In he name of God

- Needle Electromyography (EMG)
- In according: Electrodiagnostic Medicine Dumitru,2002
- Presentation By:
- Dr.Eslamian F,MD
- Associate professor of PM&R
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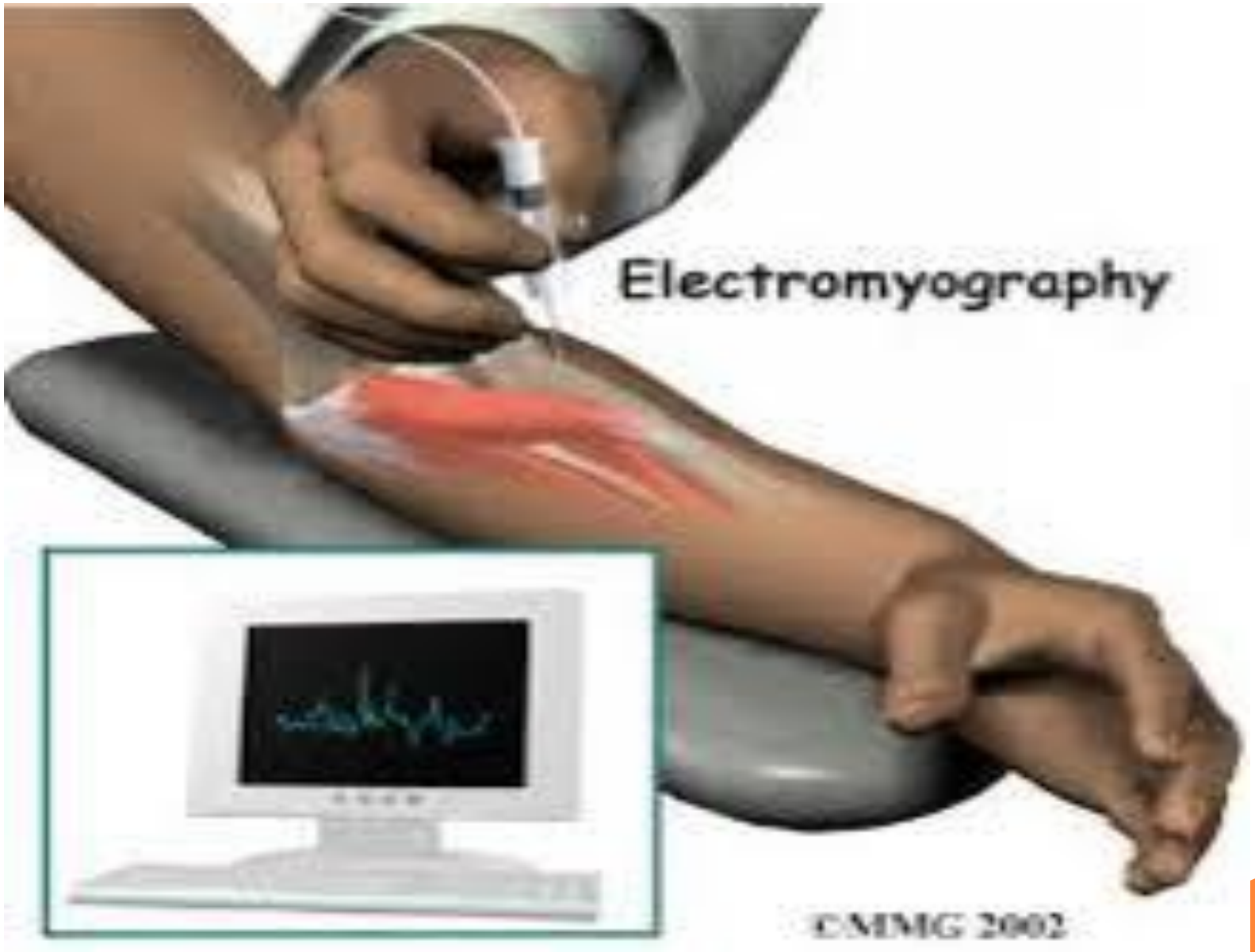

