EMG-Course
WCN 2013

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Disclosures

- There are no commercial disclosures.
- The author is a member of the UEMS/EBN and a trustee of the WFN

EMG - Learning objectives

- This is a practical basic approach towards electromyography (EMG) and includes:
- Electromyography (EMG)
- Spontaneous activity
- Motor unit potentials
- Recruitment and interference pattern
- Single fiber EMG
- Pitfalls and cautions
- Reporting

EMG

- Needle
- Recording area
- Needle insertion
- Rest, relaxation, posture
- EMG screen
- Loudspeaker
- EMG equipment (amplifier, filter,
- recording)
- Report

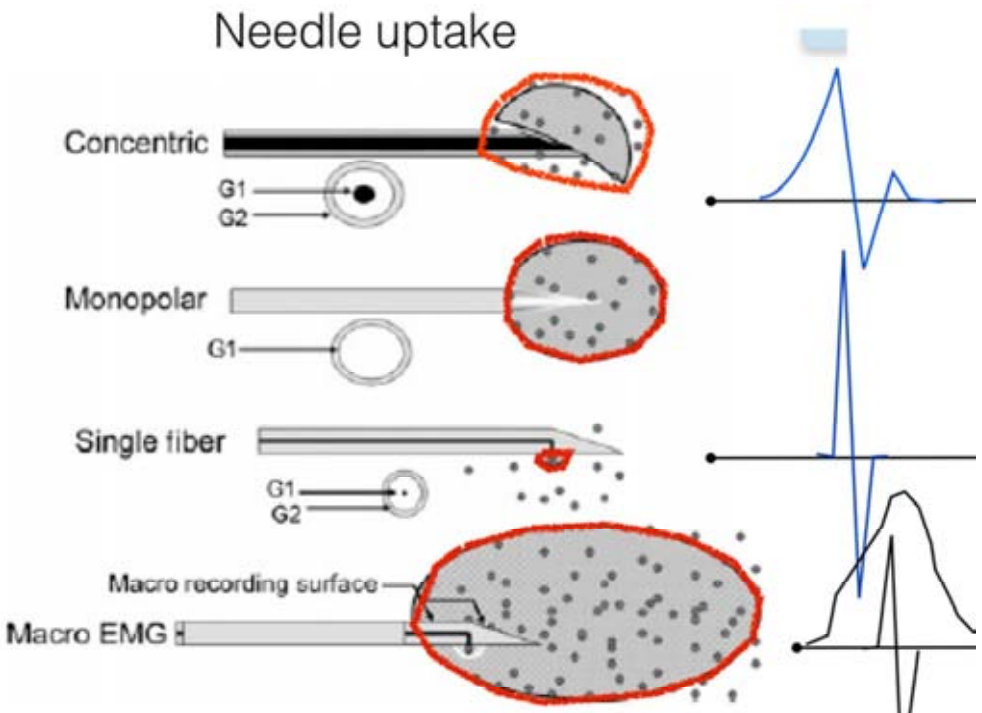


Figure 26–2. Electrode types used in recording EMG signals. The recording areas of each electrode type are shown by the hashed regions.

Jasper R. Daube,409

Needle types

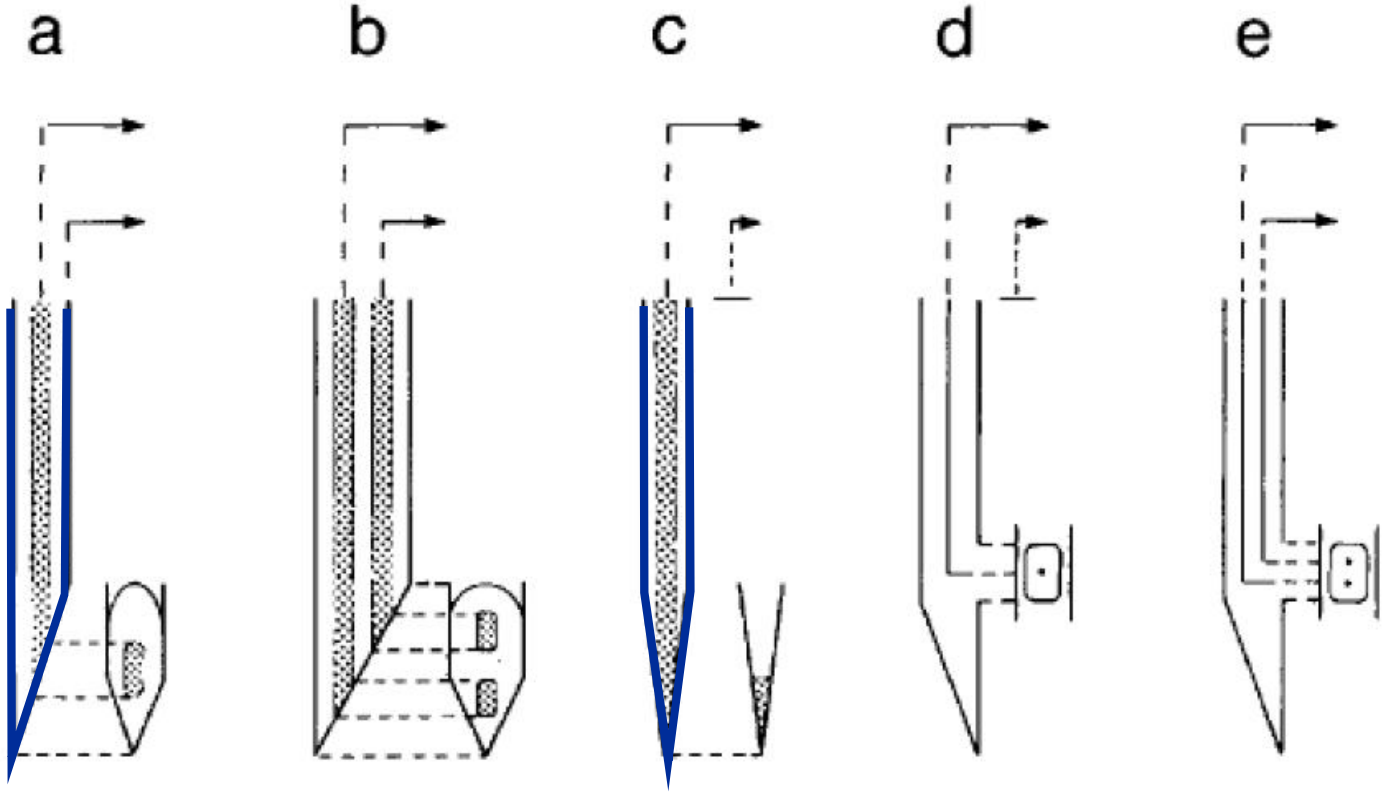
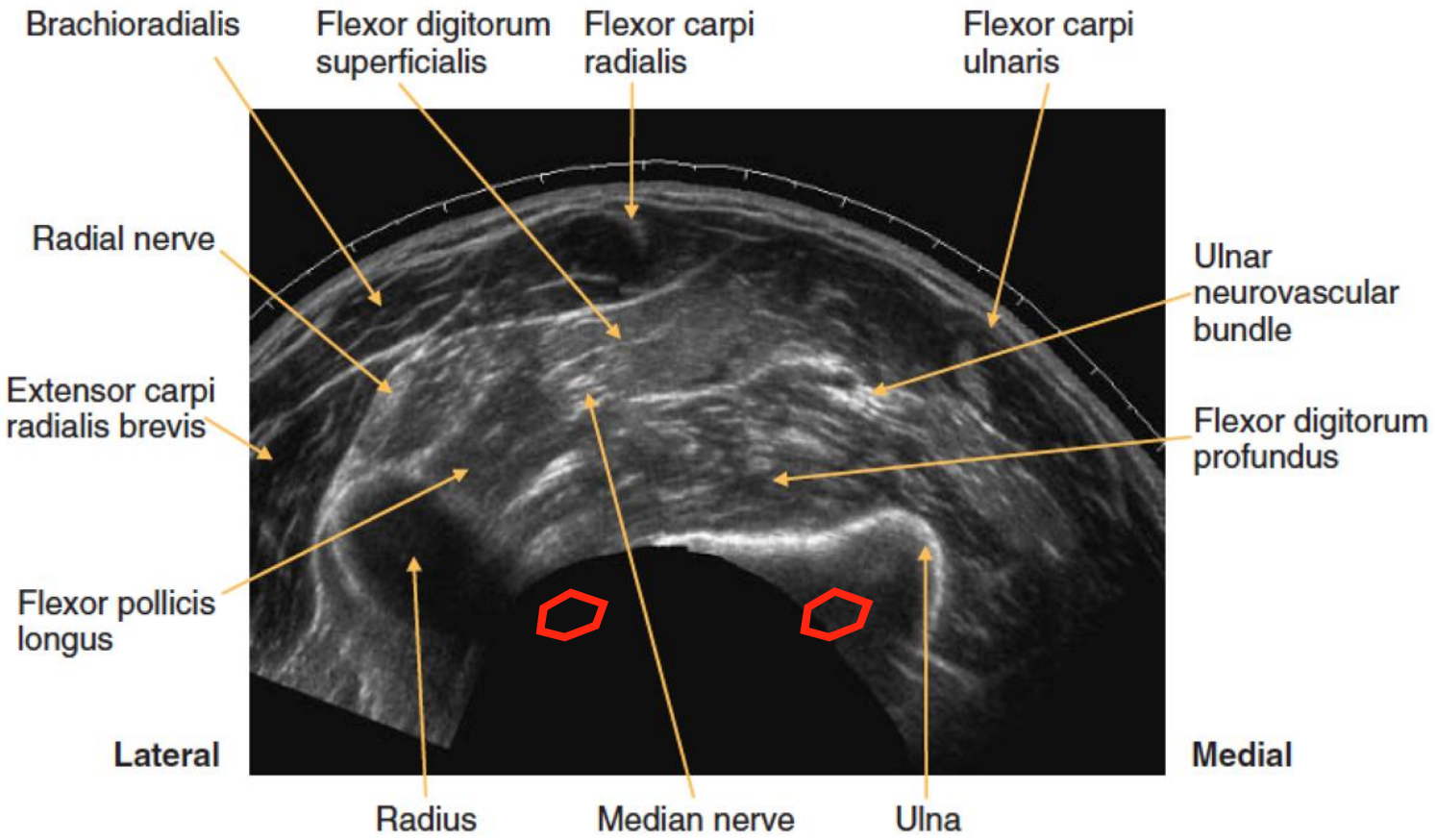


Figure 3–1. Schematic illustration of (*a*) standard or coaxial bipolar, (*b*) concentric bipolar, (*c*) monopolar, and (*d*,*e*) single-fiber needles. Dimensions vary, but the diameters of the outside cannulas shown resemble 26-gauge hypodermic needles (460 μm) for *a*, *d*, and *e*, a 23-gauge needle (640 μm) for b, and a 28-gauge needle 360 μm for c. The exposed tip areas measure 150 × 600 μm for *a*, 150 × 300 μm with spacing between wires of 200 μm center to center for *b*, 0.14 mm^2 for *c*, and 25 μm in diameter for d and e. A flat skin electrode completes the circuit with unipolar electrodes shown in *c* and *d*. [Modified from Stålberg and Trontelj.[72]]



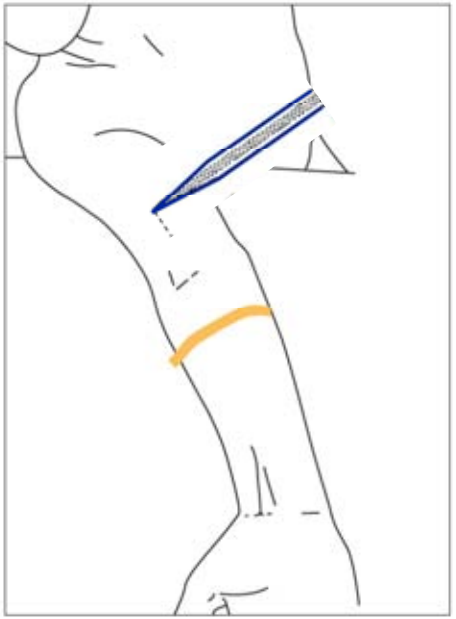
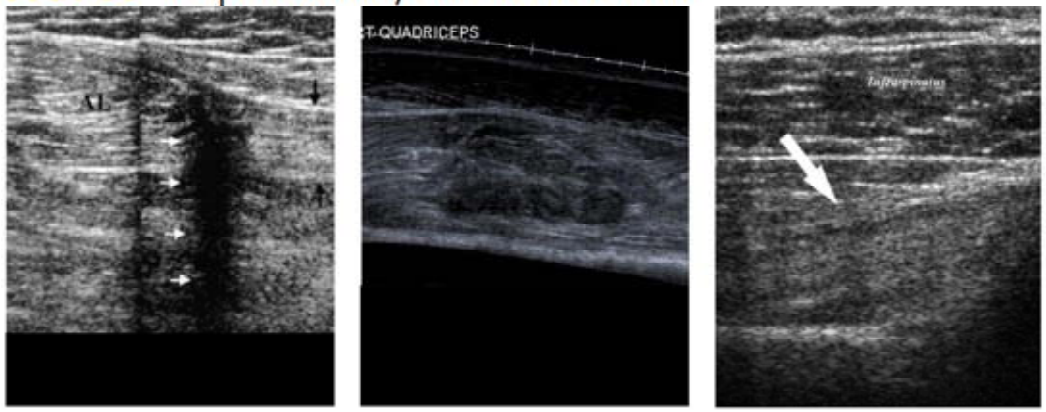


FIG. 89 TS panorama, anterior forearm



Riss Hämatom Teres min. Atrophie

Electrophysiology is an extension of clinical neurology

Neurogenic	Myopathic	NMJ	Central
Neuronopathy Radiculopathy Plexopathies Gen. neuropathies mononeuropathies	Generalized Proximal Distal Focal	Postsynaptic: MG Presynaptic: LEMS, Neuromyotonia	
NCV mononeuropathies	NCV/Rep.	Rep.	
EMG Innervation denervation „reinnervation“ distribution	**EMG** distribution acute/chronic myotonic discharges	**EMG** Neuromyotonia	**EMG** Recruitment

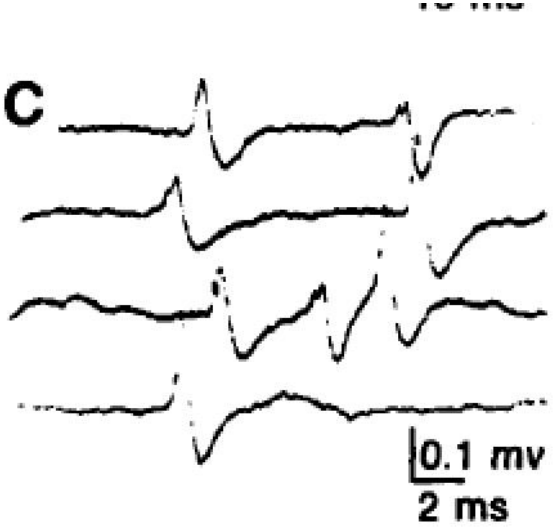
sfSSFEMG **SFEMG**

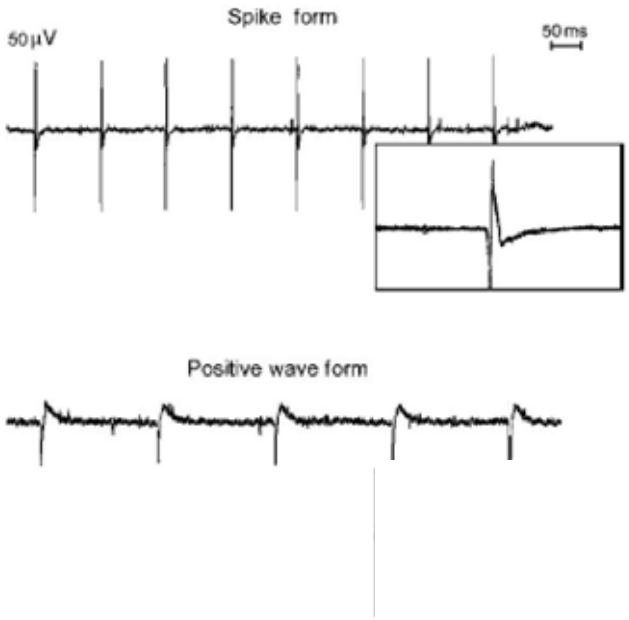
Elements of EMG analysis

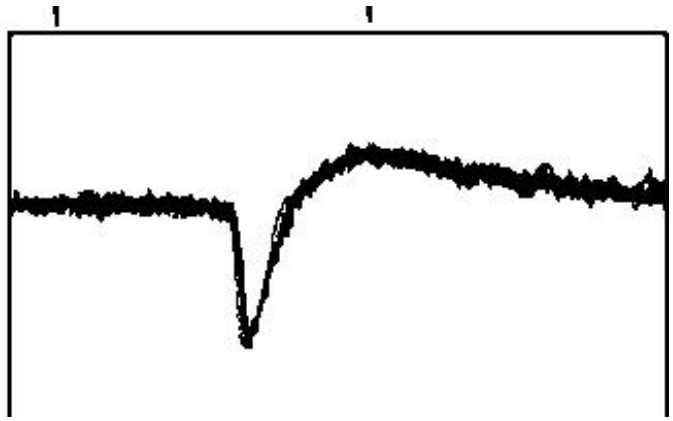
- Spontaneous activity
- MUAP (motor unit potentials)
- IF pattern (recruitment, interference pattern)

Spontaneous activity

- Endplate potentials
- Fibrillation
- Positive sharp wave
- Fasciculation
- CRD
- Myotonia/Pseudomyotonia







