neuromuscular transmission resulting in activation of previously inactive muscle fibers. May be identified in several ways: Incrementing response—a reproducible increase in the amplitude and area of successive M waves during repetitive nerve stimulation. Postactivation or posttetanic facilitation—Nerve stimulation studies performed within a few seconds after a brief period (2 to 60 s) of nerve stimulation producing tetanus or after a strong voluntary contraction may show changes in the configuration of the M wave(s) compared to the results of identical studies of the rested muscle as follows: a) repair of the decrement—A diminution of the decrementing response with slow rates (2 to 5 Hz) of repetitive nerve stimulation; b) increment after exercise—an increase in the amplitude and area of the M wave elicited by a single supramaximal stimulus. Distinguish from pseudofacilitation, which occurs in normal individuals in response to repetitive nerve stimulation at high rates (20 to 50 Hz) or after strong volitional contraction. It probably reflects a reduction in the temporal dispersion of the summation of a constant number of muscle fiber action potentials and is characterized by an increase in the amplitude of the successive M waves with a corresponding decrease in their duration. There is no net change in the area of the negative phase of successive M waves. 2) An increase in the amplitude of the motor evoked potential as a result of background muscle activation.

far-field  A region of electrical potential where the isopotential voltage lines associated with a current source change slowly over a short distance. Some use the term far-field potential to designate a potential that does not change in latency, amplitude, or polarity over infinite distances; alternative designations include “boundary potential” and “junctional potential.” The terms near-field and far-field are arbitrary designations as there are no agreed-upon criteria defining where the near-field ends and the far-field begins. Compare with near-field.

fasciculation  The random, spontaneous twitching of a group of muscle fibers belonging to a single motor unit. The twitch may produce movement of the overlying skin (if in limb or trunk muscles) or mucous membrane (if in the tongue). If the motor unit is sufficiently large, an associated joint movement may be observed. The electric activity associated with the twitch is termed a fasciculation potential. See also myokymia. Historically, the term
fibrillation was used incorrectly to describe fine twitching of muscle fibers visible through the skin or mucous membranes. This usage is no longer accepted.

*fasciculation potential* The electric activity associated with a *fasciculation* which has the configuration of a *motor unit activation potential* but which occurs spontaneously. Most commonly occur sporadically and are termed “single fasciculation potentials.” Occasionally the potentials occur as a *grouped discharge* and are termed a “brief repetitive discharge.” The repetitive firing of adjacent fasciculation potentials, when numerous, may produce an undulating movement of muscle (see myokymia). Use of the terms *benign fasciculation* and *malignant fasciculation* is discouraged. Instead, the configuration of the potentials, peak-to-peak *amplitude*, *duration*, number of *phases*, stability of configuration, and frequency of occurrence, should be specified.

**fatigue** A state of depressed responsiveness resulting from activity. Muscle fatigue is a reduction in contraction force following repeated voluntary contraction or electric stimulation.

**fiber density** 1) Anatomically, a measure of the number of muscle or nerve fibers per unit area. 2) In *single fiber electromyography*, the mean number of muscle fiber action potentials fulfilling amplitude and rise time criteria belonging to one motor unit within the recording area of a *single fiber needle electrode* encountered during a systematic search in a weakly, voluntarily contracting muscle. See also *single fiber electromyography*, *single fiber needle electrode*.

**fibrillation** The spontaneous contractions of individual muscle fibers which are not visible through the skin. This term has been used loosely in *electromyography* for the preferred term, *fibrillation potential*.

*fibrillation potential* The action potential of a single muscle fiber occurring spontaneously or after movement of a *needle electrode*. Usually fires at a constant rate. Consists of biphasic or triphasic *spikes* of short *duration* (usually less than 5 ms) with an initial positive *phase* and a peak-to-peak *amplitude* of less than 1 mV. May also have a biphasic, initially negative phase when recorded at the site of initiation. It has an associated high-pitched regular sound described as “rain on a tin roof.” In addition to this classic form, *positive sharp waves* may also be recorded from fibrillating muscle fibers when the potential arises from an area immediately adjacent to the needle electrode.

**Fibular neuropathy at the knee** A *mononeuropathy* involving the common fibular nerve as it passes around the head of the fibula. The presumed mechanism is compression of the nerve against the fibula.

**firing pattern** Qualitative and quantitative descriptions of the sequence of *discharge* of electric *waveforms* recorded from muscle or nerve.

**firing rate** Frequency of repetition of a potential. The relationship of the frequency to the occurrence of other potentials and the force of muscle *contraction* may be described. See also *discharge frequency*.

**flexor reflex** A reflex produced by a noxious cutaneous *stimulus*, or a train of electrical stimuli, that activates the flexor muscles of a limb and thus acts to withdraw it from the stimulus. In humans, it is well-characterized only in the lower extremity.

**focal zone** The narrowest portion of the ultrasound beam, where ultrasound intensity is at its highest. Tissues in this zone will appear relatively hyperechoic. The focal zone is adjustable and centered on the region of interest when imaging.

**forearm exercise test** Screening test for disorders of muscle glycogen metabolism by measuring plasma ammonia and lactate levels after one minute of repetitive *contraction* of forearm muscles. Previously performed under ischemic conditions. Now performed under non-ischemic conditions.

**frequency** 1. In EMG, the number of complete cycles of a repetitive waveform in 1 second. Measured in *hertz* (Hz) or *cycles per second* (cps). 2. In ultrasound, the number of occurrences of a repeating event per unit time. Measured in MHz.

**frequency analysis** Determination of the range of frequencies composing a waveform, with a measurement of the absolute or relative amplitude of each component frequency.

**full interference pattern** See *interference pattern*.

*full wave rectified EMG* The absolute value of a raw *EMG* signal. Involves inverting all the *waveforms* below the *isopotential line* and displaying them with opposite polarity above the line. A technique used to analyze *kinesiologic EMG* signals.

**functional refractory period** See *refractory period*.

**G1, G2** Abbreviation for grid 1 and grid 2.

**gain** In EDX, the degree of *amplification* of voltage signals generated that will result in improved observation on the Y axis. In NMUS, the degree of amplification applied to all returning *ultrasound* signals. Higher gain results in brighter (hyperechoic) images.

**generator** In *volume conduction* theory, the source of electrical activity, such as an *action potential*. See far-field and near-field.

**“giant” motor unit action potential** Use of term discouraged. Refers to a *motor unit action potential* with a peak-to-peak *amplitude* and *duration* much
greater than the range found in corresponding muscles in normal subjects of similar age. Use of term is discouraged. Quantitative measurements of amplitude and duration are preferable.

**giant somatosensory evoked potential** Enlarged somatosensory evoked potentials seen as a characteristic of cortical reflex myoclonus and reflecting cortical hyperexcitability.

**gray scale or grayscale** The digital image method used by most ultrasound systems in which the relative amplitude or intensity of returning echoes is displayed by varying degrees of brightness. Black is the lowest intensity and white the highest, with most echoes presented in shades of gray.

**grid 1** Synonymous with G1, input terminal 1 (E-1), or active or exploring electrode. Use of the term G1 is discouraged. See recording electrode.

**grid 2** Synonymous with G2, input terminal 2 (E-2), or reference electrode. Use of the term Grid 2 is discouraged. See recording electrode.

**ground electrode** A connection from the patient to earth. Used as a common return for an electric circuit and as an arbitrary zero potential reference point.

**grouped discharge** Term used historically to describe three phenomena: (1) irregular, voluntary grouping of motor unit action potentials as seen in a tremulous muscular contraction, (2) involuntary grouping of motor unit action potentials as seen in myokymia, (3) general term to describe repeated firing of motor unit action potentials. See preferred term, repetitive discharge.

**Guillain-Barré syndrome** Eponym for acute inflammatory neuropathy. Also referred to as Landry-Guillain-Barré syndrome or Landry-Guillain-Barré-Strohl syndrome.

**H reflex** Abbreviation for Hoffmann reflex. See H wave.

**H response** See preferred term H wave.

**H wave** A compound muscle action potential with a consistent latency recorded from muscles after stimulation of the nerve. Regularly found in adults only in a limited group of physiologic extensors, particularly the calf muscles. Compared to the M wave of the same muscle, has a longer latency and thus is one of the late responses (see A and F wave). Most reliably elicited with a stimulus of long duration (500 to 1000 µs). A stimulus intensity sufficient to elicit a maximal amplitude M wave reduces or abolishes the H wave. Thought to be due to a spinal reflex, with electric stimulation of afferent fibers in the mixed nerve and activation of motor neurons to the muscle mainly through a monosynaptic connection in the spinal cord. The latency is longer with more distal sites of stimulation. The reflex and wave are named in honor of Hoffman’s description (1918). Compare the F wave and A wave.

**habituation** Decrease in size of a reflex motor response to an afferent stimulus when the latter is repeated, especially at regular and recurring short intervals.

**harmonic** A whole number multiple of the fundamental frequency of a periodic quantity. For example, the second harmonic of a 1 MHz piezoelectric element is at 2 MHz. (Subharmonics also are possible, for example at 1/2, 1/3, etc. of the fundamental frequency.)

**harmonic imaging** Method of imaging in which ultrasound is transmitted at a fundamental frequency and is detected at harmonic frequencies. Harmonics are generated by the propagation medium or by nonlinear reflectors such as contrast microbubbles. The resulting harmonic is displayed as an image to improve the resolution for a given penetration.

**hemifacial spasm** Clinical condition characterized by frequent, repetitive, unilateral, involuntary contractions of the facial muscles. Electrodiagnostic studies demonstrate brief discharges of groups of motor unit action potentials occurring simultaneously in several facial muscles. Occasionally high frequency discharges occur.

**hertz (Hz)** Unit of frequency. Synonymous with cycles per second.

**Hoffmann reflex** See H wave.

**honeycomb appearance** A phrase used to describe the pattern of hyperechoic, rounded areas surrounded by a hyperechoic rim that characterizes the peripheral nerve when viewed in cross-section. It is believed to represent nerve fascicles bounded by perineurial tissue. Sometimes described as a “stippled appearance.”

**hyperechoic** See echogenicity.

**hyperekplexia** Clinical condition characterized by exaggerated startle reflexes. Startle reflexes can be exaggerated by being more extreme than expected (larger amplitude or more widespread) or by lack of normal habituation to repeated similar stimuli. Can be either genetic or acquired.

**hyperpolarization** A change in the existing membrane potential to a more negative value.

**hypertonia** See tone.

**hypoechoic** See echogenicity.

**hypotonia** See tone.

**Hz** Abbreviation for hertz.

**impulse blocking** See blocking.

**inching** A nerve conduction study technique consisting of applying stimuli at multiple short distance increments along the course of a nerve. This technique is used to localize an area of focal slowing or conduction block.

**incomplete activation** Motor unit action potentials firing, on requested maximal effort, in decreased numbers at their normal physiological rates, within the basal firing range of 5 to 10 Hz. Causes include

* Illustration in Section II & III
upper motor neuron syndrome, pain on muscle contraction, hysteria/conversion reaction and malingering. Contrast with reduced recruitment.

increased insertion activity See insertion activity.
increased through transmission See acoustic enhancement.
increment after exercise See facilitation.
incremental response See preferred term, incrementing response.
*incrementing response A reproducible increase in amplitude and/or area of successive M waves to repetitive nerve stimulation. The rate of stimulation and the number of stimuli should be specified. Commonly seen in two situations. First, in normal subjects the configuration of the M wave may change in response to repetitive nerve stimulation so that the amplitude progressively increases as the duration decreases, leaving the area of the M wave unchanged. This phenomenon is termed pseudofacilitation. Second, in neuromuscular transmission disorders, the configuration of the M wave may change with repetitive nerve stimulation so that the amplitude and the area of the M wave progressively increase. This phenomenon is termed facilitation. Contrast with decrementing response.

indifferent electrode Synonymous with reference electrode. Use of term discouraged. See recording electrode.
infraclavicular plexus Segments of the brachial plexus inferior to the divisions; includes the three cords and the terminal peripheral nerves. This clinically descriptive term is based on the fact that the clavicle overlies the divisions of the brachial plexus when the arm is in the anatomic position next to the body.
inhibitory postsynaptic potential (IPSP) A local graded hyperpolarization of a neuron in response to activation at a synapse by a nerve terminal. Contrast with excitatory postsynaptic potential.
injury potential 1) The potential difference between a normal region of the surface of a nerve or muscle and a membrane region that has been injured; also called a “demarcation,” or “killed end” potential. Approximates the potential across the membrane because the injured surface has nearly the same potential as the interior of the cell. 2) In electrodagnostic medicine, the term is also used to refer to the electrical activity associated with needle electrode insertion into muscle. See preferred terms fibrillation potential, insertion activity, and positive sharp wave.
*in-plane approach Ultrasound needle guidance approach requires alignment of the US transducer beam with the shaft and tip of the needle. This method is generally preferred since it allows visualization of the entire needle pathway to the targeted injection site. Contrast with out-of-plane approach.

input terminal 1 The input terminal of a differential amplifier at which negativity, relative to the other input terminal, produces an upward deflection. Synonymous with active or exploring electrode, EI or less preferred term, grid 1. See recording electrode.
input terminal 2 The input of a differential amplifier at which negativity, relative to the other input terminal, produces a downward deflection. Synonymous with reference electrode, E-2 or less preferred term, grid 2. See recording electrode.
*insertion activity Electric activity caused by insertion or movement of a needle electrode within a muscle. The amount of the activity may be described as normal, reduced, or increased (prolonged), with a description of the waveform and repetition rate. See also fibrillation potential and positive sharp wave.
integrated EMG Mathematical integration of the full wave rectified EMG signal. Reflects the cumulative EMG activity of a muscle over time. See also linear envelope EMG.
interdischarge interval Time between consecutive discharges of the same potential. Measurements should be made between the corresponding points on each waveform.
interference Unwanted electric activity recorded from the surrounding environment.
*interference pattern Electric activity recorded from a muscle with a needle electrode during maximal voluntary effort. A full interference pattern implies that no individual motor unit action potentials can be clearly identified. A reduced interference pattern (intermediate pattern) is one in which some of the individual motor unit action potentials may be identified while others cannot due to superimposition of waveforms. The term discrete activity is used to describe the electric activity recorded when each of several different motor unit action potentials can be identified in an ongoing recording due to limited superimposition of waveforms. The term single unit pattern is used to describe a single motor unit action potential, firing at a rapid rate (should be specified) during maximum voluntary effort. The force of contraction associated with the interference pattern should be specified. See also early recruitment, recruitment pattern, reduced recruitment pattern.
interference pattern analysis Quantitative analysis of the interference pattern. This can be done either in the frequency domain using fast Fourier transformation (FFT) or in the time domain. Can be done using a fixed load (e.g. 2 kg), at a given

* Illustration in Section II & III
proportional strength (e.g. 30% of maximum) or at random strengths. The following are measured in the time domain: a) the number of turns per second and b) the amplitude, defined as the mean amplitude between peaks.

