Entwurf

LEHRZIELKATALOG FÜR KLINISCHE ELEKTROMYOGRAPHIE

Im folgenden sind die wichtigsten Punkte des Prüfungsinhaltes zusammengestellt.

1) Überprüfen des EMG-Gerätes, Vorbereitung des Gerätes für die Durchführung der unterschiedlichen elektromyographischen und elektroneurographischen Techniken. Kenntnis der grundsätzlichen Funktionsweise des EMG-Gerätes (z.B. Vorverstärker, Verstärker, Polaritätskonvention, Filterwirkung, Empfindlichkeit, Dokumentationsmöglichkeit, usw.)

2) Kenntnisse über unterschiedliche Elektrodenarten, Eigenschaften der Elektroden und ihr Einfluss auf die elektrischen Signale, Sterilisation der Elektroden.

3) Erstellung eines elektrophysiologischen Untersuchungsplanes bei bestimmten klinischen Fragestellungen.

4) Indikation sowie Grenzen der einzelnen elektromyographischen und elektro-neurographischen Untersuchungstechniken.

5) Kenntnisse der unterschiedlichen elektromyographischen Signale.

6) Einfluss endogener physiologischer sowie exogener Faktoren auf die einzelnen Signale.

7) Detaillierte Kenntnisse der elektromyographischen und elektroneurographischen Befunde bei folgenden Krankheitsbildern:
   a) Vorderhornzelllaesionen
   b) Radikulopathien und Plexopathien
   c) Laesionen einzelner peripherer Nerven
   d) Krankheitsbilder mit Störungen der neuromuskulären Übertragung

8) Theoretische und praktische Kenntnisse über die Methodik der
   a) Elektromyographie (Kurzelektromyographie und quantitative Elektromyographie)
   b) Motorische Nervenleitgeschwindigkeiten (N. medianus, N. ulnaris, N. radialis, N. peronaues, N. tibialis)
   c) Sensible antidrome Nervenleitgeschwindigkeit (N. medianus, N. ulnaris, N. radialis, N. suralis)
   d) Sensible orthodrome Nervenleitgeschwindigkeit (N. medianus, N. ulnaris, N. radialis, N. suralis)
   e) F-Wellen Untersuchung
   f) Repetitive Stimulation

9) Aufbau eines elektromoygraphischen bzw. elektroneurographischen Befundes.

Wissenspunkte für die EMG-Prüfung der Österreichischen Gesellschaft für klinische Neurophysiologie

I. Technischer Teil (Kenntnisse)

1. Einfluss des Elektrodentyps auf die registrierten Potentiale.
2. Prinzip des Gleichspannungsverstärkers.
3. Eingangsimpedanz
4. Rausch-Signalverhältnis
5. Einfluss von Frequenzverhalten, Filtereinstellung und Auflösung
6. Cross-talk
7. Grundeigenschaften der Reizgeräte
8. Averaging, Prinzip und Anwendung
9. Triggerung, Prinzip und Anwendung
10. Polungsprobleme
11. Artefakte, Artefaktbeseitigung, Artefaktkompensation, Erdung
12. Sterilisation

II. Anatomie und Physiologie (Kenntnisse)

1. Anatomie und Physiologie der motorischen Einheit
2. Physiologie der Erregungsleitung von Muskel und Nerv
3. Physiologie der neuromuskulären Übertragung
4. Absolute und relative Refraktärzeit
5. Muskelkontraktion und elektromechanische Koppelung
6. Einfluss von Alter und Temperatur auf Muskel, Nerv und Endplatte
7. H-Reflex und F-Welle
8. Volums-Leitung
9. Leitgeschwindigkeit von Nerv und Muskel
10. Kennmuskeln der spinalen Segmente und peripheren Nerven
11. Innervationsanomalien