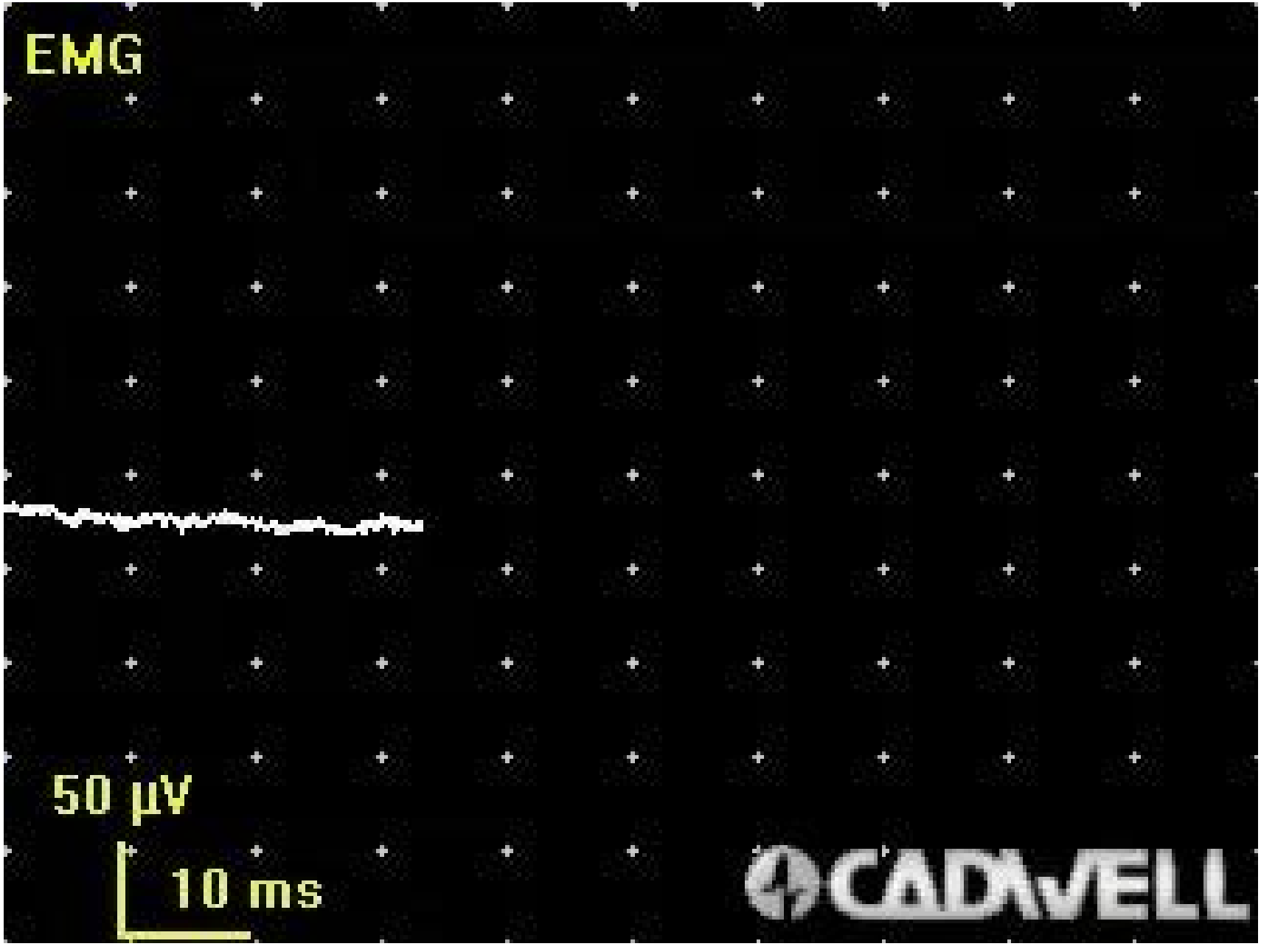
Endplate

Fibrillation

Positive sharp wave

Kimura 312

Fibrillation1



Fibrillation 2

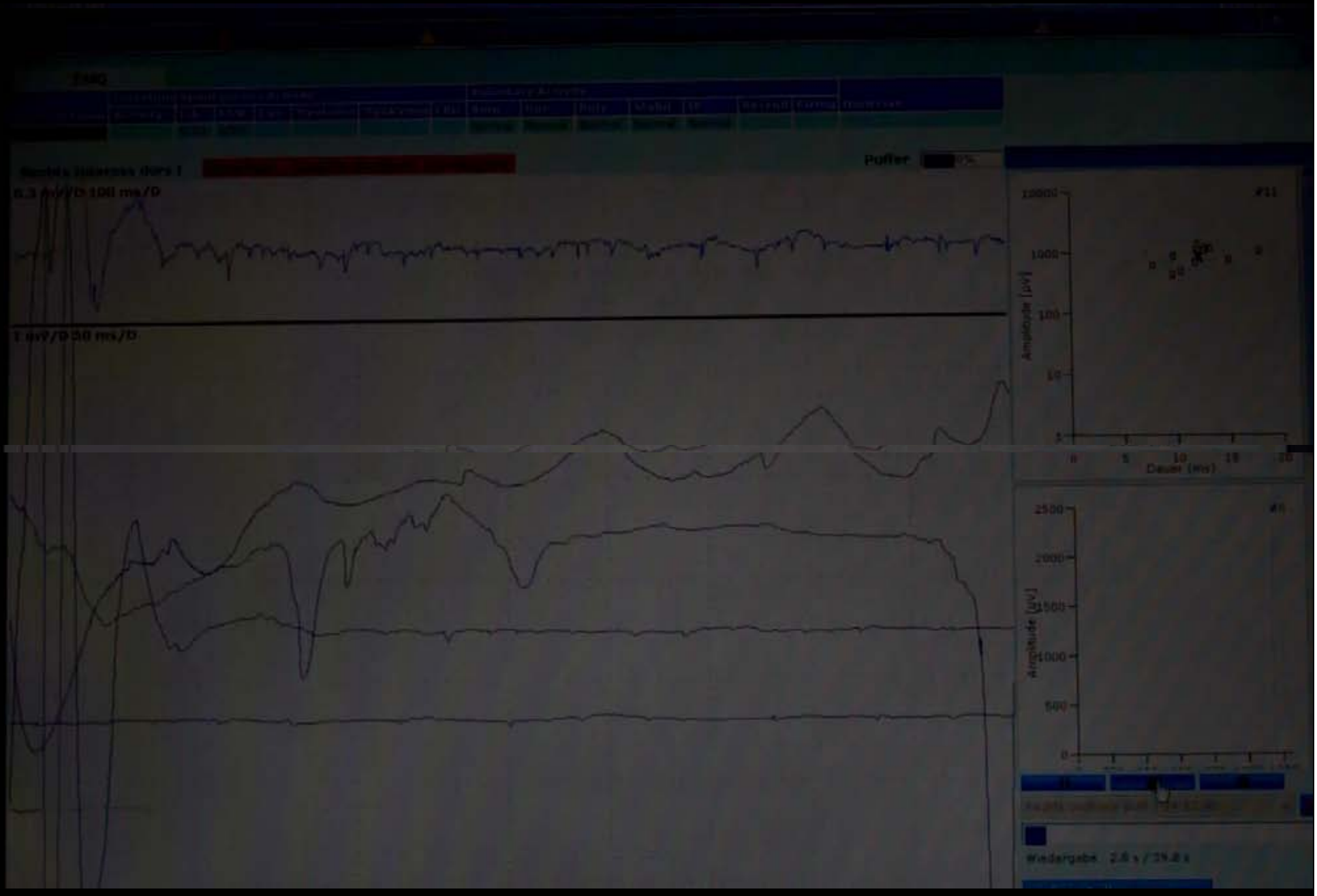


Table 26–3 Diseases Associated with Fibrillation Potentials

Lower motor neuron diseases	Anterior horn cell diseases (e.g., ALS) Polyradiculopathies Radiculopathies Plexopathies Peripheral neuropathies, especially axonal Mononeuropathies
Neuromuscular junction diseases	Myasthenia gravis, severe Botulinum intoxication Lambert–Eaton myasthenic syndrome, severe
Myopathies	Inflammatory (e.g., polymyositis, dermatomyositis, inclusion body myositis) Infiltrative (e.g., sarcoidosis, amyloid) Muscular dystrophies (e.g., Duchenne, Becker, limb-girdle) Myotonic dystrophy Toxic myopathies (e.g., lipid-lowering agents, chloroquine) Metabolic myopathies (e.g., acid maltase) Congenital myopathies (e.g., myotubular, late onset rod myopathy) Infectious myopathy (e.g., viral myositis, trichinosis)
Other	Muscle trauma and rhabdomyolysis

Fasciculation

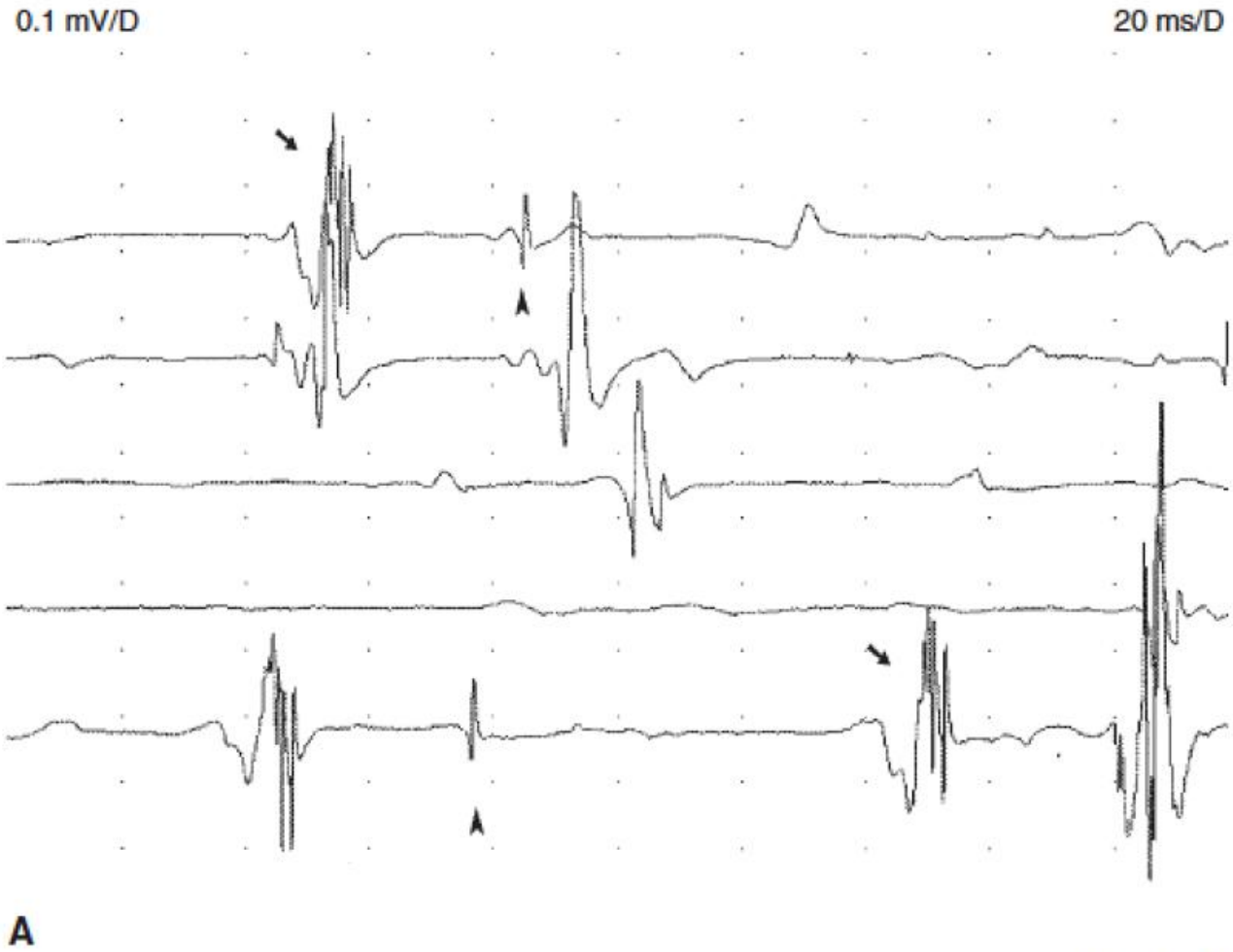
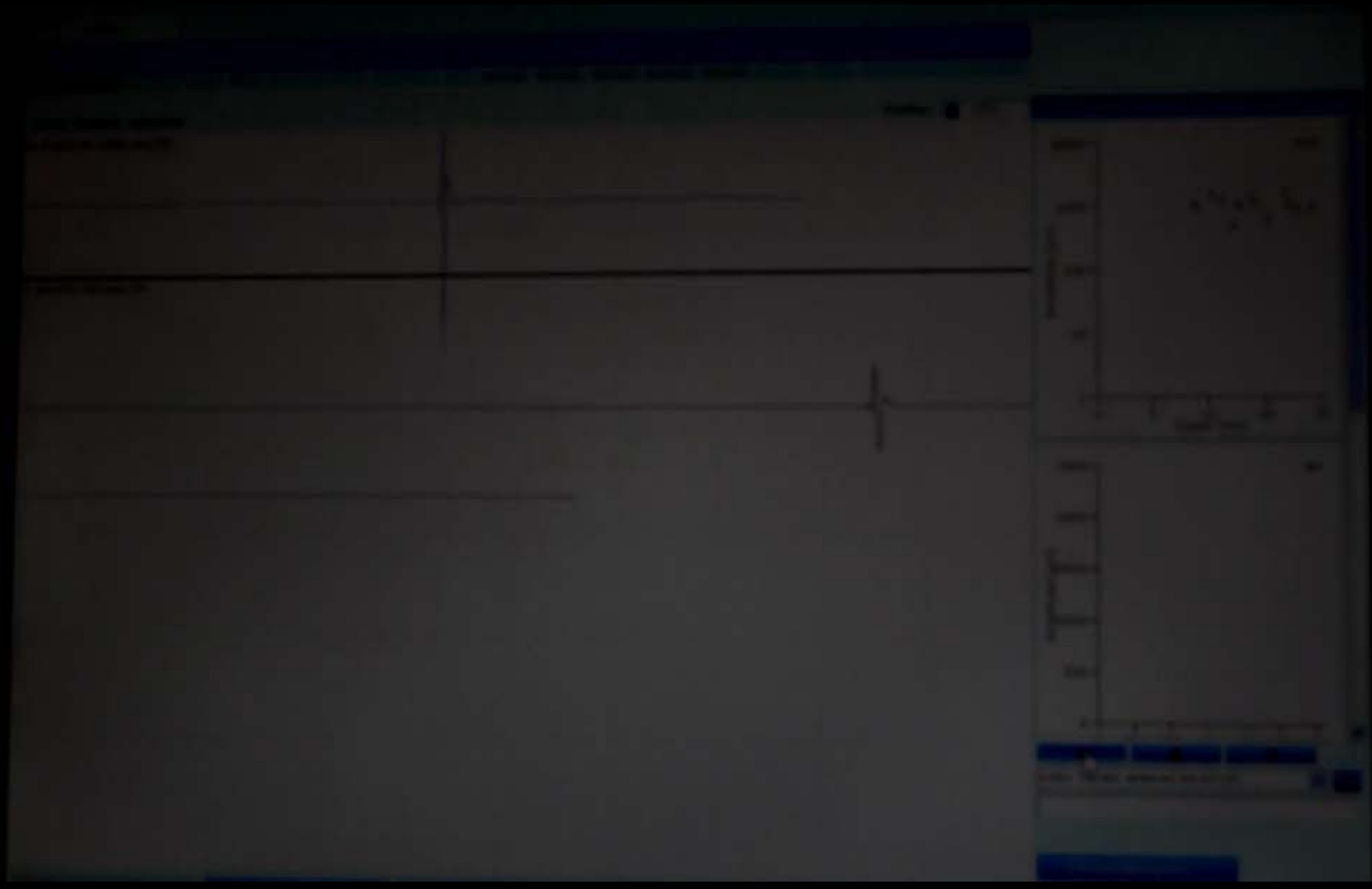
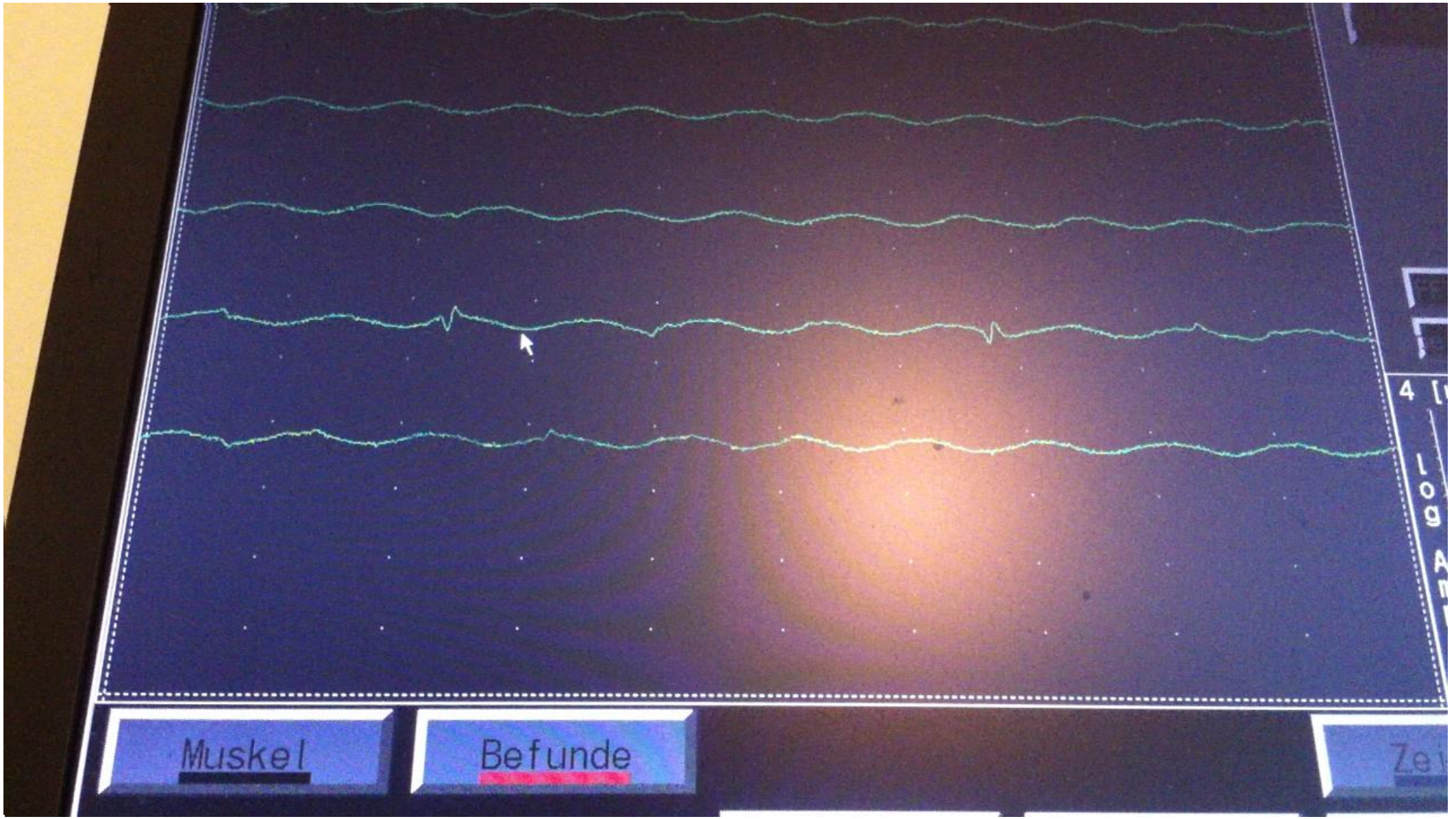


