# SYLLABUS

## WS04: Electromyography (EMG) Hands On

Tuesday, November 15, 2011 09:00 - 18:00 Hall 2

Marrakesh, Morocco, November 12-17, 2011

XX$^{th}$ WORLD CONGRESS OF NEUROLOGY

XX$^{th}$ WCN 2011 MARRAKESH World Congress of Neurology

WFN

SMN SOCIETE MAROCAINE DE NEUROLOGIE

## ELECTROMYOGRAPHY (EMG) HANDS ON

Chairperson: **Jun Kimura**, *USA*

09:00 **MOTOR NERVE CONDUCTION STUDIES**
**Jun Kimura**, *USA*

10:30 *Coffee Break*

11:00 **SENSORY NERVE CONDUCTION STUDIES**
**Nazha Birouk**, *Morocco*

12:30 *Lunch Break*

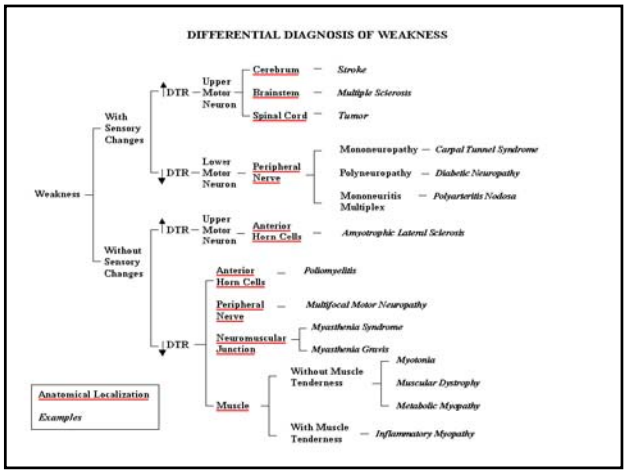
14:30 **REPETITIVE NERVE STIMULATION**
**William J. Litchy**, *USA*

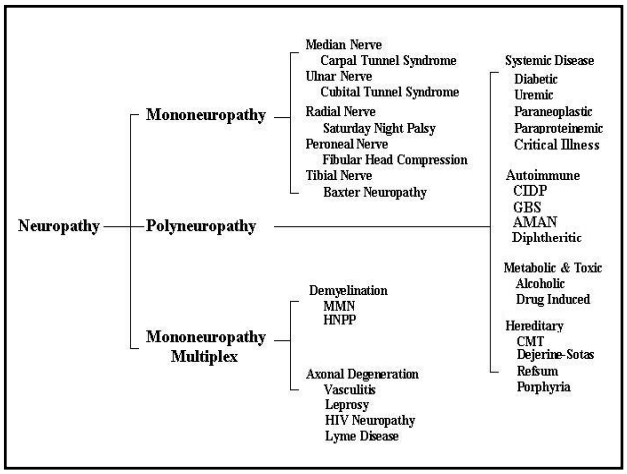
16:00 *Coffee Break*

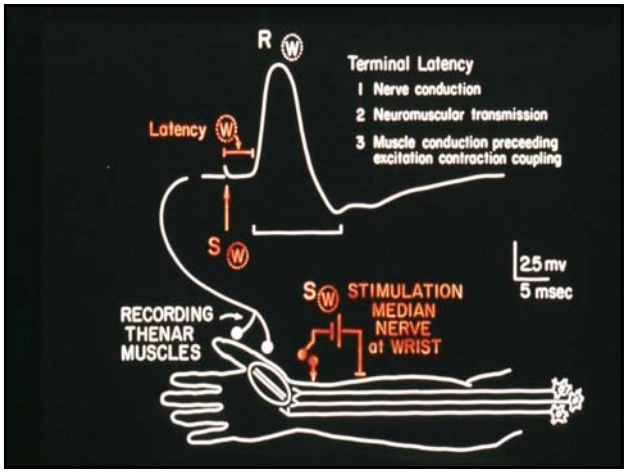
16:30 **REFLEXES AND LATE RESPONSES**
**Josep Valls-Sole**, *Spain*

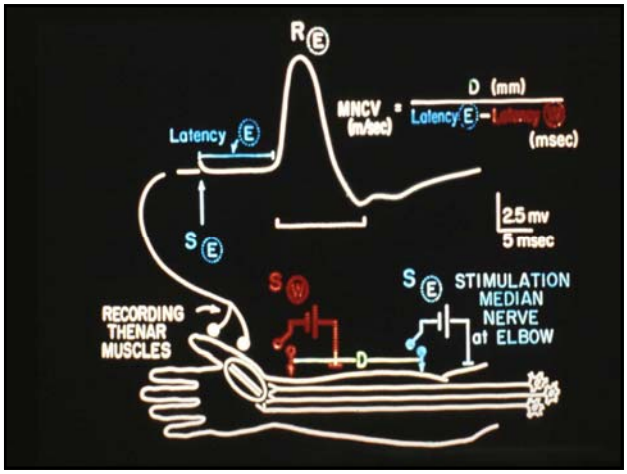

## Principles and Practice

1) Hx & Px before EDx
2) Watch twitch, then measure
3) Distal vs Proximal Shocks
4) Linear or Nonlinear Changes
5) Short and Long of NCS

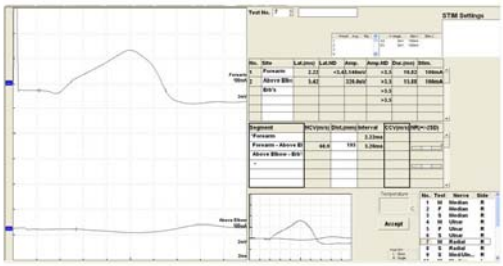


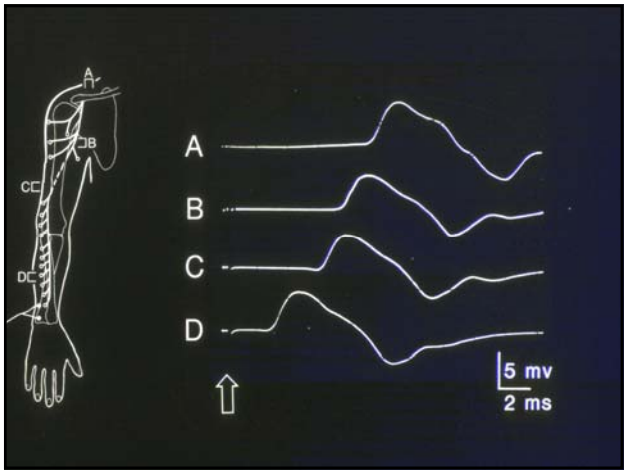

Neuropathy
Mononeuropathy
Polyneuropathy
Mononeuropathy Multiplex
Median Nerve
Carpal Tunnel Syndrome
Ulnar Nerve
Cubital Tunnel Syndrome
Radial Nerve
Saturday Night Palsy
Peroneal Nerve
Fibular Head Compression
Tibial Nerve
Baxter Neuropathy
Demyelination
MMN
HNPP
Axonal Degeneration
Vasculitis
Leprosy
HIV Neuropathy
Lyme Disease
Systemic Disease
Diabetic
Uremic
Paraneoplastic
Paraproteinemic
Critical Illness
Autoimmune
CIDP
GBS
AMAN
Diphtheritic
Metabolic & Toxic
Alcoholic
Drug Induced
Hereditary
CMT
Dejerine-Sotas
Refsum
Porphyria

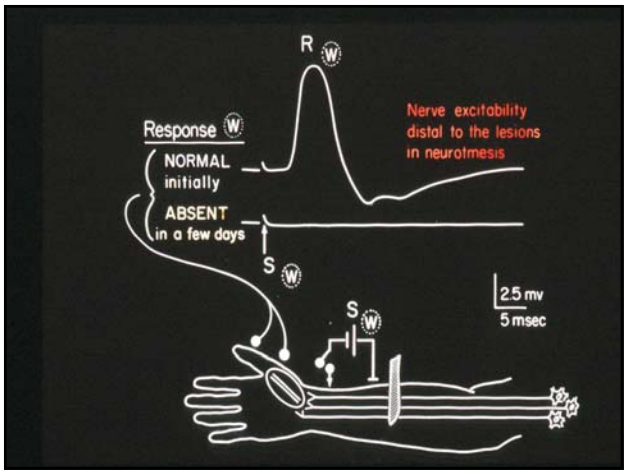

R
Terminal Latency
1 Nerve conduction
2 Neuromuscular transmission
3 Muscle conduction preceding excitation contraction coupling
Latency
S
25 mv
5 msec
S STIMULATION MEDIAN NERVE at WRIST
RECORDING THENAR MUSCLES

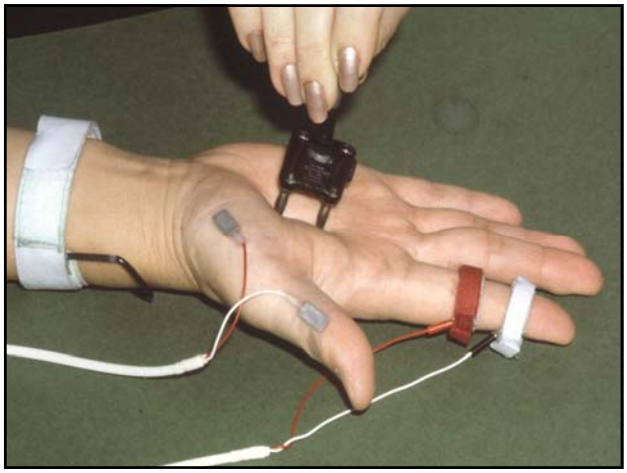

R
MNCV (m/sec) = D (mm) / Latency (E) − (msec)
Latency
S
25 mv
5 msec
S STIMULATION MEDIAN NERVE at ELBOW
RECORDING THENAR MUSCLES
D

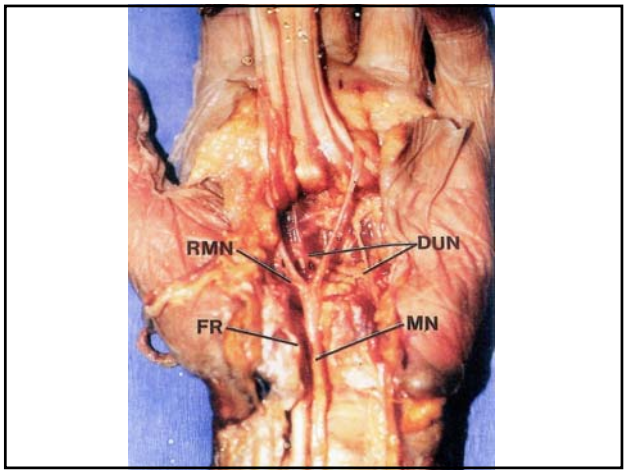
## Radial Nerve ( EIP)





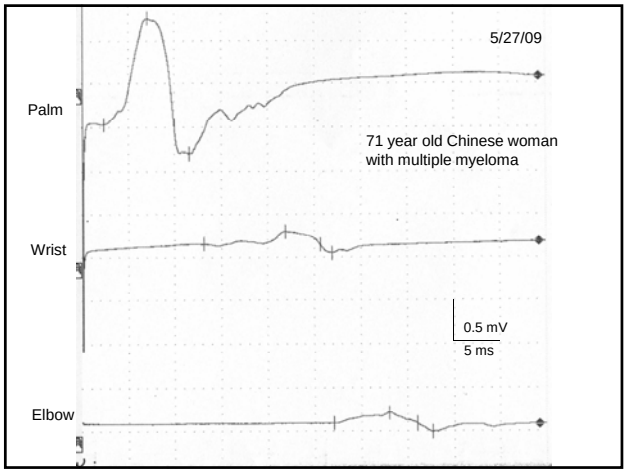

R
W
Response W
NORMAL
initially
ABSENT
in a few days
S
W
S
W
Nerve excitability
distal to the lesions
in neurotmesis
2.5 mv
5 msec

