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# Electromyography, evoked potentials

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# DEFINITION OF ELECTROMYOGRAPHY (EMG)

EMG is an electrodiagnostic method aimed at the diagnosis of neuromuscular disorders (i.e., involvement of peripheral motor, sensory, and autonomic neurons, neuromuscular transmission and voluntary muscles).

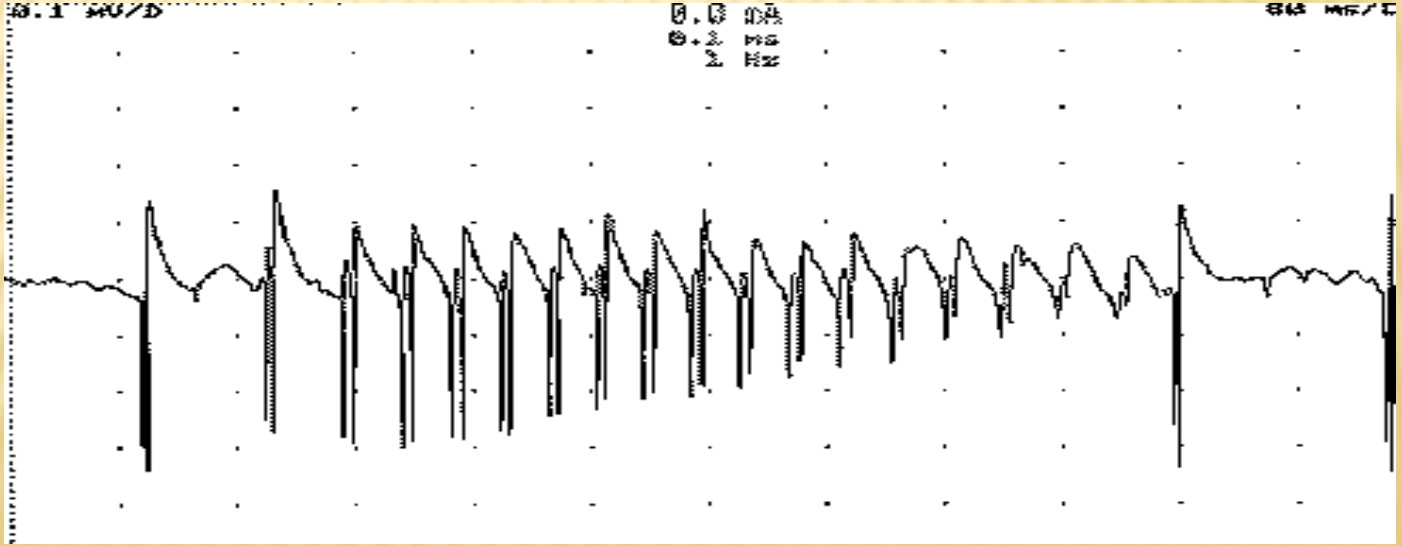
Methodologically it comprises two groups of techniques:

- **Needle EMG** using needle recording electrodes for registration of bioelectrical potentials from voluntary muscles;
- **Conduction studies** using artificial electrical stimulation of nerves and recording evoked responses from muscles or nerves with surface recording electrodes.

# NEEDLE EMG I

## 1. Insertion activity:

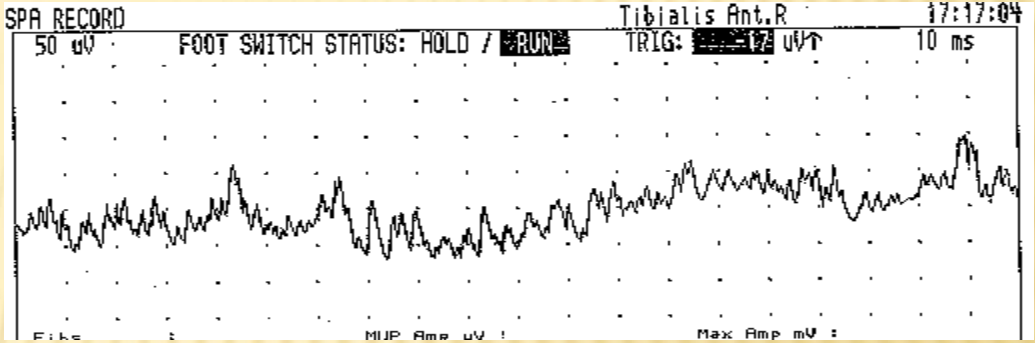
Example of abnormal insertion activity: **myotonic discharges**



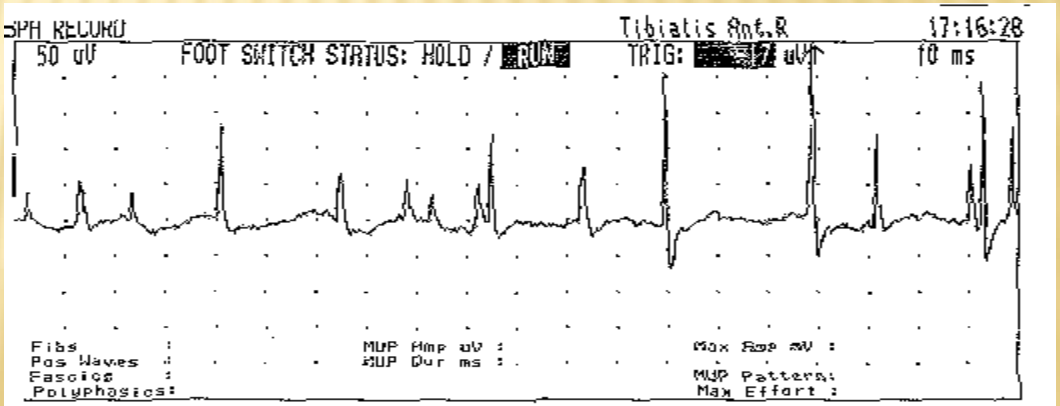
# NEEDLE EMG II

## 2. Abnormal spontaneous activity: end-plate activity

- („end-plate noise“)



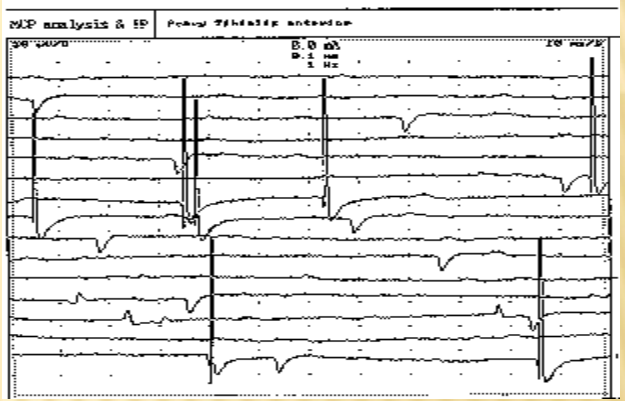

- („end-plate spikes“)