Figure 2–20. *Fasciculation potentials recorded, in raster mode, from the vastus lateralis in a patient with motor neuron disease. In (**A**) the sweep speed is set at 20 ms/division while in*

Continued

ELECTROMYOGRAPHY IN CLINICAL PRACTICE ISBN: 978-0-323-02899-8




Muskel
Befunde

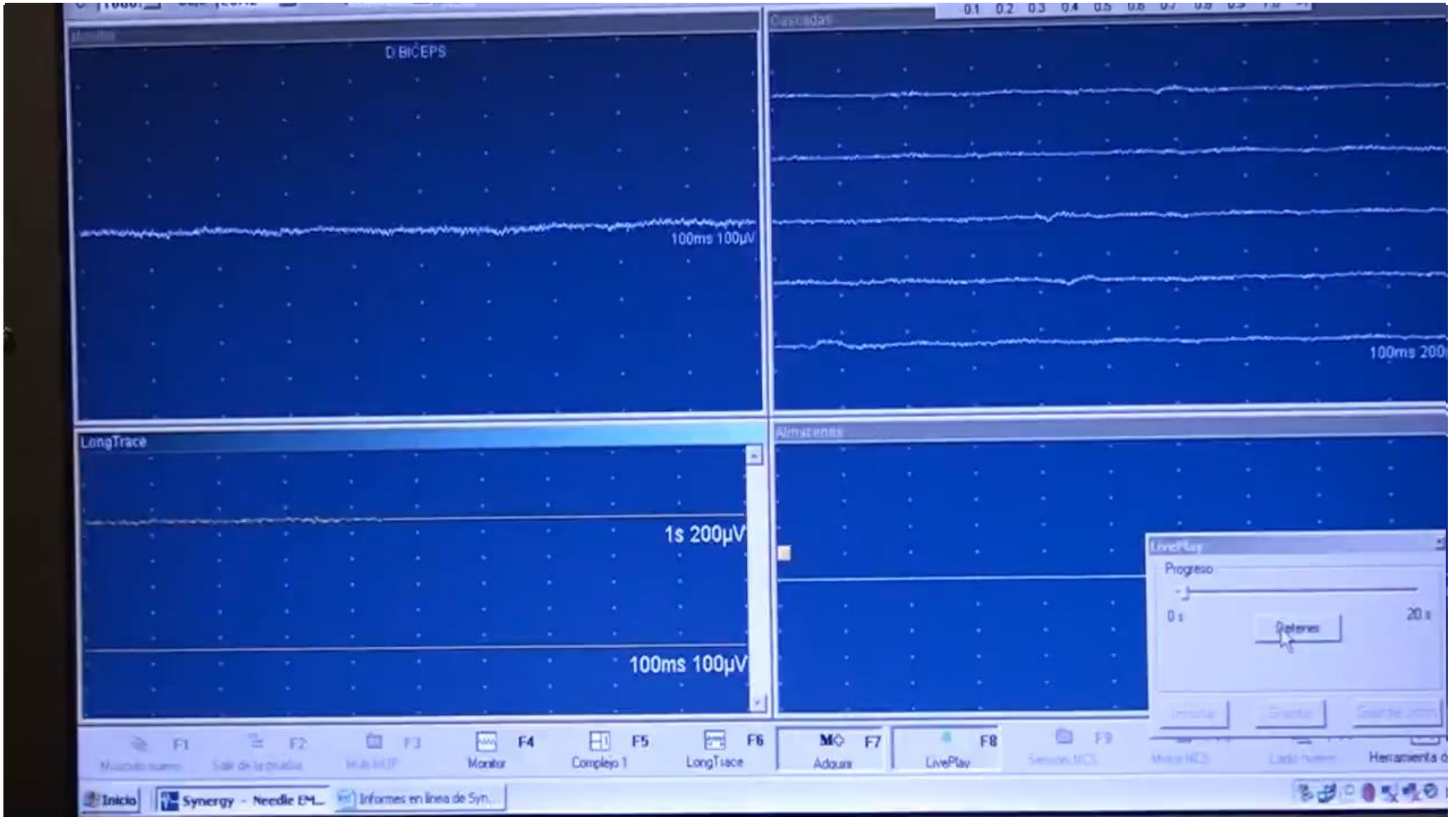
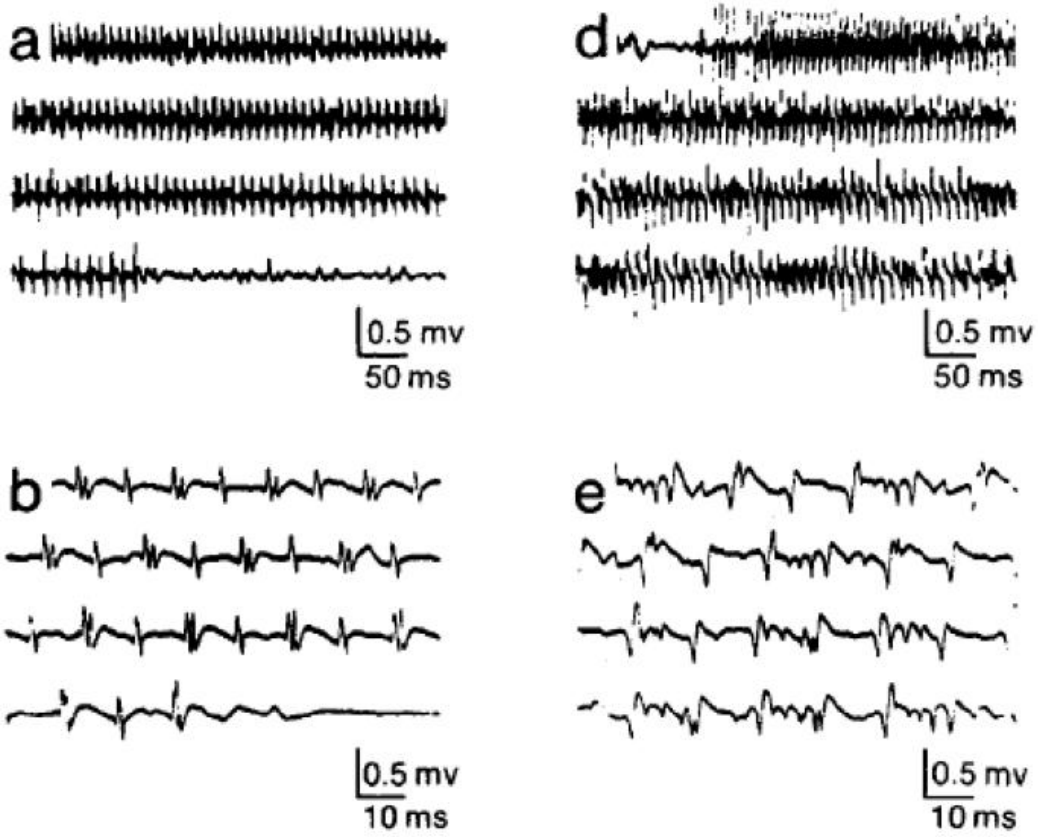

D BICEPS
100ms 100µV
100ms 200
LongTrace
1s 200µV
100ms 100µV
Progreso
0 s
20 s
Retener
F1
F2
F3
F4
Monitor
F5
Complejo 1
F6
LongTrace
F7
Adquis
F8
LivePlay
F9
Herramienta
Inicio
Synergy - Needle EM...
Informes en línea de Syn...

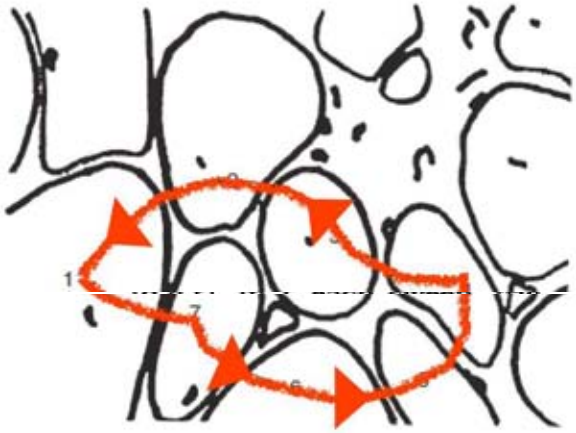
Table 26–6 Disorders Associated with Fasciculation Potentials

Normal	Benign fasciculation syndrome
Peripheral nerve hyperexcitability syndrome	Cramp fasciculation syndrome
Neurogenic disorders	Anterior horn cell diseases (e.g., ALS, Kennedy disease, spinal muscular atrophy) Peripheral neuropathies, axonal Radiculopathies
Metabolic disorders	Hyperthyroidism
Medications	Anticholinesterase agents

Complex repetitive discharges

CRD





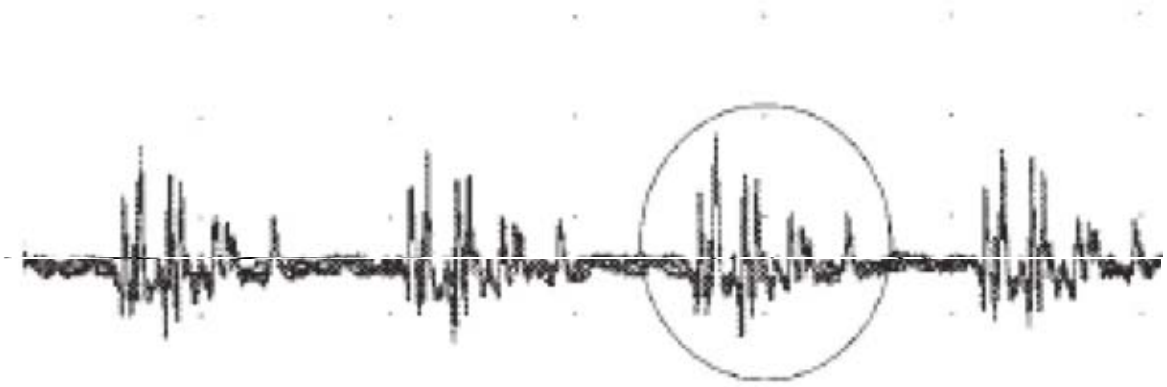


Figure C20–5. *Pathophysiology of a complex repetitive discharg (CRD): an ephaptic transmission from muscle fiber to musci fiber that creates a circus movement without an intervenin synapse. (Courtesy of Dr. David Preston.)*

CRD

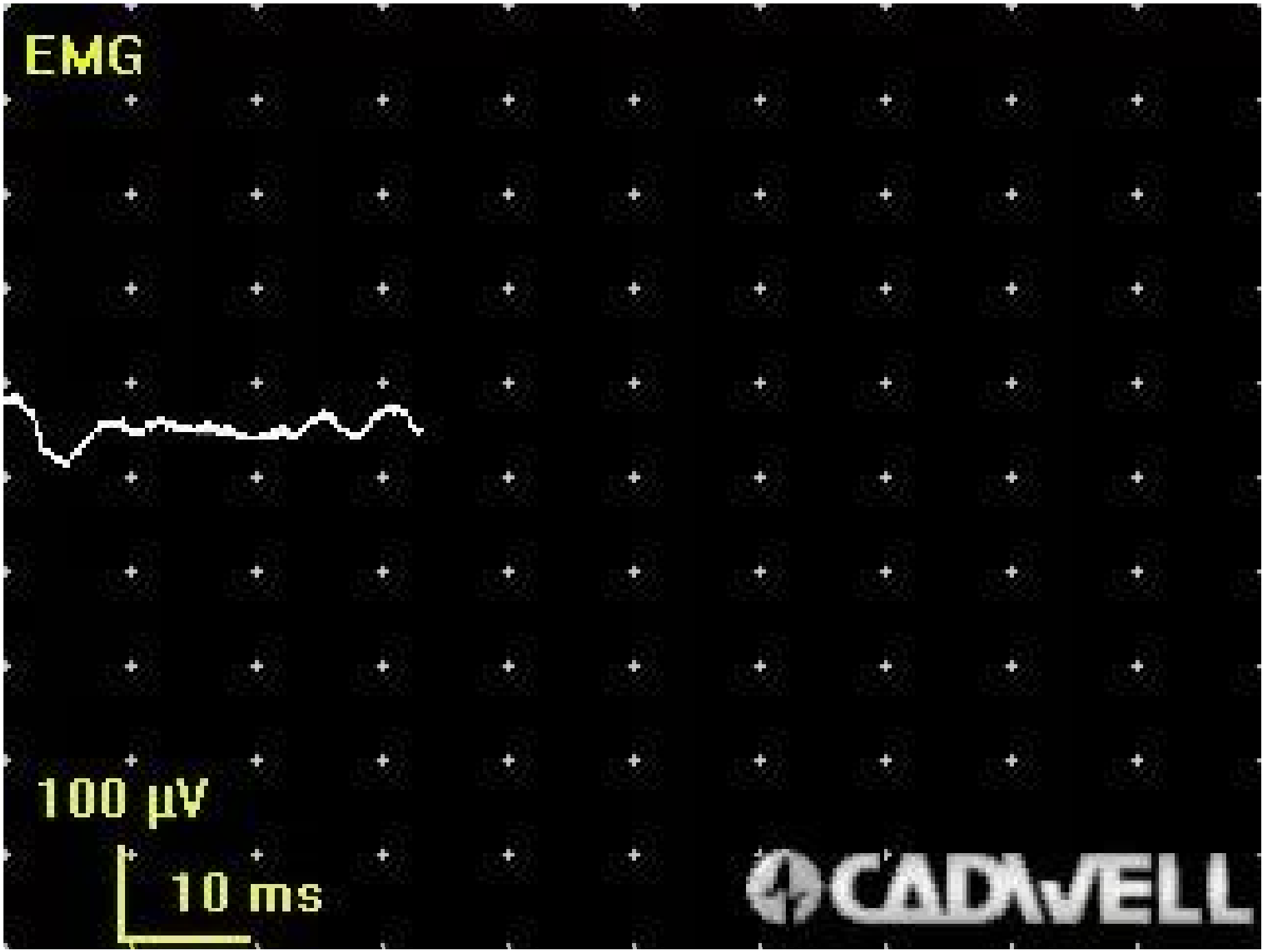


Table 26–5 **Disorders Associated with Complex Repetitive Discharges**

Neurogenic disorders	Chronic anterior horn cell diseases (e.g., ALS, spinal muscular atrophy, polio) Chronic radiculopathies Chronic axonal neuropathies (e.g., CMT)
Myopathies	Chronic inflammatory myopathies (e.g., polymyositis, inclusion body myositis) Muscular dystrophies Hypothyroid myopathy Schwartz–Jampel syndrome
Normal muscles	Iliopsoas Biceps