Electromyography
©MMG 2002

* Preparation

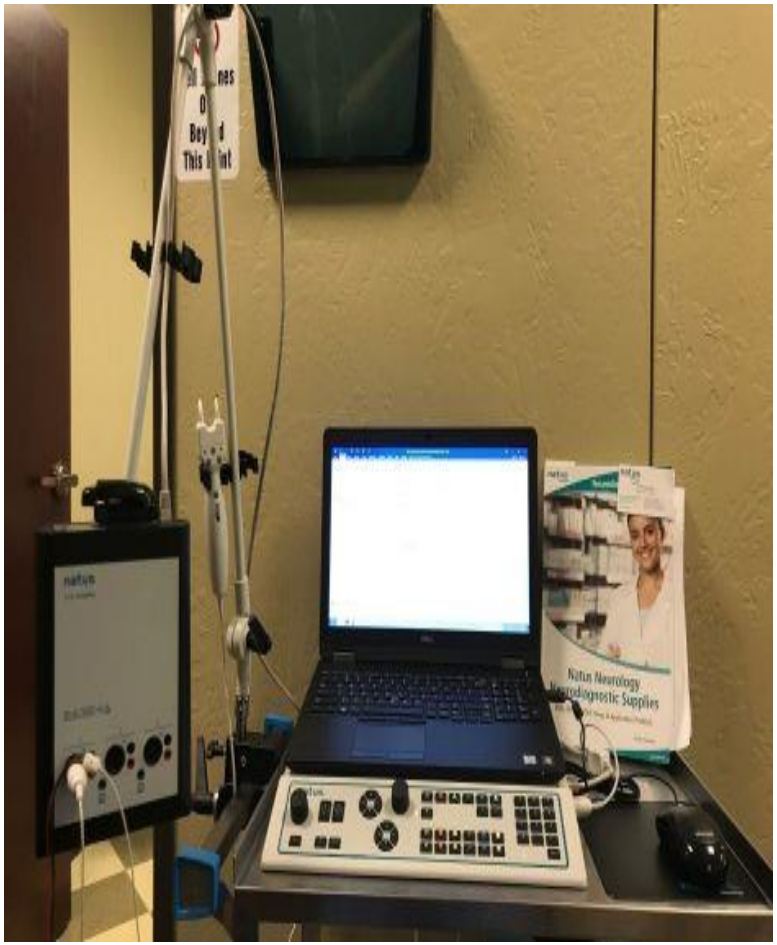
- **Patient**
- to gain confidence and cooperation of patient, physician should inform the patient as to the reason of performing the needle exam
- به بیمار نگویید دردناک نیست در حالیکه درد واقعا وجود دارد
- نشان دادن نیدل به بیمار توصیه نمیشود زیرا دیدن طول نیدل درد را به بیمار القا می کند
- بیشتر وقتها به جای سوزن گفتن کلمه ای مانند سنجاق اضطراب بیمار را کاهش می دهد
- بعد از خروج نیدل با گاز یا پنبه پک کنید و وسایل اغشته به خون را از معرض دید بیمار دور کنید
- تعداد تقریبی نیدل عضلات را قبل از انجام بگویید
- بگویید که یکی دو روز درد مختصری خواهد داشت وبعد رفع میشود

the examiner

- is a medical consultant
- dynamic process rather than routine process
- needles must be disposable
- standard old none disposable needle are also acceptable
- those should be kept in hypochlorite Na 15 min then rinsed clean and then sterilized.
- Distraction technique for entrance

3.Preparation : The equipment

- Purchasing
  - Amplifier input impedance and CMRR
  - Variable filter
  - A-D conversion
  - Trigger and delay
  - CRT resolution
  - Services



Equipment

- Input impedance &Common mode rejection ratio,
- amplification of differences and removing of similar potentials
- CRT resolution
- analogue to digital conversion
- delay and trigger line
- service of factory
- filter setting:10-30 Hz (low frequency filter or high pass)_10000-30000Hz (high frequency filter or low pass)
- It should be remember that the skill required to perform a competent needle exam is in the hands of practitioner not the instrument, irrespective of its cost.

The art of Needle exam

- before punctuation:
- pinching the skin or applying firm pressure near the needle site, or stretching the region to be penetrated with first and second digits of opposite hand to facilitate needle insertion and reduced discomfort
  - بعد از نیدل زدن و بررسی در یک نقطه در حالت rest ، نیدل را زیرجلدی کنید و سپس در مسیر دیگری در همان عضله تغییر جهت دهید. از مناطق دردناک دوری کنید مانند ناحیه end plate تاندون اعصاب عروق و پریوست استخوان.
  - در هنگام voluntary MUAP هم برای تغییر جهت باید ابتدا زیر جلدی کنید تا درون عضله خم نشود یا باعث پارگی فیبرهای عضله نگردد.