**intermediate interference pattern** See **interference pattern**.

**international 10-20 system** A system of electrode placement on the scalp in which electrodes are placed either 10% or 20% of the total distance on a line on the skull between the nasion and inion in the sagittal plane and between the right and left preauricular points in the coronal plane.

**interpeak interval** Difference between the peak latencies of two components of a waveform.

**interpotential interval** Time between two different potentials. Measurement should be made between the corresponding parts of each waveform.

**intraoperative monitoring** The use of electrophysiological stimulating and recording techniques in an operating room setting. The term is usually applied to techniques which are used to detect injury to nervous tissue during surgery or to guide the surgical procedure.

**involuntary activity** Motor unit action potentials that are not under volitional control. The condition under which they occur should be described, e.g., spontaneous or **reflex** potentials. If elicited by a **stimulus**, its nature should be described. Contrast with spontaneous activity.

**IPSP** Abbreviation for inhibitory postsynaptic potential.

**irregular potential** See preferred term, **serrated action potential**.

**isoechoic** Two structures of equal **echogenicity**.

**isoelectric line** In electrophysiologic recording, the display of zero potential difference between the two input terminals of the recording apparatus. See **baseline**.

**iterative discharge** See preferred term, repetitive discharge.

**jiggle** Shape variability of **motor unit action potentials** recorded with a conventional **EMG needle electrode**. A small amount occurs normally. In conditions of disturbed neuromuscular transmission, including early reinnervation and myasthenic disorders, the variability can be sufficiently large to be easily detectable by eye. Quantitative methods for estimating this variability are not yet widely available.

**jitter** The variability of consecutive discharges of the interpotential interval between two **muscle fiber action potentials** belonging to the same **motor unit**. Usually expressed quantitatively as the mean value of the difference between the interpotential intervals of successive discharges (the **mean consecutive difference, MCD**). Under certain conditions, it is expressed as the mean value of the difference between interpotential intervals arranged in the order of decreasing interdischarge intervals (the **mean sorted difference, MSD**). See single **fiber electromyography**.

**Jolly Test** A technique named for Friedrich Jolly, who applied an electric current to excite a **motor nerve** repetitively while recording the force of muscle **contraction**. Use of the term is discouraged. Inappropriately used to describe the technique of repetitive **nerve stimulation**.

**kinematics** Technique for description of body movement without regard to the underlying forces. See **kinesiologic EMG**.

**kinesiologic EMG** The muscle electrical activity recorded during movement. Gives information about the timing of muscle activity and its relative intensity. Either **surface electrodes** or intramuscular fine wire electrodes are used. Synonymous with **dynamic EMG**.

**kinesiology** The study of movement. See **kinesiologic EMG**.

**kinetics** The internal and external forces affecting the moving body. See **kinesiologic EMG**.

**Lambert Eaton myasthenic syndrome** An autoimmune disorder which depletes presynaptic voltage-gated calcium channels on peripheral motor and autonomic nerves characterized by fluctuating muscle weakness, depressed deep tendon reflexes, and autonomic changes including dry eyes, dry mouth, slowed bladder contraction and reduced sweating.

**late component (of a motor unit action potential)** See preferred term, **satellite potential**.

**late response** A general term used to describe an **evoked potential** in motor nerve conduction studies having a longer latency than the **M wave**. Examples include **A wave**, **F wave**, and **H wave**.

**latency** Interval between a **stimulus** and a **response**. The **onset latency** is the interval between the onset of a stimulus and the onset of the **evoked potential**. The peak latency is the interval between the onset of a stimulus and a specified peak of the evoked potential.

**latency of activation** The time required for an electric **stimulus** to depolarize a nerve fiber (or bundle of fibers as in a nerve trunk) beyond **threshold** and to initiate an **action potential** in the fiber(s). This time is usually of the order of 0.1 ms or less. An equivalent term, now rarely used, is the “utilization time.”

**latent period** See preferred term, latency.

**linear array** A type of ultrasound **transducer** that propagates sound waves in a linear fashion, parallel to the transducer. This type of transducer is best for imaging of the musculoskeletal and peripheral nervous systems.

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* Illustration in Section II & III
linear envelope EMG Moving average of the full wave rectified EMG. Obtained by low pass filtering the full wave rectified EMG. See also integrated EMG.
linked potential See preferred term, satellite potential.
lipoatrophy Pathologic loss of subcutaneous fat and connective tissues overlying muscle which mimics the clinical appearance of atrophy of the underlying muscle.
*long axis The plane observed and described when the ultrasound transducer is parallel to the structure of interest. An image can be simultaneously long axis and short axis to differing structures in the same image. Also known as longitudinal plane. Compare with short axis.
longitudinal plane Synonymous with long axis.
long-latency reflex A reflex with many synapses (polysynaptic) or a long pathway (long-loop) so that the time to its occurrence is greater than the time of occurrence of short-latency reflexes. See also long-loop reflex.
long-loop reflex A reflex thought to have a circuit that extends above the spinal segment of the sensory input and motor output. May involve the cerebral cortex. Should be differentiated from reflexes arising from stimulation and recording within a single or adjacent spinal segments (i.e., a segmental reflex). See also long-latency reflex.
M response See preferred term, M wave.
*M wave A compound muscle action potential evoked from a muscle by an electric stimulus to its motor nerve. By convention, the M wave elicited by a supramaximal stimulus is used for motor nerve conduction studies. Ideally, the recording electrodes should be placed so that the initial deflection of the evoked potential from the baseline is negative. Common measurements include latency, amplitude, and duration. Also referred to as the motor response. Normally, the configuration is biphasic and stable with repeated stimuli at slow rates (1 to 5 Hz). See repetitive nerve stimulation.
macro motor unit action potential The average electric activity of that part of an anatomic motor unit that is within the recording range of a macro-EMG needle electrode. Characterized by consistent appearance when the small recording surface of the macro-EMG electrode is positioned to record action potentials from one muscle fiber. The following characteristics can be specified quantitatively: (1) maximal peak-to-peak amplitude, (2) area contained under the waveform, (3) number of phases.
macro MUAP Abbreviation for macro motor unit action potential.
*macroelectromyography (macro-EMG) General term referring to the technique and conditions that approximate recording of all muscle fiber action potentials arising from the same motor unit. See macro motor unit action potential.
macro-EMG Abbreviation for macroelectromyography.
*macro-EMG needle electrode A modified single fiber electromyography electrode insulated to within 15 mm from the tip and with a small recording surface (25 µm in diameter) 7.5 mm from the tip.
malignant fasciculation Used to describe large, polyphasic fasciculation potentials firing at a slow rate. This pattern has been seen in progressive motor neuron disease, but the relationship is not exclusive. Use of this term is discouraged. See fasciculation potential.
maximal stimulus See stimulus.
maximum conduction velocity See conduction velocity.
MCD Abbreviation for mean consecutive difference. See jitter.
mean consecutive difference (MCD) See jitter.
mean sorted difference (MSD) See jitter.
megahertz (MHz) A measure of frequency, defined as one million cycles per second. The common unit for describing ultrasound transducer frequency.
membrane instability Tendency of a cell membrane to depolarize spontaneously in response to mechanical irritation or following voluntary activation. May be used to describe the occurrence of spontaneous single muscle fiber action potentials such as fibrillation potentials during needle electrode examination.
MEP Abbreviation for motor evoked potential.
MEPP Abbreviation for miniature end-plate potential.
microneurography The technique of recording peripheral nerve action potentials in humans by means of intraneural electrodes.
miniature end-plate potential (MEPP) The postsynaptic muscle fiber potentials produced through the spontaneous release of individual acetylcholine quanta from the presynaptic axon terminal. As recorded with monopolar or concentric needle electrodes inserted in the end-plate region, MEPPs are monophasic, negative, short duration (less than 5 ms), and generally less than 20 µV in amplitude.
minimum conduction velocity The nerve conduction velocity measured from slowly conducting nerve fibers. Special techniques are needed to produce this measurement in motor or sensory nerves.
mirror image artifact (doppler) The appearance of Doppler spectral components on the “wrong” side of the zero-flow baseline, so that flow spectra in both directions are mirror images of each other. Caused by a Doppler angle of 90°, by technical deficiencies

* Illustration in Section II & III
in the Doppler demodulator, or by overload of the equipment.

**mirror image artifact (imaging)** A multiple-path reflection artifact in which the ultrasonographic image of a structure is duplicated in a different location and appears as a mirror image of the original.

**mixed nerve** A nerve composed of both motor and sensory axons.

*M motion mode* Motion mode captures returning echoes in a line of B mode image displayed over time axis. Often B mode and M mode are imaged together. Compare with B mode.

**MNCV** Abbreviation for *motor nerve conduction velocity*. See *conduction velocity*.

**mononeuritis multiplex** A disorder characterized by axonal injury and/or demyelination affecting nerve fibers in multiple nerves (multiple *mononeuropathies*). Usually occurs in an asymmetric anatomic distribution and in a temporal sequence which is not patterned or symmetric.

**mononeuropathy** A disorder characterized by axonal injury and/or demyelination affecting nerve fibers exclusively along the course of one named nerve.

**monophasic action potential** An *action potential* with the *waveform* entirely on one side of the baseline.

**monophasic end-plate activity** See *end-plate activity (monophasic)*.

**monopolar needle electrode** A solid wire electrode coated with Teflon™, except at the tip. Despite the term monopolar, a separate surface or subcutaneous reference electrode is required for recording electric signals. May also be used as a cathode in *nerve conduction studies* with another electrode serving as an anode.

*M motion mode (M-mode)* A form of *ultrasound* in which either A-mode or B-mode images are made in rapid sequence. This technique creates a video. As the organ boundaries that produce reflections move relative to the probe, this can be used to determine the velocity of specific organ structures.

**motor evoked potential (MEP)** A *compound muscle action potential* produced by either transcranial magnetic stimulation or transcranial electrical stimulation.

**motor latency** Interval between the onset of a *stimulus* and the onset of the resultant *compound muscle action potential (M wave)*. The term may be qualified, as proximal motor latency or *distal motor latency*, depending on the relative position of the stimulus.

**motor nerve** A nerve containing axons which innervate extrafusal and intrafusal muscle fibers. These nerves also contain sensory afferent fibers from muscle and other deep structures.

**motor nerve conduction velocity (MNCV)** The speed of propagation of *action potentials* along a *motor nerve*. See *conduction velocity*.

**motor neuron disease** A clinical condition characterized by degeneration of *motor nerve* cells in the cortex, brain stem, and spinal cord. The location of degeneration determines the clinical presentation. Primary lateral sclerosis occurs when degeneration affects mainly corticospinal tract motor fibers. Spinal muscular atrophy occurs when degeneration affects lower motor neurons located in the brainstem and spinal cord. Amyotrophic lateral sclerosis occurs when degeneration affects both corticospinal tracts and lower motor neurons.

**motor point** The site over a muscle where *contraction* may be elicited by an electric *stimulus* of lowest intensity and/or shortest *duration* in the technique of classic *electrodiagnosis*. This is also usually the point at which a *motor nerve* enters a muscle.

**motor response**
1. The *compound muscle action potential (M wave)* recorded over a muscle in response to stimulation of the nerve to the muscle. 2) The muscle twitch or contraction elicited by stimulation of the nerve to a muscle. 3) The muscle twitch elicited by an activation of the *muscle stretch reflex*.

**motor unit** The anatomic element consisting of an anterior horn cell, its axon and branches, the neuromuscular junctions, and all the muscle fibers innervated by the axon.

**motor unit action potential (MUAP)** The summated muscle fiber *action potentials* of a *motor unit* within the recording range of an electrode. In voluntary muscle *contraction*, MUAPs are characterized by consistent appearance and relationship to the contraction force. The following measures may be specified, quantitatively if possible, after the *recording electrode* is optimally placed within the muscle:

1. **Configuration**
   a. *Amplitude*, peak-to-peak (µV or mV).
   b. *Duration*, total (ms).
   c. *Number of phases* (monophasic, biphasic, triphasic, tetraphasic, polyphasic).
   d. *Polarity of each phase* (negative, positive).
   e. *Number of turns*.
   f. *Variation of shape* (jiggle), if any, with consecutive discharges.
   g. *Presence of satellite (linked) potentials*, if any.
   h. *Spike duration*, including satellites.
   i. *Rise time*.

2. **Recruitment characteristics**
   a. *Threshold of activation* (first recruited, low threshold, high threshold).
   b. *Onset frequency*. 

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* Illustration in Section II & III
c. Recruitment frequency (Hz) or recruitment interval (ms) of individual potentials.
d. Recruitment ratio.
3. Descriptive terms implying diagnostic significance are not recommended, e.g. myopathic, neuropathic, regeneration, nascent, giant, BSAP and BSAPP. See polyphasic action potential, serrated action potential.

**Motor unit potential (MUP)**

**Motor unit number estimation (MUNE)**

**Motor unit number estimate (MUNE)** A quantitative technique for determining the number of functioning motor units in a muscle. A variety of methods, including spike-triggered averaging, incremental motor nerve stimulation, F-wave measurement, or a Poisson statistical technique can be used. Synonyms can include motor unit number estimation and motor unit number estimating.