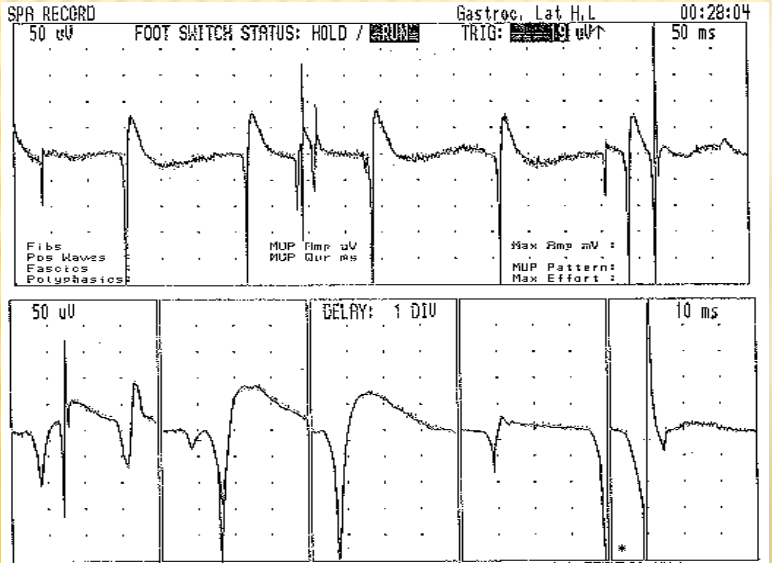


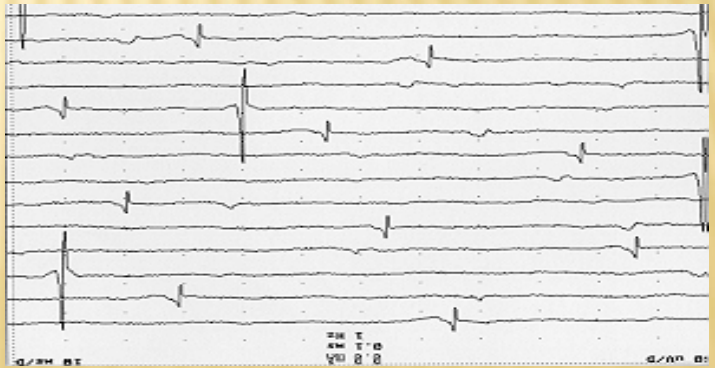
# NEEDLE EMG III

**2. Abnormal spontaneous activity:**

**fibrillation potentials and positive sharp waves**



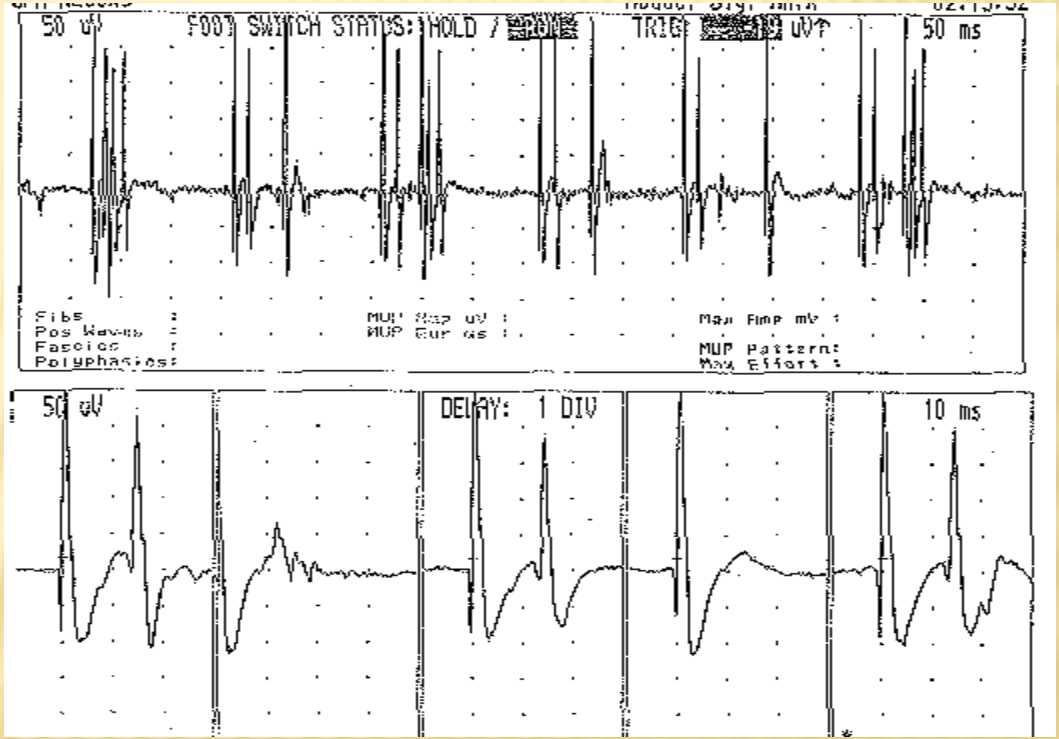


# NEEDLE EMG IV

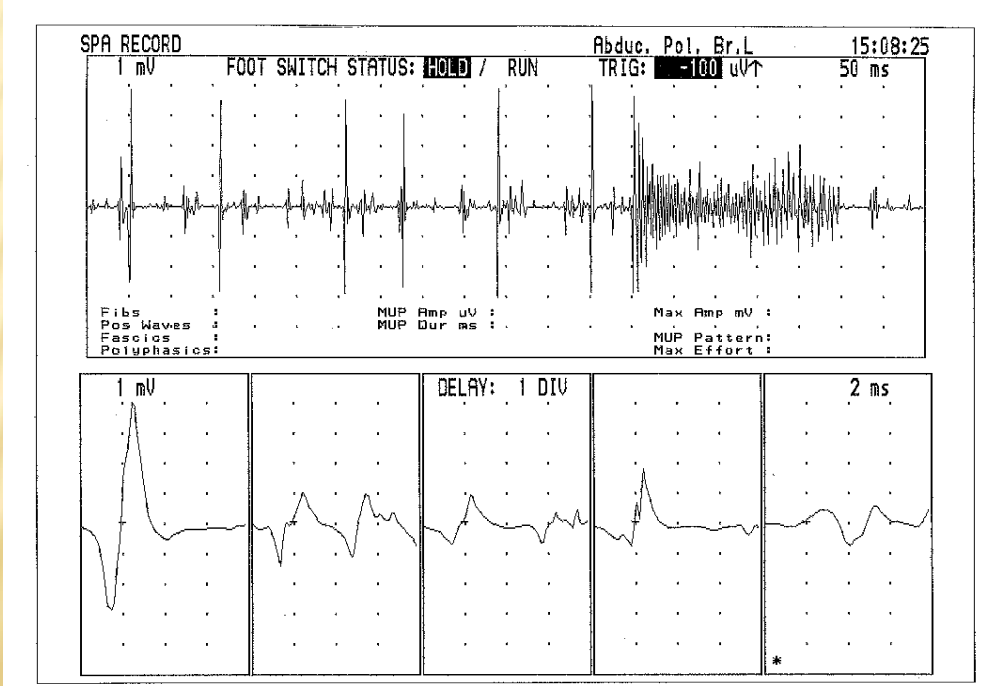
2. Abnormal spontanneous activity:

   tetanic discharges (dublets, triplets, multiplets)



# NEEDLE EMG V

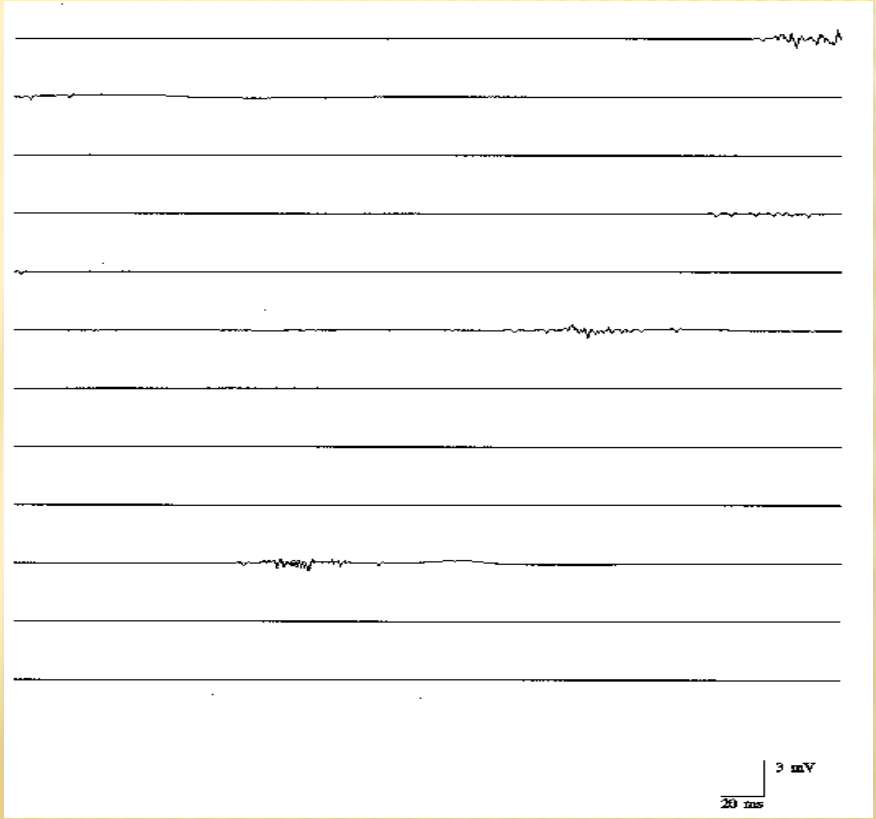
## 2. Abnormal spontaneous activity: neuromyotonic discharges



# NEEDLE EMG VI

3. **Quantification of parameters of motor unit potentials (MUPs) – indicator of microarchitecture of motor unit**