III. Durchführung der EMG-Untersuchung (Kenntnisse und Fertigkeiten)

1. Lagerung des Patienten
2. Reiz- und Ableittechnik
3. Protokollführung und Dokumentation
4. Ableitung der Spontanaktivität
5. Bestimmung der Potentiale motorischer Einheiten
6. Darstellung der maximalen Aktivitätsdichte
7. Bestimmung der motorischen und sensiblen Nervenleitgeschwindigkeit (antidrom/orthodrom)
8. Folgende Nerven müssen elektroneurographisch untersucht werden können (in Klammer sind die jeweiligen Untersuchungstechniken angeführt):
   * N. facialis (mot.)
   * N. medianus (mot., sens. antidrom/orthodrom, F-Welle)
   * N. ulnaris (mot., sens. antidrom/orthodrom, F-Welle)
   * N. radialis (mot., sens. antidrom/orthodrom)
   * N. axillaris (mot.)
   * N. femoralis (mot.)
   * N. ischiadicus (mot.)
   * N. peronaeus (mot., sens. antidrom/orthodrom)
   * N. tibialis: (mot., sens. antidrom/orthodrom, F-Welle, H-Reflex) bzw. N. plantaris, lateralis und medialis (sens.)
   * N. suralis (sens. antidrom/orthodrom)

Weitere Reflexuntersuchungen: Blinkreflex
Masseterreflex

Nur Kenntnisse (Fertigkeit wird nicht geprüft):
* N. ilioinguinalis
* N. cutaneus femoralis lateralis
* Automatische Analyse des Interferenzmusters
* Jitter-Untersuchung

9. Prüfung der Endplattenfunktion
10. Provokationsverfahren (Ischaemie-Test, Hyperventilationstest, Tensilontest usw.)
11. Überprüfung von Innervationsanomalien.

IV. Befundung (Kenntnisse/Fertigkeiten)
1. Differenzierung physiologischer und pathologischer Spontanaktivität
2. „Myopathie“-EMG oder „Neuropathie“-EMG, Polyphasie
3. Reinnervation
4.Rekrutierungsverhalten
5. Störung der neuromuskulären Übertragung
6. Neurapraxie/Leitungsblock
7. Axonale Neuropathie oder Markscheidenlaesionen
8. Lokalisation von Laesionen
9. Probleme der Normwerterstellung.

V. Klinische Interpretation (Kenntnisse und Fertigkeiten)
Der Kandidat muss in der Lage sein, bestimmte EMG-Syndrome (z.B. Myotonie,Muskelischaemie, Muskelkontraktur, Myoedem, idiomuskuläre Wulstbildung,Myokymie,Polyneuropathie, Nerven- oder Wurzelkompressions-Syndrom, Vorderhornprozess, Inaktivitäts-atrophie, Konduktorinnen für Muskelatrophie)
zu beschreiben, die EMG-Befunde bei bestimmtenKrankheiten (z.B. Tetanie, Tetanus, Fazialisspasmus, Guillain-Barrè-Syndrom, Myasthenie, Engpass-Syndrom peripherer Nerven, hypokalaemische Lähmung, thyreotoxische Myopathie, myotonische Dystrophie, Para-myotonie, McArdle-Syndrom, Botulismus, psychogene Lähmung, spastische Lähmung)
zu nennen und die Untersuchungsstrategie darzulegen.

K = Kenntnisse
F = Fertigkeiten

Prüfungsfragen EMG

A. ad ELEKTRODEN / Gerätekenntnisse

A.1. Eigenschaften
A.2. Sterilisation
A.3. Physiologische Grundlagen der EMG und ENG
A.3.1.Altersabhängigkeit von EMG und EMG- Parametern
A.3.2.Anatomische Variationen peripherer Nerven
A.3.2.1.Anatomische Variationen peripherer Nerven N.medianus
A.3.2.2.Anatomische Variationen peripherer Nerven N.ulnaris
A.3.2.3.Anatomische Variationen peripherer Nerven N.peronäus
A.3.2.Technisch/physikalisch begründete Variabilitäten
A.3.2.1.Technisch/physikalisch begründete Variabilitäten - Stimulation
A.3.2.2.Technisch/physikalisch begründete Variabilitäten - Ableitetechnik
A.3.2.3.Technisch/physikalisch begründete Variabilitäten - Temperatur
A.4. PathoPhysiologische Grundlagen der EMG und ENG
A.4.1.Spontanaktivität im EMG
A.4.2.Einfluß axonaler Läsion auf das EMG
A.4.3.Einfluß axonaler Läsion auf das ENG
A.4.4.Einfluß demyelinisierender Läsion auf das EMG
A.4.4.Einfluß demyelinisierender Läsion auf das ENG
A.5. Elektrophysiologischer Untersuchungsplan