**Motor unit number estimation (MUNE)** See motor unit number estimate (MUNE).

**Motor unit potential (MUP)** See synonym, motor unit action potential.

**Motor unit territory** The area of a muscle cross-section within which the muscle fibers belonging to an individual motor unit are distributed.

**Movement artifact** See artifact.

**Movement-related cortical potential**

Electroencephalogram activity associated with (before and after) a voluntary movement. There are several components including the Bereitschaftspotential before the movement and the motor potential at about the time of the movement. See also Bereitschaftspotential.

**MSD** Abbreviation for mean sorted difference. See jitter.

**MUAP** Abbreviation for motor unit action potential.

**Multi MUP analysis** A template matching, decomposition EMG method used for MUAP analysis.

**Multilead electrode** See multilead electrode.

**Multifocal motor neuropathy** A disease characterized by selective focal block of motor nerve conduction in multiple nerves secondary to poorly understood mechanisms affecting the myelin sheath or nodes of Ranvier. Motor nerve conduction studies may permit identification and localization of the affected nerve segments.

**Multilead electrode** Three or more insulated wires inserted through apertures in a common metal cannula with their bared tips flush with the cannula’s outer circumference. The arrangement of the bare tips relative to the axis of the cannula and the distance between each tip should be specified. See electrode.

**Multiple discharge** Four or more motor unit action potentials of the same form and nearly the same amplitude occurring consistently in the same relationship to one another and generated by the same axon. See multiplet, double and triple discharge.

**Multiplet** See multiple discharge.

**MUNE** Abbreviation for motor unit number estimate, motor unit number estimation, and motor unit number estimating.

**MUP** Abbreviation for motor unit potential. See preferred term, motor unit action potential.

**Muscle action potential** Term commonly used to refer to a compound muscle action potential.

**Muscle atrophy** Decrease in size of a muscle volume that may be due to diseases of nerve or muscle, or to disuse.

**Muscle cramp** An involuntary, painful muscle contraction associated with electrical activity. Cramp discharges are most common, but other types of repetitive discharges can also be seen.

**Muscle fiber action potential** Action potential recorded from a single muscle fiber.

**Muscle fiber conduction velocity** The speed of propagation of a single muscle fiber action potential, usually expressed as meters per second. Usually less than most nerve conduction velocities, varies with the rate of discharge of the muscle fiber, and requires special techniques for measurement.

**Muscle hypertrophy** Increase in the size of a muscle volume due to an increase in the size of the muscle fibers or replacement or displacement of muscle fibers by other tissues. The latter is also referred to by the term pseudohypertrophy, because the muscle is enlarged but weak. Muscle fibers increase in size as a physiologic response to repetitive and forceful voluntary contraction or as a pathologic response to involuntary electric activity in a muscle, for example, myotonic discharges or complex repetitive discharges.

**Muscle stretch reflex** Activation of a muscle which follows stretch of the muscle, e.g. by percussion of a muscle tendon. See stretch reflex, T wave.

**Muscle tone** See tone.

**Myasthenia gravis** A disease characterized by muscle weakness which increases with repetitive muscle activation. Most commonly, an autoimmune disease caused by the presence of antibodies to the acetylcholine receptors or muscle-specific tyrosine kinase at the neuromuscular junction.

**Myasthenic syndrome, congenital** Inherited neuromuscular disorders caused by defects of presynaptic, synaptic or postsynaptic components at the neuromuscular junction. Symptoms similar to...
Lambert-Eaton myasthenic syndrome and myasthenia gravis.

**myclonus** A quick jerk of a body part produced by a brief contraction of one or a group of muscles, typically originating from activity in the central nervous system. Based on the anatomic location of the pathology, may be classified as spinal, segmental, brainstem, or cortical.

**myoedema** Focal muscle contraction produced by muscle percussion. Not associated with propagated electric activity. May be seen in hypothyroidism (myxedema) and chronic malnutrition.

**myokymia** Continuous quivering or undulating movement of surface and overlying skin and mucous membrane associated with spontaneous, repetitive discharge of motor unit action potentials. See myokymic discharge, fasciculation, and fasciculation potential.

**myokymic discharge** A form of involuntary activity in which motor unit action potentials fire repetitively and may be associated with clinical myokymia. Two firing patterns have been described: (1) Commonly, the discharge is a brief, repetitive firing of single motor unit action potentials for a short period (up to a few seconds) at a uniform rate (2 to 60 Hz) followed by a short period (up to a few seconds) of silence, with repetition of the same sequence at regular intervals. (2) Rarely, the potential recurs continuously at a fairly uniform firing rate (1 to 5 Hz). Myokymic discharges are a subclass of grouped discharges and repetitive discharges. See also ephapse and ephaptic transmission.

**myopathic motor unit potential** Low amplitude, short duration, polyphasic motor unit action potentials. Use of term discouraged. It incorrectly implies specific diagnostic significance of a motor unit action potential configuration. See motor unit action potential.

**myopathic recruitment** Used to describe an increase in the number and firing rate of motor unit action potentials compared with normal for the strength of muscle contraction. Use of term discouraged.

**myopathy** Disorder affecting the structure and/or function of muscle fibers. Etiologies include hereditary, congenital, mitochondrial, inflammatory, metabolic, toxic, infectious, neoplastic, vascular, and traumatic diseases. Most, but not all of these disorders, show abnormalities on needle electromyography.

**myotome** The group of muscles innervated by a single spinal segment.

**myotonia** Delayed relaxation of a muscle after voluntary contraction or percussion. Associated with propagated electric activity, such as myotonic discharges, complex repetitive discharges or neuromyotonic discharges.

*myotonic discharge* Repetitive discharge which occurs at rates of 20 to 80 Hz. There are two types: 1) biphasic (positive-negative) spike potentials less than 5 ms in duration resembling fibrillation potentials. 2) positive waves of 5 to 20 ms duration resembling positive sharp waves. Both potential forms are recorded after needle electrode insertion, during or following voluntary muscle contraction or after muscle percussion, and are due to independent, repetitive discharges of single muscle fibers. The amplitude and frequency of the potentials must both wax and wane. This change produces a characteristic musical sound in the audio output of the electromyograph due to the corresponding change in pitch, which has been likened to the sound of a “dive bomber.” Contrast with waning discharge.

**myotonic potential** See preferred term, myotonic discharge.

**NAP** Abbreviation for nerve action potential. See compound nerve action potential.

**nascent motor unit potential** From the Latin nascent, “to be born.” Refers to very low amplitude, short duration, highly polyphasic motor unit action potentials observed during early states of reinnervation. Use of term is discouraged, as it incorrectly implies diagnostic significance of a motor unit action potential configuration. See motor unit action potential.

**NCS** Abbreviation for nerve conduction study.

**NCV** Abbreviation for nerve conduction velocity. See conduction velocity.

**near-field** A region of electrical activity where the isopotential voltage lines associated with a current source change rapidly over a short distance. The terms near-field and far-field are arbitrary designations, as there are no agreed-upon criteria defining where the near-field ends and the far-field begins. Compare with far-field.

*needle electrode* An electrical device used for recording or stimulating that is positioned near the tissue of interest by penetration of the skin. See specific electrodes: bifilar (bipolar) needle recording electrode, concentric needle electrode, macro-EMG needle electrode, monopolar needle electrode, multilead electrode, single fiber needle electrode, and stimulating electrode.

**nerve action potential (NAP)** Strictly defined, refers to an action potential recorded from a single nerve fiber. The term is commonly used to refer to the compound nerve action potential. See compound nerve action potential.

**nerve conduction study (NCS)** Recording and analysis of electric waveforms of biologic origin elicited in response to electric or physiologic stimuli. The waveforms are termed compound sensory nerve action potentials, compound muscle action
potentials, or mixed nerve action potentials. The compound muscle action potentials are generally referred to by letters, which have historical origin: M wave, F wave, H wave, T wave, A wave, and R1, R2 waves. It is possible under standardized conditions to establish normal ranges for amplitude, duration, and latency of the waveforms and to calculate the maximum conduction velocity of sensory and motor nerves. The term generally refers to studies of waveforms generated in the peripheral nervous system, whereas evoked potential studies refers to studies of waveforms generated in both the peripheral and central nervous systems. Synonymous with electroneurography.

**nerve conduction velocity (NCV)** The speed of action potential propagation along a nerve fiber or nerve trunk. Generally assumed to refer to the maximum speed of propagation unless otherwise specified. See conduction velocity.

**nerve fiber action potential** Action potential recorded from a single axon.

**nerve potential** Equivalent to nerve action potential.

**nerve trunk action potential** See preferred term, compound nerve action potential.

**neurapraxia** Clinical term used to describe the reversible motor and sensory deficits produced by focal compressive or traction lesions of large myelinated nerve fibers. The deficits in function are due to conduction block, most often caused by focal demyelination. Axons are not injured at the lesion site. Compare with axonotmesis and neurotmesis.

**neuromuscular transmission disorder** Clinical disorder associated with pathology affecting the structure and function of the neuromuscular junction and interfering with synaptic transmission at that site. Specific diseases include myasthenia gravis; Lambert-Eaton myasthenic syndrome; myasthenic syndrome, congenital; and botulism.

**neuromuscular ultrasonography (NMUS)** The ultrasound imaging of peripheral nerves and skeletal muscle, which may be affected by neuropathic and myopathic processes.

**neuromyopathy** Clinical disorder associated with pathology affecting both nerve and muscle fibers.

**neuromyotonia** Clinical syndrome of continuous muscle fiber activity manifested as continuous muscle rippling and stiffness. It may be associated with delayed relaxation following voluntary muscle contraction. The accompanying electric activity may be intermittent or continuous. Terms used to describe related clinical syndromes are continuous muscle fiber activity syndrome, Isaac syndrome, Isaac-Merton syndrome, quantal squander syndrome, generalized myokymia, normocalcemic tetany and neurotonia. Distinguish from myotonia.

**neuromyotonic discharge** Bursts of motor unit action potentials that fire at high rates (150 to 300 Hz) for a few seconds, often starting or stopping abruptly. The amplitude of the waveforms typically wanes. Discharges may occur spontaneously or be initiated by needle electrode movement, voluntary effort, ischemia, or percussion of a nerve. The activity originates in motor axons. Distinguish from myotonic discharges and complex repetitive discharges. One type of electrical activity recorded in patients who have clinical neuromyotonia.

**neuropathic motor unit potential** Abnormally high-amplitude, long-duration, polyphasic motor unit action potential. Use of term discouraged. Incorrectly implies a specific diagnostic significance of a motor unit action potential configuration. See motor unit action potential.

**neuropathic recruitment** A recruitment pattern characterized by a decreased number of motor unit action potentials firing at a rapid rate. Use of term discouraged. See preferred terms, reduced interference pattern, discrete activity, single unit pattern.

**neuropathy** Disorder of the peripheral nerves. May be classified by the anatomical structure of the nerve mostly affected by the disease: the cell body (neuronopathy), the axon (axonopathy) or the myelin sheath (demyelinating neuropathy). May selectively affect motor or sensory nerves or both simultaneously. The etiology may be genetic, metabolic, inflammatory, vascular, toxic, or unknown.

**neurotmesis** Partial or complete nerve severance including the axons, associated myelin sheaths, and supporting connective tissues, resulting in axonal degeneration distal to the injury site. Compare with axonotmesis, neurapraxia.

**neurotonic discharges** Repetitive motor unit action potentials recorded from intramuscular electrodes during intraoperative monitoring. Thought to arise from irritation or injury of nerves supplying the muscle from which the recording is made.

**noise** Electric activity not related to the signal of interest. In electrodagnostic medicine, waveforms generated by electrodes, cables, amplifier, or storage media and unrelated to potentials of biologic origin. The term has also been used loosely to refer to one form of end-plate activity.

**NMUS** Abbreviation for neuromuscular ultrasonography.

**oblique plane** A diagonal imaging plane that is in between a cross-sectional and sagittal plane.
**onset frequency** The lowest stable firing rate for a single motor unit action potential that can be voluntarily maintained by a subject.

**order of activation** The sequence of appearance of different motor unit action potentials with increasing strength of voluntary contraction. See recruitment.

**orthodromic** Propagation of a nerve impulse in the same direction as physiologic conduction; e.g. conduction along motor nerve fibers towards the muscle and conduction along sensory nerve fibers towards the spinal cord. Contrast with antidromic.

**out-of-plane approach** ultrasound needle guidance approach requires alignment of the ultrasound transducer beam perpendicular to the tip of the needle with the target injection site seen in short axis. The needle is seen as a bright dot with a black shadow or reverberation artifact. This method is less preferred since it allows visualization of only the tip of the needle at the injection site. Compare with in-plane approach.

**paired stimuli** Two consecutive stimuli delivered in a time-locked fashion. The time interval between the two stimuli and the intensity of each stimulus can be varied but should be specified. The first stimulus is called the conditioning stimulus and the second stimulus is the test stimulus. The conditioning stimulus may modify tissue excitability, which is then evaluated by the response to the test stimulus.

**paramyotonia congenita** An autosomal dominant inherited disorder characterized by cold-induced muscle stiffness that increases with activity (paradoxical myotonia). Contrast with the myotonia congenita in which the myotonia decreases with repeating activity.

**parasite potential** See preferred term, satellite potential.

**peak latency** Interval between the onset of a stimulus and a specified peak of an evoked waveform.

**peroneal neuropathy at the knee** See preferred term fibular neuropathy at the knee.

**phase** That portion of a waveform between the departure from, and the return to, the baseline.

**piezoelectric effect** The generation of electricity in quartz crystals or ceramics through the application of mechanical stress, or vice versa. In ultrasound, it refers to the vibration of these materials when exposed to an electrical field to create a sound wave, or the deformation of the crystals by the returning sound wave to create an electric signal.

**plexopathy** Axonal and/or demyelinating disorder affecting the nerve fibers exclusive to the cervical, brachial, lumbar, or sacral rearrangement of spinal nerve roots into peripheral nerves.