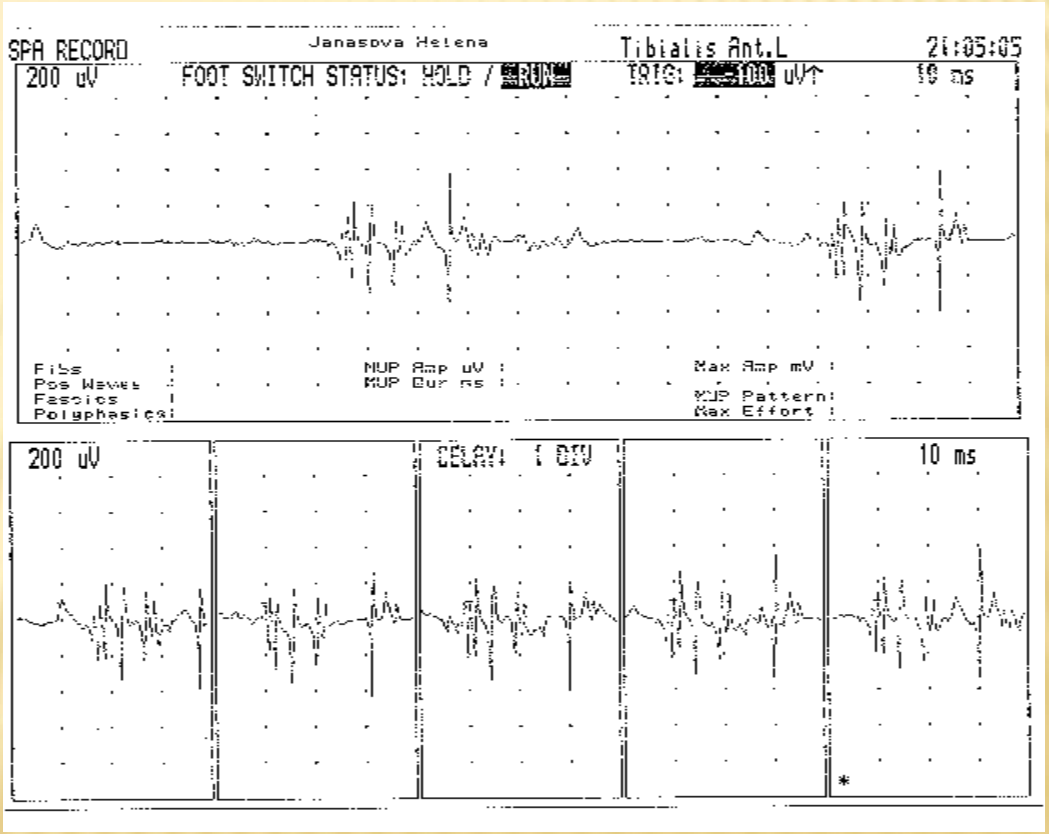
➔ **Signs of new re-innervation**



# NEEDLE EMG VII

3. Quantification of parameters of motor unit potentials (MUPs) – indicator of microarchitecture of motor unit

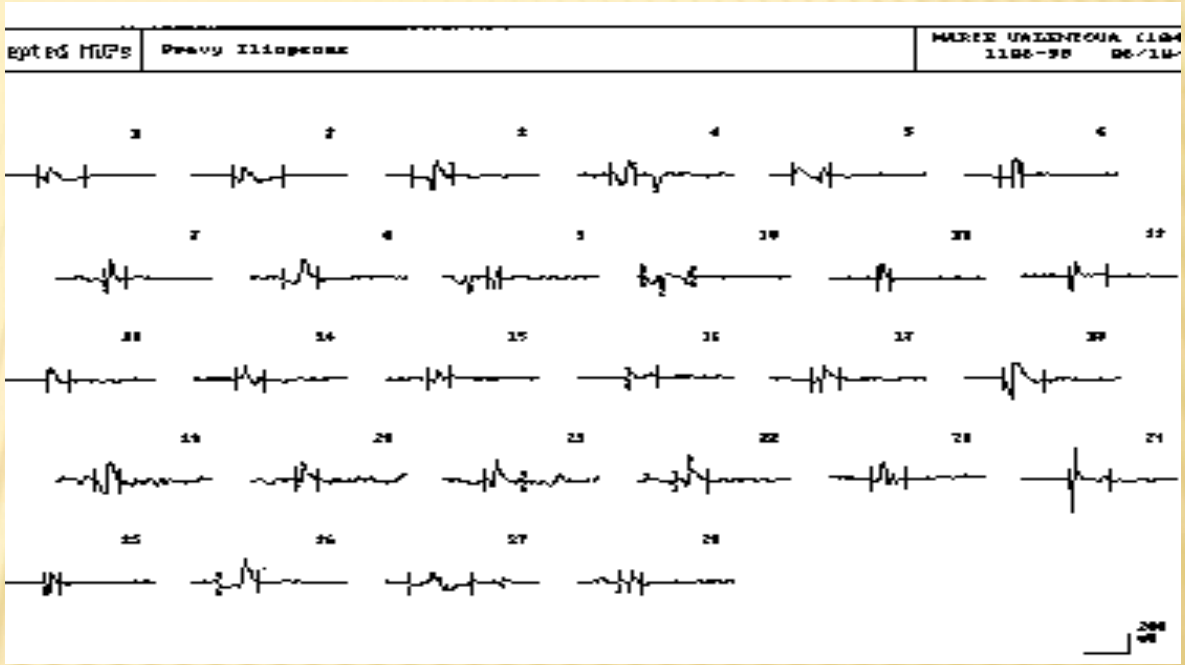
➔ Signs of chronic re-innervation



# NEEDLE EMG VIII

3. Quantification of parameters of motor unit potentials (MUPs) – indicator of microarchitecture of motor unit

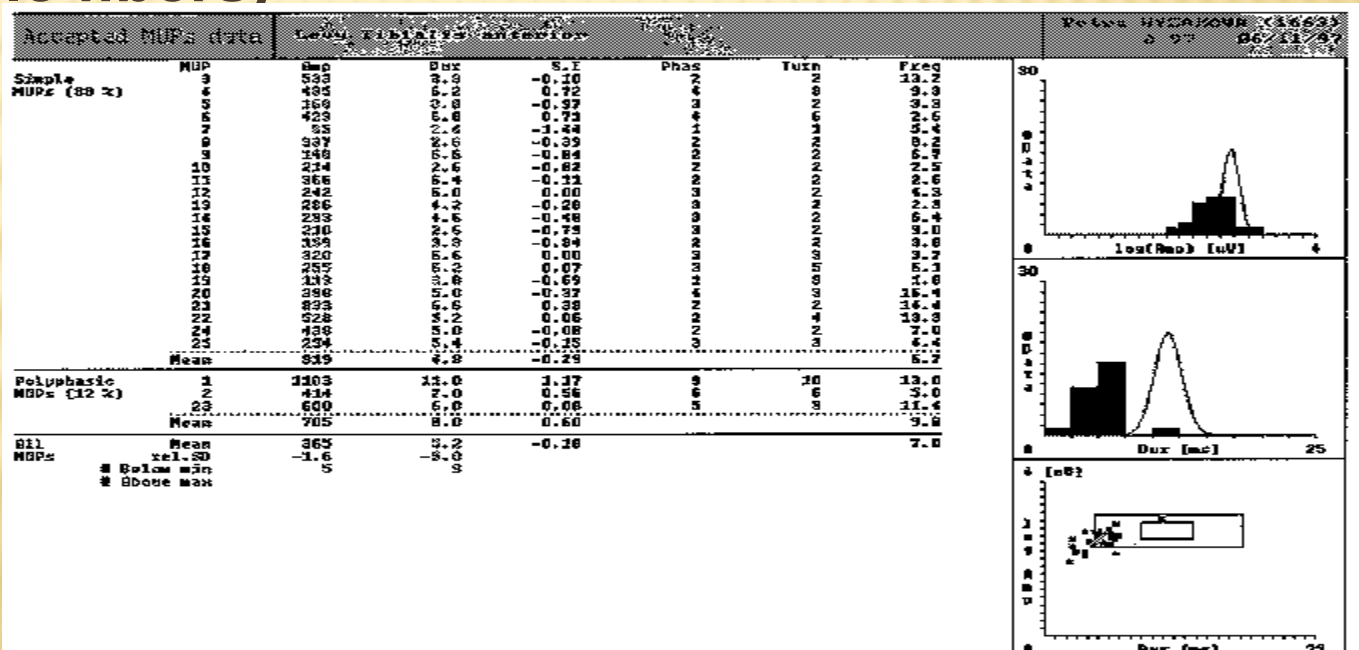
➔ Signs of myogenic lesion (decreased number of muscle fibers)