ad METHODIK

B.1. EMG Kurz EMG
B.2. Quantitatives EMG

ENG
B.3. mNLG N.medianus
B.4. mNLG N.ulnaris
B.5. mNLG N.radialis
B.6. mNLG N.peronäus
B.7. mNLG N.tibialis

B.8. saNLG N.medianus
B.9. saNLG N.ulnaris
B.10.saNLG N.radialis
B.11.saNLG N.suralis

B.12.soNLG N.medianus
B.13.soNLG N.ulnaris
B.14.soNLG N.radialis
B.15.soNLG N.suralis

B.16.F-Wellen-Untersuchung

B.17.Repetitive Stimulation

C.1.Indikationen zu EMG und ENG

EMG-Befunde bei Krankheiten
C.2. Vorderhornzell-Läsionen
C.3. Radikulopathien, Plexopathien
C.4. Läsionen einzelner peripherer Nerven

C.5. Krankheiten mit Störung der neuromuskulären šbertragung
C.6. Myopathien
C.6.1. Myopathien - Myositiden
C.6.2. Myopathien - Muskeldystrophien
C.7. Hirnnerven-Läsionen
C.8. Störungen des zenralen Neurons
C.9. Iatrogene Nervenläsionen

Recommendations for the Practice of Clinical Neurophysiology: Guidelines of the International Federation of Clinical Neurophysiology (2nd Revised and Enlarged Edition)

EDITED BY
GUNTHER DEUSCHL
ANDREW EISEN

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Part two: a glossary of terms used in electromyography [1]

Action potential: An electric event that occurs in an all-or none fashion in a single nerve or muscle cell membrane, regardless of the nature of an above-threshold stimulus.

Active electrode: Synonym of recording electrode, stigmatic electrode and cathode, like stimulating electrode.

Afterdischarge: Prolonged response ill a nerve or muscle fibre after removal of the stimulus. It can be measured in milliseconds.

Amplitude: If calculated peak-to-peak, it corresponds to the distance between the maximum positive to maximum negative peak. In a compound muscle action potential, it is usually measured from the baseline to the maximum negative peak. It is expressed in volts, millivolts or micronvolts.

Anodal block: Focal conduction block due to hyperpolarization of the nerve fibre membrane.

Anode: The positive pole in an electronic device.

Antidromic: Impulse propagation that is counter-directional to physiological propagation.

Artifact: Generally, an extraneous feature that occurs accidentally, and that impedes the correct observation of a physiological phenomenon.

A-wave: Small amplitude motor action potential of fixed latency and amplitude that follows the

M-wave. Thought to arise ephaptically through "cross talk" in nerve fibres.

Backfiring: The backward activation of a motor neuron.

Baseline: The line traced on an amplitude modulated electronic device that expresses a biological system at rest.

Bipolar needle electrode: Recording or stimulating needle electrode where two insulated wires are placed inside a steel cannula. The wires emerge either at the tip or on the side-port of the cannula, that serves as the ground electrode.

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[1] The present glossary is partly overlapping with the following earlier publication: AAEE glossary of terms in clinical electromyography. *Muscle Nerve* 1987. 10: G1-60

Cathode: The negative pole in an electronic device.

Central EMG: Electrophysiological methodology to evaluate the function of the central nervous system.

Collision: Cancellation of two impulses of opposite polarity. The refractory period that follows may be used to determine the conduction along the fibers not involved in the cancellation affect.

Compound action potential: A general term for a potential constituted by more simple potentials originating either from muscle or nerve fibres.-Along a mixed nerve it can be a mixed summation of motor and sensory nerve action potentials.

Complex repetitive discharge: Spontaneous activity of muscle akin to fibrillation and positive sharp waves but arising in a split muscle fibre. This results in the regular firing of complexes that contain many components. The jitter between each is <5 ms indicating that the neuromuscular junction is not involved.