**polarization** The presence of an electric potential difference usually across an excitable cell membrane.

**polyneuropathy** Axonal and/or demyelinating disorder affecting fibers of multiple nerves, usually in a length dependent and symmetrical fashion. May be classified as sensory, motor, or sensorimotor depending on the function of nerve fibers affected; or as axonal, demyelinating or mixed depending on the mechanism.

**polyphasic action potential** An action potential with four or more baseline crossings, producing five or more phases. See phase. Contrast with serrated action potential.

**polyradiculoneuropathy** See radiculopathy.

**positive sharp wave** A biphasic, positive than negative action potential of a single muscle fiber. It is initiated by needle electrode movement (insertional or unsustained positive sharp wave) or occurs spontaneously. Typically discharge in a uniform, regular pattern at a rate of 1 to 50 Hz; the discharge frequency may decrease gradually before cessation of discharge. The initial positive deflection is rapid (<1 ms), its duration is usually less than 5 ms, and the amplitude is up to 1 mV. The negative phase is of low amplitude, and its duration is 10 to 100 ms. A sequence of positive sharp waves is commonly referred to as a train of positive sharp waves. Assumed to be recorded from a damaged area of a muscle fiber. This configuration may result from the position of the needle electrode which is believed to be adjacent to the depolarized segment of a muscle fiber injured by the electrode. Note that the positive sharp waveform is not specific for muscle fiber damage. May occur in association with fibrillation potentials and are thought by some to be equivalent discharges. Motor unit action potentials and potentials in myotonic discharges may have the configuration of positive sharp waves.

**positive wave** Loosely defined, the term refers to a positive sharp wave. See preferred term positive sharp wave.

**postactivation** The period following voluntary activation of a nerve or muscle. Contrast with posttetanic.

**postactivation depression** A reduction in the amplitude and area of the M wave(s) in response to a single stimulus or train of stimuli which occurs within a few minutes following a 10 to 60 second strong voluntary contraction. Postactivation exhaustion refers to the cellular mechanisms responsible for the observed phenomenon of postactivation depression. Also used to describe reduction of the M wave following a tetanus, which should more logically be termed posttetanic depression.

**postactivation exhaustion** A reduction in the safety factor (margin) of neuromuscular transmission after sustained activation at the neuromuscular junction. The changes in the configuration of the M wave due to postactivation exhaustion are referred to as postactivation depression.

**postactivation facilitation** See facilitation.
postactivation potentiation  An increase in the force of contraction (mechanical response) after a strong voluntary contraction. Contrast postactivation facilitation.

posttetanic  The period following tetanus. Contrast with postactivation

posttetanic depression  See postactivation depression.

posttetanic facilitation  See facilitation, potentiation.

posttetanic potentiation  1) The incrementing mechanical response of muscle during and after repetitive nerve stimulation. 2) In central nervous system physiology, enhancement of excitability or reflex outflow of neuronal systems following a long period of high-frequency stimulation. See facilitation, potentiation.

potential  1) A difference in charges, measurable in volts, that exists between two points. Most biologically produced potentials arise from the difference in charge between two sides of a cell membrane. 2) A term for a physiologically recorded waveform.

potentiation  Physiologically, the enhancement of a response. The convention used in this glossary is to use the term potentiation to describe the incrementing mechanical response of muscle elicited by repetitive nerve stimulation, e.g., posttetanic potentiation, whereas the term facilitation is used to describe the incrementing electrical response elicited by repetitive nerve stimulation, e.g., postactivation facilitation.

power doppler  A Doppler imaging mode in which the signal displayed is based on an estimate of the integrated Doppler signal power over a period of time at a given position. The signal represents the energy in the Doppler signal and is usually displayed in color. This value is related to the volume of blood present in the resolution volume, rather than its velocity, and power Doppler does not indicate direction of flow.

prolonged insertion activity  See insertion activity.

propagation velocity of a muscle fiber  The speed of transmission of a muscle fiber action potential.

pseudodecrement  An artifact produced by movement of the stimulating or recording electrodes during repetitive nerve stimulation. The amplitude and area of the M wave can vary in a way that resembles a decrementing response, however the responses are generally irregular and not reproducible.

*pseudofacilitation  See facilitation.

pseudohypertrophy  See muscle hypertrophy.

pseudomyotonic discharge  Formerly used to describe complex repetitive discharges. Use of term discouraged.

pseudopolyphasic action potential  Use of term discouraged. See preferred term, serrated action potential.

pulse repetition frequency (PRF)  In a pulsed system, the number of ultrasonic pulses emitted by the transducer per second. Typically, the PRF of a diagnostic ultrasound system may be in the range of 0.5 to 15 kHz.

pulse waveform  The graphic record of the amplitude of a sound pulse as a function of time.

QEMG  Abbreviation for quantitative electromyography.

QSART  Abbreviation for quantitative sudomotor axon reflex test.

QST  Abbreviation for quantitative sensory testing.

quantitative electromyography (QEMG)  A systematic method for measuring the recordings made by an intramuscular needle electrode. Measurements include motor unit action potential characteristics such as amplitude, duration, and phases, or interference pattern characteristics. See turns and amplitude analysis.

quantitative sensory testing (QST)  An instrumented method for measuring cutaneous sensation.

quantitative sudomotor axon reflex test (QSART)  Test of post-ganglionic sympathetic sudomotor axons function by measuring sweat output following activation of axon terminals by iontophoresis of acetylcholine into the skin. Antidromic transmission of the impulse from the nerve terminals reaches a branch point, then travels orthodromically to release acetylcholine from the nerve terminals, inducing a sweating response. In polyneuropathies that affect small fiber function, the response may be reduced or absent. In painful neuropathies, and in reflex sympathetic dystrophy, the response may be excessive and persistent or reduced.

R1, R2 waves  See blink responses.

radiculopathy  Axonal and/or demyelinating disorder affecting the dorsal, ventral nerve roots or spinal nerve of a spinal segment. The resulting clinical syndrome includes pain, paresthesia, sensory loss, weakness, fasciculations, and muscle atrophy. Often used with a modifier like cervical, thoracic or lumbosacral. If more than one spinal root is involved, the term polyradiculopathy may be used as a descriptor.

raster  A method for display of a free-running sweep in electromyography. Sweeps are off-set vertically so that each successive sweep is displayed below the one preceding it.

raw EMG  Unprocessed EMG signal recorded with surface or intramuscular electrodes.

reciprocal inhibition  Inhibition of a motor neuron pool secondary to the activation of the motor neuron pool.
of its antagonist. It is one of several important spinal mechanisms of motor control that help to make movements smoother and utilize less energy. There are multiple mechanisms for reciprocal inhibition, including one mediated by the Ia inhibitory interneuron that activates Ia afferents and disynaptically inhibits the muscle that is antagonist to the source of the Ia afferents.

**recording electrode** Device used to record electric potential difference. All electric recordings require two electrodes. The electrode close to the source of the activity to be recorded is called the active or exploring electrode, and the other recording electrode is called the reference electrode. Active electrode is synonymous with input terminal 1, or E-1 (or older terms whose use is discouraged, grid 1, and G1). Reference electrode is synonymous with input terminal 2, or E-2 (or older terms whose use is discouraged grid 2, and G2). In some recordings it is not certain which electrode is closer to the source of the biologic activity, e.g. recording with a bifilar needle recording electrode, or when attempting to define far-field potentials. In this situation, it is convenient to refer to one electrode as input electrode 1, or E-1, and the other as input electrode 2, or E-2. By present convention, a potential difference that is negative at the active electrode (input terminal 1, E-1) relative to the reference electrode (input terminal 2, E-2) causes an upward deflection on the display screen. The term “monopolar recording” is not recommended, because all recordings require two electrodes; however, it is commonly used to describe the use of one type of intramuscular needle electrode. A similar combination of needle electrodes has been used to record nerve activity and also has been referred to as “monopolar recording.”

**recruitment** The successive activation of the same and additional motor units with increasing strength of voluntary muscle contraction. See motor unit action potential.

**recruitment frequency** Firing rate of a motor unit action potential (MUAP) when a different MUAP first appears during gradually increasing voluntary muscle contraction. This parameter is essential to assessment of recruitment pattern.

**recruitment interval** The interdischarge interval between two consecutive discharges of a motor unit action potential (MUAP) when a different MUAP first appears during gradually increasing voluntary muscle contraction. The reciprocal of the recruitment interval is the recruitment frequency. See also interdischarge interval.

*recruitment pattern* A qualitative and/or quantitative description of the sequence of appearance of motor unit action potentials during increasing voluntary muscle contraction. The recruitment frequency and recruitment interval are two quantitative measures commonly used. See interference pattern, early recruitment, reduced recruitment for qualitative terms commonly used.

**recruitment ratio** The ratio of the firing rate of the fastest firing motor unit divided by the number of distinct motor units on the screen.

**recurrent inhibition** Decreased probability of firing of a motor neuron pool mediated by Renshaw cells. Renshaw cells are activated by recurrent collaterals from the axons of alpha-motoneurons. Such inhibition influences the same cells that originate the excitatory impulses and their neighbors.

**reduced insertion activity** See insertion activity.

**reduced interference pattern** See interference pattern.

**reduced recruitment pattern** A descriptive term for the interference pattern when the number of motor units available to generate a muscle contraction are reduced. One cause for a reduced interference pattern. See interference pattern, recruitment pattern.

**reference electrode** See recording electrode.

**reflex** A stereotyped motor response elicited by a sensory stimulus and a response. Its anatomic pathway consists of an afferent, sensory input to the central nervous system, at least one synaptic connection, and an efferent output to an effector organ. The response is most commonly motor, but reflexes involving autonomic effector organs also occur. Examples include the H reflex and the sudomotor reflex. See H wave, quantitative sudomotor axon reflex test.

**refraction** The change of direction of propagation of a sound wave when it passes from one medium to another in which the sound speed is different, or when there is spatial variation in a medium’s sound speed.

**refractory period** General term for the time following an action potential when an excitatory membrane cannot be stimulated to produce another action potential. The absolute refractory period is the time following an action potential during which no stimulus, however strong, evokes a further response. The relative refractory period is the time following an action potential during which a stimulus must be abnormally large to evoke a second response. The functional refractory period is the time following an action potential during which a second action potential cannot yet excite the given region.

**refractory period of transmission** Interval following an action potential during which a nerve cannot conduct a second one. Distinguish from refractory period, as commonly used, which deals with the ability of a stimulus to produce an action potential.

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*S26 AANEM Glossary of Terms in Neuromuscular & Electrodiagnostic Medicine
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regeneration motor unit potential Use of term discouraged. See motor unit action potential.
relative refractory period See refractory period.
*repair of the decrement See facilitation.
repetitive discharge General term for the recurrence of an action potential with the same or nearly identical form. May refer to recurring potentials recorded in muscle at rest, during voluntary contraction, or in response to a single nerve stimulus. See double discharge, triple discharge, multiple discharge, myokymic discharge, complex repetitive discharge, neuromyotonic discharge, and cramp discharge.
*repetitive nerve stimulation The technique of repeated supramaximal stimulation of a nerve while recording successive M waves from a muscle innervated by the nerve. Commonly used to assess the integrity of neuromuscular transmission. The number of stimuli and the frequency of stimulation should be specified. Activation procedures performed as a part of the test should be specified, e.g. sustained voluntary contraction or contraction induced by nerve stimulation. If the test includes an activation procedure, the time elapsed after its completion should also be specified. For a description of specific patterns of responses, see incrementing response, decrementing response, facilitation, and postactivation depression.
repolarization A return in membrane potential from a depolarized state toward the normal resting level.
residual latency The calculated time difference between the measured distal latency of a motor nerve and the expected latency, calculated by dividing the distance between the stimulating cathode and the active recording electrode by the maximum conduction velocity measured in a more proximal segment of the nerve. It is due in part to neuromuscular transmission time and to slowing of conduction velocity in terminal axons due to decreasing diameter and the presence of unmyelinated segments.
response An activity elicited by a stimulus.
resting membrane potential Voltage across the membrane of an excitable cell in the absence of a stimulus. See polarization.
*reverberation Artifact that occurs at the interface of two structures with very different acoustic impedance. Repeated reflections result in parallel bands or “comet-tail” artifacts on the ultrasonographic image.
rheobase See strength-duration curve.
rigidity A velocity independent increase in muscle tone and stiffness with full range of joint motion as interpreted by the clinical examiner from the physical examination. Often associated with simultaneous low-grade contraction of agonist and antagonist muscles. Like muscle spasticity, the involuntary motor unit action potential activity increases with activity or passive stretch. Does not seem to change with the velocity of stretch, and, on passive stretch, the increased tone has a “lead pipe” or constant quality. It is a cardinal feature of central nervous system disorders affecting the basal ganglia. Contrast with spasticity.
ring down artifact Produced when small crystals such as cholesterol or air bubbles emit their own ultrasound wave after encountering a sound wave. Because the sound is emitted after the transducer receives the initial reflection, the system display suggests that the emitted sound is coming from structures deeper in the body.
rise time The interval from the onset of a polarity change of a potential to its peak. The method of measurement should be specified.
sagittal plane A vertical imaging plane that divides the structure of interest into right and left halves.
*satellite potential A small action potential separated from the main motor unit action potential by an isoelectric interval which fires in a time-locked relationship to the main action potential. It usually follows, but may precede, the main action potential. Less preferred terms include late component, parasite potential, linked potential, and coupled discharge.
scanning EMG A technique by which a needle electrode is advanced in defined steps through muscle while a separate SFEMG electrode is used to trigger both the display sweep and the advancement device. Provides temporal and spatial information about the motor unit. Distinct maxima in the recorded activity are considered to be generated by muscle fibers innervated by a common branch of an axon. These groups of fibers form a motor unit fraction.
sea shell sound (sea shell roar or noise) Use of term discouraged. See end-plate activity, monophasic.
sensory latency Interval between the onset of a stimulus and the compound sensory action potential. This term may refer to the onset or the peak of the compound sensory action potential. May be qualified as distal or proximal sensory latency, depending on the anatomic position of the stimulus.
sensory nerve A nerve containing myelinated fibers that are predominantly sensory and innervate cutaneous receptors and other structures. Also contains unmyelinated fibers that subserve somatic sensation and autonomic functions.
sensory nerve action potential (SNAP) See compound sensory nerve action potential.