# NEEDLE EMG IX

**3. Quantification of parameters of motor unit potentials (MUPs) – indicator of microarchitecture of motor unit**

- **Signs of myogennic lesion (decreased number of muscle fibers)**

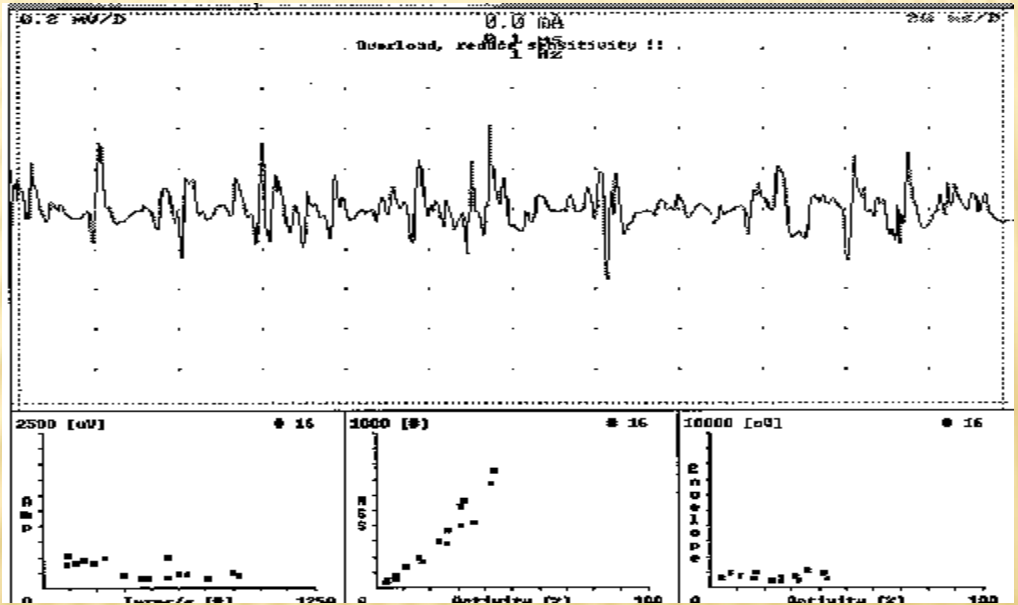


Accepted MUPs data — Tibialis anterior

| | MUP | Amp | Dur | S.I | Phas | Turn | Freq |
|---|---|---|---|---|---|---|---|
| Simple MUPs (89 %) | 3 | 533 | 8.9 | -0.10 | 2 | 2 | 13.2 |
| | 4 | 485 | 6.2 | 0.72 | 4 | 8 | 9.3 |
| | 5 | 169 | 9.8 | -0.97 | 3 | 2 | 3.3 |
| | 6 | 423 | 6.8 | 0.73 | 4 | 6 | 2.6 |
| | 7 | 85 | 2.4 | -1.44 | 1 | 3 | 5.4 |
| | 8 | 337 | 8.6 | -0.39 | 2 | 2 | 8.2 |
| | 9 | 148 | 6.6 | -0.84 | 2 | 2 | 6.7 |
| | 10 | 214 | 2.6 | -0.82 | 2 | 2 | 2.5 |
| | 11 | 366 | 6.4 | -0.11 | 2 | 2 | 2.6 |
| | 12 | 242 | 6.0 | 0.00 | 3 | 2 | 6.3 |
| | 13 | 286 | 4.2 | -0.20 | 3 | 2 | 2.3 |
| | 14 | 293 | 4.6 | -0.48 | 3 | 2 | 6.4 |
| | 15 | 230 | 2.6 | -0.79 | 3 | 2 | 9.0 |
| | 16 | 338 | 3.8 | -0.84 | 2 | 2 | 3.8 |
| | 17 | 320 | 5.6 | 0.00 | 3 | 3 | 3.7 |
| | 18 | 255 | 5.2 | 0.07 | 3 | 5 | 5.1 |
| | 19 | 113 | 3.8 | -0.69 | 1 | 3 | 1.8 |
| | 20 | 398 | 5.0 | -0.37 | 4 | 8 | 15.4 |
| | 21 | 893 | 6.6 | 0.38 | 2 | 2 | 16.4 |
| | 22 | 528 | 5.2 | 0.06 | 2 | 4 | 13.3 |
| | 24 | 438 | 5.0 | -0.08 | 2 | 2 | 7.0 |
| | 25 | 234 | 5.4 | -0.15 | 3 | 3 | 6.4 |
| | Mean | 319 | 4.8 | -0.29 | | | 5.7 |
| Polyphasic MUPs (12 %) | 1 | 1103 | 11.0 | 1.17 | 9 | 20 | 13.0 |
| | 2 | 414 | 7.0 | 0.56 | 6 | 6 | 3.0 |
| | 23 | 600 | 6.0 | 0.06 | 5 | 9 | 11.4 |
| | Mean | 705 | 8.0 | 0.60 | | | 9.8 |
| All MUPs | Mean | 365 | 5.2 | -0.20 | | | 7.0 |
| | rel.SD | -1.6 | -8.0 | | | | |
| | # Below min | 5 | 5 | | | | |
| | # Above max | | | | | | |