Concentric needle electrode: Recording needle electrode consisting of a steel cannula and an insuated wire. generally made of platinum, that emerges from the cannula tip. It records the potential difference between the exploring wire and the cannula that sheathes the wire.

Conduction block: Failure of impulse transmission anywhere along a nerve fibre, occurring at one or more sites. It may occur in acute or subacute primary demyelinating neuropathies, in multifocal motor neuropathies as well as in entrapment mono-neuropathies. While the amplitude or the area of the potential evoked by stimulation above the block is diminished more than expected when electrically stimulating two different normal nerve points, the stimulation below the block evokes potential of normal size. Reduction of CMAP-amplitude by 50% or more without definite signs of dispersion indicates conduction block.

Conduction time: Time required by an action potential to cover the distance between :stimulating and recording sites. It usually refers, to stimulation of a nerve and to recording of the same nerve from a muscle innervated by it. It is expressed in milliseconds..

Conduction velocity: The velocity with which an impulse covers a definite distance of a nerve (which can be a mixed, motor, sensory or autonomic nerve} or a muscle. It is expressed in meters/seconds.

Contraction: Shortening of muscle contracting elements,. which can occur with or without a decrease in the length of the whole muscle.

Cramp discharge: .Muscle activity associated with a clinical cramp.

Delay: The time interval between an applied stimulus from the response of the structure.

Denervation potential: Spontaneous electrical activity occurring in a denervated muscle outside the end-plate zone. This may occur when there is actual interruption of nerve fibres but also when muscle fibres are split and become "functionally denervated".

Discharge: Firing of one or more excitable structure:

Distal latency: Usually the time required to cover the distance between the most distal stimulating point and the recording point.

Double discharge: The firing of the same motor unit in a rapid but variable sequence.

Duration: The time interval between the onset and the end of an electrical phenomenon. It can indicate spontaneous, voluntary or evoked (direct or reflex) activities. When referring to a single potential, the duration can be total (from the onset to the return to baseline) or part of the total.

Electrode: Electric device through which electricity is applied or recorded Electrodes may be surface or needle. "monopolar". "concentric", "bipolar" or "multipolar". Special electrodes are. for example. SFEMG and macroEMG electrodes,.

Electromyogram: Recording of electrical activity from muscle using either surface or needle electrodes.

Electromyograph: Instrument used to perform an electromyogram .

Electromyographer: A physician who does electromyography.

Electromyography: Discipline that deals with the techniques and interpretation of electromyographic tests. Considered to also include conduction studies and reflex studies.

Electroneurography: Techniques and the interpretation of the test,, that examine nerve conduction anti generation of nerve impulses.

End-plate activity: Spontaneous, activity recorded through needle electrodes inserted into the muscle close to the end-plate zone. Two type:s of end-plate activity is seen; end-plate noise (low amplitude continuous activity) which is generated by the spontaneous release of acethvlcholine and end-plate spikes which are discrete negative going short spikes from single muscle fibres activated at the end-plate.

Exoked potential: Any potential evoked by excitation of neuronal or muscular tissue.

Excitability: The property to produce an action potential in response to a stimulus.

Fasciculation potential: Spontaneous contraction of a whole or a part of a motor unit. The potentials are usually polyphasic and discharge with irregular slow frequency.

Fibre density: Number of muscle fibres (SFEMG term) or nerve fibres (morphological term) per unit of measurement.

Fibrillation potential: The electrical activity produced by spontaneous contraction of single muscle fibres and firing regularly or irregularly, it usually appears as short biphasic potentials with a positive onset.

Frequency: Indicates the number of complete cycles per second. It is expressed in Hertz.

F-Wave: Motor action potential evoked by antidromic stimulation of a motor nerve resulting from activation of the parent anterior horn cell. The F-wave is usually <5% of the M-wave and is variable in latency and amplitude.

Ground electrode: Generally a relatively large-sized electrode that links the subject being examined to the earth for protective purposes and to avoid internal or external interference that may affect the test.