* Illustration in Section II & III
sensory nerve conduction velocity The speed of propagation of action potentials along a sensory nerve.

sensory peak latency Interval between the onset of a stimulus and the peak of the negative phase of the compound sensory nerve action potential. Contrast with sensory latency.

sensory potential Synonym for the more precise term, compound sensory nerve action potential.

sensory response Synonym for the more precise term, compound sensory nerve action potential.

SEP Abbreviation for somatosensory evoked potential.

serrated action potential A waveform with several changes in direction (turns) which do not cross the baseline. Most often used to describe a motor unit action potential. The term is preferred to complex motor unit action potential and pseudopolyphasic action potential. See also turn and polyphasic action potential.

SFEMG Abbreviation for single fiber electromyography.

shadowing See acoustic shadowing.

shear wave elastography An ultrasound measurement technique in which the speed of sound waves are pulsed at a perpendicular angle to determine tissue stiffness.

shock artifact See artifact.

*short axis The plane observed and described when the ultrasound transducer is perpendicular to the structure of interest. An image is often simultaneously long axis and short axis to differing structures in the same image. Also referred to as transverse plane. Compare with long axis.

short-latency reflex A reflex with one (monosynaptic) or few (oligosynaptic) synapses. Used in contrast to long-latency reflex.

*short-latency somatosensory evoked potential (SSEP) A somatosensory evoked potential normally occurring within 25 ms after stimulation of the median nerve at the wrist, 40 ms after stimulation of the common fibular nerve at the knee and 50 ms after stimulation of the posterior tibial nerve at the ankle. Other nerves are less commonly used to generate SSEPs.

signal averager A digital device that improves the signal-to-noise ratio of an electrophysiologic recording by adding successive time-locked recordings to preceding traces and computing the average value of each data point. A signal acquired by this method is described as an “averaged” waveform.

silent period A pause in the electric activity of a muscle that may be produced by many different stimuli. Stimuli used commonly in clinical neurophysiology include rapid unloading of a muscle, electrical stimulation of a peripheral nerve or transcranial magnetic stimulation.

*single fiber electromyography (SFEMG) The technique and conditions that permit recording of single muscle fiber action potentials.

single fiber EMG See single fiber electromyography.

single fiber needle electrode A needle electrode with a small recording surface (usually 25 µm in diameter) which permits the recording of single muscle fiber action potentials between the recording surface and the cannula. See single fiber electromyography.

single unit pattern See interference pattern.

small fiber polyneuropathy Polyneuropathy which preferentially involves the small diameter myelinated and unmyelinated peripheral nerve fibers. These axons mediate sensory functions of pain & temperature and autonomic functions.

SNAP Abbreviation for sensory nerve action potential. See compound sensory nerve action potential.

snap, crackle, and pop A benign type of increased insertion activity that follows, after a very brief period of electrical silence, the normal insertion activity generated by needle electrode movement. It consists of trains of potentials that vary in length, however, they can persist for a few seconds. Each train consists of a series of up to 10 or more potentials in which the individual components fire at irregular intervals. The potentials consistently vary in amplitude, duration, and configuration. Individual potentials may be mono-, bi-, tri-, or multiphasic in appearance; they often have a positive waveform. The variation on sequential firings produces a distinctive sound, hence the name. See most often in those with mesomorphic builds, especially young adult males. Found most often in lower extremity muscles, especially the medial gastrocnemius.

somatosensory evoked potential (SSEP) Electric waves of biologic origin elicited by electric stimulation or physiologic activation of peripheral sensory nerves and recorded from peripheral and central nervous system structures. Normally is a complex waveform with several components which are specified by polarity and average peak latency. The polarity and latency of individual components depend upon 1) subject variables, such as age, gender, and body habitus, 2) stimulus characteristics, such as intensity and rate of stimulation, and 3) recording parameters, such as amplifier time constants, electrode placement, and electrode combinations. See short-latency somatosensory evoked potentials.

spasmodic reflex myoclonus A sequence of synchronous myoclonic bursts followed by a tonic decrescendo activity over a few seconds, mostly recorded with needle examination of the lower trunk paraspinal or abdominal muscles in response to a single electric stimulation. Mostly seen in stiff person syndrome.
spasticity A velocity-dependent increase in muscle tone due to a disease process that interrupts the suprasegmental tracts to the alpha motor neurons, gamma motor neurons, or segmental spinal neurons. May be elicited and interpreted by the clinical examiner during the physical examination by brisk passive movement of a limb at the joint. Almost uniformly accompanied by hyperreflexia, a Babinski sign, and other signs of upper motor neuron pathology, including clonus and the clasp-knife phenomenon. The clasp-knife phenomenon is a rapid decrease of tone following a period of increased tone during passive rotation of the joint. The pathophysiology is not certain and may include more than dysfunction of the corticospinal tracts.

spatial compounding Acquiring and combining ultrasound echo data from the same location, but with different orientations to create better image quality.

spike 1) A short-lived (1 to 3 ms), all-or-none waveform that arises when an excitable membrane reaches threshold. 2) The electric record of a nerve or muscle impulse.

spinal evoked potential Electric waveforms of biologic origin recorded over the spine in response to electric stimulation or physiologic activation of peripheral sensory fibers. See preferred term, somatosensory evoked potential.

spontaneous activity Electric activity recorded from muscle at rest after insertion activity has subsided and where there is not voluntary contraction or an external stimulus. Compare with involuntary activity.

SSEP Abbreviation for short-latency somatosensory evoked potential.

staircase phenomenon The progressive increase in muscle contraction force observed in response to continued low rates of muscle activation.

startle (reflex) A response produced by an unanticipated stimulus that leads to alerting and protective movements such as eye lid closure and flexion of the limbs. Auditory stimuli are typically most efficacious.

Stiffperson syndrome A disorder characterized by continuous muscle contraction giving rise to severe stiffness. Axial muscles are typically affected most severely. Patients have difficulty moving. Walking and voluntary movements are slow. Sensory stimulation often induces severe spasms. Electromyography demonstrates continuous activity of motor unit action potentials in a normal pattern that cannot be silenced by contraction of the antagonist muscle. Serum antibodies to glutamic acid decarboxylase (GAD) are often present, and the resulting deficiency of GABA may play a role in the pathophysiology. Stiffman syndrome and Moersch-Woltman syndrome are less preferred terms.

stimulated SFEMG See preferred term stimulation SFEMG.

stimulating electrode Device used to deliver electric current. All electric stimulation requires two electrodes; the negative terminal is termed the cathode, and the positive terminal is the anode. By convention, the stimulating electrodes are called bipolar if they are encased or attached together and are called monopolar if they are not. Electric stimulation for nerve conduction studies generally requires application of the cathode in the vicinity of the neural tissue to produce depolarization.

stimulation single fiber electromyography (stimulation SFEMG) Use of electrical stimulation instead of voluntary activation of motor units for the analysis of single fiber electromyography. The method is used in patients who are unable to produce a steady voluntary muscle contraction. The stimulation can be delivered to intramuscular axons, nerve trunks, or muscle fibers.

stimulus Any external agent, state or change that is capable of influencing the activity of a cell, tissue, or organism. In clinical nerve conduction studies, an electric stimulus is applied to a nerve. It may be described in absolute terms or with respect to the evoked potential of the nerve or muscle. In absolute terms, it is defined by a duration (ms), a waveform (square, exponential, linear, etc.), and a strength or intensity measured in voltage (V) or current (mA). With respect to the evoked potential, the stimulus may be graded as subthreshold, threshold, submaximal, maximal, or supramaximal. A threshold stimulus is one just sufficient to produce a detectable response. Stimuli less than the threshold stimulus are termed subthreshold. The maximal stimulus is the stimulus intensity after which a further increase in intensity causes no increase in the amplitude of the evoked potential. Stimuli of intensity below this level but above threshold are submaximal. Stimuli of intensity greater than the maximal stimulus are termed supramaximal. Ordinarily, supramaximal stimuli are used for nerve conduction studies. By convention, an electric stimulus of approximately 20% greater voltage/current than required for the maximal stimulus is used for supramaximal stimulation. The frequency, number and duration of a series of stimuli should be specified.

stimulus artifact See artifact.

strain elastography 1. The amount of tissue displacement seen in response to an external force, specifically pressure from the transducer, or internal oscillations from breathing or heartbeat, which is

* Illustration in Section II & III
used in ultrasonographic elastography. 2. The measurement of two pixels on an image.

**strength-duration curve** Graphic presentation of the relationship between the intensity (Y axis) and various durations (X axis) of the threshold electric stimulus of a nerve or muscle. The rheobase is the intensity of an electric current of infinite duration necessary to produce a minimal action potential. The chronaxie is the time required for an electric current twice the rheobase to elicit the first visible action potential. Measurement of the strength-duration curve is not a common practice in modern electrodiagnostic medicine.

**stretch reflex** Passive lengthening or stretch of a muscle that causes contraction of the muscle within a short latency to preserve muscle length. The afferent action potentials arise from group Ia and group II muscle spindle afferents. The resulting muscle contraction has several phases. The earliest component is monosynaptic and is also called the myotatic reflex, or tendon reflex. There are also long-latency stretch reflexes. See also muscle stretch reflex, T wave.

**submaximal stimulus** See stimulus.

**subnormal period** A time interval that immediately follows the supernormal period of nerve which is characterized by reduced excitability compared to the resting state. Its duration is variable and is related to the refractory period.

**subthreshold stimulus** See stimulus.

**supernormal period** The time interval immediately following the refractory period corresponding to a period of partial depolarization during which nerve excitability is increased. A less intense electrical stimulus than normal is needed to excite the nerve in this period.

**supraclavicular plexus** That portion of the brachial plexus which is located superior to the clavicle.

**supraclavicular stimulation** Percutaneous nerve stimulation at the base of the neck which activates the upper, middle, and/or lower trunks of the brachial plexus. This term is preferred to Erb’s point stimulation.

**supramaximal stimulus** See stimulus.

**surface electrode** Conducting device, for stimulating or recording, placed on the skin surface. The material (metal, fabric, etc.), configuration (disk, ring, etc.), size, and separation should be specified. See electrode (ground, recording, stimulating).

**sympathetic skin response** Electrical potential resulting from electrodermal activity in sweat glands in response to both direct and reflex peripheral or sympathetic trunk stimulation of autonomic activity.

**synkinesis** Involuntary movement made by muscles distant from those activated voluntarily. It is commonly seen during recovery after facial neuropathy. It is due to aberrant reinnervation and/or ephaptic transmission.

**T wave** A compound muscle action potential evoked from a muscle by rapid stretch of its tendon, as part of the muscle stretch reflex.

**tardy ulnar palsy** Mononeuropathy involving the ulnar nerve at the elbow, which typically manifests years after a causative event associated with elbow deformity. See also cubital tunnel syndrome and ulnar neuropathy at the elbow.

**template matching** An automated method used in quantitative electromyography for selecting motor unit action potentials for measurement by extracting only potentials which resemble an initially identified potential.

**temporal dispersion** Relative desynchronization of components of a compound muscle action potential due to different rates of conduction of each synchronously evoked component from the stimulation point to the recording electrode. It may be due to normal variability in individual axon conduction velocities, especially when assessed over a long nerve segment, or to disorders that affect myelination of nerve fibers.

**terminal latency** Synonymous with preferred term, distal latency. See motor latency and sensory latency.

**TES** Abbreviation for transcranial electrical stimulation.

**test stimulus** See paired stimuli.

**tetanic contraction** The contraction produced in a muscle through repetitive maximal direct or indirect stimulation at a sufficiently high frequency to produce a smooth summation of successive maximum twitches. The term may also be applied to maximum voluntary contractions in which the firing frequencies of most or all of the component motor units are sufficiently high that successive twitches of individual motor units fuse smoothly. Their combined tensions produce a steady, smooth, maximum contraction of the whole muscle.

**tetanus** A clinical disorder caused by circulating tetanus toxin. Signs and symptoms are caused by loss of central inhibition and are characterized by muscle spasms, hyperreflexia, seizures, respiratory spasms, and paralysis.

**tetany** The continuous contraction of muscle caused by repetitive stimulation or discharge of nerve or muscle.

**tetraphasic action potential** Action potential with three baseline crossings, producing four phases.

**thermography** A technique for measuring infrared emission from portions of the body surface. The degree of emission depends upon the amount of heat produced by the region that is studied. Its use in the diagnosis of radiculopathy, peripheral nerve injury,
and disorders of the autonomic nervous system is controversial.

**Thermoregulatory sweat test** A technique for assessing the integrity of the central and peripheral efferent sympathetic pathways. It consists of measuring the sweat distribution using an indicator powder while applying a controlled heat *stimulus* to raise body temperature sufficient to induce sweating.

**Thoracic outlet syndrome** An *entrapment neuropathy* caused by compression of the neurovascular bundle as it traverses the shoulder region. Compression arises from acquired or congenital anatomic variations in the shoulder region. Symptoms can be related to compression of vascular structures, portions of the *brachial plexus*, or both.

**Threshold** The level at which a clear and abrupt transition occurs from one state to another. The term is generally used to refer to the *voltage* level at which an *action potential* is initiated in a single axon or muscle fiber or a group of axons or muscle fibers.

**Threshold stimulus** See *stimulus*.

**Tic** Clinical term used to describe a sudden, brief, stereotyped, repetitive movement. When associated with vocalizations, may be the primary manifestation of Tourette syndrome.

**Tilt table test** A test of autonomic function that is performed by measuring blood pressure and heart rate before and a specified period of time after head up tilt. The *duration* of recording and amount of tilt should be specified.

**Time-gain compensation (TGC)** At increasing depths of imaging, echo amplitude is lost. TGC is a means of increasing the gain to adjust for loss of *amplitude* and vice versa. This is commonly used to improve image quality and is an adjustment performed in real time by the sonographer.