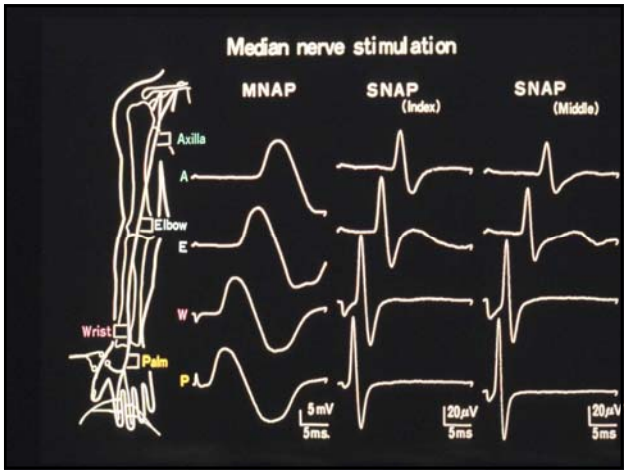


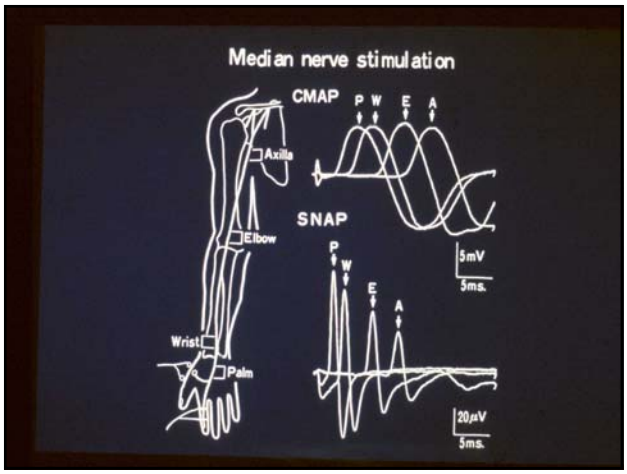

RMN
DUN
FR
MN

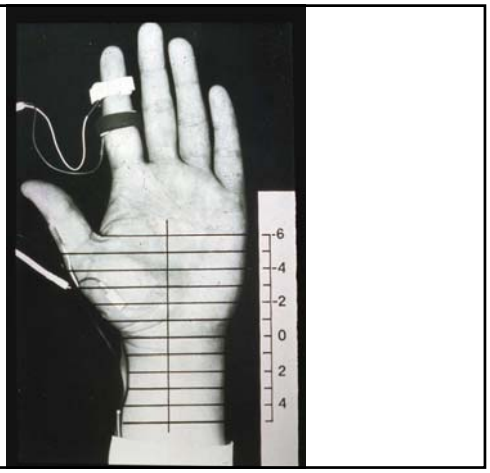
# Hx:

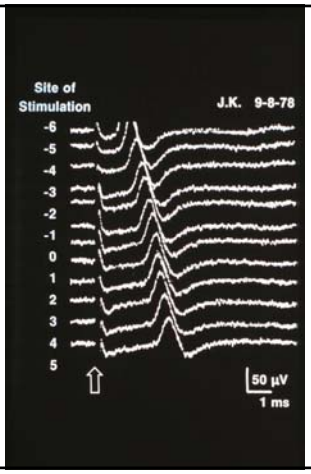
- 72 year-old Chinese woman
- Progressive numbness & weakness involving
- Digits 1-3 on left (03/09)
- Digits 1-3 on right (07/08)
- Feet and toes, bilateral (01/09)

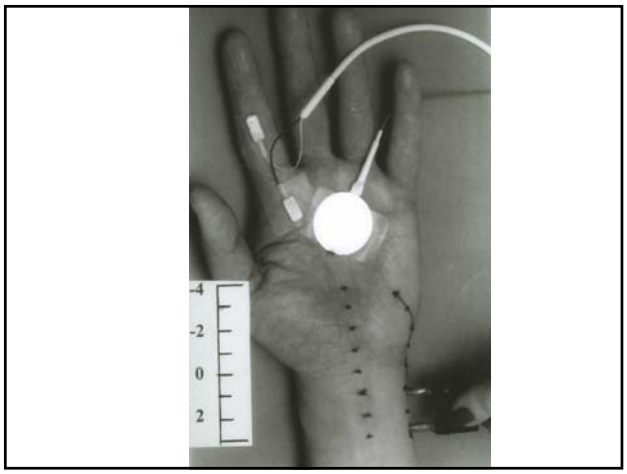


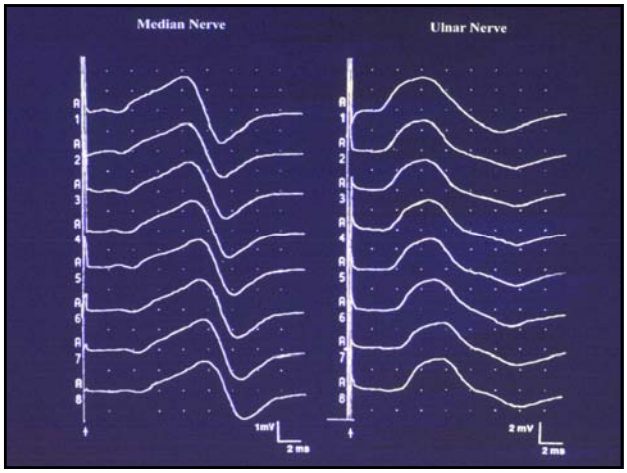




Median nerve stimulation
CMAP
P W E A
Axilla
Elbow
SNAP
P
W
E
A
5mV
5ms.
Wrist
Palm
20μV
5ms.

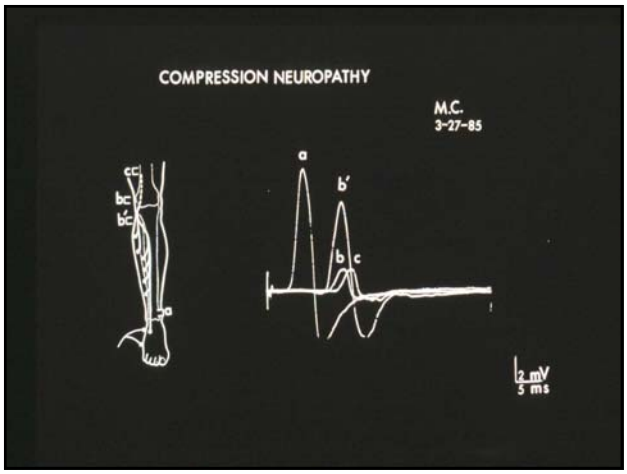

-6
-4
-2
0
2
4

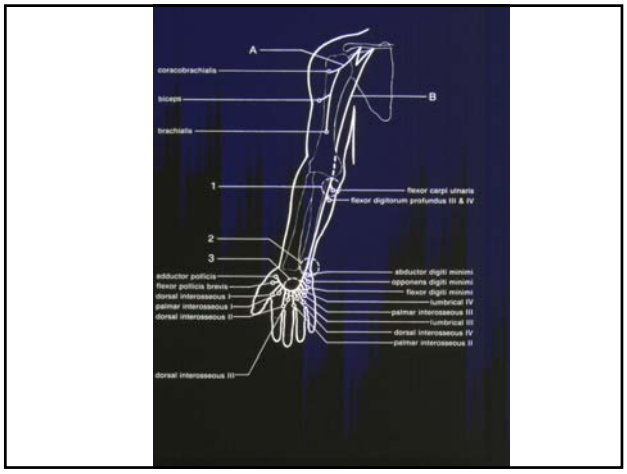

Site of
Stimulation
J.K. 9-8-78
-6
-5
-4
-3
-2
-1
0
1
2
3
4
5
50 μV
1 ms

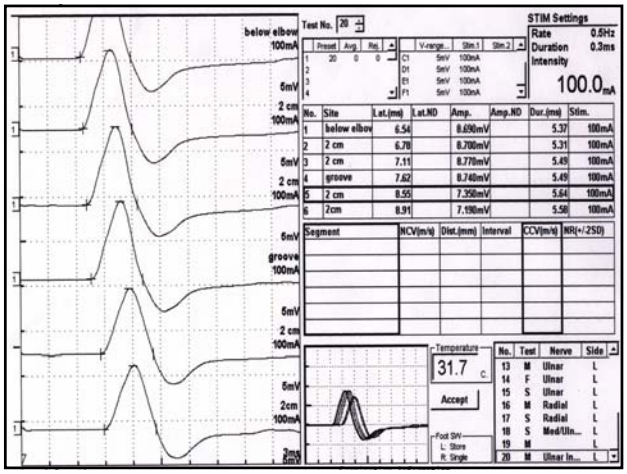

-4
-2
0
2

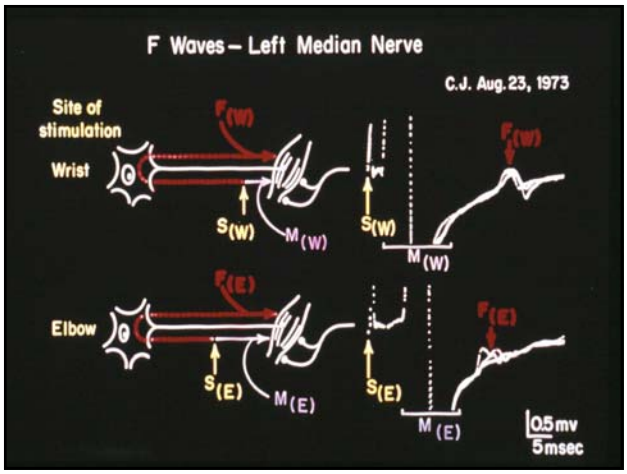

Median Nerve
Ulnar Nerve
1mV
2 ms
2 mV
2 ms

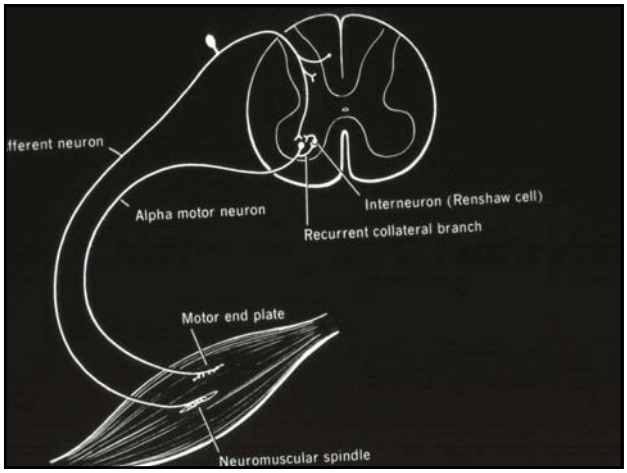

87 9 11

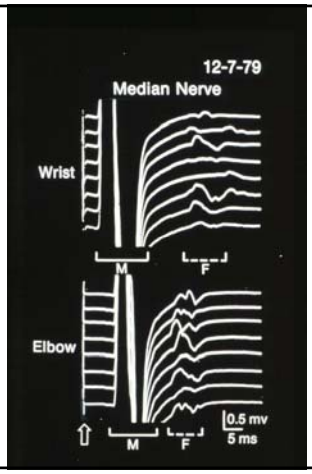

COMPRESSION NEUROPATHY
M.C.
3-27-85
a
b'
b
c
2 mV
5 ms

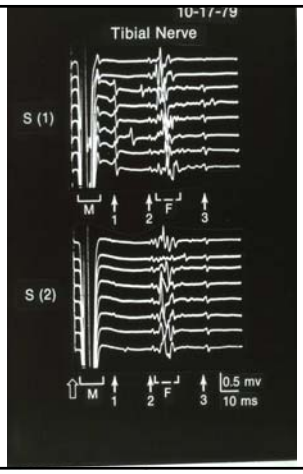

A
coracobrachialis
biceps
B
brachialis
1
flexor carpi ulnaris
flexor digitorum profundus III & IV
2
3
adductor pollicis
flexor pollicis brevis
dorsal interosseous I
palmar interosseous I
dorsal interosseous II
abductor digiti minimi
opponens digiti minimi
flexor digiti minimi
lumbrical IV
palmar interosseous III
lumbrical III
dorsal interosseous IV
palmar interosseous II
dorsal interosseous III