H-reflex: Electrical equivalent of the deep tendon reflex. However. the stimulus by-passes the spindle apparatus. Difficult to obtain in muscles other than the gastrocnemius- soleus complex.

Inching technique: Application of stimuli to a nerve at fixed intervals f.'om the recording electrode. Shoxvn to be of `.alue in clemonstrating conduction slow ing in carpal tunnel sx ndrome.
Indifferent electrode: Usuall`.. the reference electrocie.

Insertional activity: Short electric discharges of muscle origin resuhing fi'om the mechanical irritation occurring during tile needle electrode move-meats. It can be prolonged when the excitabilit`. is increased·

Interference pattern: The interference of the electrical activity produced by voluntary activated motor units during maximum effort. In the case of the number of active motor units, the interference pattern is described as "full". "reduced" or "discrete".

Jiggle: Instability of al single motor unit recorded sequentialIy using a delay line. Abnormal jiggle indicates an active disease process which can be of nerve, neuromuscular or muscle origin.

Jitter: In SFEMG it describes the variability at consecutive discharges in time interval between two single muscle fibre action potentials. It is expressed in microseconds,.

Latency: The time interval between application of the stimulus and the response to it. It can be measured to the onset or to any peak of the evoked potential.

M response: The muscle response to supramaximal electrical stimulation of the corresponding motor nerve.

Macroelectromyography: Electromyographic technique by which all muscle electric activity produced by a single motor unit is recorded.

Maximum conduction velocity: The conduction velocity of the fastest conducting nerve fibres. It is measured in routine examinations.

Minimum conduction velocity: The velocity measured along the slow conducting nerve fibres. Along the motor nerves it can be measured by using the collision technique: along sensory fibres it is evaluated with averaging technique using needle electrodes for recording.

Motor latency: The time interval between application of the stimulus, and the onset of the evoked muscle action potential.

Motor unit action potential: Action potential constituted by the single action potentials originating from the muscle fibres of a motor unit situated in the range of action of the recording needle electrode. Normally, its duration, amplitude and shape vary in function with the density of muscle fibres and temporal dispersion of their action potentials,. It depends on muscle, site in the muscle in relation to depth and distance to end-plate zone. temperature, age of subject, electrode and amplifier characteristics. In abnormal conditions motor unit action potential parameters vary depending on the type of disorder.

Motor unit estimate (MUNE): A method for estimating the number of motor units in a muscle. Several different methods have been developed.

Myokymic discharges: Repetitive discharges reflecting the clinical, spontaneous, slow, continuous, wave-like movements known as "myokymioe".

Myotonic discharges: Spontaneous or variously provoked discharges from a single muscle fibre of mainly biphasic or monophasic positive potentials that occur at a high frequency.

have a continuously variable amplitude, and last a few seconds. They. sound like a "dive bomber" or a Formula I car during a radio commentary of a race.

Nerve action potential: Generally used to indicate a compound potential originating from a nerve trunk as a response to the application of a stimulus.

Nerve conduction velocity: Literally. the speed of propagation of an impulse along a peripheral nerve.

Noise: Disturbances originating from the electromyographic apparatus. In wide vision, "noise" also indicates the presence of biological activity that must be eliminated in order to reveal what is of interest. This is the case in normal cerebral activity, which "hides" the cerebral time-related evoked potentials.

Orthodromic: The physiological direction along the nerve fibres of a propagated evoked impulse.

Paired stimuli: A pair of stimuli, whose time interval, duration and intensity can be manipulated.

Polyphasic potential: Action potential with 5 or more phases.

Positive sharp wave: A positive monophasic potential which can present spontaneously in denervated muscles or as a train of discharges in myotonia.

Recruitment: The manner of progressively activating the motor units by increasing muscle activity.

Repetitive stimulation: The technique of stimulating at various frequencies a nerve by recording from a muscle it innervates in order to study neuromuscular transmission.

Satellite potential: Small action potential that appears also after many milliseconds, and always at the same point after a main motor unit action potential.

Sensory nerve action potential: A compound potential originating either in a pure nerve after stimulation of its trunk or in a mixed nerve after stimulation of its sensory components.