**TMS** Abbreviation for *transcranial magnetic stimulation*.

**Tone** The resistance to passive stretch of a joint. When the resistance is high, this is called *hypertonia*, and when the resistance is low, this is called *hypotonia*. Two types of hypertonia are *rigidity* and *spasticity*.

**Train of positive sharp waves** See *positive sharp wave*.

**Train of stimuli** A group of *stimuli*. The *duration* of the group or the number of stimuli as well as the stimulation *frequency* should be specified.

**Transcranial electrical stimulation (TES)** Stimulation of the cortex of the brain through the intact skull and scalp by means of a brief, very high *voltage*, electrical *stimulus*. *Activation* is more likely under the *anode* rather than the *cathode*. Because it is painful, this technique has largely been replaced by *transcranial magnetic stimulation*.

**Transcranial magnetic stimulation (TMS)** Stimulation of the cortex of the brain through the intact skull and scalp by means of a brief magnetic *stimulus*. In practice, a brief pulse of strong current is passed through a coil of wire in order to produce a time-varying magnetic field in the order of 1 to 2 Tesla. Contrast with *transcranial electrical stimulation*.

**Transducer** The part of the *ultrasound* system that makes physical contact with the patient. Connected to the computer by a cable, it sends and receives ultrasound signals. The frequency and crystal array of the probe determines its imaging properties. Most transducers now have an adjustable range of frequencies.

**Transverse plane** Synonymous with *short axis* or *cross-sectional plane*.

**Tremor** Rhythmical, involuntary oscillatory movement of a body part.

**Triphasic action potential** *Action potential* with two *baseline* crossings, producing three phases.

**Triple discharge** Three *motor unit action potentials* of the same form and nearly the same *amplitude*, occurring consistently in the same relationship to one another and generated by the same axon. The interval between the second and third *action potentials* often exceeds that between the first two, and both are usually in the range of 2 to 20 ms. See also *double discharge*, *multiple discharge*.

**Triplet** Synonym for the preferred term, *triple discharge*.

**Turn** Point of change in polarity of a *waveform* and the magnitude of the *voltage* change following the turning point. It is not necessary that the voltage change pass through the *baseline*. The minimal excursion required to constitute a change should be specified.

**Turns and amplitude analysis** See preferred term *interference pattern analysis*. Refers to the interference pattern analysis developed by Robin Willison in the 1960s.

**Ulnar neuropathy at the elbow** A *mononeuropathy* involving the ulnar nerve in the region of the elbow. At least two sites of *entrapment neuropathy* have been recognized. The nerve may be entrapped or compressed as it passes through the retrocondylar groove at the elbow. Alternatively, it may be entrapped just distal to the elbow as it passes through the cubital tunnel. Anatomic variations or deformities of the elbow may contribute to nerve injury. See also *cubital tunnel syndrome* and *tardy ulnar palsy*.

**Ultrasonography** The practice of using *ultrasound* to create images of body tissues.

**Ultrasound** Sound frequencies above the limits of human hearing (>20 kHz).
unipolar needle electrode  See synonym, monopolar needle recording electrode.

upper motor neuron syndrome  A clinical condition of the central nervous system resulting from a pathological process affecting descending motor pathways including the corticospinal tract or its cells of origin. Signs and symptoms include weakness, spasticity, and slow or clumsy motor performance. On electromyographic examination of weak muscles, there is slow motor unit action potential firing at maximal effort.

utilization time  See preferred term, latency of activation.

Valsalva maneuver  A forcible exhalation against the closed glottis which creates an abrupt, transient elevation of intrathoracic and intra-abdominal pressure. This results in a characteristic pattern of heart rate and blood pressure changes that can be used to quantify autonomic function. See Valsalva ratio.

Valsalva ratio  The ratio of the fastest heart rate occurring at the end of a forced exhalation against a closed glottis (phase II of the Valsalva maneuver), and the slowest heart rate within 30 seconds after the forced exhalation (phase IV). In patients with disorders of the autonomic nervous system, the ratio may be reduced.

VEP  Abbreviation for visual evoked potential.

VER  Abbreviation for visual evoked response. See visual evoked potential.

*visual evoked potential (VEP)  Electric waveforms of biologic origin recorded over the cerebrum and elicited in response to visual stimuli. They are classified by stimulus rate as transient or steady state, and they can be further divided by stimulus presentation mode. The normal transient VEP to checkerboard pattern reversal or shift has a major positive occipital peak at about 100 ms (P100), often preceded by a negative peak (N75). The precise range of normal values for the latency and amplitude of P100 depends on several factors: 1) subject variables, such as age, gender, and visual acuity, 2) stimulus characteristics, such as type of stimulator, full-field or half-field stimulation, check size, contrast and luminescence, and 3) recording parameters, such as placement and combination of recording electrodes.

visual evoked response (VER)  Synonym for preferred term, visual evoked potential.

volitional activity  Synonym for voluntary activity.

voltage  Potential difference between two recording sites usually expressed in volts (V) or millivolts (mV).

volume conduction  Spread of current from a potential source through a conducting medium, such as body tissues.

voluntary activity  In electromyography, the electric activity recorded from a muscle with consciously controlled contraction. The effort made to contract the muscle may be specified relative to that of a corresponding normal muscle, e.g. minimal, moderate, or maximal. If the recording remains isoelectric during the attempted contraction and equipment malfunction has been excluded, it can be concluded that there is no voluntary activity.

wake-up test  A procedure used most commonly in spinal surgery. During critical portions of an operation in which the spinal cord is at risk for injury, the level of general anesthesia is allowed to decrease to the point where the patient can respond to commands. The patient is then asked to move hands and feet, and a movement in response to commands indicates the spinal cord is intact. This procedure is used routinely in some centers. Somatosensory evoked potential monitoring has supplanted its use in most centers, except sometimes in the situation where they indicate the possibility of spinal cord injury.

wallerian degeneration  A response to nerve injury that results in axonal degeneration distal to the site of nerve injury. The axon and myelin sheath are degraded. The neurolemma remains a hollow tube. Characteristic changes also occur in the cell bodies of the affected neurons.

waning discharge  A repetitive discharge that gradually decreases in frequency or amplitude before cessation. Contrast with myotonic discharge.

wave  A transient change in voltage represented as a line of differing directions over time.

waveform  The shape of a wave. The term is often used as a synonym for wave.

wire electrodes  Thin wires that are insulated except for the tips, which are bared. The wire is inserted into muscle with a needle. After the needle is withdrawn, the wire remains in place. Wire electrodes are superior to surface electrodes for kinesiologic EMG, because they are less affected by cross talk from adjacent muscles. They also record selectively from the muscle into which they are inserted.
SECTION II:
ILLUSTRATIONS OF SELECTED WAVEFORMS

FIGURE 1  COMPOUND SENSORY NERVE ACTION POTENTIALS
FIGURE 2  SHORT-LATENCY SOMATOSENSORY EVOKED POTENTIALS MEDIAN NERVE
FIGURE 3  SHORT-LATENCY SOMATOSENSORY EVOKED POTENTIALS COMMON FIBULAR NERVE
FIGURE 4  SHORT-LATENCY SOMATOSENSORY EVOKED POTENTIALS EVOKED POTENTIALS
FIGURE 5  VISUAL EVOKED POTENTIAL
FIGURE 6  BRAINSTEM AUDITORY EVOKED POTENTIAL
FIGURE 7  M WAVE
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FIGURE 12  BLINK RESPONSES
FIGURE 13  REPETITIVE NERVE STIMULATION NORMAL RESPONSE
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FIGURE 22  MYOTONIC DISCHARGE
FIGURE 23  COMPLEX REPETITIVE DISCHARGE
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FIGURE 25  MYOKYMIC POTENTIAL
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FIGURE 28  MOTOR UNIT ACTION POTENTIALS
FIGURE 29  SATELLITE POTENTIAL
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FIGURE 31  SINGLE-FIBER ELECTROMYOGRAPHY
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FIGURE 33  NEEDLE ELECTRODES
FIGURE 34  FULL WAVE RECTIFIED EMG
FIGURE 35  SYMPATHETIC SKIN RESPONSE

Each illustration is accompanied by a complete explanation that is, in most cases, the same as that given in the alphabetic section. The definitions have been repeated in full with the illustrations so that readers do not need to refer back and forth between the illustration and definition.

The illustrations have been reproduced from the prior 2001 supplement with updated terms and definitions when needed.
COMPOUND SENSORY NERVE ACTION POTENTIAL

Figure 1. Compound sensory nerve action potentials recorded with surface electrodes in a normal subject. A compound nerve action potential is considered to have been evoked from afferent fibers if the recording electrodes detect activity only in a sensory nerve or in a sensory branch of a mixed nerve, or if the electric stimulus is applied to a sensory nerve or a dorsal nerve root, or an adequate stimulus is applied synchronously to sensory receptors. The amplitude, latency, duration, and configuration should be noted. Generally, the amplitude is measured as the maximum peak-to-peak voltage when there is an initial positive deflection or from baseline-to-peak when there is an initial negative deflection. The latency is measured as either the latency to the initial deflection or the peak latency to the negative peak, and the duration as the interval from the first deflection of the waveform from the baseline to its final return to the baseline. The compound sensory nerve action potential is also referred to by the less preferred terms sensory response, sensory potential, or SNAP.

SHORT-LATENCY SOMATOSENSORY EVOKED POTENTIAL (SSEP)

Figure 2. Short-latency somatosensory evoked potentials evoked by stimulation of the median nerve in a normal subject. Recordings were made from the scalp to a cephalic reference (C4'-Fz), the scalp to contralateral Erb’s point (C4'-EP2), cervical spine to a frontal reference (C5S-Fz), and ipsilateral Erb’s point to the contralateral Erb’s point (EP1=EP2). Short-latency somatosensory evoked potentials elicited by electrical stimulation of the median nerve at the wrist occur within 25 ms of the stimulus in normal subjects. Normal short-latency response components to median nerve stimulation are designated P9, P11, P13, P14, N20, and P23 in recordings taken between scalp and noncephalic reference electrodes, and N9, N11, N13, and N14 in cervical spine-scalp derivation. It should be emphasized that potentials having opposite polarity but similar latency in spine-scalp and scalpnoncephalic reference derivations do not necessarily have identical generator sources. The C4’ designation indicates that the recording scalp electrode was placed 2 cm posterior to the International 10-20 C4 electrode location.
SHORT-LATENCY SOMATOSENSORY EVOKED POTENTIAL (SSEP)
COMMON FIBULAR NERVE

**Figure 3.** Short-latency somatosensory evoked potentials evoked by stimulation of the common fibular nerve in a normal subject. Recordings were made from the scalp (Cz’-Fpz’), the mid-thoracic spine (T6S-4 cm rostral), the lower thoracic spine (T12S-4 cm rostral), and the lumbar spine (L3S-4 cm rostral). Short-latency somatosensory evoked potentials elicited by stimulation of the common fibular nerve at the knee occur within 40 ms of the *stimulus* in normal subjects. It is suggested that individual response components be designated as follows: (1) Spine components: L3 and T12 spine potentials. (2) Scalp components: P27 and N35. The Cz’ and Fpz’ designations indicate that the recording scalp electrode was placed 2 cm posterior to the International 10-20 Cz and Fpz electrode locations.

SHORT-LATENCY SOMATOSENSORY EVOKED POTENTIAL (SSEP)
POSTERIOR TIBIAL NERVE

**Figure 4.** Short-latency somatosensory evoked potentials evoked by stimulation of the posterior tibial nerve at the ankle. Recordings were made from the scalp (Cz’-Fpz’), the lower thoracic spine (T12S-4cm rostral), the lumbar spine (L3S-4cm rostral), and the popliteal fossa (PF-medial surface of knee). Short-latency somatosensory evoked potentials elicited by electric stimulation of the posterior tibial nerve at the ankle occur within 50 ms of the *stimulus* in normal subjects. It is suggested that individual response components be designated as follows: (1) Nerve trunk (tibial nerve) component in the popliteal fossa: PF potential. (2) Spine components: L3 and T12 potentials. (3) Scalp components: P37 and N45 waves. The Cz’ and Fpz’ designations indicate that the recording scalp electrode was placed 2 cm posterior to the International 10-20 system Cz and Fpz electrode locations.

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VISUAL EVOKED POTENTIAL (VEP)

Figure 5. Normal occipital visual evoked potential to checkerboard pattern reversal stimulation recorded between occipital (O1) and vertex (Cz) electrodes showing N75, P100 and N175 peaks. Visual evoked potentials are electric waveforms of biologic origin recorded over the cerebrum and elicited by visual stimuli. VEPs are classified by stimulus rate as transient or steady state and can be furthered divided by stimulus presentation mode. The normal transient VEP to checkerboard pattern reversal or shift has a major positive occipital peak at about 100 ms (P100), often preceded by a negative peak (N75). The precise range of normal values for the latency and amplitude of P100 depends on several factors: (1) subject variables, such as age, gender, and visual acuity, (2) stimulus characteristics, such as type of stimulator, full-field or half-field stimulation, check size, contrast and luminescence, and (3) recording parameters, such as placement and combination of recording electrodes.

BRAINSTEM AUDITORY EVOKED POTENTIAL (BAEP)

Figure 6. Normal brainstem auditory evoked potential to stimulation of the left ear, recorded between left ear (A1) and vertex (Cz) electrodes. Brainstem auditory evoked potentials are electric waveforms of biologic origin elicited in response to sound stimuli. The normal BAEP consists of a sequence of up to seven waves, designated I to VII, which occur during the first 10 ms after the onset of the stimulus and have positive polarity at the vertex of the head. In this recording, negativity in input terminal 1 or positivity in input terminal 2 causes an upward deflection.
Figure 7. M waves recorded with surface electrodes over the abductor digiti quinti muscle elicited by electric stimulation of the ulnar nerve at several levels. The M wave is a compound muscle action potential evoked from a muscle by an electric stimulus to its motor nerve. By convention, the M wave elicited by a supramaximal stimulus is used for motor nerve conduction studies. Ideally, the recording electrodes should be placed so that the initial deflection of the evoked potential from the baseline is negative. The latency, commonly called the motor latency, is the time from stimulation (ms) to the onset of the first phase (positive or negative) of the M wave. The amplitude (mV) is the baseline-to-peak amplitude of the first negative phase, unless otherwise specified. Normally, the configuration of the M wave (usually biphasic) is quite stable with repeated stimuli at slow rates (1-5 Hz). See repetitive nerve stimulation.