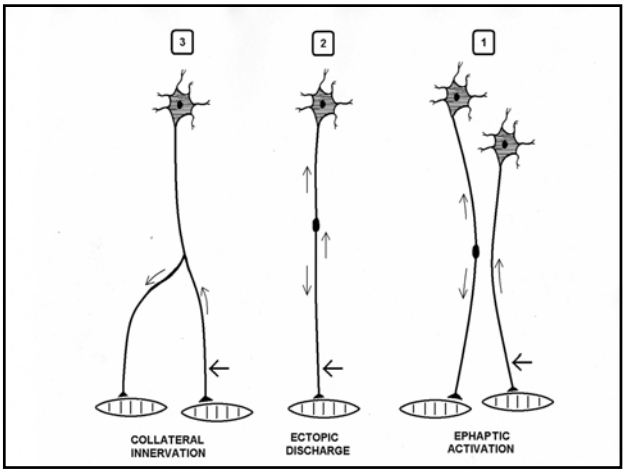

below elbow
100mA
5mV
2 cm
100mA
groove
Test No. 20
STIM Settings
Rate 0.5Hz
Duration 0.3ms
Intensity
100.0mA
No. Site Lat.(ms) Lat.ND Amp. Amp.ND Dur.(ms) Stim.
1 below elbow 6.54 8.690mV 5.37 100mA
2 2 cm 6.78 8.700mV 5.31 100mA
3 2 cm 7.11 8.770mV 5.49 100mA
4 groove 7.62 8.740mV 5.49 100mA
5 2 cm 8.55 7.350mV 5.64 100mA
6 2cm 8.91 7.190mV 5.58 100mA
Segment NCV(m/s) Dist.(mm) Interval CCV(m/s) NR(+/-2SD)
Temperature
31.7 C
Accept
No. Test Nerve Side
13 M Ulnar L
14 F Ulnar L
15 S Ulnar L
16 M Radial L
17 S Radial L
18 S Med/Uln... L
19 M L
20 M Ulnar In... L


F Waves – Left Median Nerve
C.J. Aug. 23, 1973
Site of stimulation
Wrist
F(W)
S(W)
M(W)
S(W)
M(W)
F(W)
Elbow
F(E)
S(E)
M(E)
S(E)
M(E)
F(E)
0.5 mv
5 msec


fferent neuron
Alpha motor neuron
Interneuron (Renshaw cell)
Recurrent collateral branch
Motor end plate
Neuromuscular spindle


12-7-79
Median Nerve
Wrist
M
F
Elbow
0.5 mv
5 ms
M
F

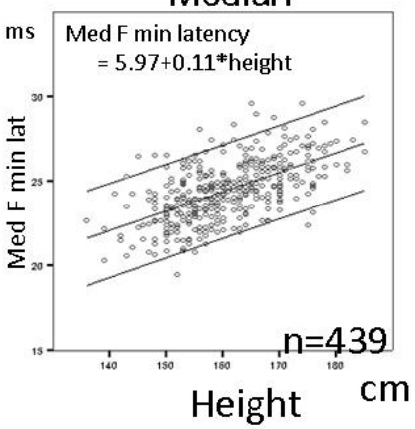


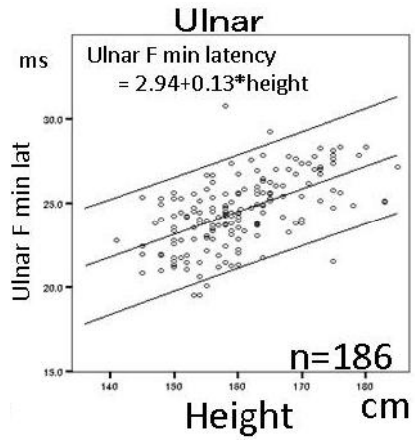

## NCS: Long and Short of It

1) Short distances magnify focal abnormality despite increased measurement error.
2) Long distances, though insensitive to focal lesions, yield better for diffuse process

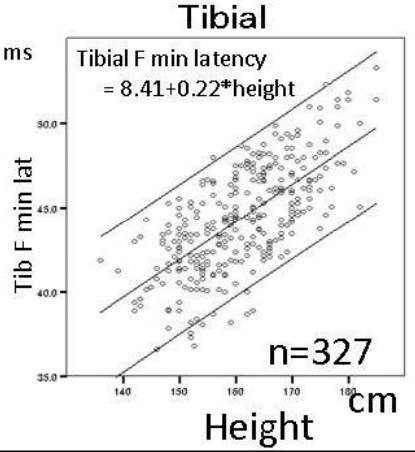
## Median

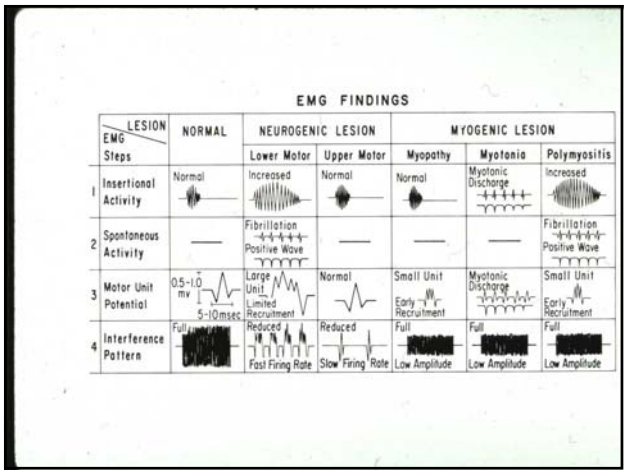


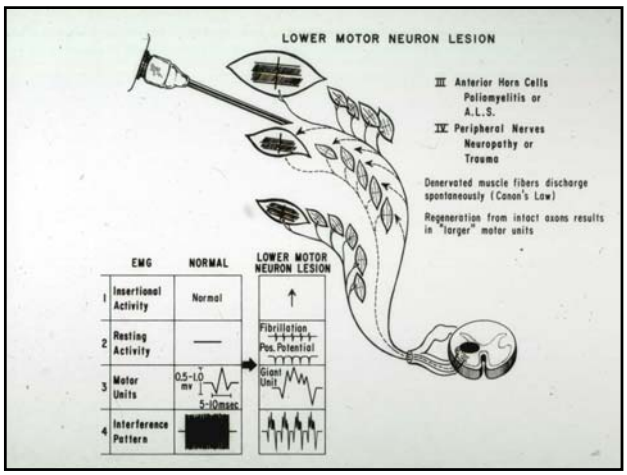

## Ulnar

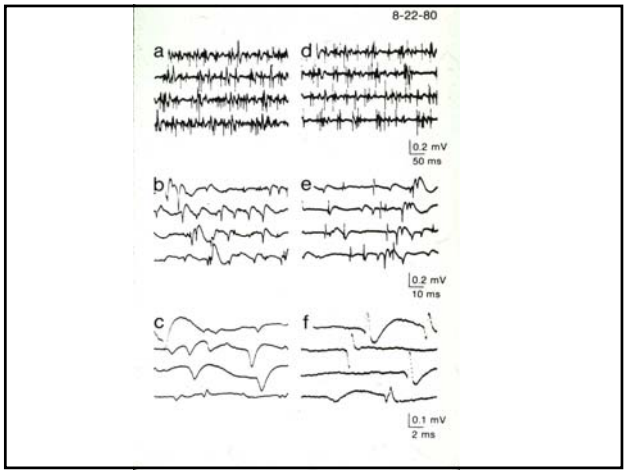



## Tibial

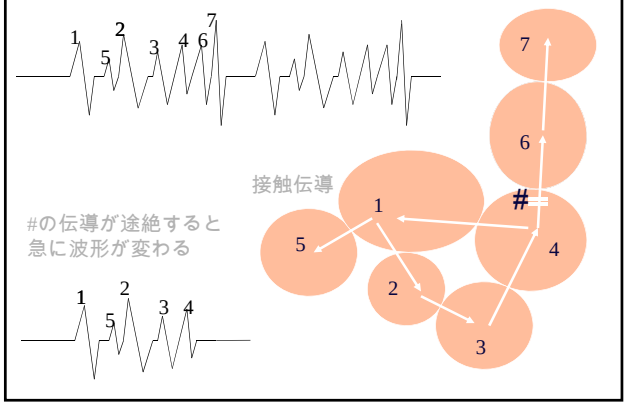


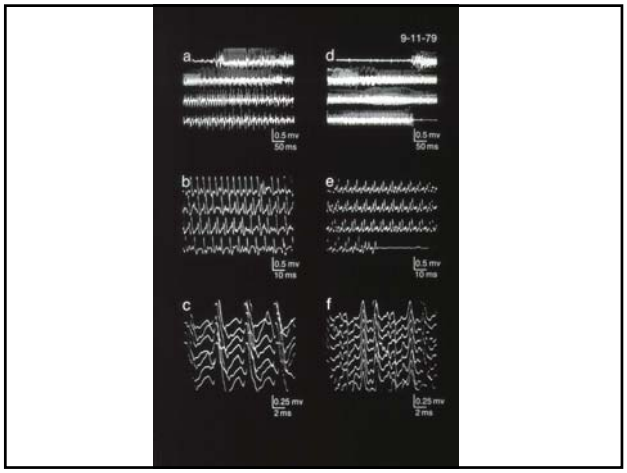

EMG FINDINGS
LESION
EMG Steps
NORMAL
NEUROGENIC LESION
MYOGENIC LESION
Lower Motor
Upper Motor
Myopathy
Myotonia
Polymyositis
1 Insertional Activity
Normal
Increased
Normal
Normal
Myotonic Discharge
Increased
2 Spontaneous Activity
Fibrillation
Positive Wave
Fibrillation
Positive Wave
3 Motor Unit Potential
0.5-1.0 mv
5-10msec
Large Unit
Limited Recruitment
Normal
Small Unit
Early Recruitment
Myotonic Discharge
Small Unit
Early Recruitment
4 Interference Pattern
Full
Reduced
Fast Firing Rate
Reduced
Slow Firing Rate
Full
Low Amplitude
Full
Low Amplitude
Full
Low Amplitude