Myotonic dystrophy

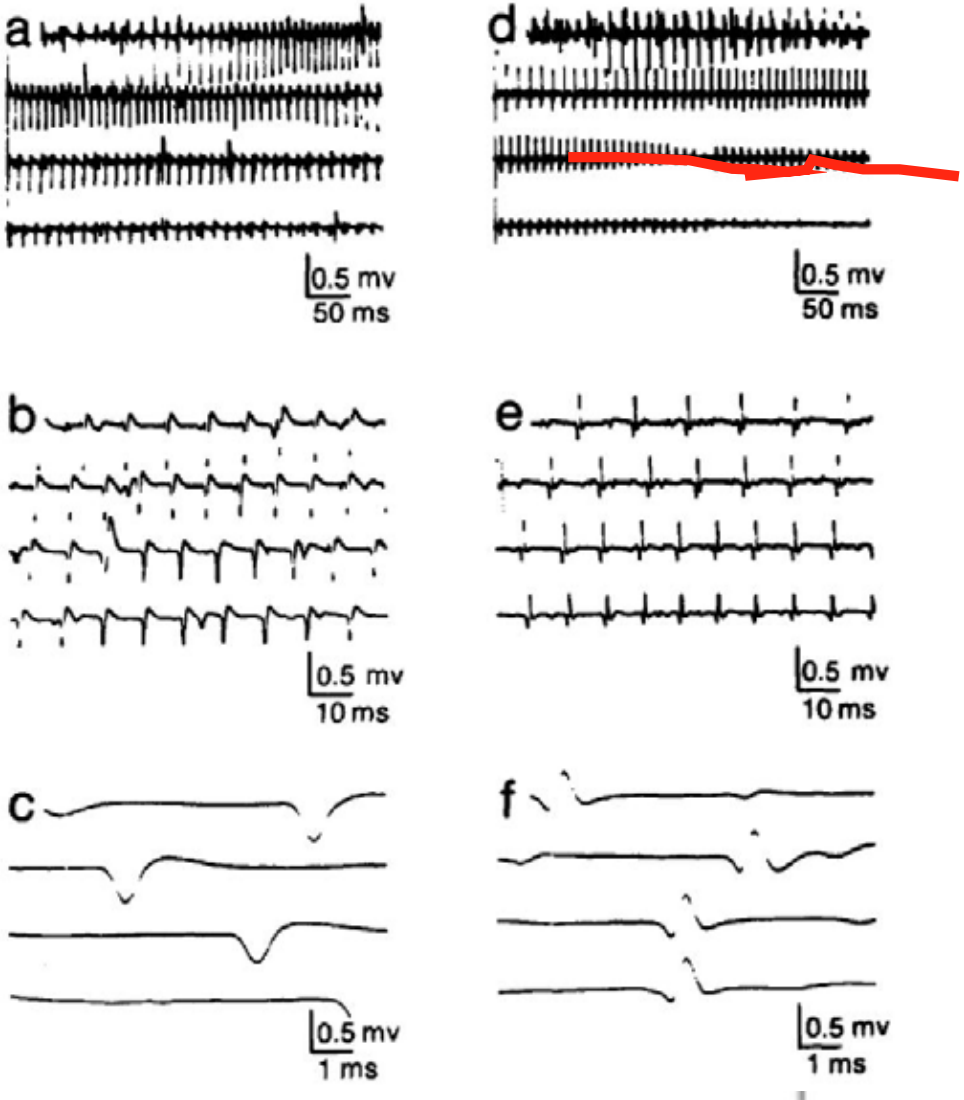
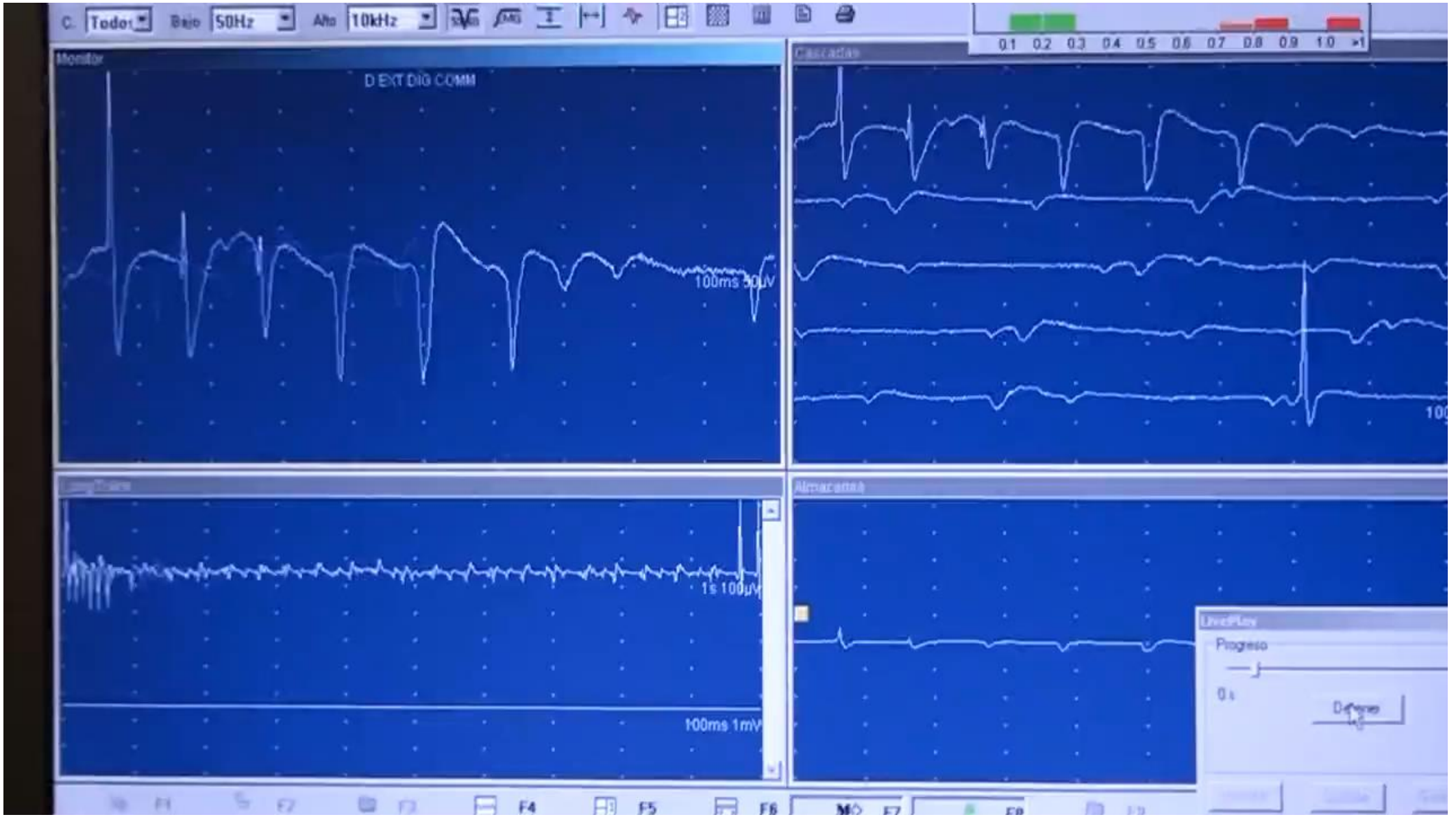
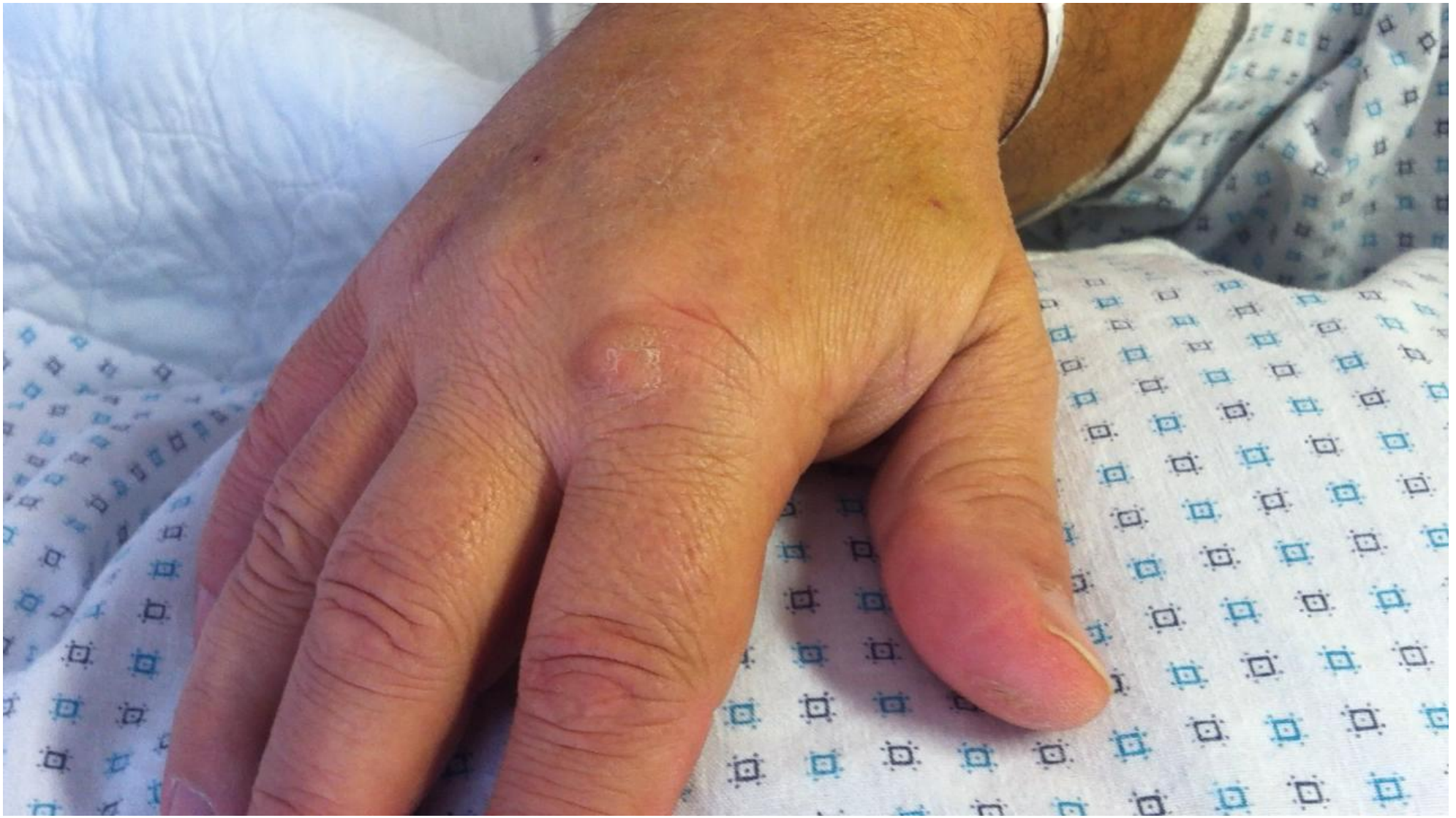


Figure 14–7. Myotonic discharges from the right anterior tibialis in a 39-year-old man with myotonic dystrophy. The tracings show two types of discharges: trains of positive sharp waves (*a,b,c*) and negative spikes with initial positivity (*d,e,f*). The discharges in *a* and *d* reveals waxing and waning quality.


Todos
Bajo
50Hz
Alto
10kHz
Monitor
D EXT DIG COMM
100ms 50µV
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
1s 100µV
100ms 1mV
Progreso
F4
F5
F6



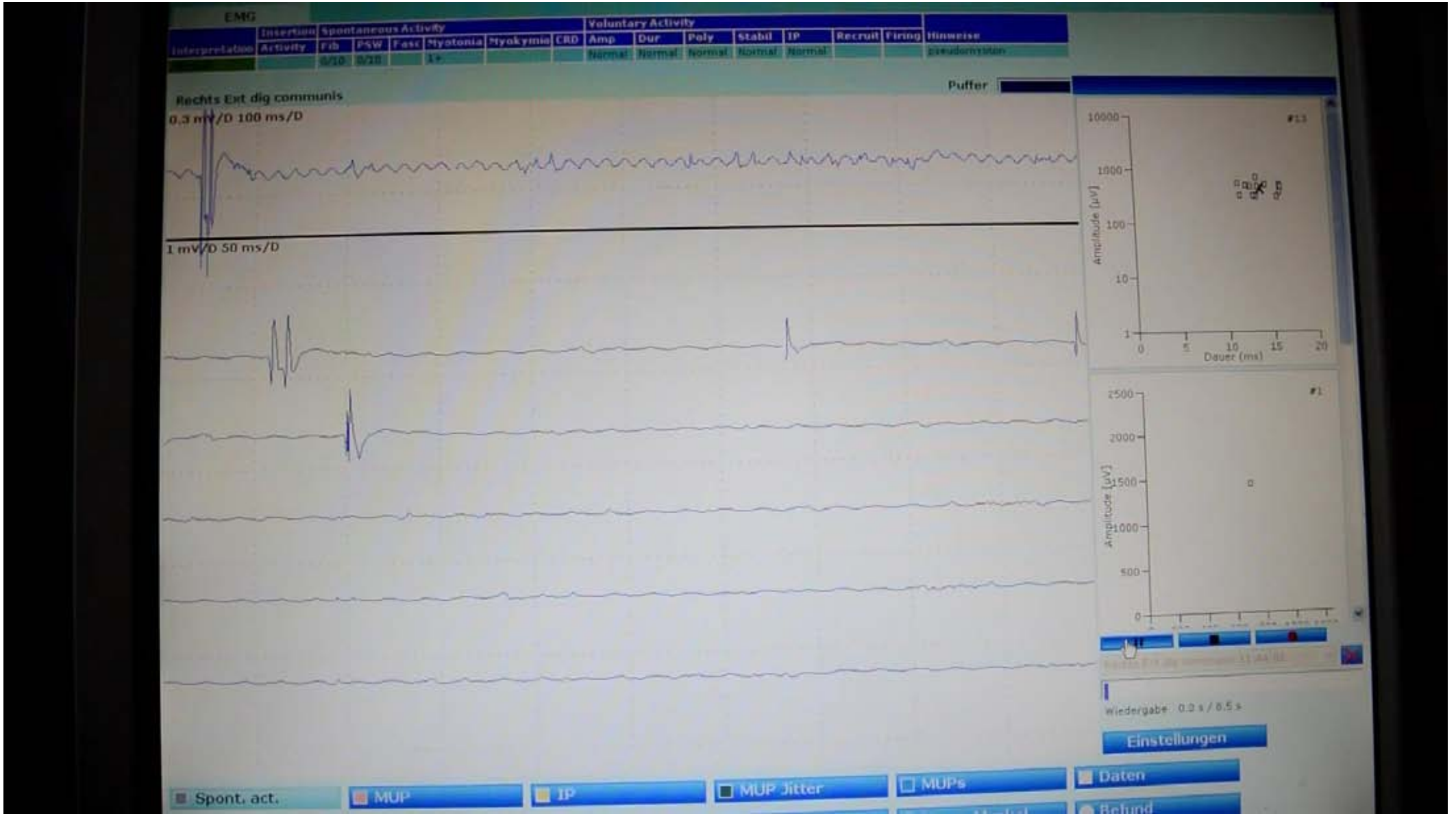
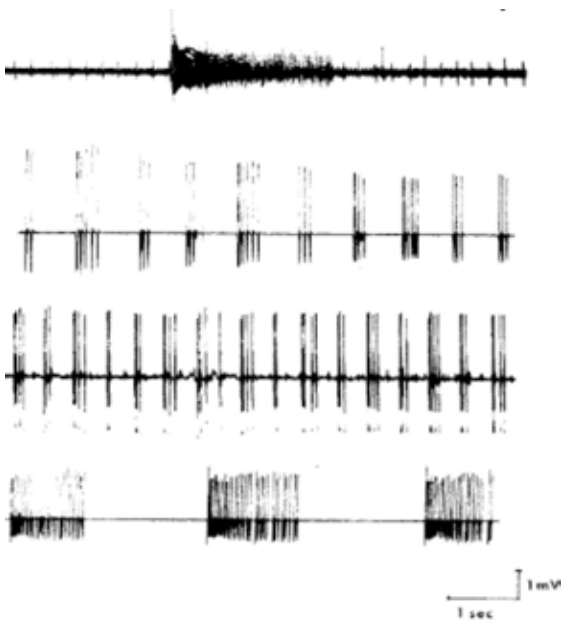

EMG
Interpretation
Insertion Activity
Spontaneous Activity
Fib
PSW
Fasc
Myotonia
Myokymie
CRD
0/10
0/10
1+
Voluntary Activity
Amp
Dur
Poly
Stabil
IP
Recruit
Firing
Normal
Hinweise
Puffer
Rechts Ext dig communis
0.3 mV/D 100 ms/D
1 mV/D 50 ms/D
Amplitude [µV]
Dauer (ms)
Wiedergabe 0.0 s / 0.5 s
Einstellungen
Spont. act.
MUP
IP
MUP Jitter
MUPs
Daten

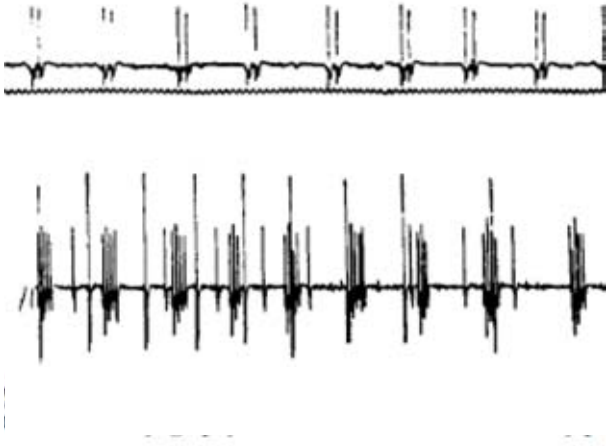
Table 26–4 **Diseases Associated with Myotonic Discharges**

Myopathies with clinical myotonia	Myotonic dystrophy type 1 and 2 (DM1, DM2) Myotonia congenita Paramyotonia congenita
Myopathies without clinical myotonia	Hyperkalemic periodic paralysis Polymyositis Acid maltase deficiency Statin-associated myopathy Toxic myopathies (e.g., colchicine myopathy) Potassium sensitive myotonia Centronuclear myopathy Hypothyroid myopathy Amyloid
Neurogenic disorders	Severe axonal disorders (e.g., peripheral neuropathies, radiculopathies)

Myokymia



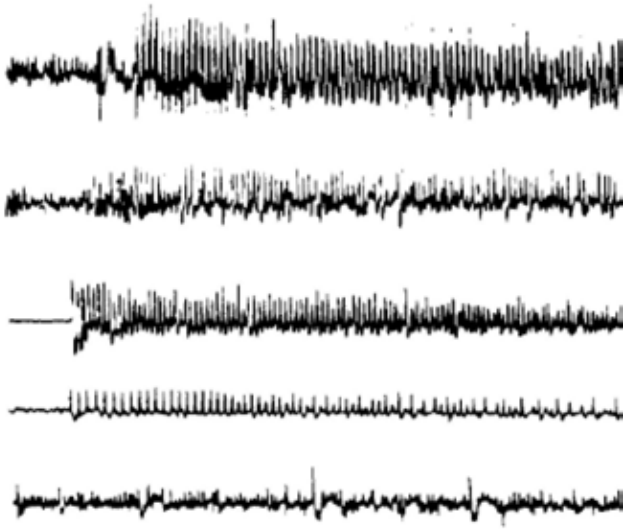
Douplets



Disorders Associated with Doublets or Multiplets

Hyperventilation
Tetany
Motor neuron disease (infrequent)
Syndrome of peripheral nerve hyperexcitability (Isaac's syndrome)
Other metabolic diseases

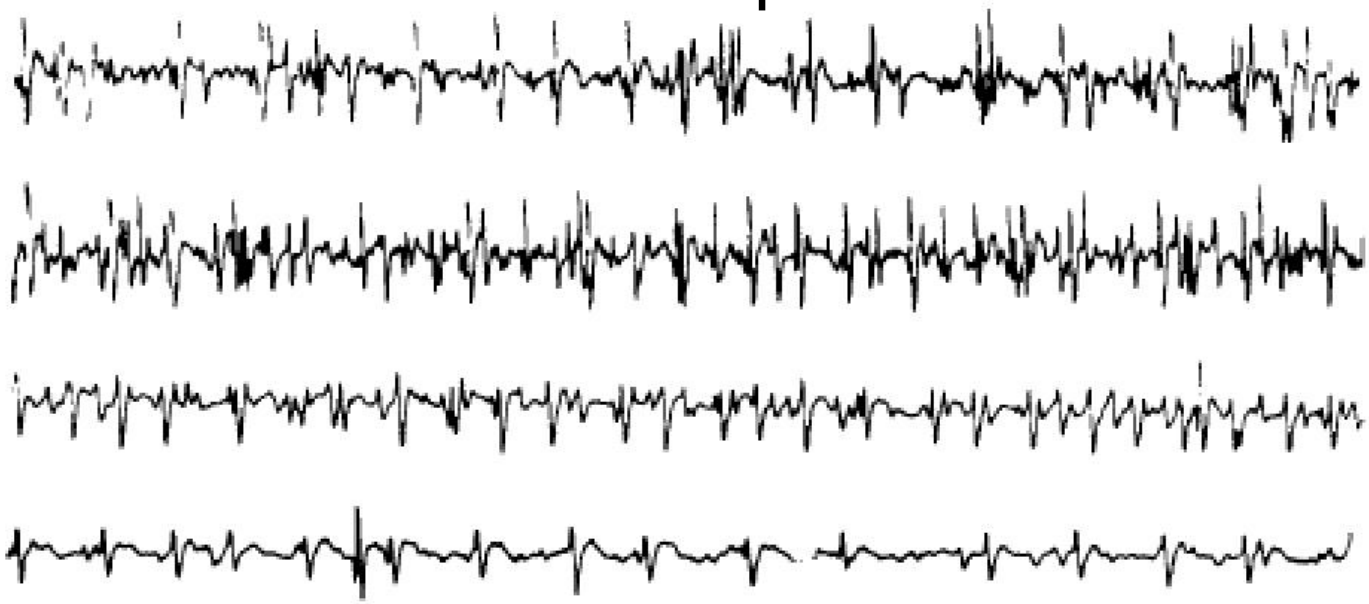
Neuromyotonia



Disorders Associated with Neuromyotonic Discharges

Hyperexcitable nerve syndromes	Syndrome of peripheral nerve hyperexcitability (Isaac's syndrome) Tetany Morvan's syndrome
Neurogenic	Chronic spinal muscular atrophy Hereditary motor neuropathy
Other	Anticholinesterase poisoning Intraoperative nerve irritation

Cramps



Disorders Associated with Cramp Discharges

Neurogenic disorders	Chronic radiculopathies Peripheral neuropathy Motor neuron disorders
Metabolic or electrolyte disorders	Salt depletion Pregnancy Hypothyroidism Uremia (dialysis)
Peripheral nerve hyperexcitability disorders	Cramp fasciculation syndrome
Other	Benign nocturnal cramps