Figure 8. F waves recorded with surface electrodes over the abductor digiti quinti muscle elicited by electric stimulation of the ulnar nerve at the wrist with two different gain settings. The F wave is an action potential evoked intermittently from a muscle by a supramaximal stimulus to the nerve. Compared with the maximal amplitude M wave of the same muscle, the F wave has a smaller amplitude (1-5% of the M wave), variable configuration and a longer, more variable latency. The F wave can be found in many muscles of the upper and lower extremities, and the latency is longer with more distal sites of stimulation. The F wave is due to antidromic activation of motor neurons. It was named by Magladery and McDougal in 1950. Compare with H wave and the A wave. One of the late responses.
Figure 9. H waves recorded with surface electrodes over the soleus muscle elicited by electric stimulation of the posterior tibial nerve at the knee. The stimulus intensity was gradually increased (top tracing to bottom tracing). The H wave is a compound muscle action potential having a consistent latency evoked regularly, when present, from a muscle by an electric stimulus to the nerve. It is regularly found in adults only in a limited group of physiologic extensors, particularly the calf muscles. The H wave is most easily obtained with the cathode positioned proximal to the anode. Compared with the maximum amplitude M wave of the same muscle, the H wave has a smaller amplitude, a longer latency, and a lower optimal stimulus intensity. The latency is longer with more distal sites of stimulation. A stimulus intensity sufficient to elicit a maximal amplitude M wave reduces or abolishes the H wave. The H wave is thought to be due to a spinal reflex, the Hoffmann reflex, with electric stimulation of afferent fibers in the mixed nerve to the muscle and activation of motor neurons to the muscle mainly through a monosynaptic connection in the spinal cord. The reflex and wave are named in honor of Hoffman’s description in 1918. Compare with the F wave.
A WAVE

Figure 10. A waves (under arrow markers) recorded with surface electrodes over the abductor hallucis brevis elicited by electric stimulation of the posterior tibial nerve at the level of the ankle (top four traces) and at the level of the knee (bottom four traces). The A wave is a compound muscle action potential evoked consistently from a muscle by submaximal stimuli to the nerve and frequently abolished by supramaximal stimuli. The amplitude of the A wave is similar to that of the F wave, but the latency is more constant. The A wave occurs before the F wave, but may occur afterwards. It is thought to be due to extra discharges in the nerve, ephapses between adjacent nerve fibers, or axonal branching. Compare with the F wave.
**T WAVE**

![T-wave diagram](image)

**Figure 11.** T waves produced by triggering a microswitch in the handle of a reflex hammer by striking the patellar tendon (quadriceps femoris) or the Achilles tendon (triceps surae). The T wave is a compound muscle action potential evoked by rapid stretch of a tendon, as part of the muscle stretch reflex.

**BLINK RESPONSES**

![Blink response diagram](image)

**Figure 12.** Blink responses recorded with surface electrodes over the right orbicularis oculi (upper tracings) and left orbicularis oculi (lower tracings) elicited by electric stimulation of the supraorbital nerve on the right (left tracings) and on the left (right tracings). The blink responses are compound muscle action potentials evoked from orbicularis oculi muscles as a result of brief electric or mechanical stimuli to the cutaneous area innervated by the supraorbital (or less commonly, the infraorbital) branch of the trigeminal nerve. Typically, there is an early compound muscle action potential (R1 wave) ipsilateral to the stimulation site with a latency of about 10 ms and a bilateral late compound muscle action potential (R2 wave) with a latency of approximately 30 ms. Generally, only the R2 wave is associated with a visible twitch of the orbicularis oculi. The configuration, amplitude, duration, and latency of the two components, along with the sites of recording and the sites of stimulation, should be specified. R1 and R2 waves are oligosynaptic and polysynaptic brainstem reflexes, respectively, together called the blink reflex. The afferent arc is provided by the sensory branches of the trigeminal nerve, and the efferent arc is provided by facial nerve motor fibers.
REPETITIVE NERVE STIMULATION
NORMAL RESPONSE

Figure 13. Repetitive nerve stimulation study in a normal subject. The successive M waves are displayed to the right. The M waves were recorded with surface electrodes over the hypothenar eminence (abductor digiti quinti) during ulnar nerve stimulation at a rate of 3 Hz. Note the configuration of successive M waves is unchanged. Repetitive nerve stimulation is a technique of repeated supramaximal stimulation of a nerve while recording M waves from the muscle innervated by the nerve. It is commonly used to assess the integrity of neuromuscular transmission. The number of stimuli and the frequency of stimulation should be specified. Activation procedures performed prior to the test should be specified, e.g., sustained voluntary contraction or contraction induced by nerve stimulation. If the test was performed after an activation procedure, the time elapsed after it was completed should also be specified. The technique is commonly used to assess the integrity of neuromuscular transmission. For a description of specific patterns of responses, see incrementing response, decrementing response, facilitation, and postactivation depression.

REPETITIVE NERVE STIMULATION
DECREMENTING RESPONSE

Figure 14. Repetitive nerve stimulation study in a patient with myasthenia gravis. Successive M waves were recorded with surface electrodes over the rested nasalis muscle during repetitive facial nerve stimulation at a rate of 2 Hz, with a display to permit measurement of the amplitude and duration of the negative phase (left) or peak-to-peak amplitude (right). A decrementing response is a reproducible decline in the amplitude and/or area of the M wave of successive responses to repetitive nerve stimulation. The rate of stimulation and the total number of stimuli should be specified. Decrementing responses with disorders of neuromuscular transmission are most reliably seen with slow rates (2-5 Hz) of nerve stimulation. A decrementing response with repetitive nerve stimulation commonly occurs in disorders of neuromuscular transmission, but can also be seen in some polyneuropathies, myopathies, and motor neuron disease. An artifact resembling a decrementing response can result from movement of the stimulating or recording electrodes during repetitive nerve stimulation (pseudodecrement). Contrast with incrementing response.
REpetitive nerve stimulation
Incrementing response

Figure 15. Repetitive nerve stimulation study in a patient with Lambert-Eaton myasthenic syndrome (LEMS). An incrementing response was recorded with surface electrodes over the hypothenar eminence (abductor digiti quinti) during repetitive ulnar nerve stimulation at a rate of 50 Hz with a display to permit measurement of the peak-to-peak amplitude (top) or amplitude and duration of the negative phase (bottom). An incrementing response is a reproducible increase in amplitude and/or area of successive responses (M waves) to repetitive nerve stimulation. The rate of stimulation and the number of stimuli should be specified. An incrementing response is commonly seen in two situations. First, in normal subjects the configuration of the M wave may change with repetitive stimulation so that the amplitude progressively increases as the duration decreases, but the area of the M wave remains the same. This phenomenon is termed pseudofacilitation. Second, in disorders of neuromuscular transmission, the configuration of the M wave may change with repetitive nerve stimulation so that the amplitude progressively increases as the duration remains the same or increases, and the area of the M wave increases. This phenomenon is termed facilitation. Contrast with decrementing response.

REPETITIVE NERVE STIMULATION
NORMAL (N), MYASTHENIA GRAVIS (MG), LAMBERT-EATON MYASTHENIC SYNDROME (LEMS)

Figure 16. Repetitive nerve stimulation studies in a normal subject (N) and patients with myasthenia gravis (MG) and Lambert-Eaton myasthenic syndrome (LEMS). Three successive M waves were elicited by repetitive nerve stimulation at a rate of 2 Hz. The three responses were superimposed. This method of display emphasizes a change in the configuration of successive responses, but does not permit identification of their order. In each superimposed display of three responses where the configuration did change, the highest amplitude response was the first and the lowest amplitude response was the third. After testing the rested muscle, the muscle was maximally contracted for 10 to 30 seconds (exercise time). Repetitive nerve stimulation was carried out again 3 s, 2 min, and 10 min after the exercise ended. The results illustrate facilitation and postactivation depression.
Figure 17. Repetitive nerve stimulation study in a normal subject. The successive M waves were recorded with surface electrodes over the hypothenar eminence (abductor digiti quinti) during ulnar nerve stimulation at a rate of 30 Hz. Pseudofacilitation may occur in normal subjects with repetitive nerve stimulation at high (20-50 Hz) rates or after strong volitional contraction, and probably reflects a reduction in the temporal dispersion of the summation of a constant number of muscle fiber action potentials due to increases in the propagation velocity of muscle cell action potentials with repeated activation. Pseudofacilitation should be distinguished from facilitation. The recording shows an incrementing response characterized by an increase in the amplitude of the successive M waves with a corresponding decrease in the duration, resulting in no change in the area of the negative phase of successive M waves.

Figure 18. Insertion activity recorded by an intramuscular needle electrode in a normal subject. Insertion activity is the electric activity caused by insertion or movement of a needle electrode within a muscle. The amount of the activity may be described as normal, reduced, or increased (prolonged), with a description of the waveform and repetitive rate.
END-PLATE ACTIVITY

Figure 19. Spontaneous activity recorded by an intramuscular needle electrode close to muscle end-plates. May be either of two forms.

1. **Monophasic end-plate activity** (upper and lower traces): Low amplitude (10 to 20 µV), short duration (0.5 to 1 ms), monophasic (negative) potentials that occur in a dense, steady pattern and are restricted to a localized area of the muscle. Because of the multitude of different potentials occurring, the exact **frequency**, although appearing to be high, cannot be defined. These nonpropagated potentials are probably **miniature end-plate potentials** recorded extracellularly. This form of end-plate activity has been referred to as **end-plate noise** or **sea shell sound** (sea shell noise or roar).

2. **Biphasic end-plate activity** (upper trace): Moderate amplitude (100 to 300 µV), short-duration (2 to 4 ms), biphasic (negative-positive) spike potentials that occur irregularly in short bursts with a high frequency (50 to 100 Hz), restricted to a localized area within the muscle. These propagated potentials are generated by muscle fibers excited by activity in nerve terminals. These potentials have been referred to as **end-plate spikes**, and incorrectly, **nerve potentials**.

FIBRILLATION POTENTIAL

Figure 20. Fibrillation potentials recorded by an intramuscular needle electrode. The top trace shows the waveform of a single fibrillation potential. The bottom trace shows the pattern of discharge of two other fibrillation potentials which differ with respect to **amplitude** and **discharge frequency**. A fibrillation potential is the electric activity associated with a spontaneously contracting (fibrillating) muscle fiber. It is the **action potential** of a single muscle fiber. The action potentials may occur spontaneously or after movement of the needle electrode. They usually fire at a constant rate, although a small proportion fire irregularly. Classically, the potentials are biphasic spikes of short **duration** (usually less than 5 ms) with an initial positive phase and a peak-to-peak amplitude of less than 1 mV. When recorded with concentric or monopolar needle electrode, the firing rate has a wide range (1 to 50 Hz) and often decreases just before cessation of an individual discharge. A high-pitched regular sound is associated with the discharge of fibrillation potentials and has been described in the older literature as “rain on the roof.” In addition to this classic form of fibrillation potentials, **positive sharp waves** may also be recorded from fibrillating muscle fibers when the action potentials arise from an area immediately adjacent to the needle electrode.
POSITIVE SHARP WAVE

Figure 21. Positive sharp waves recorded by an intramuscular needle electrode. The top trace shows a single positive sharp wave. The bottom trace shows the pattern of initial discharge of a number of different positive sharp waves after movement of the needle electrode in a denervated muscle. A positive sharp wave is a biphasic, positive-negative action potential initiated by needle movement and recurring in a uniform, regular pattern at a rate of 1 to 50 Hz. The discharge frequency may decrease slightly just before cessation. The initial positive deflection is rapid (<1 ms), its duration is usually less than 5 ms, and the amplitude is up to 1 mV. The negative phase is of low amplitude with a duration of 10 to 100 ms. A sequence of positive sharp waves is commonly referred to as a train of positive sharp waves. Positive sharp waves can be recorded from the damaged area of fibrillating muscle fibers. Their configuration may result from the position of the needle electrode which is believed to be adjacent to the depolarized segment of a muscle fiber injured by the electrode. Note that the positive sharp waveform is not specific for muscle fiber damage. Motor unit action potentials and potentials in myotonic discharges may have the configuration of positive sharp waves.

MYOTONIC DISCHARGE

Figure 22. Myotonic discharge recorded by an intramuscular needle electrode. A myotonic discharge is a repetitive discharge which fires at rates of 20 to 80 Hz. There are two types: (1) biphasic (positive-negative) spike potentials less than 5 ms in duration resembling fibrillation potentials, and (2) positive waves of 5 to 20 ms duration resembling positive sharp waves. Both potential forms are recorded after needle electrode insertion, voluntary muscle contraction or muscle percussion, and are due to independent, repetitive discharges of single muscle fibers. The amplitude and frequency of the potentials must both wax and wane to be identified as a myotonic discharge. This change produces a characteristic musical sound in the audio display of the electromyograph due to the corresponding change in pitch, which has been likened to the sound of a "dive bomber." Contrast with waning discharge.
COMPLEX REPETITIVE DISCHARGE

Figure 23. Complex repetitive discharges recorded by an intramuscular needle electrode. A complex repetitive discharge is a polyphasic or serrated action potential that may begin spontaneously or after needle movement. The discharges have a uniform frequency, shape, and amplitude, with abrupt onset, cessation or change in configuration. Amplitudes range from 100 µV to 1 mV and the frequency of discharge from 5 to 100 Hz. This term is preferred to bizarre high frequency discharge, bizarre repetitive discharge, bizarre repetitive potential, or pseudomyotonic discharge.