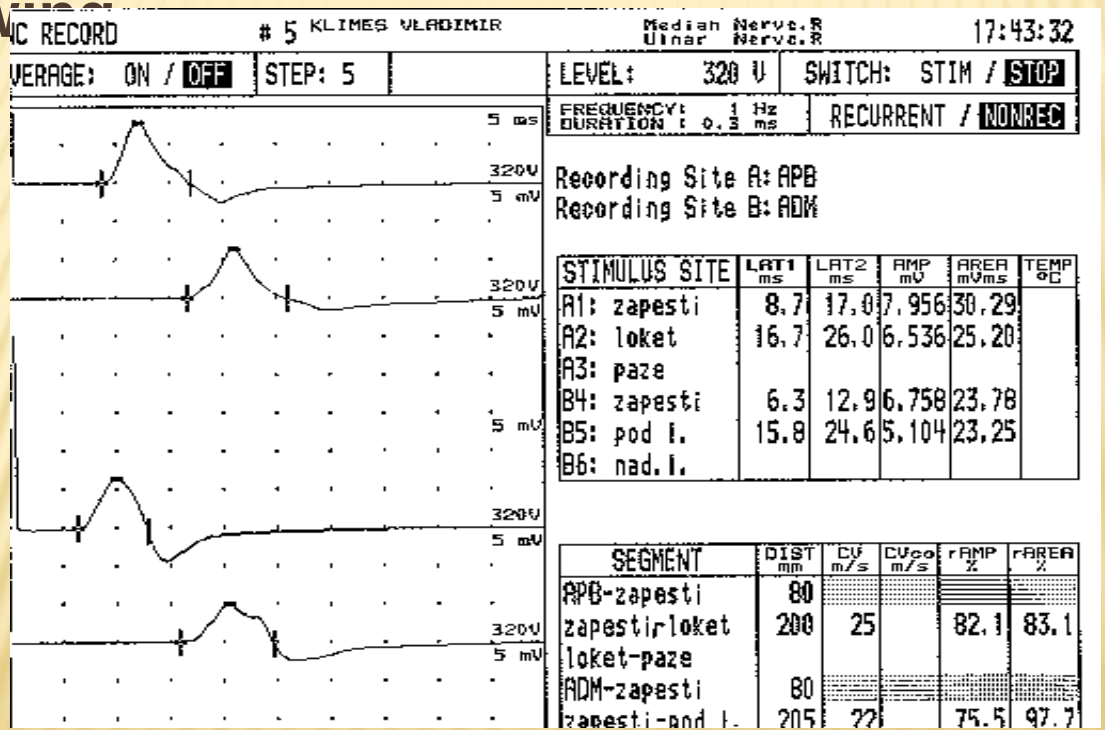
# NEEDLE EMG X

**4. Assessment of recruitment of motor units and interference pattern**



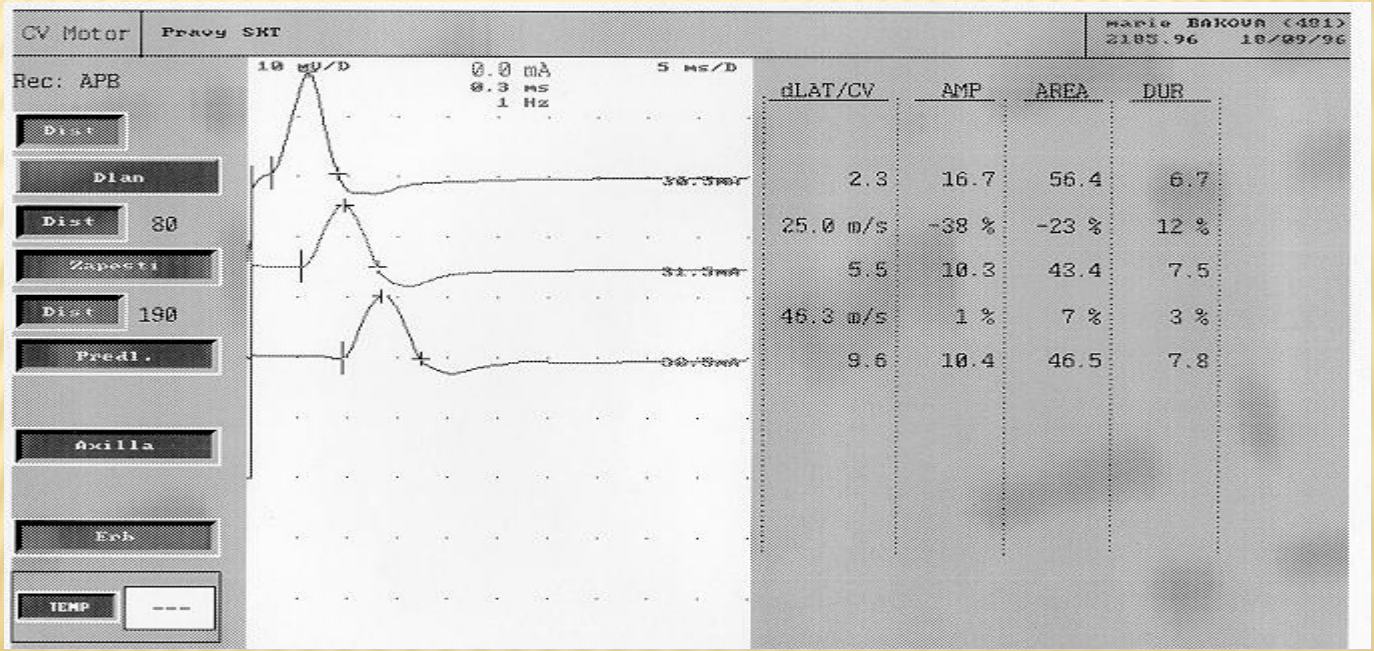
# CONDUCTION STUDIES I

1. Motor conduction studies: diffuse conduction slowing



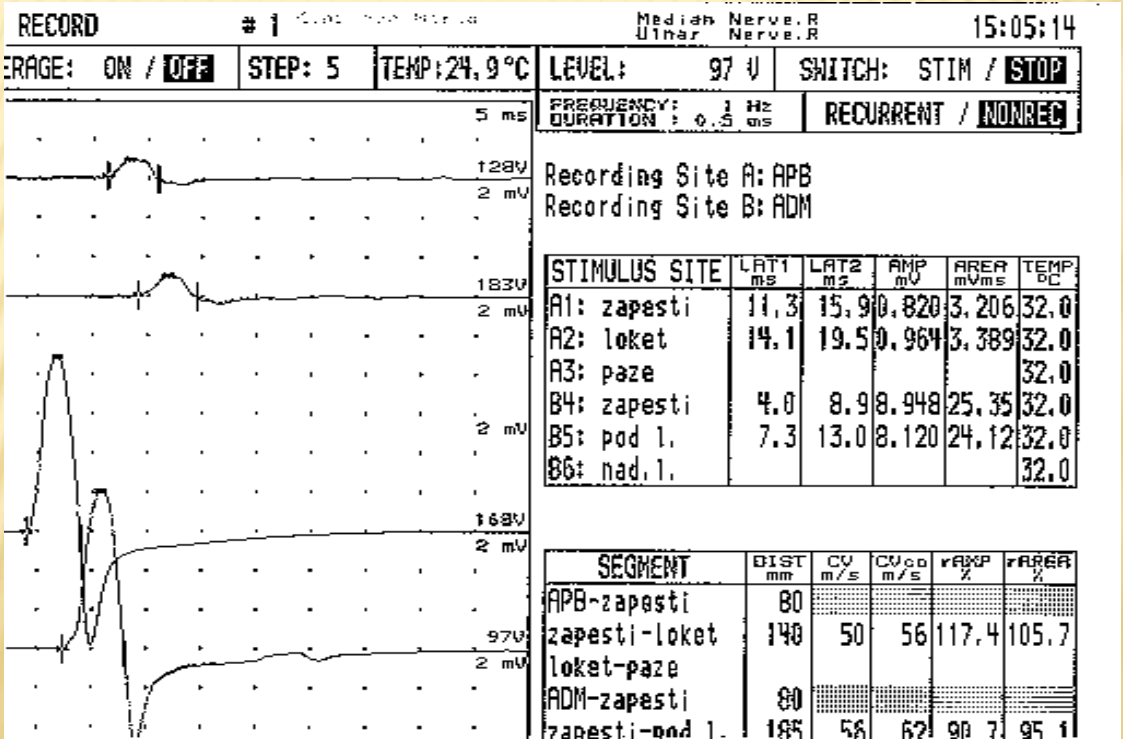
# CONDUCTION STUDIES II

1. **Motor conduction studies : focal conduction slowing + conduction block**



# CONDUCTION STUDIES III

1. **Motor conduction studies : focal conduction slowing + axonal loss**



RECORD # 1 Median Nerve.R Ulnar Nerve.R 15:05:14

ERAGE: ON / OFF | STEP: 5 | TEMP: 24,9 °C | LEVEL: 97 V | SWITCH: STIM / STOP

FREQUENCY: 1 Hz DURATION: 0,5 ms | RECURRENT / NONREC

5 ms

128V 2 mV

183V 2 mV

2 mV

168V 2 mV

97V 2 mV

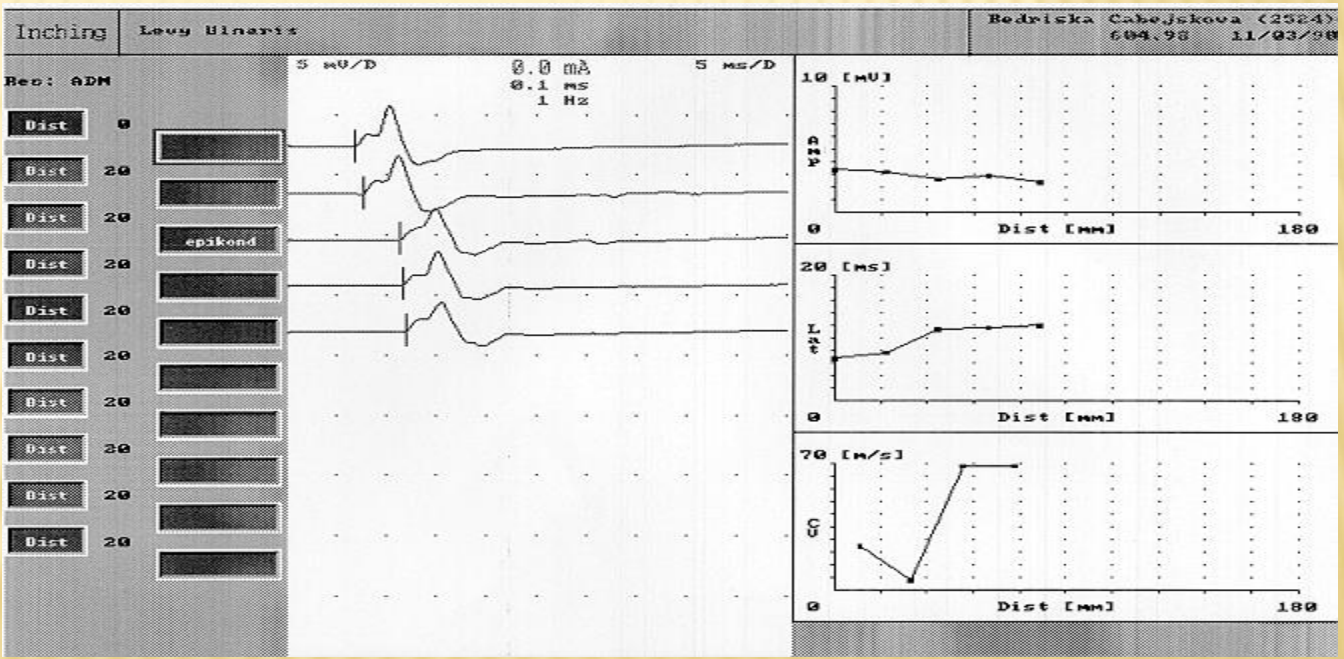
Recording Site A: APB
Recording Site B: ADM

| STIMULUS SITE | LAT1 ms | LAT2 ms | AMP mV | AREA mVms | TEMP °C |
|---|---|---|---|---|---|
| A1: zapesti | 11,3 | 15,9 | 0,820 | 3,206 | 32,0 |
| A2: loket | 14,1 | 19,5 | 0,964 | 3,389 | 32,0 |
| A3: paze | | | | | 32,0 |
| B4: zapesti | 4,0 | 8,9 | 8,948 | 25,35 | 32,0 |
| B5: pod l. | 7,3 | 13,0 | 8,120 | 24,12 | 32,0 |
| B6: nad.l. | | | | | 32,0 |

| SEGMENT | DIST mm | CV m/s | CVcp m/s | rAMP % | rAREA % |
|---|---|---|---|---|---|
| APB-zapesti | 80 | | | | |
| zapesti-loket | 140 | 50 | 56 | 117,4 | 105,7 |
| loket-paze | | | | | |
| ADM-zapesti | 80 | | | | |
| zapesti-pod l. | 185 | 56 | 62 | 90,7 | 95,1 |