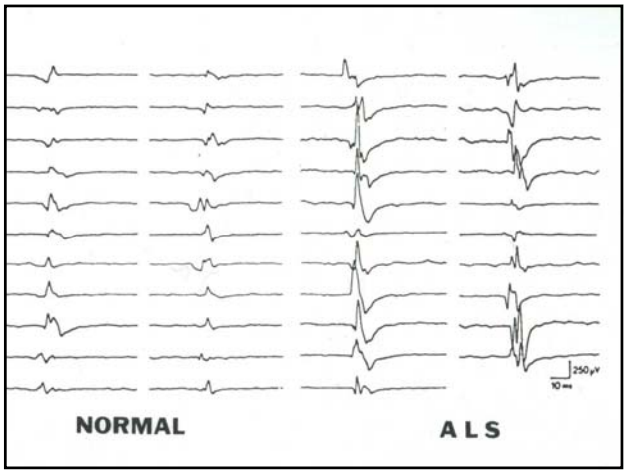

LOWER MOTOR NEURON LESION
III Anterior Horn Cells
Poliomyelitis or
A.L.S.
IV Peripheral Nerves
Neuropathy or
Trauma
Denervated muscle fibers discharge spontaneously (Conan's Law)
Regeneration from intact axons results in "larger" motor units
EMG
NORMAL
LOWER MOTOR NEURON LESION
1 Insertional Activity
Normal
2 Resting Activity
Fibrillation
Pos. Potential
3 Motor Units
0.5-1.0 mv
5-10msec
Giant Unit
4 Interference Pattern

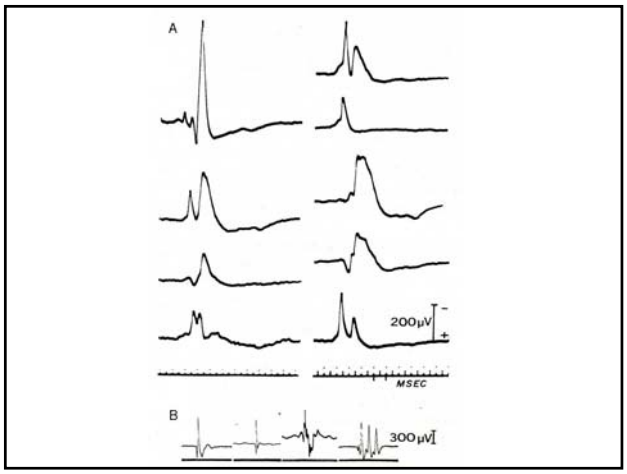

8-22-80
a
d
0.2 mV
50 ms
b
e
0.2 mV
10 ms
c
f
0.1 mV
2 ms

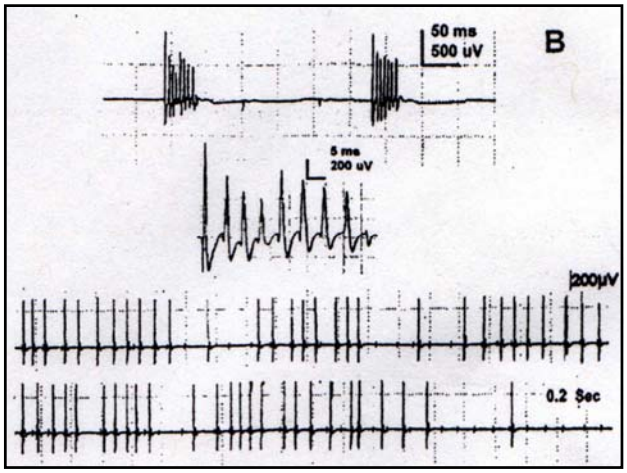
## 複合反復放電のメカニズム

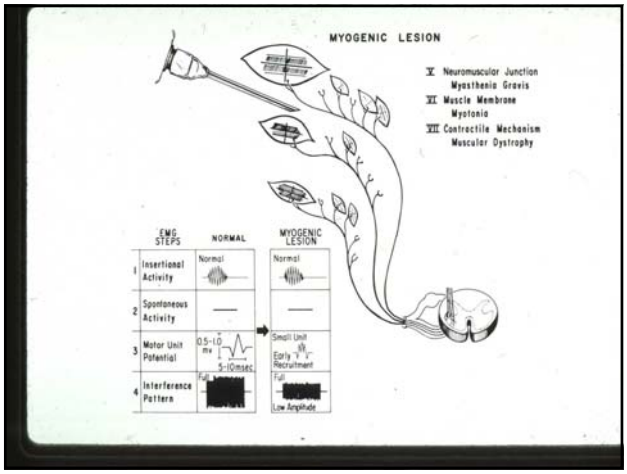


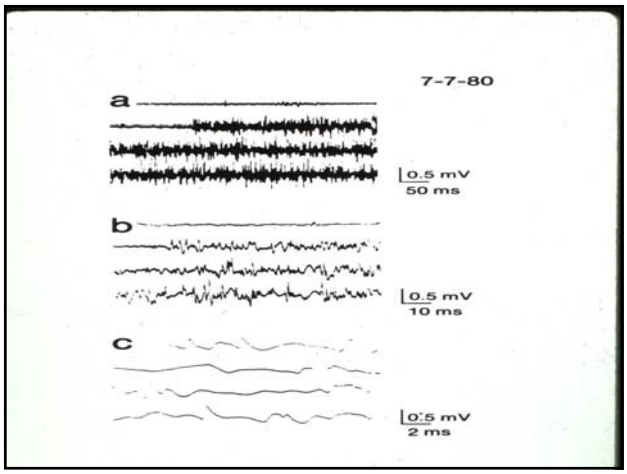




A
200μV
MSEC
B
300μV


50 ms
500 uV
B
5 ms
200 uV
200μV
0.2 Sec


MYOGENIC LESION
X Neuromuscular Junction
Myasthenia Gravis
XI Muscle Membrane
Myotonia
XII Contractile Mechanism
Muscular Dystrophy
EMG STEPS
NORMAL
MYOGENIC LESION
1 Insertional Activity
Normal
Normal
2 Spontaneous Activity
3 Motor Unit Potential
0.5-10 mv
5-10msec
Small Unit
Early Recruitment
4 Interference Pattern
Full
Full
Low Amplitude




1) *Muscle Fiber*
   - Insertional Positive Waves
   - Myotonic Discharge
   - Fibrillation Potential
   - Positive Sharp Waves
   - Complex Repetitive Discharge
   - End-plate Noise
   - End-plate Spikes

2) *Lower Motor Neuron*
   - Fasciculation Potential
   - Myokymic Discharge
   - Neuromyotonic Discharge
   - Cramp Discharges
   - Hemifacial Spasm
   - Hemimasticatory Spasm

3) *Upper Motor Neuron*
   - Stiffman Syndrome
   - Involuntary Movement

# Sensory Nerve Conduction

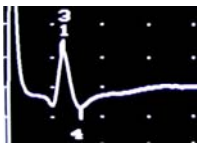
Prof. Nazha Birouk
Service de Neurophysiologie Clinique
Hôpital des Spécialités, CHU Ibn Sina
Rabat, Morocco

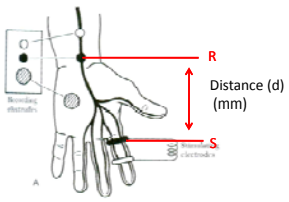
XX th WCN 2011 MARRAKESH مراكش World Congress of Neurology

# General considerations

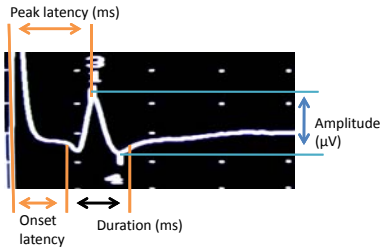
- Large diameter sensory nerve fibers examination
- Stimulation and response on the nerve
- 2 methods :
  - Orthodromic : response proximally to stimulation
  - Antidromic : response distally to stimulation
- Skin preparation
- Skin temperature
- Signal averager : about 20 to 40 responses

# Sensory CNAP



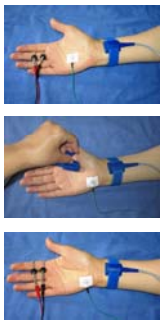


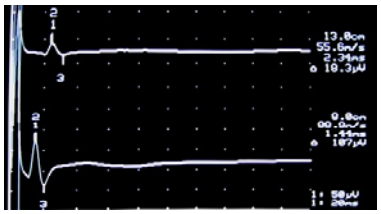
## Sensory CNAP



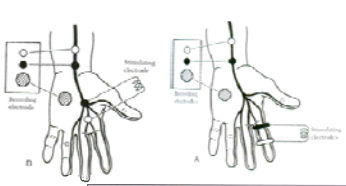

NCV (m/sec) = d (S-R) (mm) / Latency (msec)

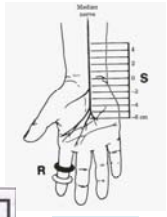
## Media nerve



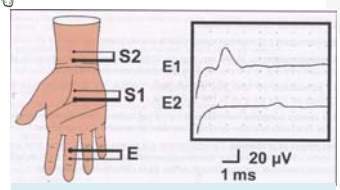


## Sensory nerve conduction across the carpal tunnel



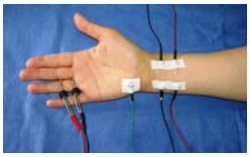


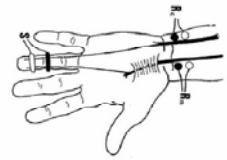

Inching test



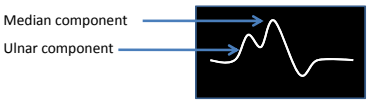

Transcarpal sensory conduction velocity with orthodromic stimulation

## 4th digit, Median-Ulnar nerve



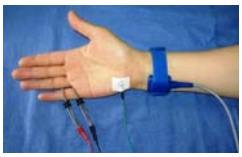


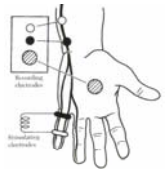
Comparison of median/ulnar latencies with 4th digit ring stimulation and recording at the wrist  N ≤ 0.5 msec

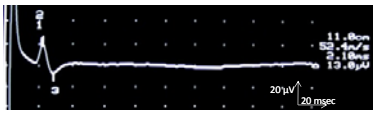



Median nerve
4th digit-wrist
Carpal tunnel syndrome

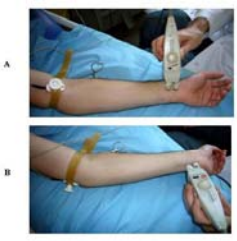
## Ulnar Nerve

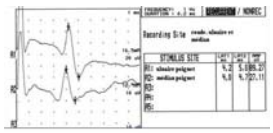




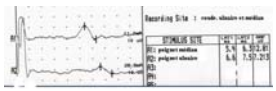



## Mixed potentials





normal

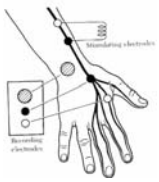


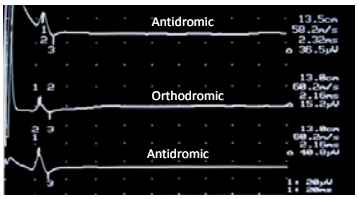
Latency difference of 1.3 msec
Ulnar nerve compression at the elbow

Comparison of median/ulnar latencies above the elbow:
Stimulation at the wrist. Same distances
Usual difference on normal subject ≤ 0,7 msec