FASCICULATION POTENTIAL

Figure 24. Fasciculation potentials recorded by an intramuscular needle electrode. Six different fasciculation potentials are displayed in the top traces, on a time scale which permits characterization of the individual waveforms. The bottom two traces display fasciculation potentials on a time scale which demonstrates the random discharge pattern. A fasciculation potential is an action potential which is often associated with a visible fasciculation. It has the configuration of a motor unit action potential but occurs spontaneously. Most commonly these potentials occur sporadically and are termed “single fasciculation potentials.” Occasionally, the potentials occur as a grouped discharge and are termed a “brief repetitive discharge.” The repetitive firing of adjacent fasciculation potentials, when numerous, may produce an undulating movement of muscle (see myokymia). Use of the terms benign fasciculation and malignant fasciculation is discouraged. Instead, the configuration of the potentials, peak-to-peak amplitude, duration, number of phases, and stability of configuration, in addition to the frequency of occurrence, should be specified.
MYOKYMIC DISCHARGE

Figure 25. Tracings of two different myokymic discharges recorded with an intramuscular needle electrode are displayed on a time scale (left) which illustrates the firing pattern and with a different time scale (right) which illustrates that the individual potentials have the configuration of a motor unit action potential. A myokymic discharge is a group of motor unit action potentials that fire repetitively and may be associated with clinical myokymia. Two firing patterns have been described. (1) Commonly, the discharge is a brief, repetitive firing of single motor unit action potentials for a short period (up to a few seconds) at a uniform rate (2 to 60 Hz) followed by a short period (up to a few seconds) of silence, with repetition of the same sequence for a particular potential. (2) Rarely, the potential recurs continuously at a fairly uniform firing rate (1 to 5 Hz). Myokymic discharges are a subclass of grouped discharges and repetitive discharges.

NEUROMYOTONIC DISCHARGE

Figure 26. Neuromyotonic discharges recorded by an intramuscular needle electrode are shown on a time scale which illustrates the characteristic firing pattern. A neuromyotonic discharge is a burst of motor unit action potentials which originates in motor axons firing at high rates (150 to 300 Hz) for a few seconds. They often start and stop abruptly. The amplitude of the waveforms typically wanes. Discharges may occur spontaneously or be initiated by needle electrode movement, voluntary effort, ischemia, or percussion of the nerve. These discharges should be distinguished from myotonic discharges and complex repetitive discharges. They are one type of electrical activity that may be recorded in patients who have clinical neuromyotonia.
CRAMP DISCHARGE

Figure 27. Cramp discharges recorded by an intramuscular needle electrode. A cramp discharge arises from the involuntary repetitive firing of motor unit action potentials at a high frequency (up to 150 Hz) in a large area of muscle, usually associated with painful muscle contraction. Both the discharge frequency and the number of motor unit action potentials firing increase gradually during development, and both subside gradually with cessation. See muscle cramp.

MOTOR UNIT ACTION POTENTIALS

Figure 28. A selection of different motor unit action potentials recorded with an intramuscular needle electrode. A motor unit action potential is a potential which reflects the electrical activity of a single motor unit. It is the compound action potential of those muscle fibers within the recording range of an electrode. When it is produced by voluntary muscle contraction, the potential is characterized by its consistent appearance and relationship to the force of contraction. The following parameters may be specified, quantitatively if possible, after the recording electrode is placed randomly within the muscle.

1. Configuration
   a. Amplitude, peak-to-peak (µV or mV).
   b. Duration, total (ms).
   c. Number of phases (monophasic, biphasic, triphasic, tetraphasic, polyphasic).
   d. Sign of each phase (negative, positive).
   e. Number of turns.
   f. Variation of shape (jiggle), if any, with consecutive discharges.
   g. Presence of satellite (linked potentials), if any.
   h. Spike duration, including satellites.
   i. Rise time.

2. Recruitment characteristics
   a. Threshold of activation (first recruited, low threshold, high threshold).
   b. Onset frequency.
   c. Recruitment frequency (Hz) or recruitment interval (ms) of individual potentials.
   d. Recruitment ratio.

Descriptive terms implying diagnostic significance are not recommended, e.g. myopathic, neuropathic, regeneration, nascent, giant, BSAP and BSAPP. See polyphasic action potential, serrated action potential.
SATellite POTENTIAL

**Figure 29.** Four discharges of the same motor unit action potential with satellite potentials are indicated by the arrows. A satellite potential is a small action potential separated from the main motor unit action potential by an isoelectric interval which fires in a time-locked relationship to the main action potential. These potentials usually follow, but may precede, the main action potential. Less preferred terms include late component, parasite potential, linked potential, and coupled discharge.

RECRUITMENT PATTERN/INTERFERENCE PATTERN

**Figure 30.** Recordings are made with an intramuscular needle electrode at five different levels of force of voluntary contraction. Recruitment refers to the successive activation of the same and new motor units with increasing strength of voluntary muscle contraction. The recruitment pattern is a qualitative and/or quantitative description of the sequence of appearance of motor unit action potentials during increasing voluntary muscle contraction. The recruitment frequency and recruitment interval are two quantitative measures commonly used. The interference pattern is electric activity recorded from a muscle with a needle electrode during maximal voluntary effort. A full interference pattern implies that no individual motor unit action potentials can be clearly identified (see tracing on far right). A reduced interference pattern (intermediate interference pattern) is one in which some of the individual motor unit action potentials may be identified while others cannot due to superimposition of waveforms. The term discrete activity is used to describe the electric activity recorded when each of several different motor unit action potentials can be identified due to limited superimposition of waveforms. The term single unit pattern is used to describe a single motor unit action potential, firing at a rapid rate (should be specified) during maximum voluntary effort. The force of contraction associated with the interference pattern should be specified.
**Figure 31.** Schematic representation of the location of the recording surface of a *single fiber needle electrode* recording from two muscle fibers innervated by the same motor neuron (row 1). Consecutive *discharges* of a *potential* pair are shown in a superimposed display (row 2) and in a *raster* display (row 3). The potential pairs were recorded from the extensor digitorum of a patient with *myasthenia gravis*. They show normal jitter (column A), increased jitter (column B), and increased jitter and *impulse blocking* (column C, arrows). Jitter is synonymous with “single fiber electromyographic jitter.” It is the variability of the *interpotential interval* between two *muscle fiber action potentials* belonging to the same *motor unit* on consecutive discharges (*the mean consecutive difference, MCD*). Under certain conditions, jitter is expressed as the mean value of the difference between interpotential intervals arranged in the order of decreasing interdischarge intervals (*the mean sorted difference, MSD*).
MACROELECTROMYOGRAPHY (MACRO-EMG)

Figure 32. Schematic representation of the location of the recording surface of the macro-EMG needle electrode recording from all muscle fibers innervated by the same motor neuron (upper diagram). Macro motor unit potentials recorded by the technique of macroelectromyography (lower traces) from a healthy subject (column A) and from a patient with amyotrophic lateral sclerosis (column B). Macroulectromyography is a general term referring to the technique and conditions that approximate recording of all muscle fiber action potentials arising from the same motor unit.
NEEDLE ELECTRODES

Figure 33. Schematic representation of five different types of needle electrodes. (1) The *concentric needle electrode* consists of a hollow, stainless steel cannula (light gray) containing a centrally located wire (black) from which it is insulated. The latter serves as the *active electrode* (E1), while the entire barrel of the needle serves as the *reference electrode* (E2). (2) The *monopolar needle electrode* consists of a solid stainless steel needle coated with insulation except for its distal tip, which serves as the cone-shaped recording surface (E1). The reference electrode (E2) consists of either another monopolar needle electrode or a *surface electrode*. (3) The *bipolar needle electrode* consists of a stainless steel hollow cannula which contains two wires, insulated from each other and from the cannula itself. The exposed distal tips of these wires on the bevel surface serve as the active (E1) and reference (E2) electrodes. (4) *Single fiber needle electrode*. Similar to the concentric needle electrode, the proximal portion of this electrode consists of a hollow cannula, which contains a central wire from which it is insulated. This wire, instead of ending on the bevel tip, is exposed through a side port in the cannula opposite the bevel tip. The bared area serves as the active electrode (E1) while the surface of the cannula serves as the reference electrode (E2). (5) The *macro-EMG needle electrode* consists mainly of a modified single fiber electrode. Two different *potentials* are recorded. The first is recorded from the single fiber EMG needle electrode. The recording surface opposite the bevel serves as the active electrode (E1), and the uninsulated portion of the cannula (light gray) serves as the reference electrode (E2). The potential recorded from this electrode is used to trigger the sweep for recording the *macro motor unit potential* from the second electrode. The second electrode consists of the uninsulated portion of the cannula, which serves as the active electrode (E1). A surface electrode serves as the reference electrode (E2).

FULL WAVE RECTIFIED EMG

Figure 34. *Motor unit action potentials* recorded normally (top sweep) and simultaneously as a *full wave rectified EMG signal* (bottom sweep). A full wave rectified EMG signal is the absolute value of the raw EMG signal. Full wave rectification involves inverting all of the waveforms below the *isopotential line* and displaying them with opposite polarity above the line. A technique used to analyze *kinesiologic EMG signals*. 
SYMPATHETIC SKIN RESPONSE

Figure 35. Sympathetic skin response recorded from the palm following stimulation of the contralateral median nerve. The sympathetic skin response is an electric potential resulting from electrodermal activity in sweat glands in response to both direct and peripheral or sympathetic trunk stimulation of autonomic activity.
SECTION III:
ILLUSTRATIONS OF SELECTED ULTRASOUND IMAGES

FIGURE 36  SHORT AXIS ULTRASOUND VIEW
FIGURE 37  SHORT AXIS ULTRASOUND VIEW
FIGURE 38  LONG AXIS ULTRASOUND VIEW
FIGURE 39  IN-PLANE NEEDLE APPROACH
FIGURE 40  REVERBERATION ARTIFACT (COMET-TAIL)
FIGURE 41  ECHOGENICITY (HYPERECHOIC/HYPOECHOIC IMAGES)
FIGURE 42  ULTRASOUND ARTIFACT: ANISOTROPY
FIGURE 43  ULTRASOUND MODES (B MODE/M MODE)

Each illustration is accompanied by a complete explanation that is, in most cases, the same as that given in the alphabetic section. The definitions have been repeated in full with the illustrations so that readers do not need to refer back and forth between the illustration and definition.
Figure 36. In ultrasound, *short axis* is the plane observed and described when the *transducer* is perpendicular to the structure of interest. An image can be simultaneously *long axis* and *short axis* to differing structures in the same image. Also referred to as *transverse plane*. *Short axis* view of a bifid median nerve and persistent median artery at the wrist is demonstrated.

Figure 37. This *ultrasound* shows a *short axis* image of the median nerve in a patient with focal entrapment at the wrist by *EDX* study. The median nerve showed an increase in cross sectional area at the wrist. The flexor tendons are also seen in *short axis*. 
LONG AXIS ULTRASOUND VIEW

Figure 38. In ultrasound, the long axis plane observed and described when the transducer is parallel to the structure of interest. Also known as longitudinal plane. Long axis view of a persistent median artery at the wrist is demonstrated. This image is the same patient in Figure 36 with the US transducer rotated 90 degrees with added color doppler to confirm the presence of the persistent median artery. Color doppler shows the blood flow dependent of the positioning of the transducer relative to the direction of blood flow: red represents flow toward the transducer and blue represents flow away from the transducer. This image demonstrates a depth of the sound beam of 1.8 cm.
IN-PLANE NEEDLE APPROACH

Figure 39. An image of a popliteal (Baker's) cyst, with an 18 gauge needle in place, showing an in plane approach for visualizing needle guidance. In-plane approach is an ultrasound needle guidance approach that requires alignment of the US transducer beam with the shaft and tip of the needle. This method is generally preferred since it allows visualization of the entire needle pathway to the targeted injection site. The needle is observed in long axis. The entire length of the needle is viewed with the in plane approach. Contrast with out-of-plane approach.
REVERBERATION ARTIFACT (COMET TAIL)

Figure 40. An image of the same popliteal (Baker’s) cyst shown in Figure 39, with an 18 gauge needle in place, also showing reverberation (or “comet tail”) artifact. Reverberation is an artifact that occurs at the interface of two structures with very different acoustic impedance. Repeated reflections result in parallel bands or “comet-tail” artifacts on the ultrasonographic image.
ECHOGENICITY
HYPERECHOIC/HYPOECHOIC COMPARISON

Figure 41. *Echogenicity* is the ability to create an echo (ie. return a signal to the transducer). Tissues that return more signal create a relatively brighter image and are referred to as *hyperechogenic* or *hyperechoic*. Conversely, those tissues that absorb and do not return most of the signal appear darker on imaging and are called *hypoechogenic* or *hypoechoic*. The absence of an echoic image is termed *anechoic*. An image of the biceps brachii muscle, in *transverse plane* or *short axis* view, showing bright white (*hyperechoic*) connective tissue, interspersed with darker (*hypoechoic*) muscle fibers.
Figure 42. Anisotrophy is the change in sonographic appearance that is dependent upon the orientation of the ultrasound beam (i.e. directionally dependent). Also refers to change in reflective properties of tissue related to the incidence of the angle of the ultrasound beam relative to the tissue. A second image of the same muscle on the previous page shows a significant change in echogenicity, due to a slight change in angle of the transducer on the skin. This change in echogenicity with the change in angle of insonation is an example of anisotropy.
ULTRASOUND MODES
B MODE/M MODE

Figure 43. An image of the diaphragm recorded in 2 different ultrasound modes. The upper image is B mode, which shows a 2 dimensional image of the diaphragm muscle. B mode or brightness mode provides structural information using different shades of gray in a two dimensional image. The intensity of the image is represented by brightness of the image and the position relative to the transducer.

The lower image is in M mode and demonstrates motion of the diaphragm towards and away from the transducer with breathing. The amount of excursion can be measured by placing electronic calipers as shown. Motion mode captures returning echoes in a line of B mode image displayed over time axis. Often B mode and M mode are imaged together, as demonstrated here.
SECTION IV: ABBREVIATIONS

The Glossary follows the recommendations of the Council of Science Editors Style Manual (7th edition)\(^1\) for abbreviations of units of measurement. The abbreviations are as follows:

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