MUAP

- Duration
- Amplitude
- Rise Time
- Spike duration
- Phase and Turns
- Stability and variation

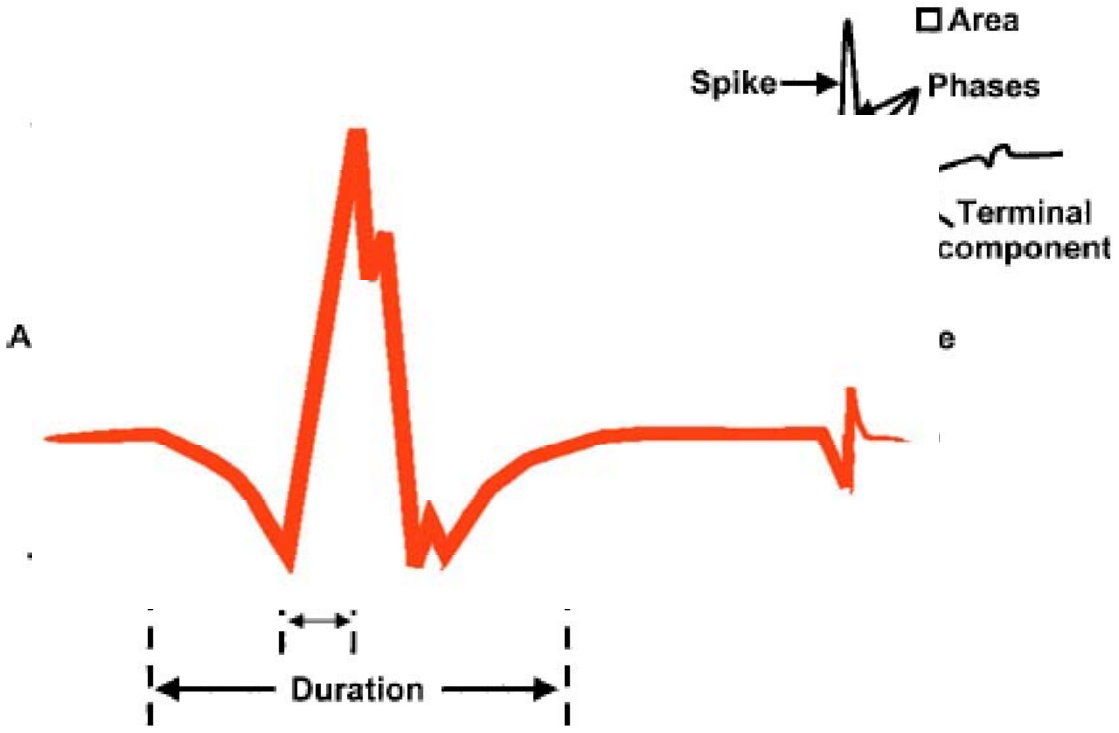
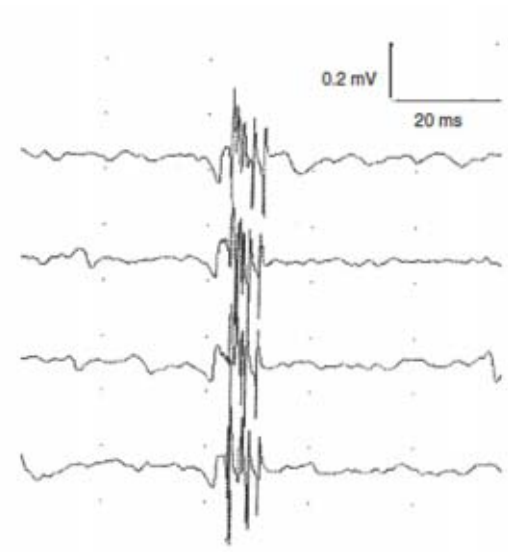
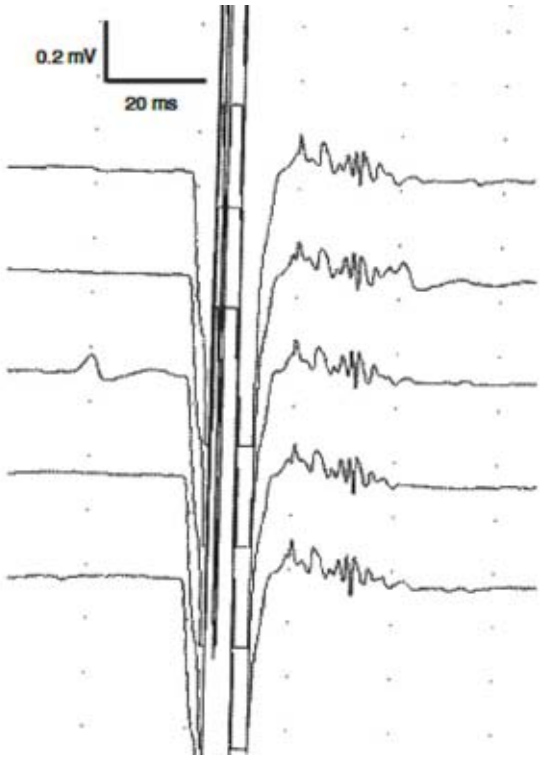
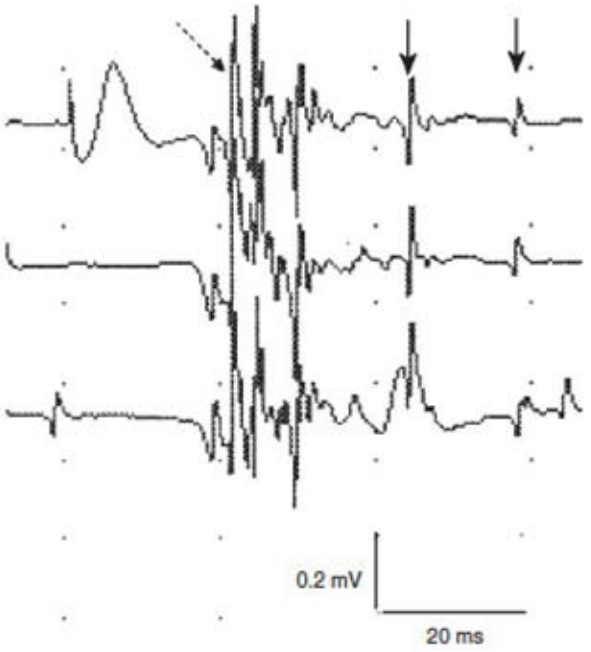


Figure 27–4. Commonly measured variables of the MUP.

Types of MUAPS







Polyphasia

Long duration

Nascent (regen.)

Katiriji 76

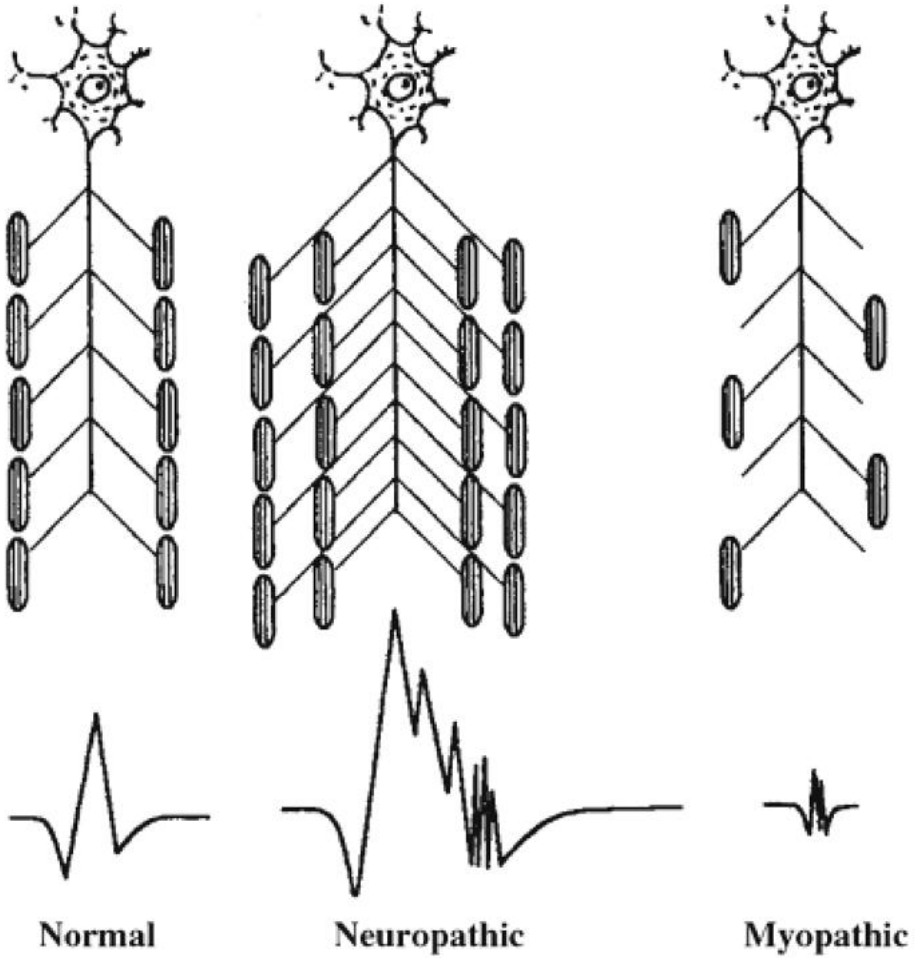
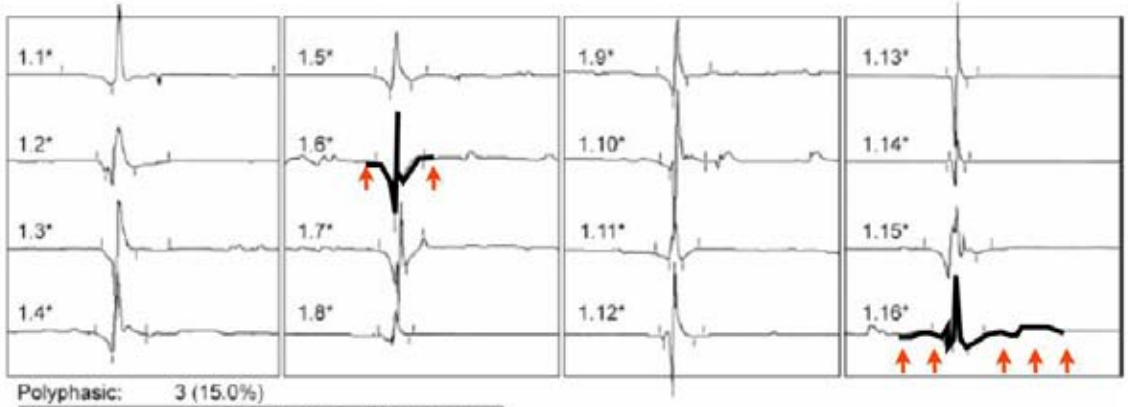


Fig. 7.4 Motor unit action potential (MUAP) morphologies. Normal MUAPs have two to four phases. In chronic neuropathic lesions that occur after reinnervation, the number of muscle fibers per motor unit increases, resulting in long-duration, high-amplitude, and polyphasic MUAPs. In myopathies or in neuromuscular junction disorders with block, the number of functional muscle fibers in the motor unit decreases. This leads to short-duration, small-amplitude, and polyphasic MUAPs. (From **Ref. 3**. Reprinted from Clinical-Electrophysiologic Correlations, copyright Butterworth-Heinemann. 1998. Reproduced with permission from copyright holder Butterworth-Heinemann/Elsevier)

Analysis

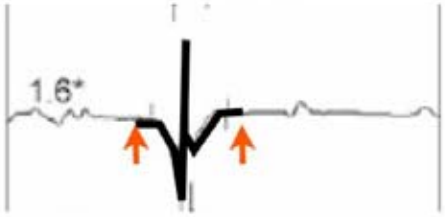
- **Manual**
- Computer-Assisted Quantitative Analysis of User Selected MUP
- Several others (eg MUNE)

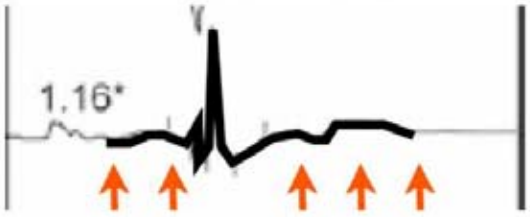


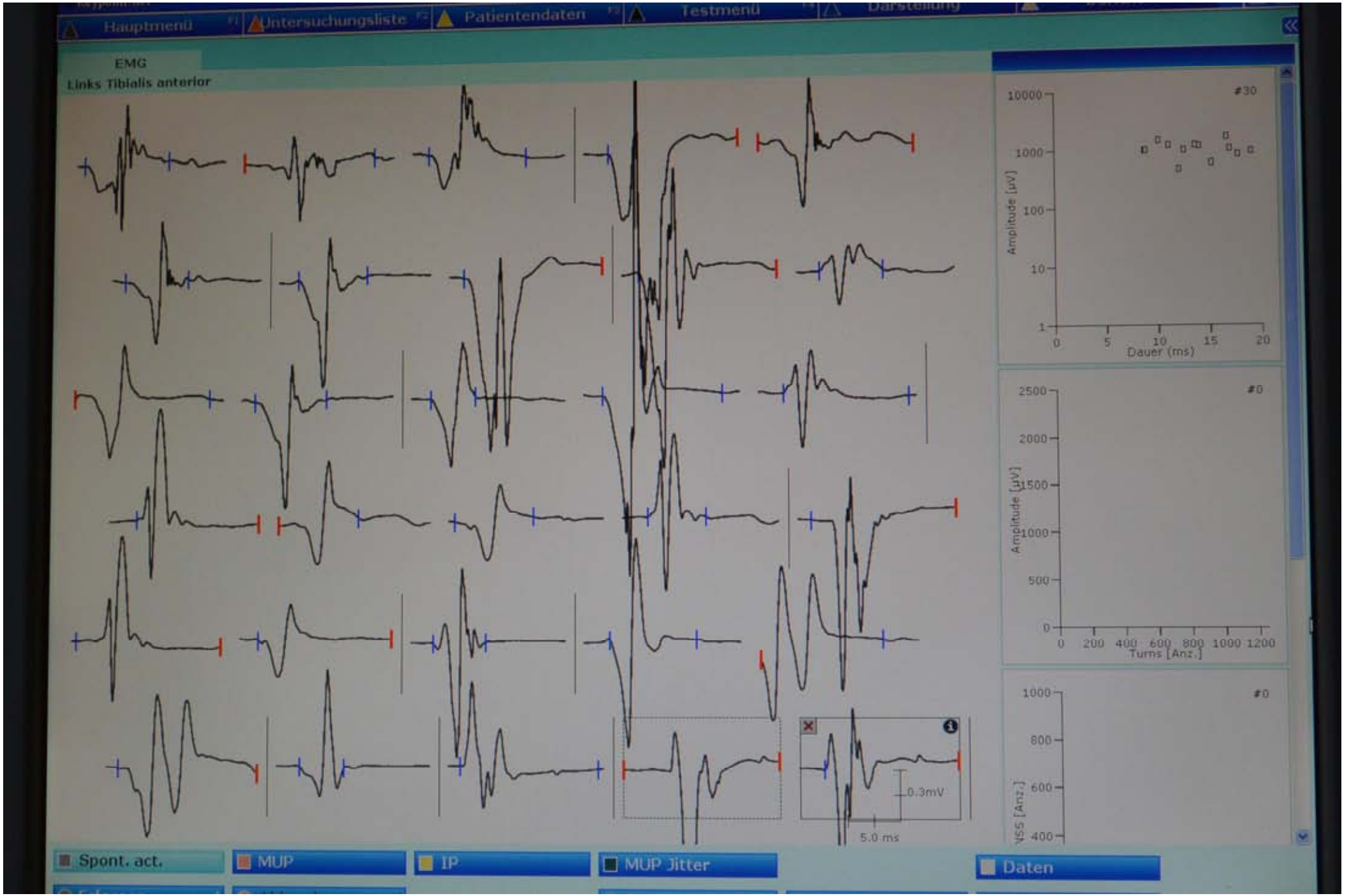
Polyphasic: 3 (15.0%)

Analyzed MUPs: 20	MUP 1.20*	All MUPs Mean	All MUPs SD	NonPolyph. Mean	NonPolyph. SD
Duration ms	7.6	10.2	7.1	10.3	7.7
Amplitude uV	Ovfl	1060	436	994	419
Phases	3	3.6	1.3	3.1	0.7

Figure 27–10. *A*, Display of sixteen of twenty MUPs that were isolated, selected and averaged as shown in Figure 27–9. *B*, Mean duration, amplitude, and phases calculated for all isolated MUPs (MUP 1.20* column is not shown in the panel of 16).






Hauptmenü
Untersuchungsliste
Patientendaten
Testmenü
Darstellung
EMG
Links Tibialis anterior
#30
Amplitude [µV]
Dauer (ms)
#0
Amplitude [µV]
Turns [Anz.]
#0
VSS [Anz.]
0.3mV
5.0 ms
Spont. act.
MUP
IP
MUP Jitter
Daten

The concept of normal values

Table 13–1 Mean Action Potential Duration (in milliseconds) in Various Muscles at Different Ages (concentric electrodes)

	Arm Muscles						Leg Muscles					Facial Muscles
Age in Years	Deltoideus	Biceps Brachii	Triceps Brachii	Extensor Digitorum Communis	Opponens Pollicis; Interosseus	Abductor Digiti Quinti	Biceps Femoris; Quadriceps	Gastroc-nemius	Tibialis Anterior	Peroneus Longus	Extensor Digitorum Brevis	Orbicularis Oris Superior; Triangularis; Frontalis
0	8.8	7.1	8.1	6.6	7.9	9.2	8.0	7.1	8.9	6.5	7.0	4.2
3	9.0	7.3	8.3	6.8	8.1	9.5	8.2	7.3	9.2	6.7	7.2	4.3
5	9.2	7.5	8.5	6.9	8.3	9.7	8.4	7.5	9.4	6.8	7.4	4.4
8	9.4	7.7	8.6	7.1	8.5	9.9	8.6	7.7	9.6	6.9	7.6	4.5
10	9.6	7.8	8.7	7.2	8.6	10.0	8.7	7.8	9.7	7.0	7.7	4.6
13	9.9	8.0	9.0	7.4	8.9	10.3	9.0	8.0	10.0	7.2	7.9	4.7
15	10.1	8.2	9.2	7.5	9.1	10.5	9.2	8.2	10.2	7.4	8.1	4.8
18	10.4	8.5	9.6	7.8	9.4	10.9	9.5	8.5	10.5	7.6	8.4	5.0
20	10.7	8.7	9.9	8.1	9.7	11.2	9.8	8.7	10.8	7.8	8.6	5.1
25	11.4	9.2	10.4	8.5	10.2	11.9	10.3	9.2	11.5	8.3	9.1	5.4
30	12.2	9.9	11.2	9.2	11.0	12.8	11.1	9.9	12.3	8.9	9.8	5.8
35	13.0	10.6	12.0	9.8	11.7	13.6	11.8	10.6	13.2	9.5	10.5	6.2
40	13.4	10.9	12.4	10.1	12.1	14.1	12.2	10.9	13.6	9.8	10.8	6.4
45	13.8	11.2	12.7	10.3	12.5	14.5	12.5	11.2	13.9	10.1	11.1	6.6
50	14.3	11.6	13.2	10.7	12.9	15.0	13.0	11.6	14.4	10.5	11.5	6.8
55	14.8	12.0	13.6	11.1	13.3	15.5	13.4	12.0	14.9	10.8	11.9	7.0
60	15.1	12.3	13.9	11.3	13.6	15.8	13.7	12.3	15.2	11.0	12.2	7.1
65	15.3	12.5	14.1	11.5	13.9	16.1	14.0	12.5	15.5	11.2	12.4	7.3
70	15.5	12.6	14.3	11.6	14.0	16.3	14.1	12.6	15.7	11.4	12.5	7.4
75	15.7	12.8	14.4	11.8	14.2	16.5	14.3	12.8	15.9	11.5	12.7	7.5

The values given are mean values from different subjects without evidence of neuromuscular disease. The standard deviation of each value is 15 percent (20 potentials for each muscle). Therefore, deviations up to 20 percent are considered within the normal range when comparing measurements in a given muscle with the values of the table.