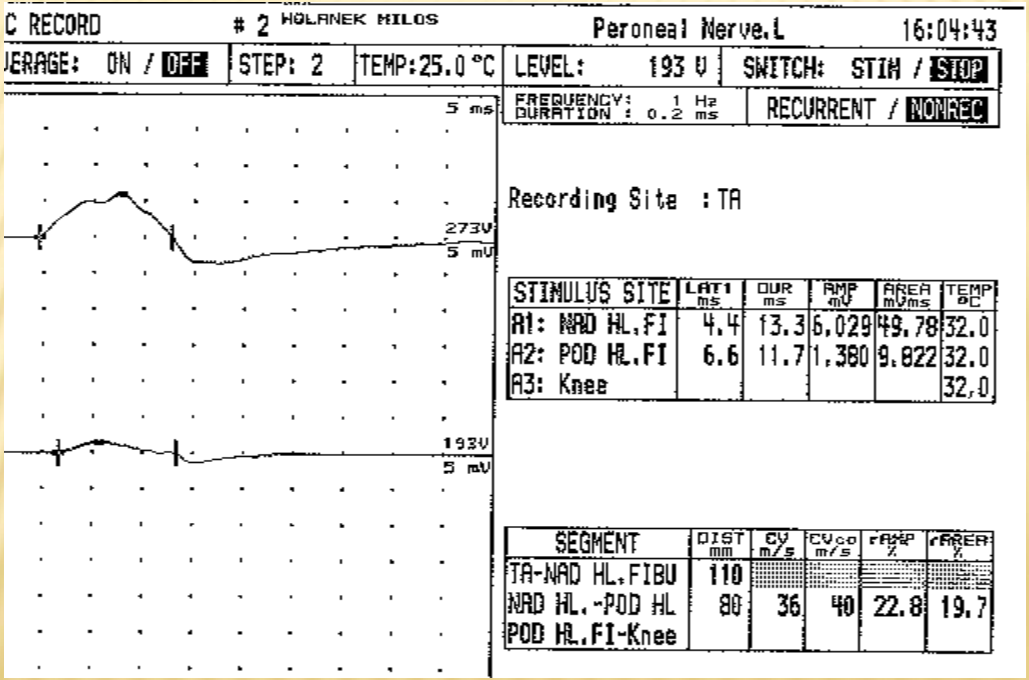
# CONDUCTION STUDIES IV

1. **Motor conduction studies : focal conduction slowing („inching“ technique)**



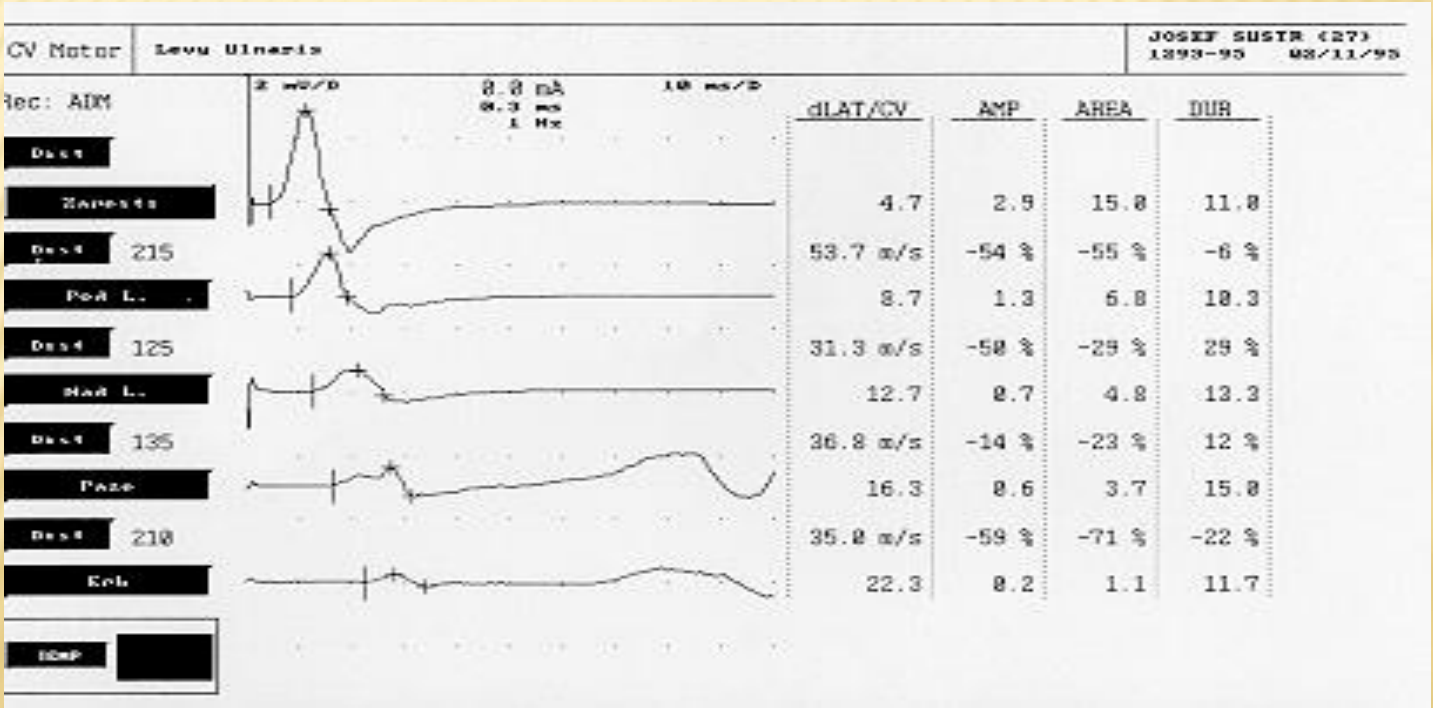
# CONDUCTION STUDIES V

1. **Motor conduction studies : focal parcial conduction block**



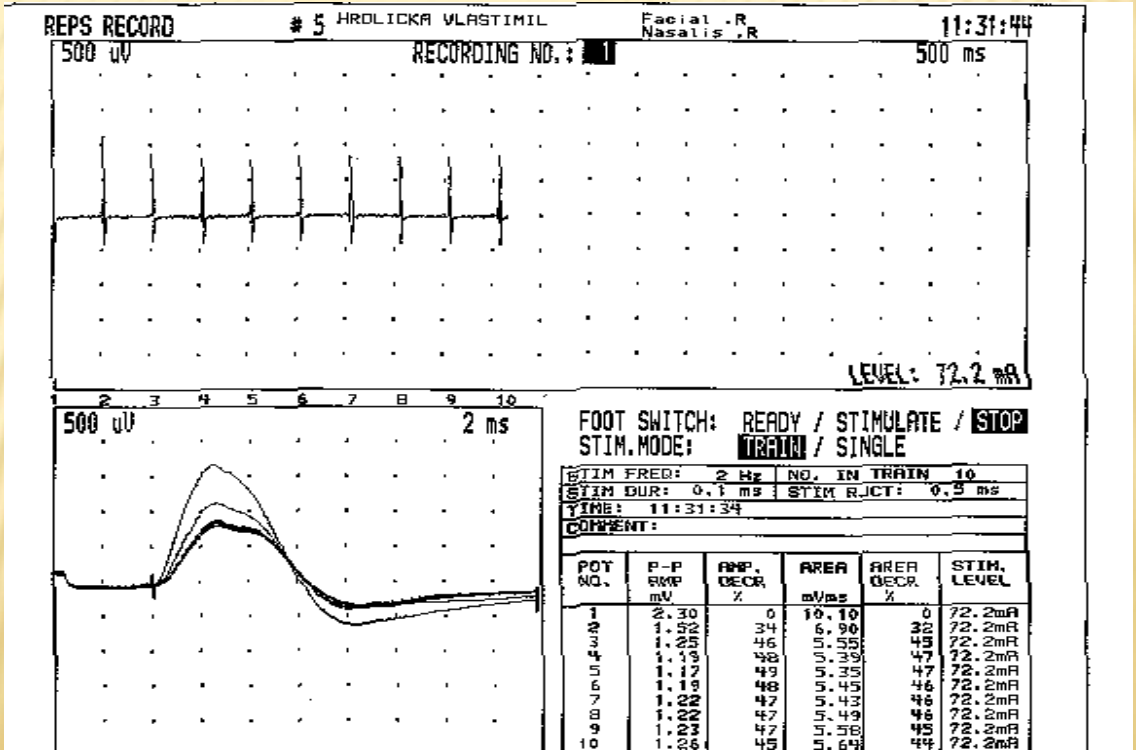
# CONDUCTION STUDIES VI

1. **Motor conduction studies : multifocal conduction slowing + conduction block**