## Radial Nerve

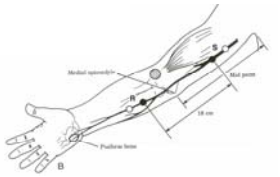
Antidromic method






## Musculocutaneous nerve
(lateral antebrachial cutaneous nerve)

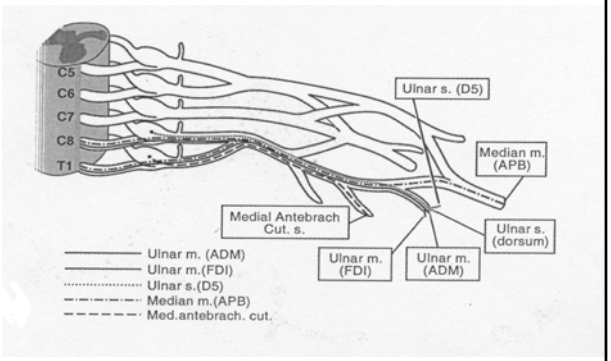
## Medial Antebrachial Cutaneous Nerve



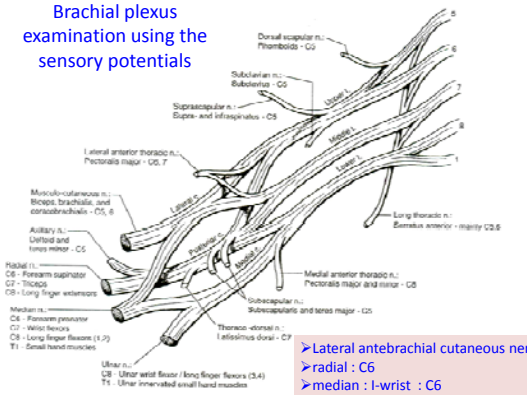
- Girl, 16 years
- Since 1 year : Neuropathic pain in the right UL + slight motor disability in right hand


| | Right median nerve (II) | Right ulnar nerve | MABCN |
|---|---|---|---|
| Motor response | Low Amplitude | Low Amplitude | - |
| Sensory response | Normal | Absent | Absent |

## Brachial plexus




## Brachial plexus examination using the sensory potentials



- Lateral antebrachial cutaneous nerve : C5-C6
- radial : C6
- median : I-wrist : C6
- median : III-wrist : C7
- ulnar : V-wrist : C8
- medial antebrachial cutaneous nerve : C8-T1

## Brachial plexus lesion examination using the sensory potentials

### Upper trunk (C5-C6)

Altered potentials:
- LABCN 100% des cas
- median I 100%
- median II 20%
- median III 10%
- radial 60%

Potentials always normal:
- MABCN
- ulnar (V)

## Brachial plexus lesion examination using the sensory potentials

### middle trunk (C6-C7)

Altered potentials:
- median II 80%
- median III 70%
- radial 40%

Potentials always normal:
- median I
- LABCN
- MABCN
- ulnar (V)

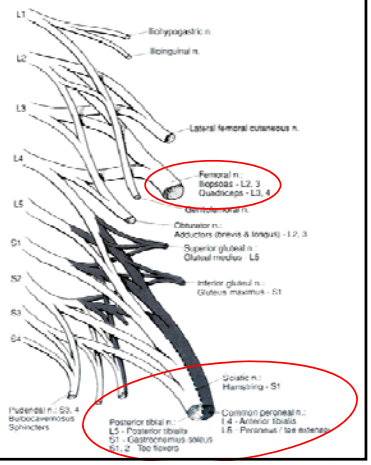
## Brachial plexus lesion examination using the sensory potentials

### lower trunk (C7-C8-T1)

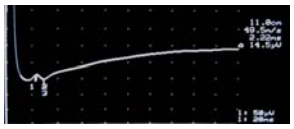
Altered potentials:
- MABCN 100%
- ulnar 100%
- median III 20%

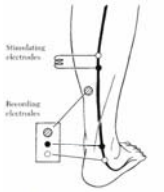
Potentials always normal:
- median I and II
- LABCN
- radial

## Lumbosacral plexus




## Sural Nerve

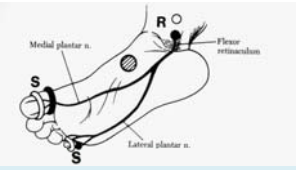





Antidromic method

Plexus : S1
Sciatic nerve
Tibial nerve

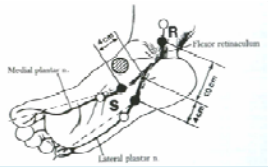
## Tibial nerve (1)




Sensory nerve conduction of plantar nerves (Oh's method)

Tarsal Tunnel Syndrome
Tibial nerve
Sciatic nerve
Plexus : S1, S2

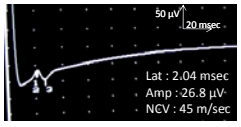
## Tibial nerve (2)

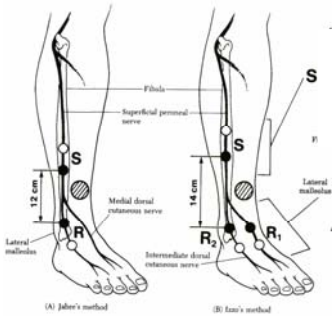



Mixed nerve conduction of the plantar nerves (Saeed & Gatens)

Tarsal Tunnel Syndrome
Tibial nerve
Sciatic nerve
Plexus : S1, S2

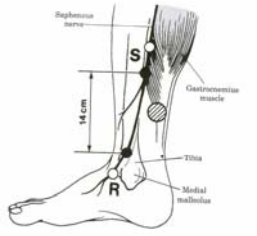
## Superficial peroneal nerve




Plexus : L5
Sciatic Nerve
Common peroneal nerve

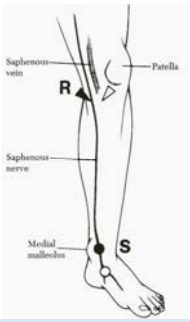
## Saphenous Nerve (1)




Wainapel's method (antidromic)

Femoral nerve
Plexus : L2, L3, L4

## Saphenous Nerve (2)




Senden's method (orthodromic)

Antidromic

Femoral nerve
Plexus : L2, L3, L4

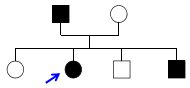
## Interpretation of sensory nerve conduction data

| Parameter | Axonal degeneration | Segmental demyelination |
|---|---|---|
| Amplitude | ↓↓ or often absent | N, ↓, or absent |
| Duration | N | ↑ or rarely dispersion |
| Conduction velocity | N or ↓ | ↓↓ |

## Polyneuropathy (PN)

- Axonal length dependent PN : sensory responses more alerted in the lower limbs : Low amplitudes or absent
- Demyelinating PN : sensory responses often more altered in the upper limbs : reduced NCV, Low amplitude or absent
- Hereditary NP of CMT type : Sensory responses often absent usually contrasting with normal clinical sensory examination (or few clinical sensory signs)
- Small fibers sensory neuropathy : Normal sensory responses.

## Case 1



Hajar , 8 years, CMT1A (duplication PMP22)
Onset at 2 years, Typical CMT phenotype, moderate disability, No clinical sensory signs

| Motor Nerve Conduction | | | |
|---|---|---|---|
| | Median (R/L) | Peroneal (R/L) | Tibial (R/L) |
| DML (ms) | 21 / 18.4 | 0 / 36.3 | 0 / 30.6 |
| Amplitude D (mV) | 0.1 / 0.2 | 0 / 0.2 | 0 / 0.16 |
| Amplitude P (mV) | 0.07 / 0.2 | 0 / 0.2 | 0 / 0.10 |
| NCV (m/s) | 5.8 / 6 | 0 / 6 | 0 / 6.2 |
| **Sensory Nerve Conduction** | | | |
| | Median (R) | Sural (R / L) | Ulnar (L) |
| Amplitude (µV) | 0.6 | 0 / 0 | 0 |
| NCV (m/s) | 19 | 0 / 0 | 0 |

## Case 2

Rayan, 4 years, Recurrent CIDP since 6 months
Complete clinical recovery after steroids therapy

| Motor nerve conduction | | | |
|---|---|---|---|
| | Median R | Peroneal (L) | Tibial (R) |
| DML (ms) | 5.3 | 7.7 | 6.1 |
| Amplitude D (mV) | 2.8 | 0.5 | 0.5 |
| Amplitude P (mV) | 2.7<br>TD | 0.5<br>TD | 0.2<br>TD |
| NVC (m/s) | 16.7 | 23 | 20 |
| **Sensory nerve conduction** | | | |
| | Median R | Ulnar L | Sural R |
| Amplitude (µV) | 0.5 | 0 | 4 |
| NCV (m/s) | 30 | 0 | 31 |

## Conclusion

- Important step in ENMG test
- Rigorous technique is necessary :
  - Skin preparation and temperature
  - Electrodes placement
  - Eliminate artifacts sources…
- Nerves examined routinely : Normal values for each laboratory
- Nerves examined occasionally : comparison with other side often useful


# Repetitive Stimulation

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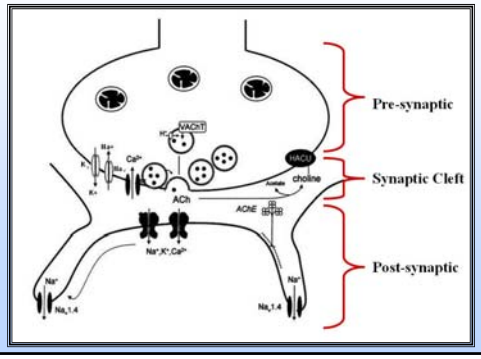
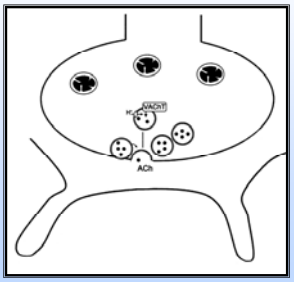
# NMJ Anatomy



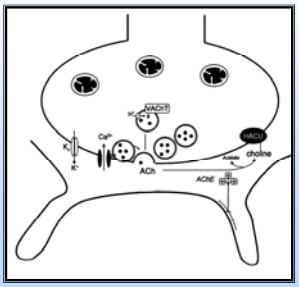



# NMJ Anatomy




- Pre-synaptic
  - Synaptic Vesicles
    - Acetylcholine
      - (5-10,000)
      - Quanta
    - Ions
      - $Ca^{2+}$, $Mg^{2+}$
    - ATP
    - Proteoglycan
  - Active Zones
- Ion Channels
  - Na+
  - Ca++
  - K+
    - Voltage gated
    - Ca++ activated
  - Voltage Gated P/Q

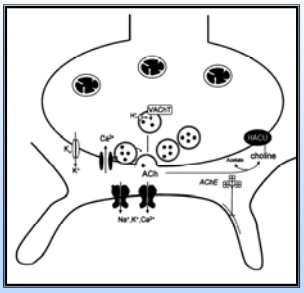
# NMJ Anatomy




- Synaptic Cleft
  - Small space
  - Acetylcholinesterase (AChE)
    - Two functional sites
    - 5000 molecules/sec
  - Controls ACh content