Source: From Buchthal,[32] with permission.

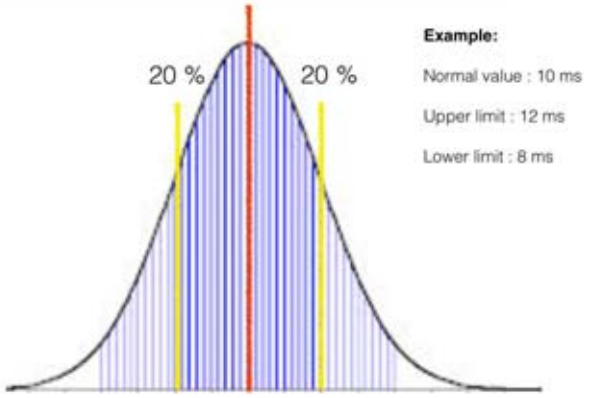
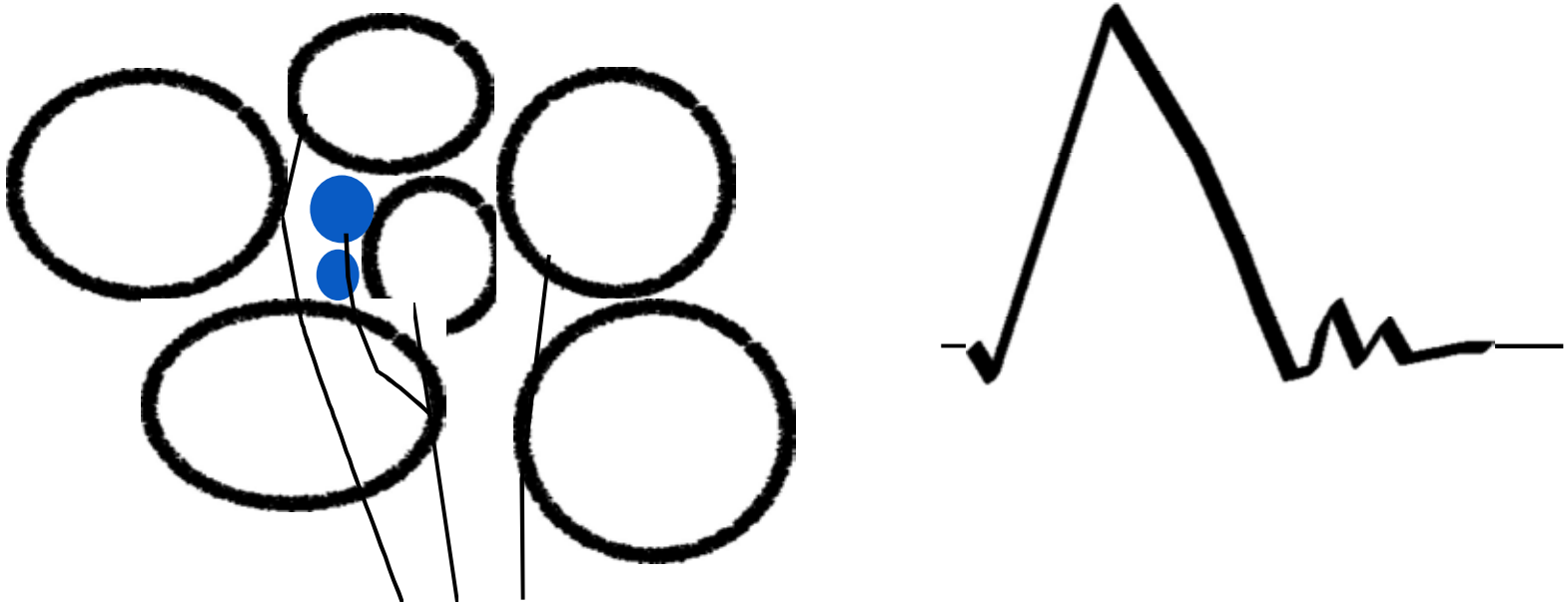
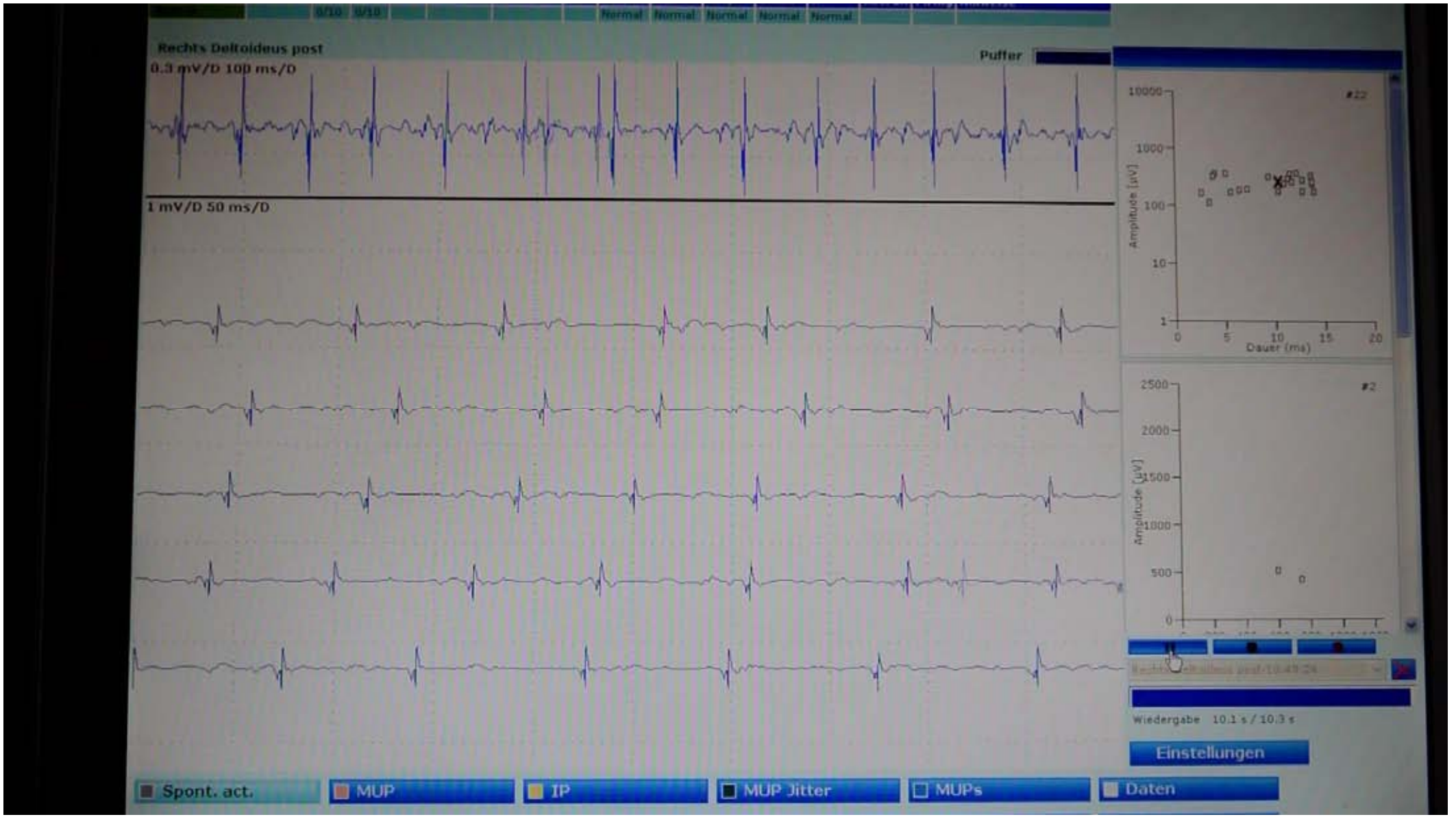
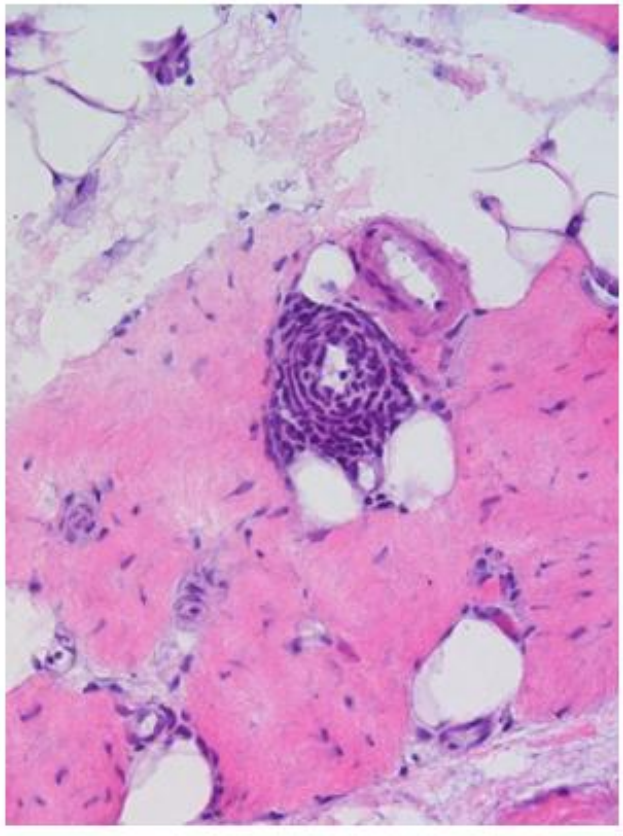


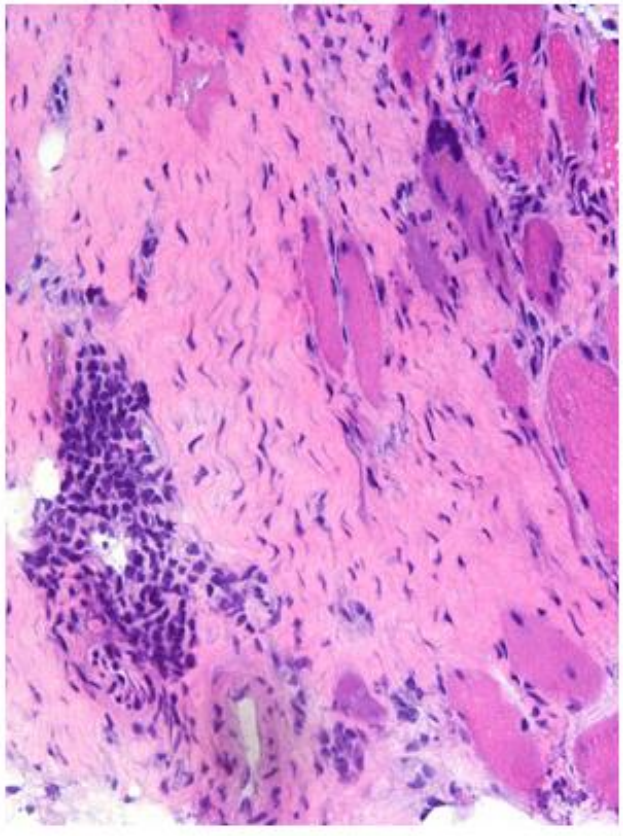
Table 26–10 Disorders Associated with Long-Duration MUPs

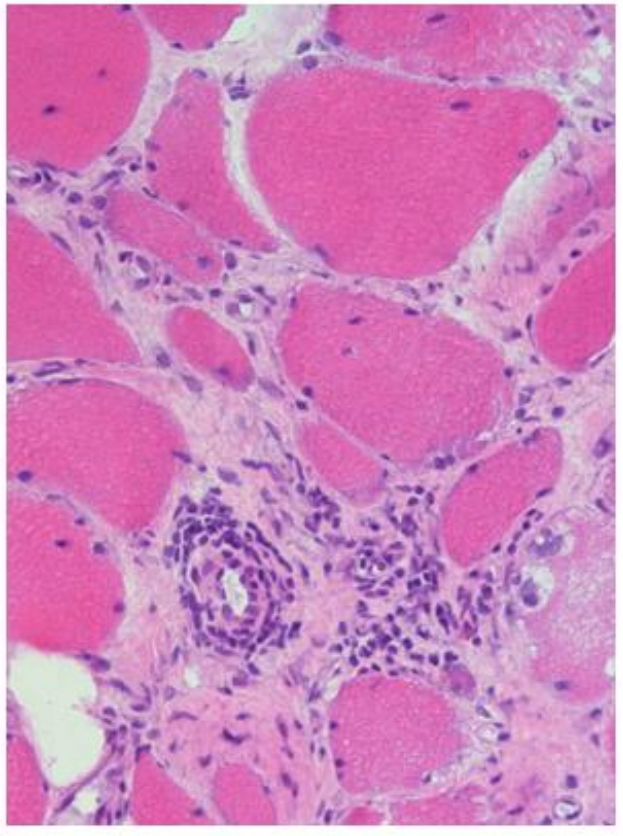
Neurogenic disorders	Motor neuron diseases (e.g., ALS, poliomyelitis, spinal muscular atrophy) Chronic axonal neuropathies (e.g., hereditary motor sensory neuropathy type 2, diabetic neuropathy) Chronic radiculopathies or the residua of an old radiculopathy Chronic mononeuropathies or the residua of an old mononeuropathy
Myopathies	Chronic myopathies (e.g., inclusion body myositis)




Rechts Deltoideus post
Puffer
0.3 mV/D 100 ms/D
1 mV/D 50 ms/D
Amplitude [µV]
Dauer (ms)
Wiedergabe 10.1 s / 10.3 s
Einstellungen
Spont. act.
MUP
IP
MUP Jitter
MUPs
Daten







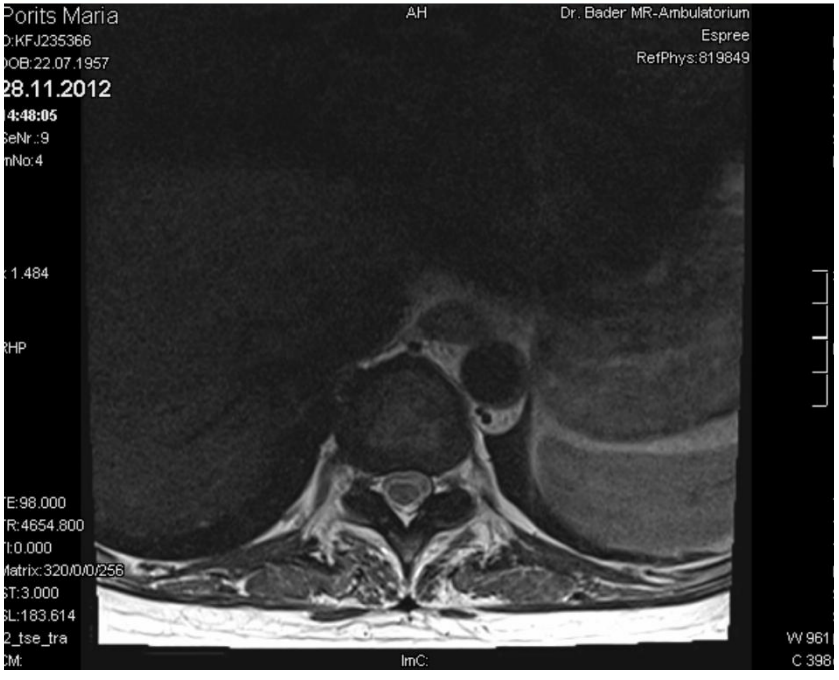
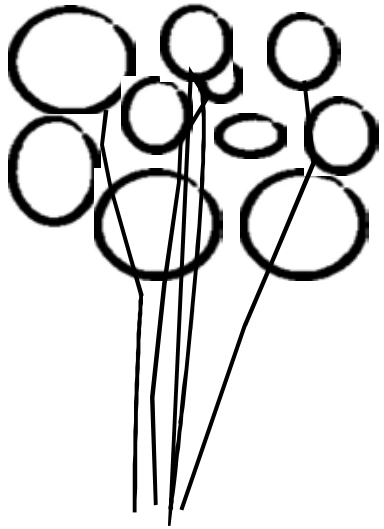
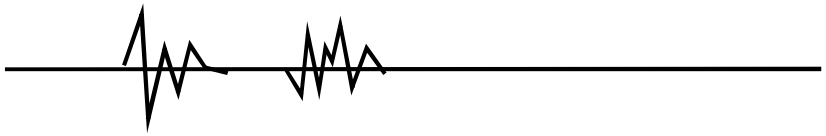

Porits Maria
AH
Dr. Bader MR-Ambulatorium
Espree
RefPhys:819849
28.11.2012
W 961
C 398