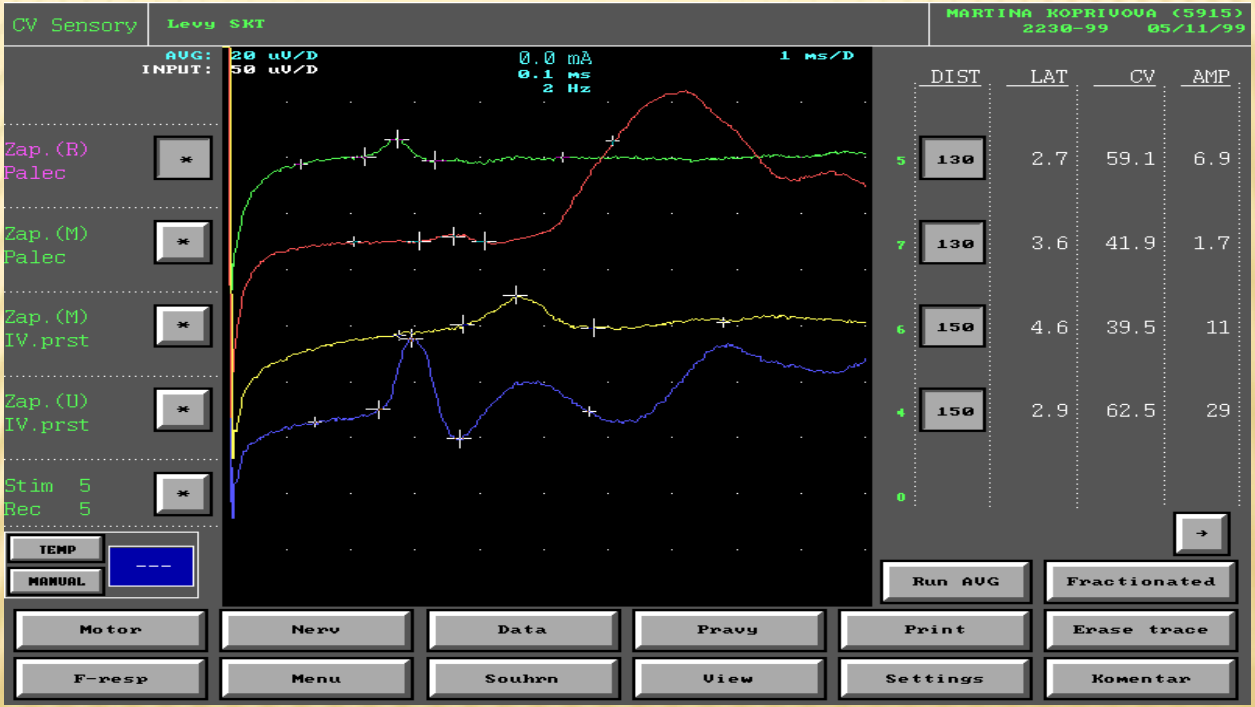
# CONDUCTION STUDIES VII

1. **Motor conduction studies : repetitive stimulation of motor nerve**



# CONDUCTION STUDIES VIII

## 2. Sensory conduction studies:



# EVOKED POTENTIALS (EP): DEFINITION

**Evoked potentials** represents **bioelectrical response of the brain (or spinal cord and peripheral nerves) to external stimuly** (mostly of sensory character) – **sensory EP**.

**Evoked potentials (as a diagnostic method or tool)** are **elektrodiagnostic methods** that register and evaluate bioelectrical potentials triggered by **visual (VEP), auditory (BAEP)** and **somatosensory stimuli (SEP).**

**Motor evoked potentials (MEP)** use magnetic (originally electrical) stimulation to excitate motor cortex (transcranially) and to register response from a muscle.

**Endogenous or congitive potentials** are long-latency responses related to cognitive processes or iniciation of voluntary movement; it is mostly research tool.

# EVOKED POTENTIALS: TECHNICAL PRINCIPLE

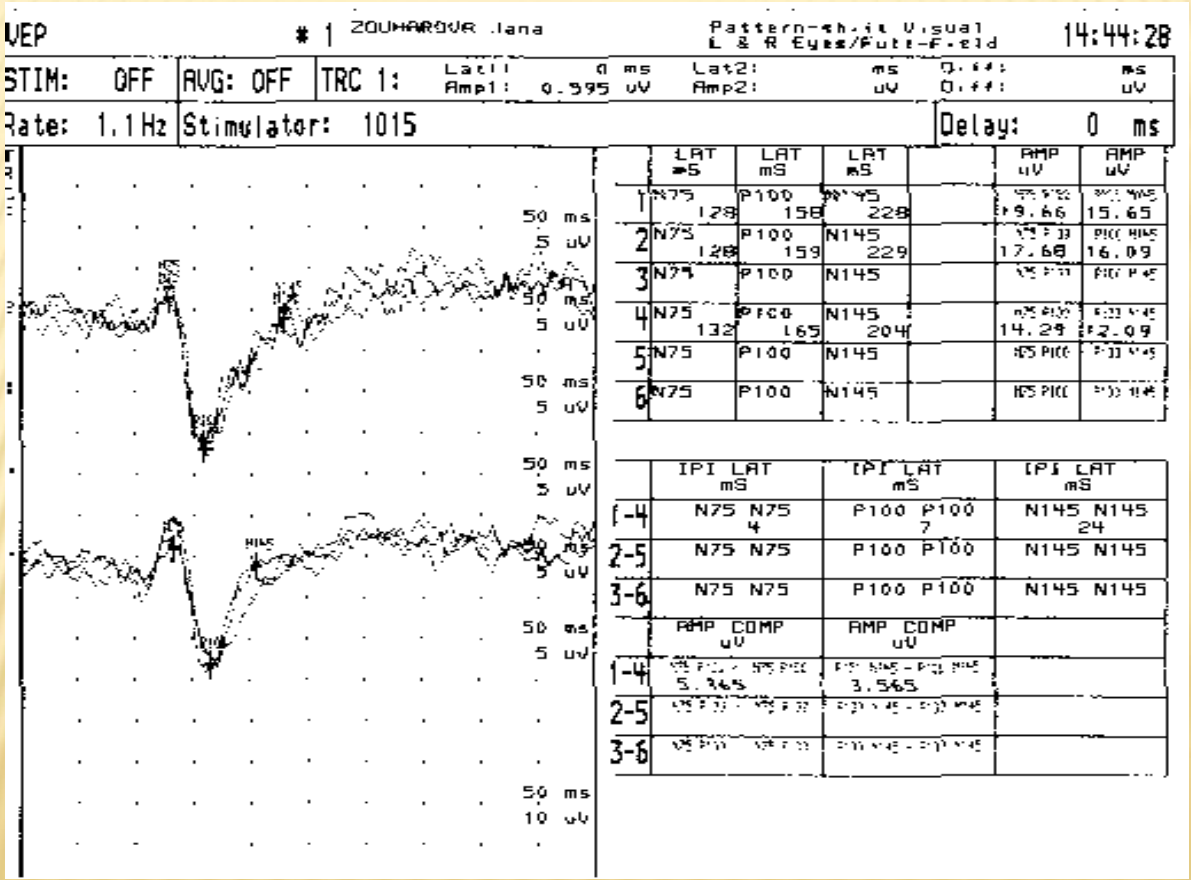
Evoked potentials generated in the cortex or spinal cord and recorded over the scalp or the spine have the magnitude in order of microvolts (therefore lower than EEG or artifacts). Extraction of these EP „burried“ in other electrical activity at the recording areas is enabled by the „averaging“ method performed by a computer. EP appears in a constant time interval from the stimulus (in contrast to otherwise accidental other electrical activities).