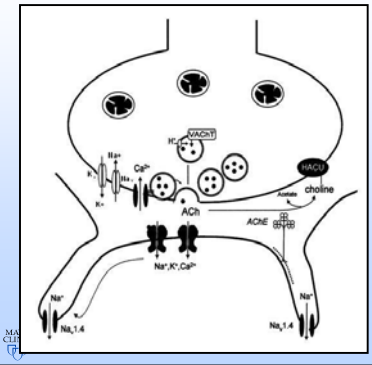
# NMJ Anatomy

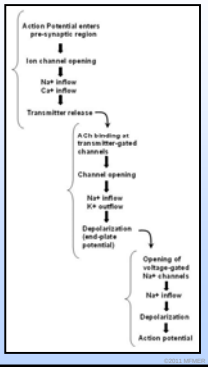



- Post-synaptic
  - Acetylcholine Receptors
    - 5 subunits
    - 1 ε, 1β, 1δ, 2 α
    - α subunit binds ACh
    - 2 ACh for channel opening
    - Produce non propagating potentials
    - End Plate Potential (EPP)
    - $Na^+$ gated ion channels
      - EPP activates opening
      - Produces action potential
  - MuSK Receptors

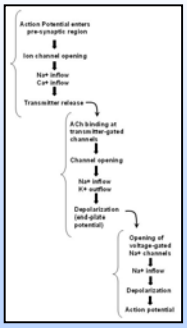


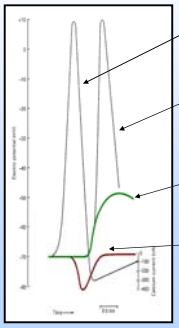
# NMJ Physiology



# NMJ Physiology



Action Potential (axon)

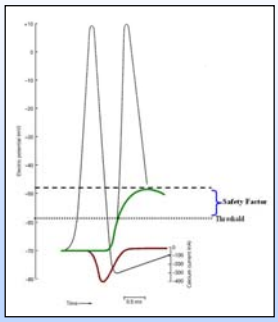
Action Potential (Muscle)

Post synaptic depolarization

$Ca^{2+}$ current Pre-synaptic



# NMJ Physiology




## Threshold

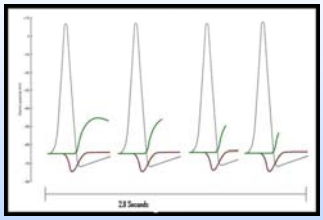
The minimum post synaptic depolarization to produce an action potential.

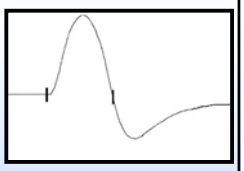
## Safety Factor

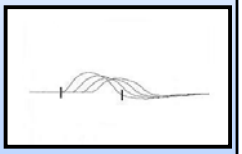
The difference between the depolarization caused by AChR activation and the depolarization required to activate Na 1.4 receptors.



# NMJ Physiology





# Techniques for Evaluation of NMJ

Routine Nerve Conduction Studies

➡ Repetitive Nerve Stimulation (RNS)

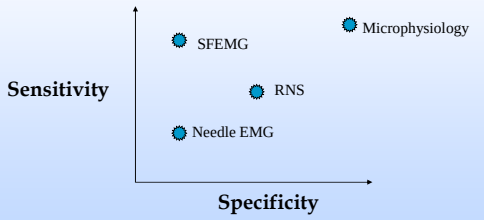
Needle Electromyography

➡ Single Fiber EMG

End-plate potential analysis



# NMJ Evaluation






# Technique for RNS

Patient Preparation — **Instruction**, **Warm**

Equipment — **Recording Electrodes**, **Stimulating Electrodes**, **Instrument**, **Immobilizing joint**

Nerve/Muscle Examined — Clinically Involved, Reliable, Reproducible, Patient Comfort, Physician Comfort

# Nerve/Muscle Choice

| Nerve | Muscle | Stimulation Site | Advantages | Disadvantages | Immobilization |
|---|---|---|---|---|---|
| Ulnar | Abductor digiti quinti | Wrist | Reliably immobilized, well tolerated | Distal muscle may be spared | Velcro strap, damp |
| Median | Abductor pollicis brevis | Wrist | Well tolerated | Distal muscle may be spared, difficult to immobilize | Thumb restrained |
| Musculocutaneous | Biceps | Lower edge axilla | Proximal muscle | Unstable stimulus, difficult to immobilize | Board |
| Radial | Anconeus | Nerve to anconeus in the forearm | Forearm muscle, comfortable for the patient | Requires a needle for stimulation | None |
| Radial | Extensor digitorum communis | Elbow | Forearm muscle | Unstable stimulus muscle artifact | Board |
| Axillary | Deltoid | Supraclavicular | Proximal muscle | Unstable stimulus, difficult to immobilize | Large Velcro strap or sheet |
| Spinal accessory | Trapezius | Posterior border Upper sternocleidomastoid | Proximal muscle | Difficult to immobilize | Large Velcro strap or sheet |
| Facial | Nasalis | Between mastoid and tragus | Proximal muscle | Unstable stimulation, shock artifact, cannot immobilize | None |
| Peroneal | Anterior tibial | Popliteal fossa | Leg muscle | Distal muscle may be spared | Board |
| Femoral | Rectus femoris | Femoral triangle | Proximal leg muscle | Difficult to immobilize | Board |

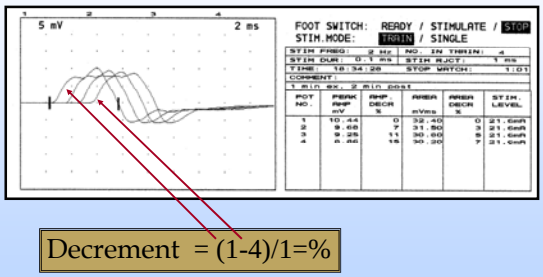
# Stimulation Parameters

**Duration**
**Strength**
**Frequency**
**Number of Stimuli**

# Measurements

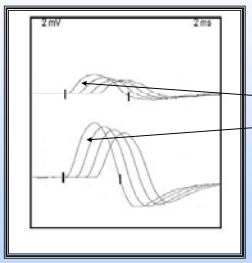
**Decrement**
**Increment**
**Facilitation**
**Post activation exhaustion**
**Decrement Repair**

# Repetitive Stimulation Decrement




Decrement = (1-4)/1=%

# Repetitive Stimulation Facilitation



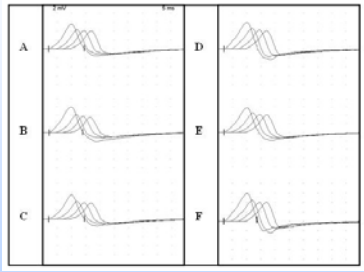

Facilitation

The change in the amplitude (area) of the first response in one set compared to the first response in a second set.

# Myasthenia Gravis Protocol

- Warm patient
- Select muscle
- Routine nerve conduction study
- Repetitive stimulation--2Hz
- Exercise--short/long
- Post exercise: immediate, 30,60,120,180

# Myasthenia Gravis



# Criteria for Abnormality

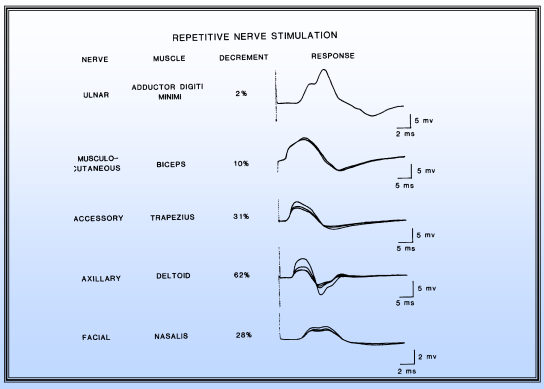
- **Amount of Decrement**
  - Amplitude > 10% (1st to 4th response)
- **Pattern of Abnormality**
  - Largest decrement between 1st and 4th response
  - Decrement repairs with exercise
  - Evidence of post activation exhaustion
- **Found with more then one nerve**



# Results for Myasthenia Gravis

- Overall
  - Class I 15 -17 %
  - Class II- IV 53 – 100%
- Specific Nerve
  - Ulnar < Radial < Accessory < Nasalis < Axillary





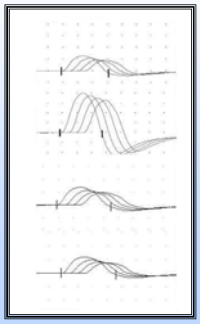
# Technical Considerations

Patient
- Temperature
- Medication

Technical
- Over/under stimulation
- Choice of nerve



# Lambert-Eaton Myasthenic Syndrome



**Before Exercise**

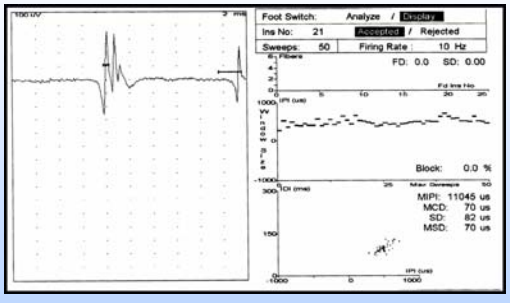
**Immediately after exercise**

**30 seconds after exercise**

**1 Minute after exercise**



# Single Fiber EMG



# Single Fiber EMG

Concentric Needle

| Width | Length | Area |
|---|---|---|
| 150 µ | 550 µ | 0.07 $mm^2$ |
| 25 µ | 25 µ | 0.0005 mm2 |

Single Fiber Needle

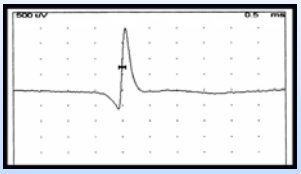


# Concentric Needle Recordings

- Advantages
  - Available
  - Inexpensive
  - Easy
- Disadvantages
  - Technically more difficult
  - More difficult to record single fiber potentials

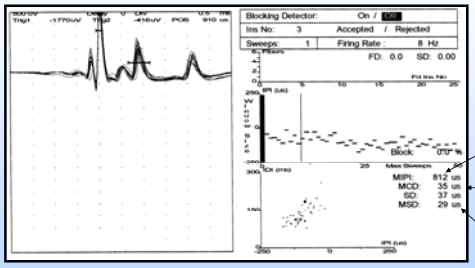


# Characteristics of Single Fiber Potentials



- Amplitude > 100 µVolt
- Risetime 75-200 µS
- Duration 1-3 msec

# Characteristics of Single Fiber Pairs



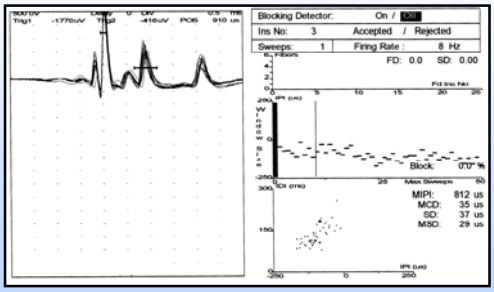

MIPI

MCD

MSD

MCD -- The calculation of the consecutive interpotential interval differences and then take the mean value.