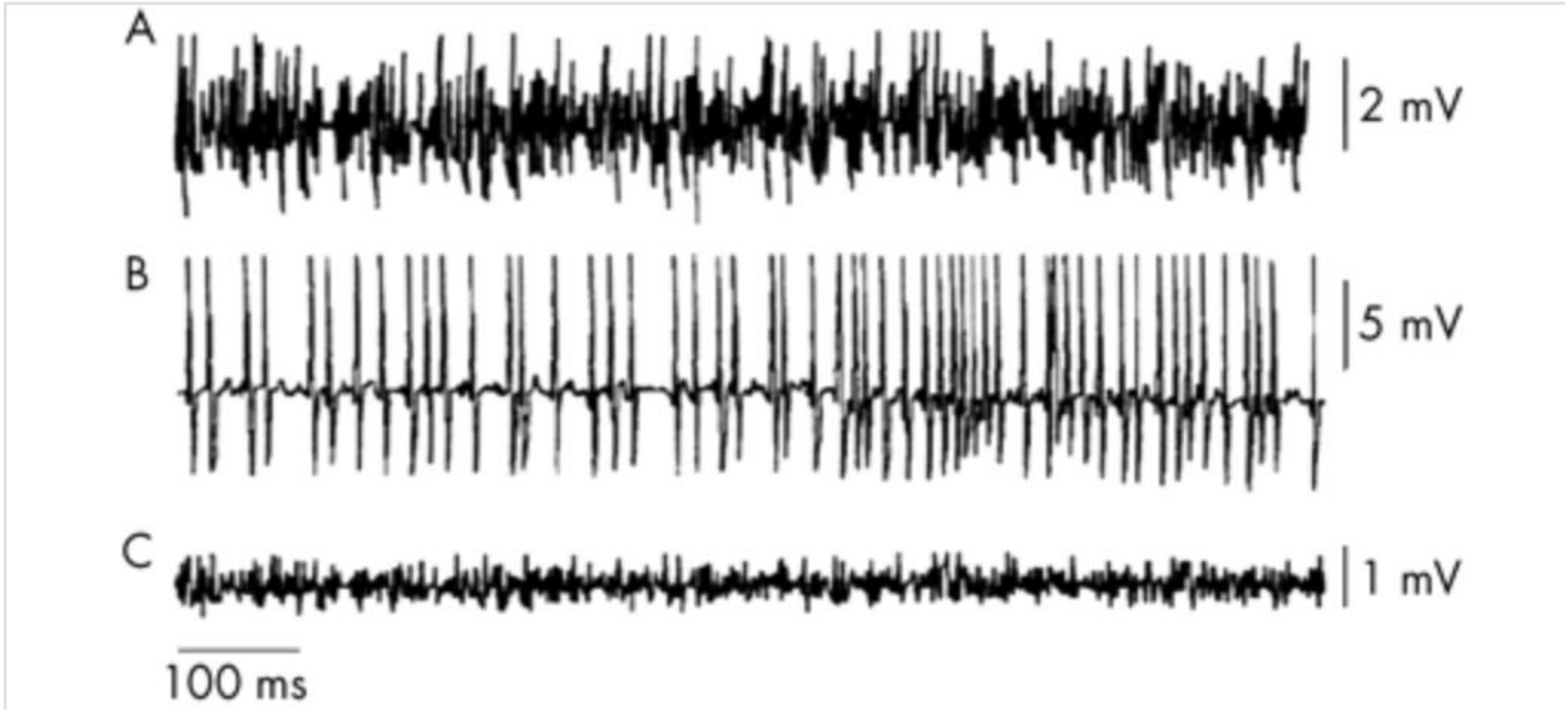
Table 26–11 Disorders Associated with Short-Duration MUPs

Myopathies	Muscular dystrophies Inflammatory myopathies (e.g., polymyositis, inclusion body myositis) Infiltrative myopathies (e.g., sarcoidosis, amyloid) Toxic myopathies (e.g., lipid-lowering agents, chloroquine) Congenital myopathies Endocrine myopathies (e.g., hypothyroid)
Neuromuscular junction disorders	Myasthenia gravis Lambert–Eaton myasthenic syndrome Botulinum intoxication
Neurogenic disorders	Early reinnervation after nerve damage ("nascent MUP") Late-stage neurogenic atrophy
Disorders of muscle membrane	Periodic paralysis





Recruitement/“Interference pattern



From: *J Neurol Neurosurg Psychiatry* 2005;**76**:ii32-ii35 doi:10.1136/jnnp.2005.069211

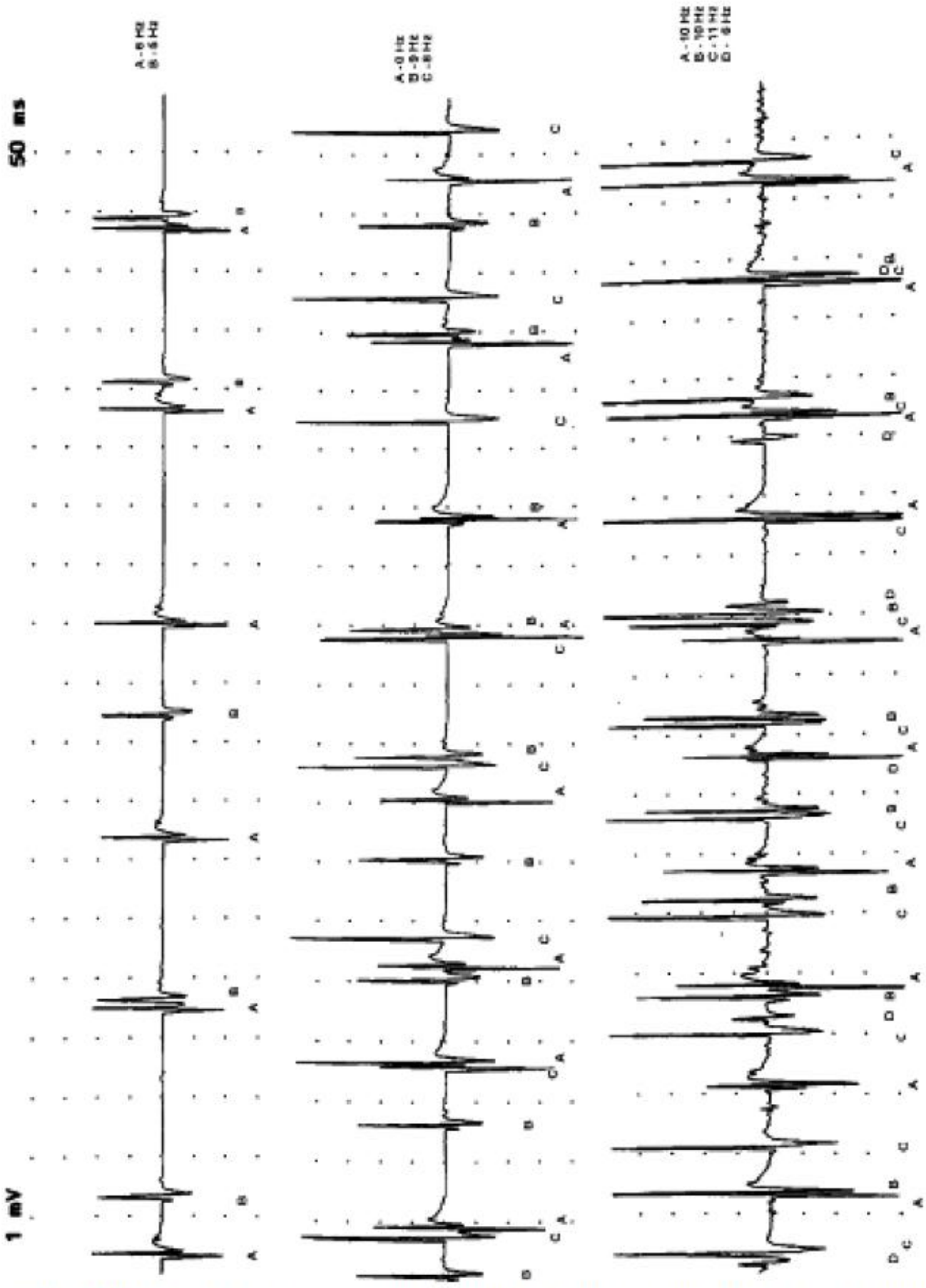
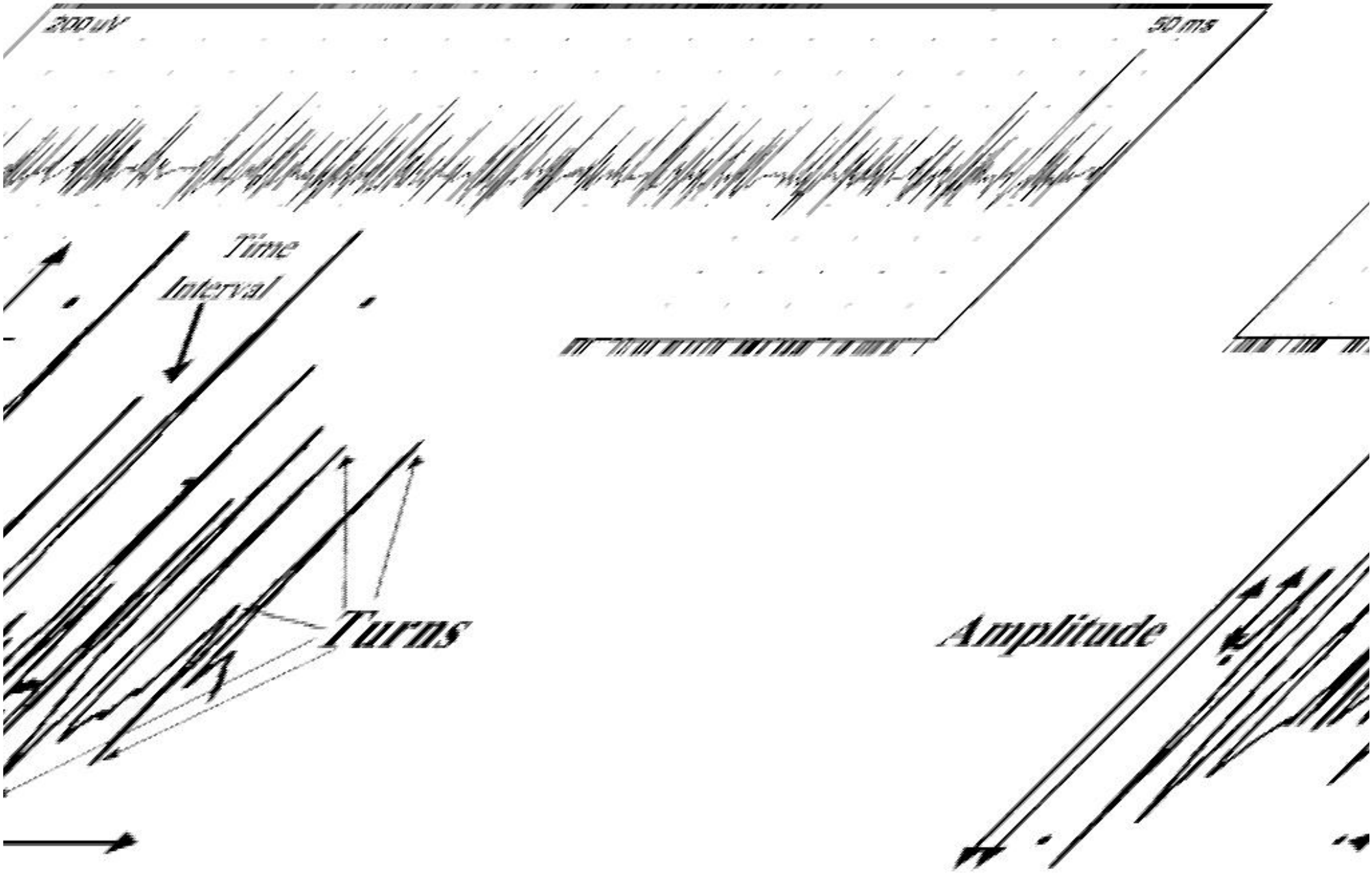


Figure 26–7. MUP firing under voluntary control showing minimal reduction in recruitment in an extensor carpi radialis muscle with normal strength. *Top*, Two motor units (*A* and *B*) initially fire at 5 and 6 Hz. *Middle*, With increased voluntary effort, firing rate of *A* and *B* increases to 8 and 9 Hz, with recruitment of a third unit (*C*). *Bottom*, With greater effort, the rates increase to 10 and 11 Hz, with no additional nearby units recruited. Only a small, distant unit begins firing at 7 Hz (*D*). (From Daube, J. R. 2000. Electrodiagnostic studies in amyotrophic lateral sclerosis and other motor neuron disorders. *Muscle & Nerve* 23:1488–502. By permission of John Wiley & Sons.) (From Daube JR. AAEM minimonography #11: needle examination in clinical electromyography. Muscle & Nerve. 1991;14:685–700. Used with permission of the publisher.)

Interference pattern Turn/Amplitude



Single Fiber EMG: SFEMG

- **Identify the presence of a disorder of neuromuscular transmission when other electrophysiologic assessments are normal.**
- **Follow the course of mild defects of neuromuscular transmission.**
- **Identify the presence of signs of regeneration in neurogenic and myopathic**
- **Fiber density**
- **Calculate muscle fiber membrane propagation velocity**

- Fiber density reflects the packing density of muscle fibers within the recording area of the single fiber electrode. It correlates with the degree of motor unit potential polyphasia in concentric needle EMG recordings. Fiber density is increased in neurogenic and myopathic disease.

- Jitter measures the latency variability of muscle fiber action potentials within the same motor unit. It reflects the variability in rise time of the end plate potential, providing a sensitive indicator of a mild defect of neuromuscular transmission.

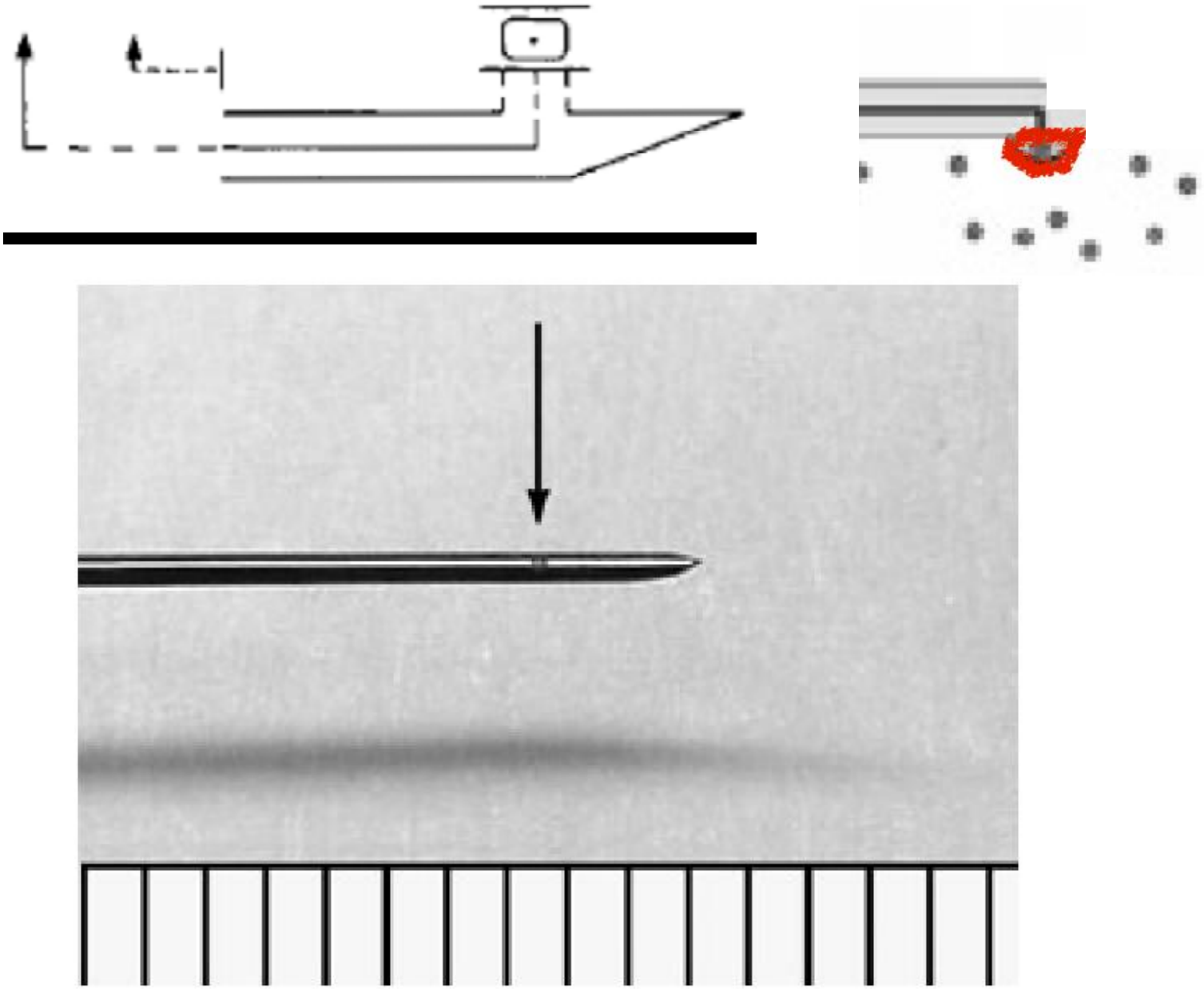
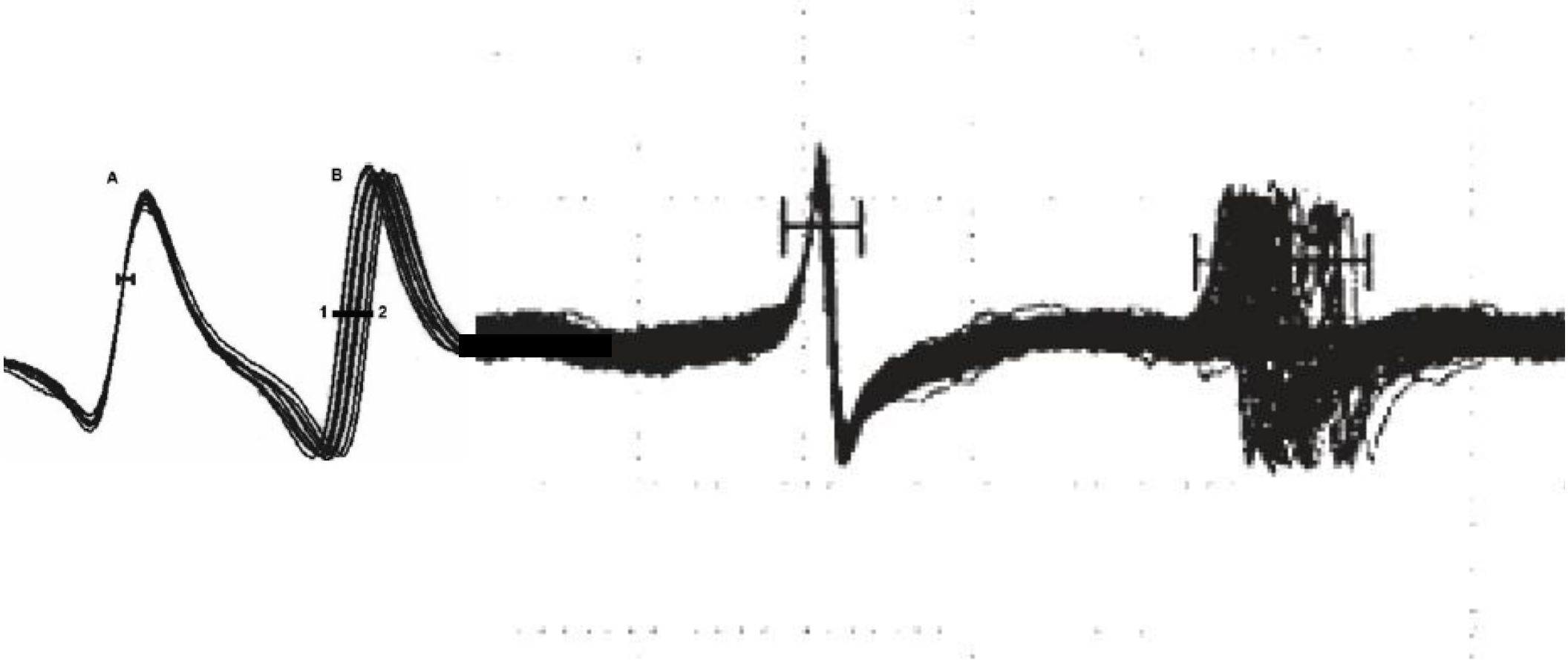