# EVOKED POTENTIALS: CLINICAL IMPORTANCE

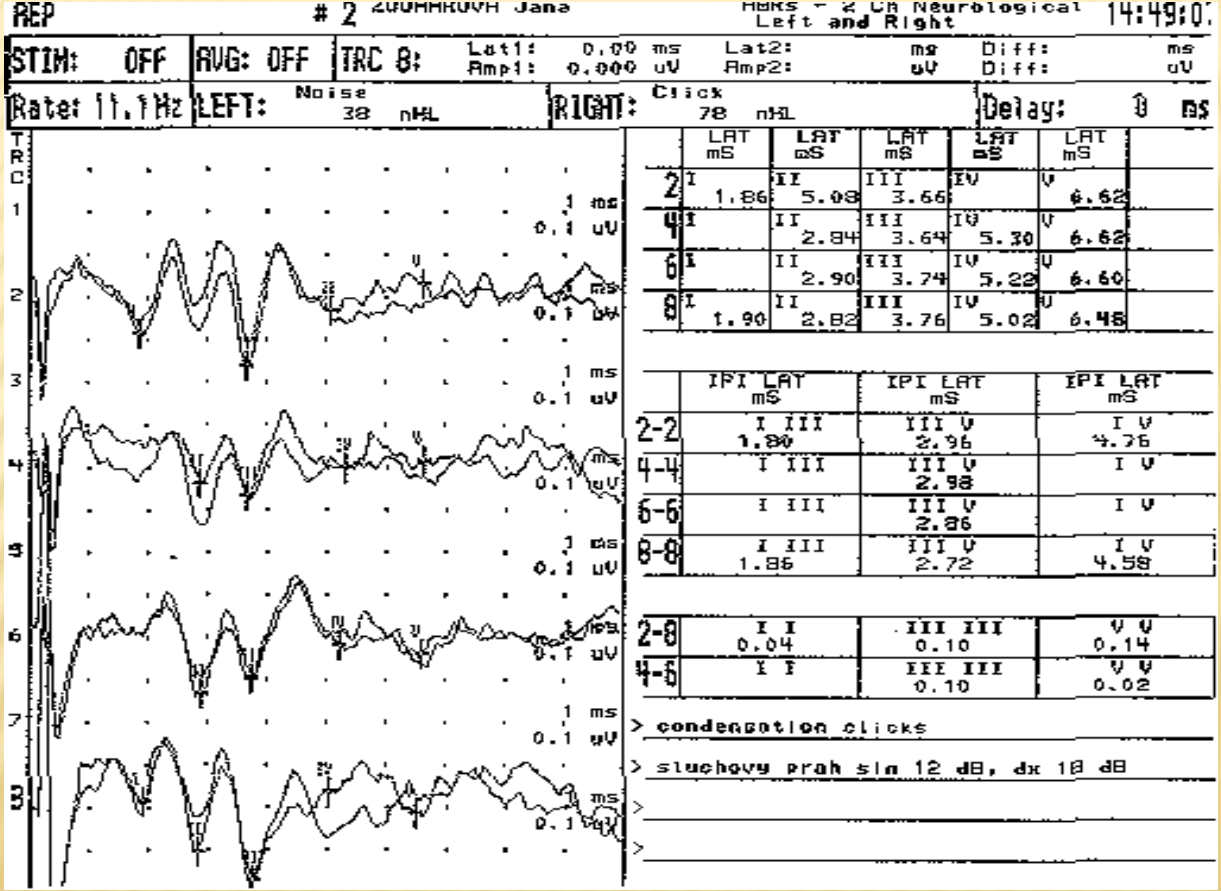
They:

- Objectify clinical data and offer quantitative information;
- Capture subclinical lesion or dysfunction
- Offer precision of localisation of the lesion;
- Could monitor function of the system or pathway during surgery

# VISUAL EVOKED POTENTIALS

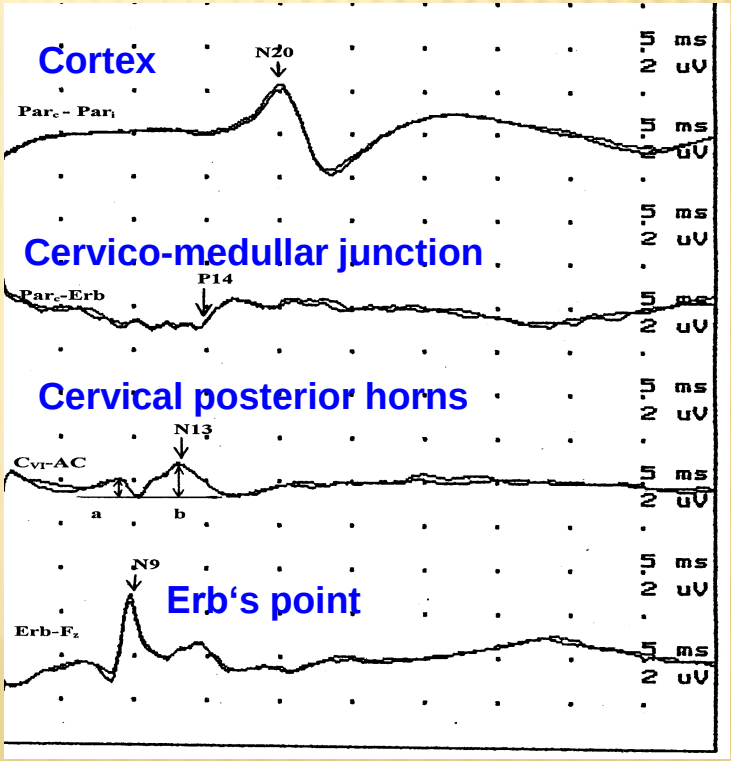


# BRAINSTEM AUDITORY EVOKED POTENTIALS



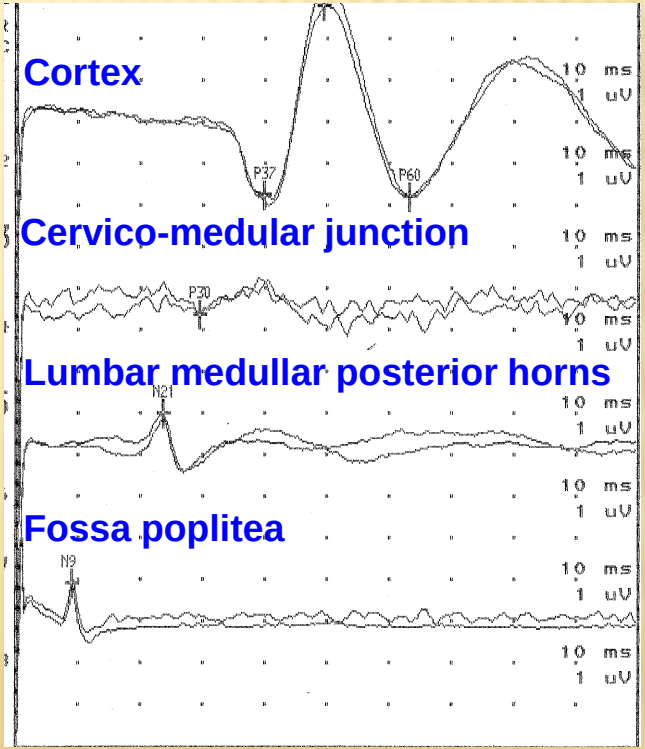
# SOMATOSENSORY EVOKED POTENTIALS

- **Electrical stimulation of the median nerve at the wrist**
- **Used montage:**
  - **Cortical pariental wave N 20** (from contralateral parietal scalp C3/4' - $Par^c$ – referred to contralateral pariental scalp C3/4' - $Par^i$);
  - **Cervico-medullar wave P14** (from ipsilateral parienta scalp C3/4' - Pari - 2 cm behind vertex and 7 cm laterally referred to non-cephalic reference);
  - **Segmental medullar wave N13 from posterior horns** (from processus spinosus C VI referred to ventral neck electrode),
  - **Brachial plexus wave N9** (from ipsilateral Erb's point to reference electrode at Fz).



# SOMATOSENSORY EVOKED POTENTIALS

- **Electrical stimulation of the median nerve at the wrist**
- **Used montage:**
  - **Cortical parietal wave P40** (from Cz' 2 cm behind vertex to cephalic reference Fpz);
  - **Cervico-medullar wave P30** (from ipsilateral parietal C3/4' - Pari - 2 cm behind vertex and 7 cm laterally to non-cephalic reference);
  - **Segmental medullar wave N22 from posterior horns** (from processus spinosus L I to reference electrode from contralateral spina iliaca),
  - **Wave N9 from tibial nerve** (from ipsilateral fossa poplitea to reference electrode from patella).



# MOTOR EVOKED POTENTIALS

**Transcranial and root magnetic stimulation**

**Recording from m. abductor digiti quinti (ADQ) and abductor hallucis (AH) bilaterally;**

**Measured parameters:**

- **Shortest motor latencies after cortical and root stimulation;**
- **Difference between cortical and root latencies: central motor conduction time;**
- **Largest motor amplitudes after cortical stimulation and ratio of cortical and peripheral (nerve) motor amplitudes: MEP/CMAP**