# Jitter Measurement



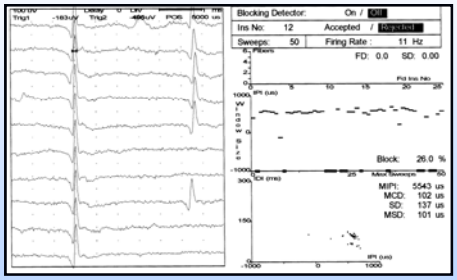

# SFEMG - Blocking

A measure of the number of times a motor unit fires and a muscle fiber is not activated

Not present in normal muscles

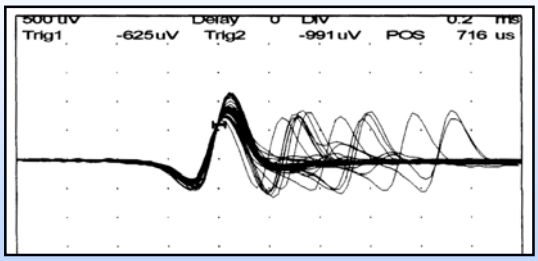
Occurs when jitter is large

# SFEMG - Blocking



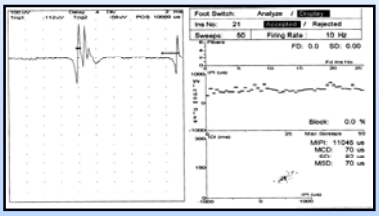



# Jitter-Myasthenia Gravis




# SFEMG - Fiber Density

- A measure of the number of muscle fiber potentials recorded on a single recording area.
- Normally between 1.3 and 1.8.
- Increases with age
- Increases in disorders with de/re-innervation



# SFEMG -- Stimulated

- **Technique**
  - Nerve branch stimulated
  - Record single fiber potential from muscle
  - Stimulate at different frequencies
  - Record Jitter (MCD)
- **Advantages**
  - Any muscle
  - Does not require cooperation of patient
  - Can be performed with patient (child) sedated
  - Can be performed quickly
- **Disadvantages**
  - Technically very demanding
  - Requires additional skills
  - Technical errors
    - Record incorrect potentials
    - Stimulate at incorrect frequencies
    - Requires different reference values



# Selected Reading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# Reflexes and late responses

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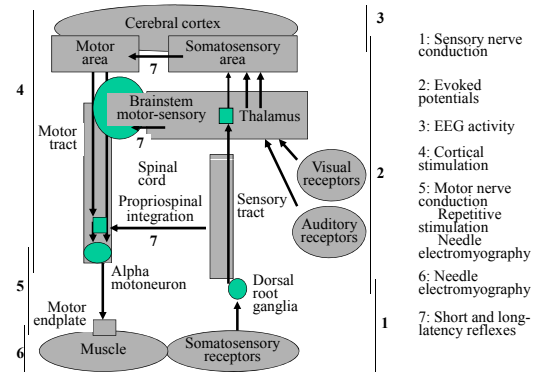
## ELECTRODIAGNOSIS OF THE NERVOUS SYSTEM IN HUMANS



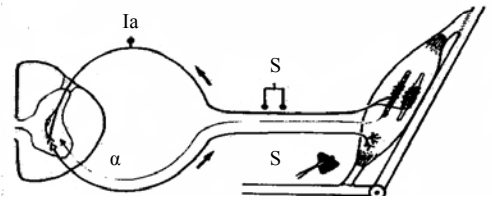

## REFLEXES INVOLVING MUSCLE RESPONSES

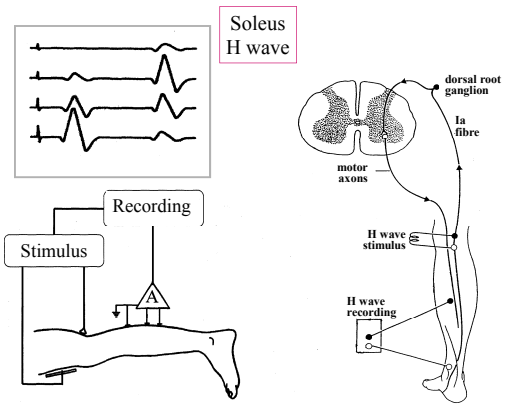
| | Stimuli | Resting condition | Sustained muscle contraction |
|---|---|---|---|
| Monosynaptic | Mechanical | Tendon jerk (T wave) | |
| | Electrical<br>-Ia afferents | H reflex | - |
| Polysynaptic | Electrical<br>-Cutaneous | Blink reflex (R1, R2, R3) | Cutaneo-muscular reflex (E)<br>Voluntary potential (V)<br>Masseteric inhibitory reflex (MIR) |
| | -Cutaneous<br>-Mixed | C reflex (C wave)<br>Nociceptive withdrawal (RIII)<br>Palmomental | Long latency reflexes (LLR) |
| | Vibration | Tonic vibration reflex (TVR) | |
| | Muscle stretch | | Stretch reflex (M2, M3) |
| | Muscle shortening | Shortening reaction (SR) | |

## SHORT LATENCY RESPONSES TO SEGMENTAL AFFERENTS

## MONOSYNAPTIC REFLEX RESPONSES AND THEIR CIRCUITS AND INTEGRATION SITES

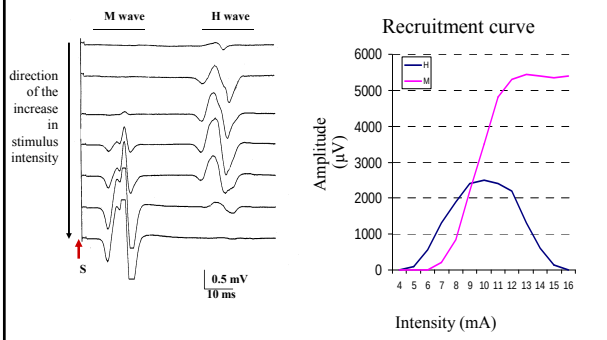
| | |
|---|---|
| H wave | Ia afferents<br>Alpha motoneurons |
| T wave | Gamma motoneurons<br>Muscle spindles and Ia afferents<br>Alpha motoneurons |

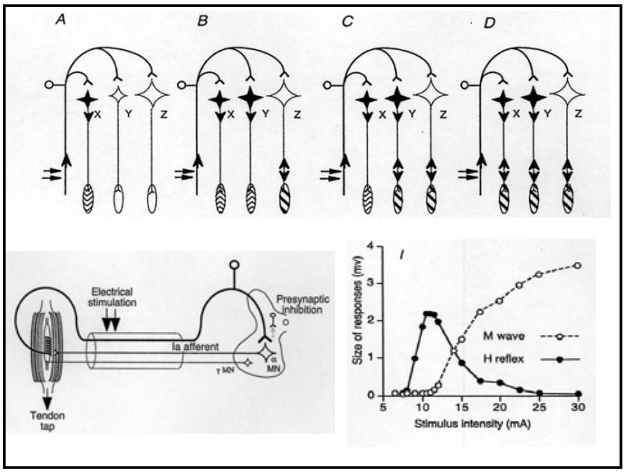



Techniques for recording the soleus H reflex

## H reflex

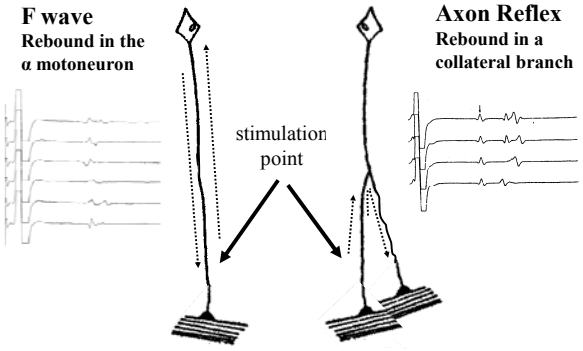



## Non-reflex responses

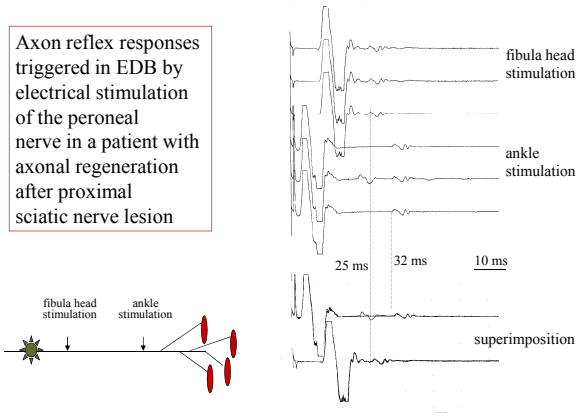
**F wave**
**Rebound in the α motoneuron**

**Axon Reflex**
**Rebound in a collateral branch**




Stimuli in the motor nerve can elicit long latency action potentials

Axon reflex responses triggered in EDB by electrical stimulation of the peroneal nerve in a patient with axonal regeneration after proximal sciatic nerve lesion




**The utility of the H reflex and F waves in clinical practice**

**Peripheral nervous system**

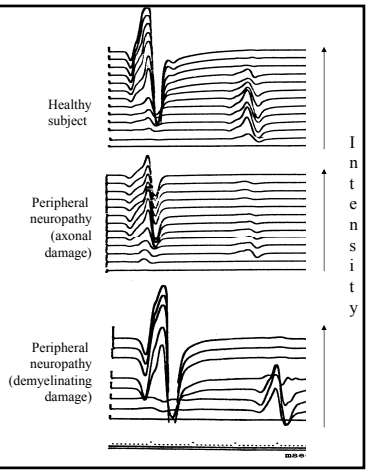
Polineuropathies
Focal lesions
Radiculopathies

**Central nervous system**

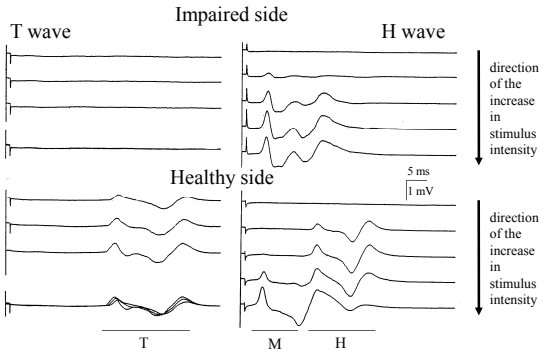
Spasticity
Dystonia
Rigidity and other disorders of propriospinal interneurons

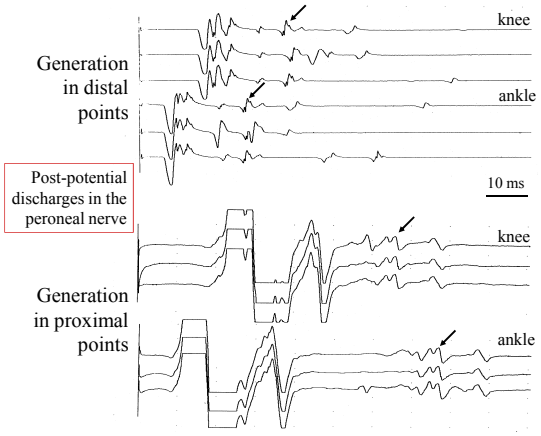
The H reflex in polyneuropathies

The soleus H reflex in clinical practice

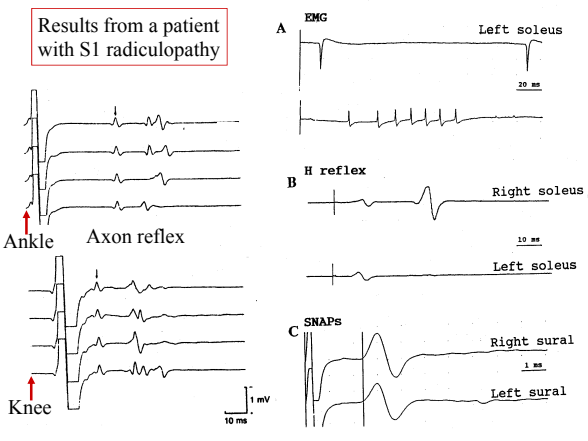


Absence of vastus medialis T and H waves in a L4 radiculopathy

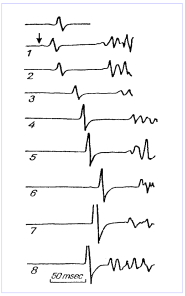



Results from a patient with S1 radiculopathy



Gerilovsky et al., 1975
Neurofiziologia,



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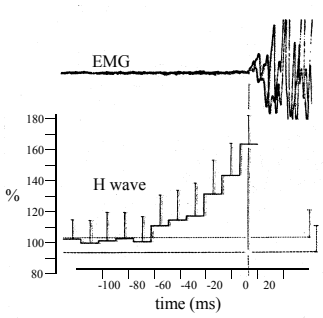
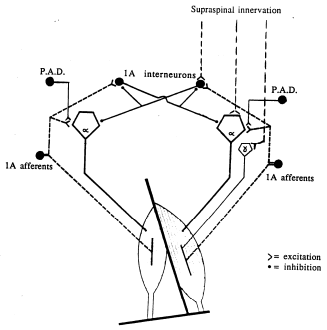
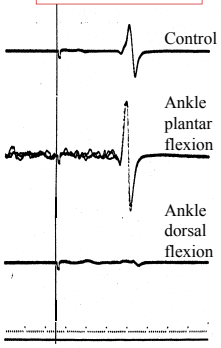