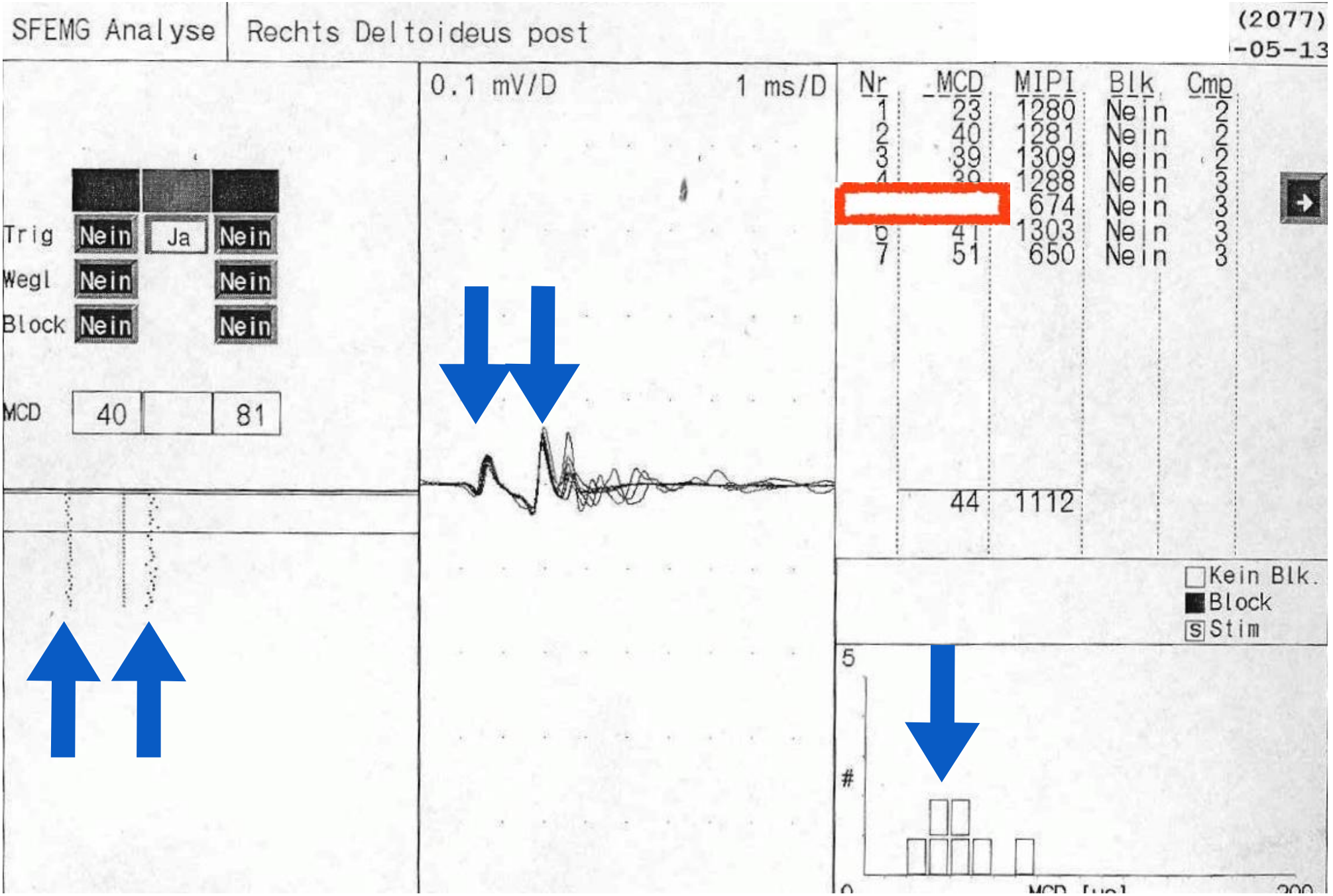
Figure 28–1. SFEMG electrode with active electrode (*arrow*) located along needle shaft proximal to tip of needle.

What do you need ?

- SFEMG needle or
- Concentric needle
- Spontaneous vs simulated
- Software

Jitter

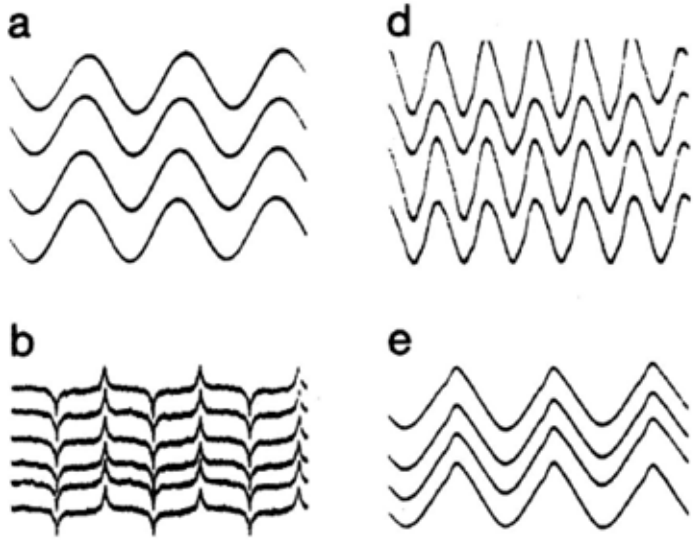



SFEMG Analyse
Rechts Deltoideus post
(2077)
-05-13
0.1 mV/D
1 ms/D
Trig
Wegl
Block
Nein
Ja
MCD
40
81
Nr
MCD
MIPI
Blk
Cmp
1 23 1280 Nein 2
2 40 1281 Nein 2
3 39 1309 Nein 2
1288 Nein 3
674 Nein 3
1303 Nein 3
7 51 650 Nein 3
44 1112
Kein Blk.
Block
Stim
5
#
0
MCD [us]
200

Jitter Measurement During Voluntary Activation

Artefacts

- Electrode noise
- Amplifier noise
- Defect recording electrodes
- Movement artifact
- Electrostatic and magnetic interference
- Radio- and mobile phone interference



EMG complications

- Anticoagulation and bleeding
- Lymph edema and skin
- Infections
- Peripleural muscles
- Pacemaker
- Obese patients
- Low pain tolerance

Table 1. Effects of 60-Hz electrical shock current through the body trunk in an average individual.*

Current intensity (mA)	Effect
1	Sensation threshold
5	Accepted as maximum harmless current intensity
10–20	"Let-go" current before sustained muscle contraction
50	Pain; possible fainting, exhaustion, mechanical injury; heart and respiratory functions continue
100–300	Ventricular fibrillation starts, but respiratory center remains intact; usually results in death

*The effects are indicated of current flowing from one side of the body to the other, in contrast to nerve conduction studies (NCS) where current flow is restricted to the area immediately under the stimulator. From Oh,[38] with permission.

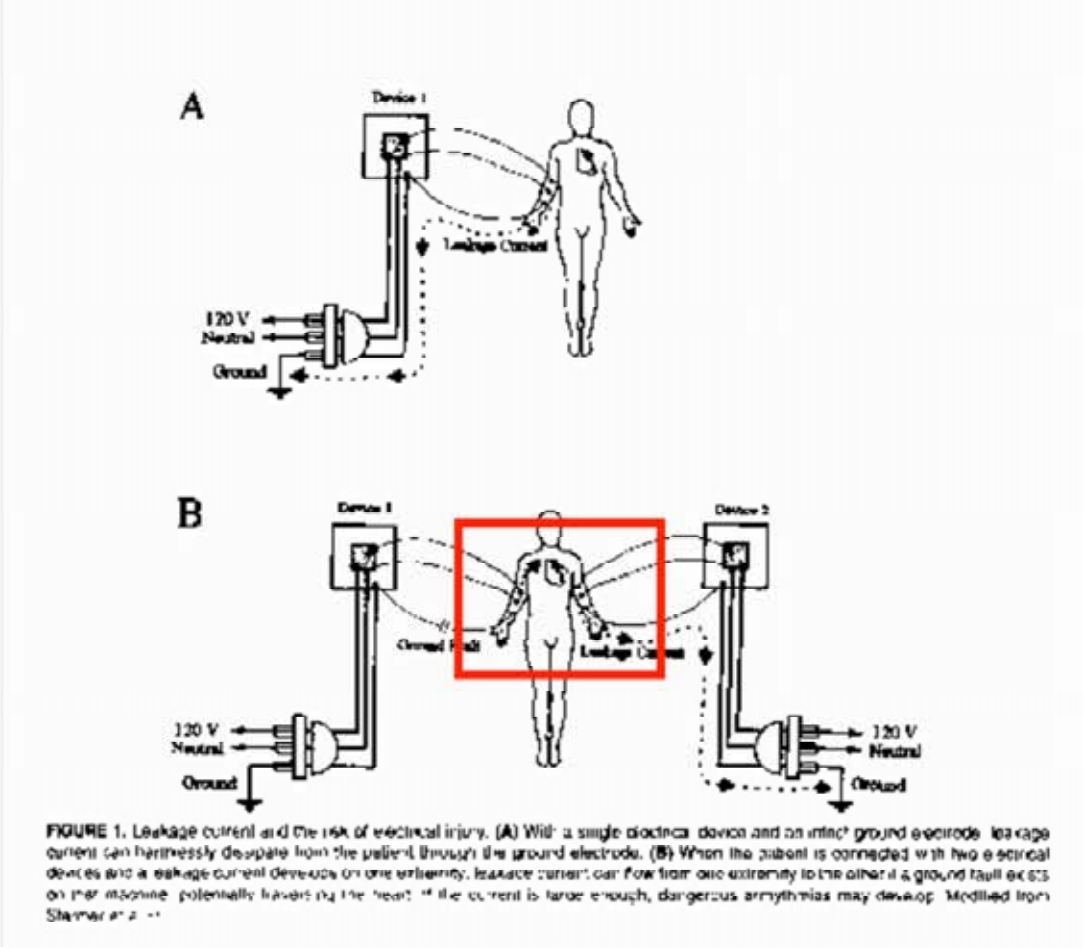
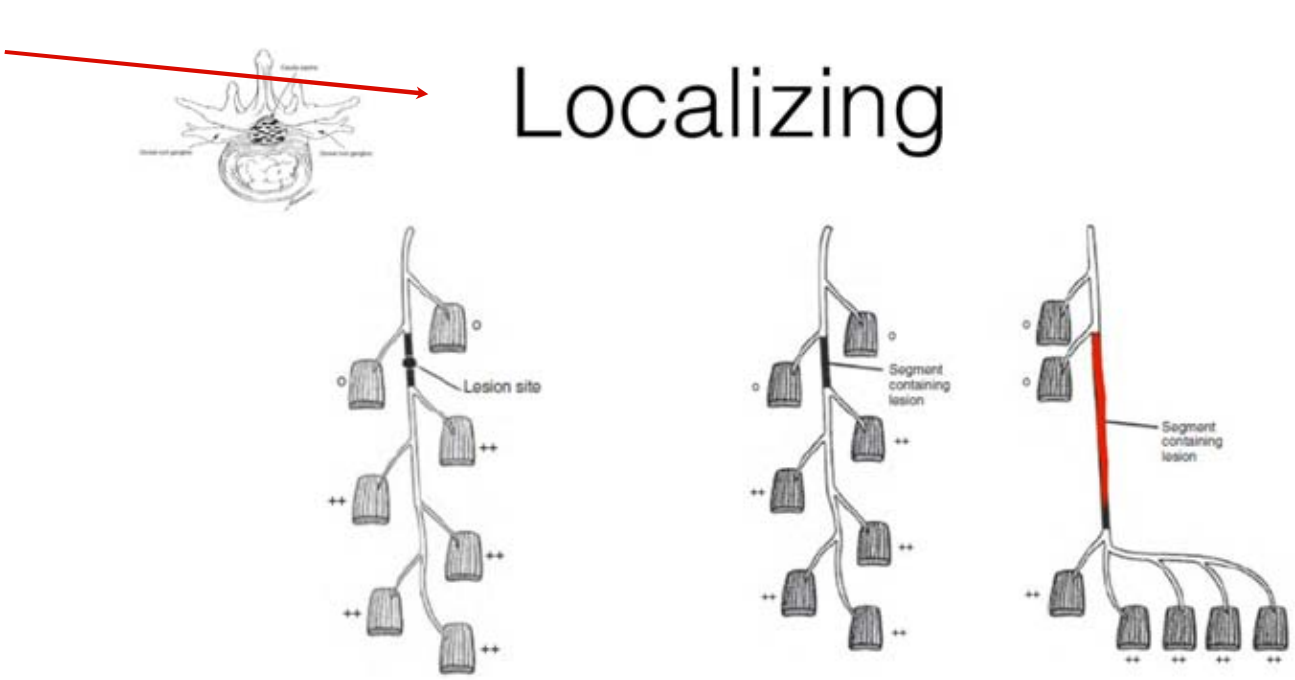


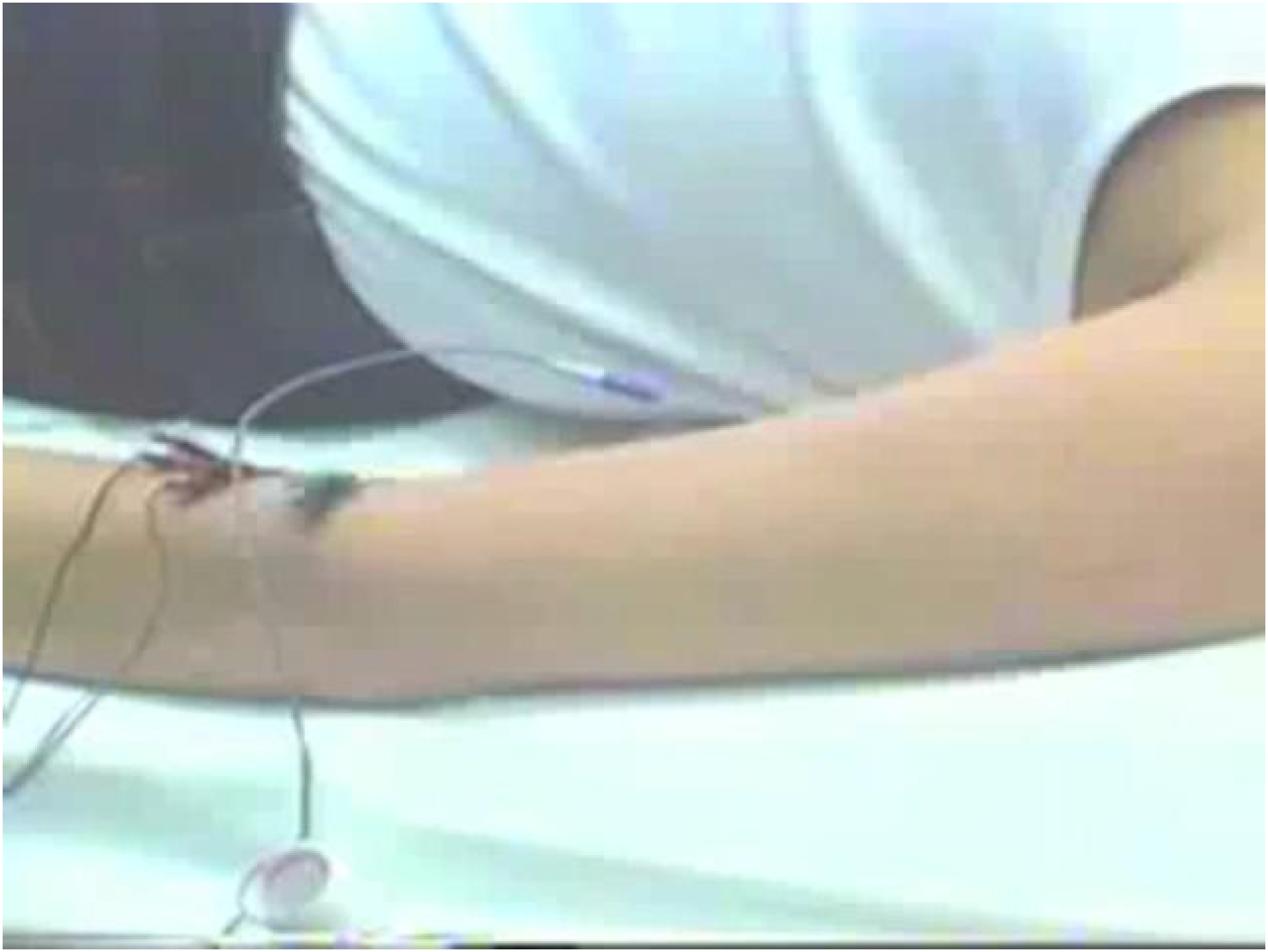
FIGURE 1. Leakage current and the risk of electrical injury. (A) With a single electrical device and an intact ground electrode, leakage current can harmlessly dissipate from the patient through the ground electrode. (B) When the patient is connected with two electrical devices and a leakage current develops on one extremity, leakage current can flow from one extremity to the other and a ground fault exists on the machine, potentially harmful to the heart. If the current is large enough, dangerous arrhythmias may develop. Modified from Skinner et al.[41]

- Muscle Nerve: 1. Al-Shekhlee A, et al. Iatrogenic complications and risks of nerve conduction studies and needle electromyography. Muscle Nerve 2003;27:517-526.

Examples of Diseases

- Localizing
- Distribution
- Myopathies
- Polygraphy
- Interventions





Interventions

- Botulinus toxin treatment
- Infiltration
- Pain therapy

Reporting normal Rt biceps brachii

- Rt. biceps brachii muscle
- Conditions: good, impression: normal muscle, no atrophy
- At 6/6 positions no spontaneous activity. The mean duration of the MUAPs is 10,5 ms (age related normal value 10 ms), which corresponds to + 5 %. Maximal contraction shows an interference pattern with an amplitude of 2 mV.

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