Single fibre electromyography: The technique by which recordings can be made from one or two single muscle fibres within a motor unit. The activation of the motor unit may be either voluntary or via axon microstimulation.

Spontaneous activity: Electrical activity originating during rest either in muscle or nerve fibres.

Stimulus: A particular form of energy to which an excitable tissue is sensitive. This may be an. external agent: in clinical neurophysiology, the stimuli generally used are either electrical or mechanical. It must be stated that the stimuli are adequate. In addition, one must define the duration. the waveform, the amplitude, rise time. and frequency. One must also state if' the stimulus is subthreshold, submaximal, supramaximal or maximal.

Temporal dispersion: Temporal dispersion is a term indicating that individual action potentials (in muscle or nerve) are arriving at the target asynchronously. In motor or sensory evoked responses, the phenomenon increases as the distance between the stimulating and recording electrodes increases. In the muscle, temporal dispersion leads to polyphasic motor unit potentials. Temporal dispersion of an afferent nerve volley may lead to a small EPSP and therefore weak reflex response.

Threshold: The limit at which minimal intensity of an adequate stimulus produces an impulse in an single muscle, nerve fibre or cortical neurone.

Turn: Directional change of the waveform not necessarily crossing the baseline.

T-wave: Electrically recorded tendon jerk. Evoked by tapping the tendon so that the response includes the spindle apparatus.

Volume conduction: In extracellular recording. it is the diffusion of current in the surrounding conduction medium.

TABLE I

PARAMETERS USED IN MUP ANALYSIS

Parameter	Significance	Usually measured as	Analysis mode
Amplitude	No. of fibres within 0.5 mm	Peak-peak (μV)	a/m
Area	No. of fibres within 2 mm	Total area within dur (μV ms)	a
Duration	No. of fibres within 2.5 mm	Slope criteria (ms)	a/m
No. of phases	Temporal dispersion	Zero-crossing +1	a/m
No. of turns	Temporal dispersion	No. Of changes in direction	a
No. Of sattellites	Excessive temporal dispersion	No. Of spikes	m
Jiggle	Neuromusc. Transmission	Shape stability	m

TABLE 4[2]

PARAMETERS USUALLY MEASURED IN MOTOR NERVE STUDIES:

Parameter	Significance	Usually measured as	Analysis mode
CMAP			
Amplitude	No. of axons, synchronisation	Negative amplitude {μV)	a/m
Area	No. of axons, synchronisation	Negative area (mV ms)	a
Duration	Neg. peak duration	ms	
Amplitude decay	Cond block – dispersion	% reduction in amplitude	a
Dispersion	Axonal velocity dispersion	% increase in duration	a
CV	Velocity of fastest axons	Latency difference (m/s)	a/m
Distal latency	Velocity of fastest axons	Latency (ms)	a/m
F- waves			
Latency	Cond. of fastest axons along entire nerve	Latency (min., mean in ms)	
Dispersion	Axonal velocity dispersion	Min. and max. latency (ms)	a/m
No. of F-waves	No. of axons and MN excitability	No. of F-waves 20 stimuli	a/m
Amplitude	MUP shape - no. of F- waves	Peak-peak amplitude (μV)	a/m
H- Reflex			
Latency.	Cond. along reflex arc	H-lat minus M-1at. (ms)	a
Amplitude	Excitability of MN	M ampl./H ampl.	a
A-wave			
Presence	Abnormal nerve excitability,	Present or not	m

TABLE 6

PARAMETERS USUALLY MEASURED IN SENSORY NEUROGRAPHY

Parameter	Significance	Usually measured as	Analysis mode	Comment
Latency	Conduction velocity	Positive peak {ms)	a/m	
CV	Conduction velocity	Distance/latency {m/s)	a/m	
Amplitude	No. of axons, temp,disp.	Peak-peak (μV)	a/m	
Area	No. of axons, temp.disp.	Total area (μV ms)	a	
Duration	Dispersion	Pos.-pos,. peak dur (ms)	a/m	
Late components	Conduction dispersion	Shape	m	In needle rec.

[2] CMAP. compound muscle action potential: CV. conduction velocity MN motor neurone.