Pre-movement facilitation of the soleus H reflex

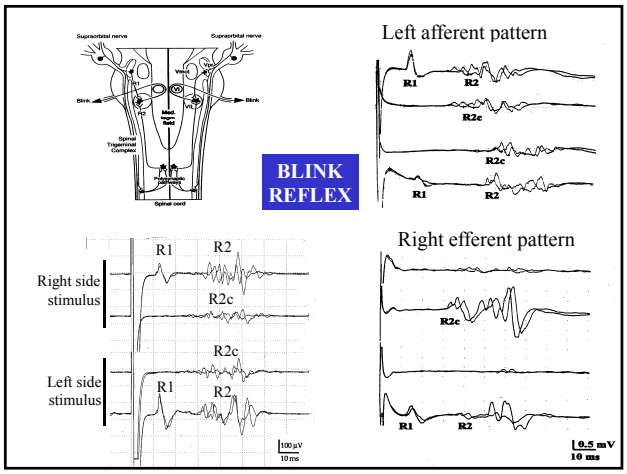


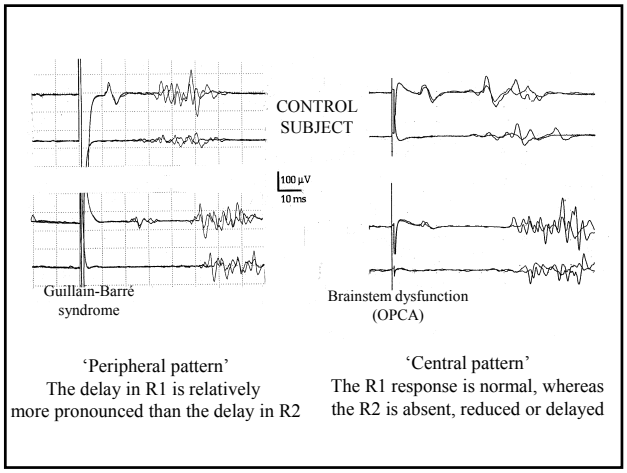

A fast evaluation of reciprocal inhibition in the soleus H reflex




Presynaptic inhibition
Reciprocal Ia inhibition
Autogenic Ib inhibition
Recurrent (Renshaw) inhibition

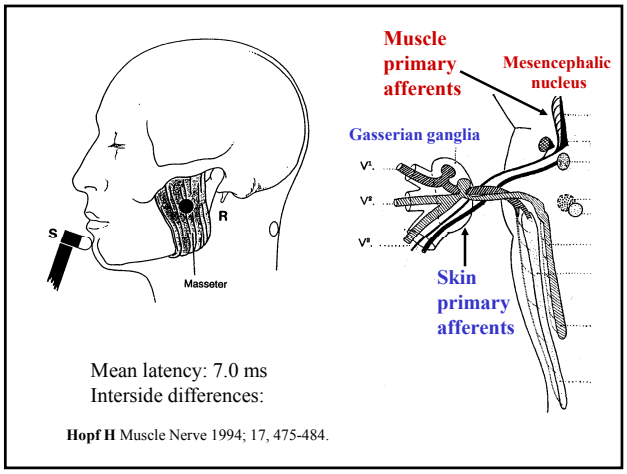
CRANIAL NERVE REFLEXES




'Peripheral pattern'
The delay in R1 is relatively more pronounced than the delay in R2

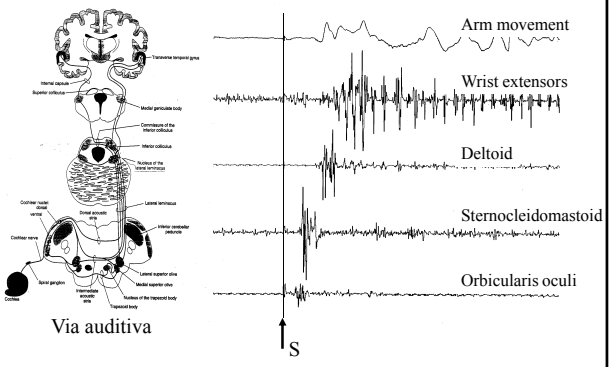
'Central pattern'
The R1 response is normal, whereas the R2 is absent, reduced or delayed



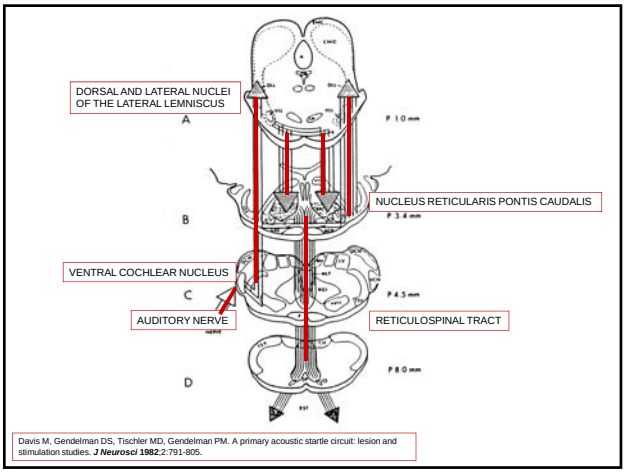

Mean latency: 7.0 ms
Interside differences:

**Hopf H** Muscle Nerve 1994; 17, 475-484.

The startle reaction to an auditory stimulus



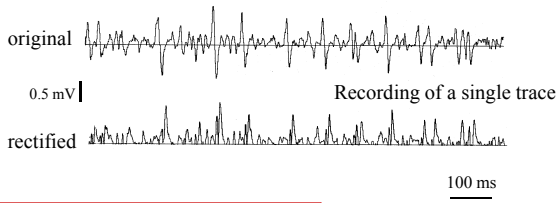

Via auditiva



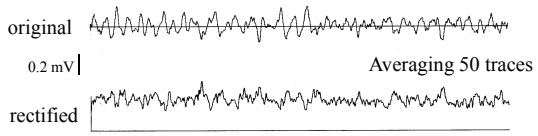

Davis M, Gendelman DS, Tischler MD, Gendelman PM. A primary acoustic startle circuit: lesion and stimulation studies. ***J Neurosci* 1982**;2:791-805.

# SILENT PERIODS AND INHIBITORY REFLEXES

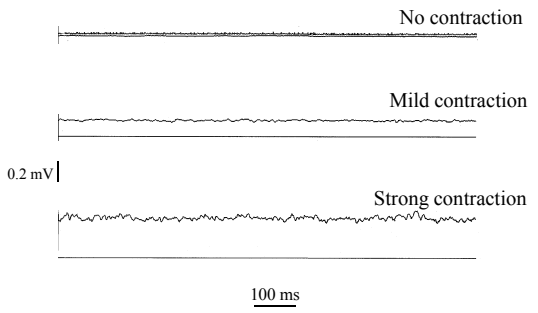
REFLEXES REQUIRING BACKGROUND CONTRACTION

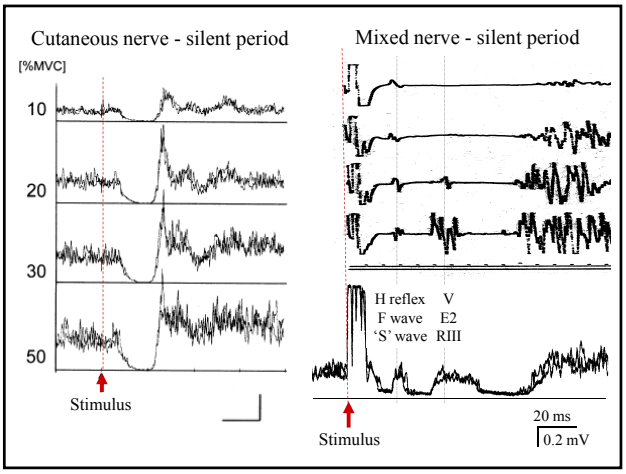


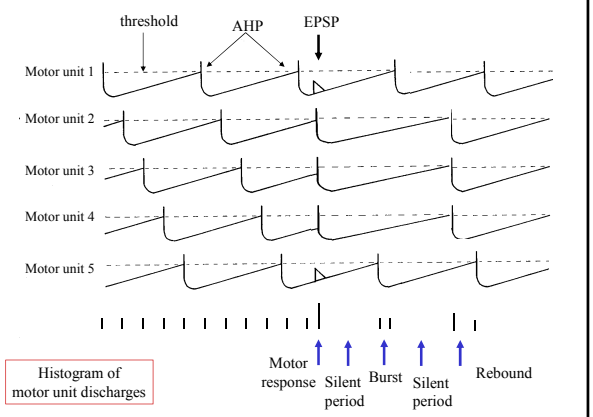

AVERAGING OF RECTIFIED EMG



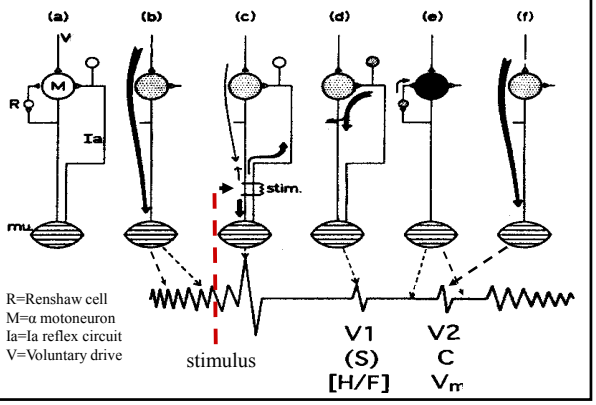

Averaging 100-200 traces of rectified EMG






Mechanisms of generation of the silent period to mixed nerve stimuli




## CONCLUSIONS

The H reflex, T wave and F wave should be part of the clinical studies of proximal nerve conduction when suspecting polyneuropathies or radiculopathies

The blink reflex, jaw jerk and masseteric inhibitory reflex are useful in the study of cranial nerves and brainstem lesions

The study of inhibitory reflexes requires modulation of the EMG activity. The silent period to cutaneous afferents differs from that to mixed nerve afferents. Collision between antidromic impulses and descending volleys explains the presence of bursts in the middle of the silent period to mixed nerve stimuli