طریقه ریلاکس کردن عضلات پاراسپاینال

- گذاشتن چند لایه بالش زیر شکم برای کمری و زیر سینه برای گردنی
- فشردن عضلات معده برای کمری یا ناحیه پیشانی برای گردنی
- گذاشتن بالش زیر زانوها و اویزان کردن دستها از بغل
- خوابیدن به پهلوها

5 STEPS IN NEEDLE EMG(DR.JHANSON & DUMITRU CRITERIA)

- **at rest**
- **insertional activity**
- **minimal to moderate contraction,**
- **maximal contraction**
- **Information synthesis**
- **Impression formulation**

PERFORMING THE NEEDLE ELECTROMYOGRAPHIC EXAMINATION

JOHNSON'S 5 STEP TO NEEDLE EXAMINATION

- 1. muscle **at rest** / same
- 2. **insertional activity** / same
- 3. **minimal** muscle contraction / minimal to moderate
- 4. **maximal** muscle contraction/ information synthesis
- 5. **exploration** / impression formulation

1.Muscle in rest

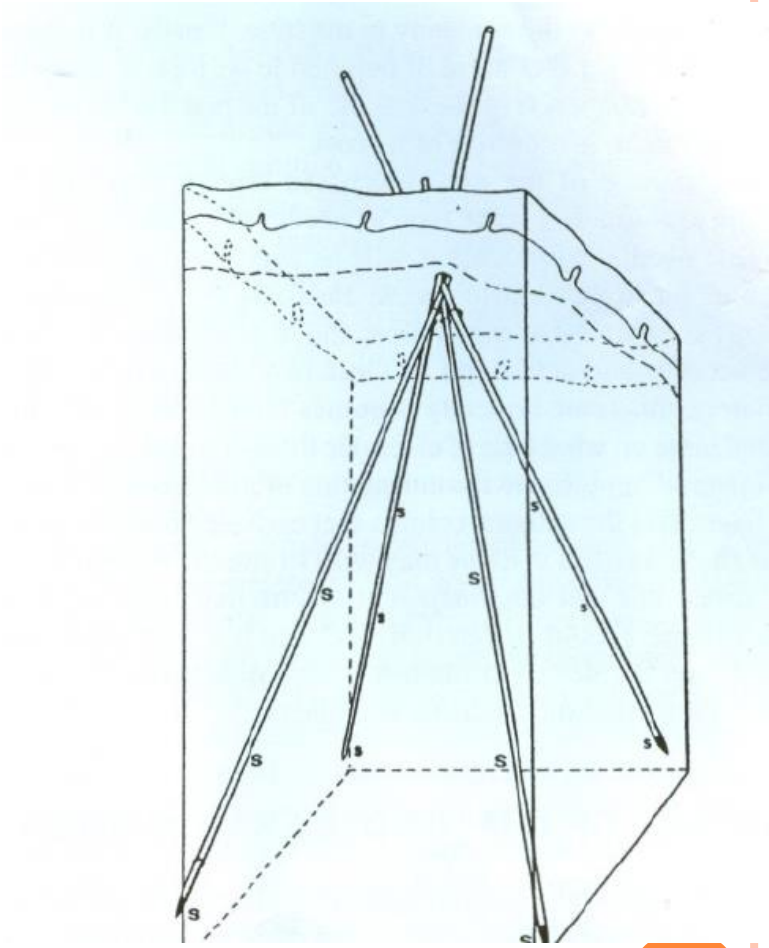
- Sensitivity : 50 micro volt/ div
- sensitivity of 100μv/div can be used
- Sweep speed: 10 ms/div
- filter setting: low filter 10-30 Hz and high filter setting of 10000-30000 Hz will avoid distortion of potentials
- Monopolar : reference elect. Close to site
- Quickly insertion through the skin
- as before noted taut and spread the skin with other hand
- the aim of this part: to observe the spontaneous activity if exist
- Beginning practitioner…..

2.INSERTIONAL ACTIVITY

- to induce the electrical activity that is not present spontaneously
- Pyramidal space
- 0.5- 2 mm increments with a several second pause between each insertion
- depth: several mm in facial and sphincter muscles and several cm in limb or paraspinals
- then withdraw to S.C tissue and redirect along a different axis
- Needle mechanically

depolarize muscle fibers

- Injury potential



3.Minimal to moderate contraction

- Gentle activate the muscle Think of small contraction
- Type I fiber analysis
- 500 μv/div
- High amp >5 mv or more
- Polyphasia >4
- duration long or short
- Interference pattern : minimal information
  - Pain
  - Patient effort
  - Ability for resistance applied be examiner
- Exception of max contraction benefit: type II fiber atrophy (steriod myopathy)
  - In maximal contraction normal high amp MUAP are absent. It is necessary to ensure superficial placement of needle to avoid bending needle and consequent trauma.

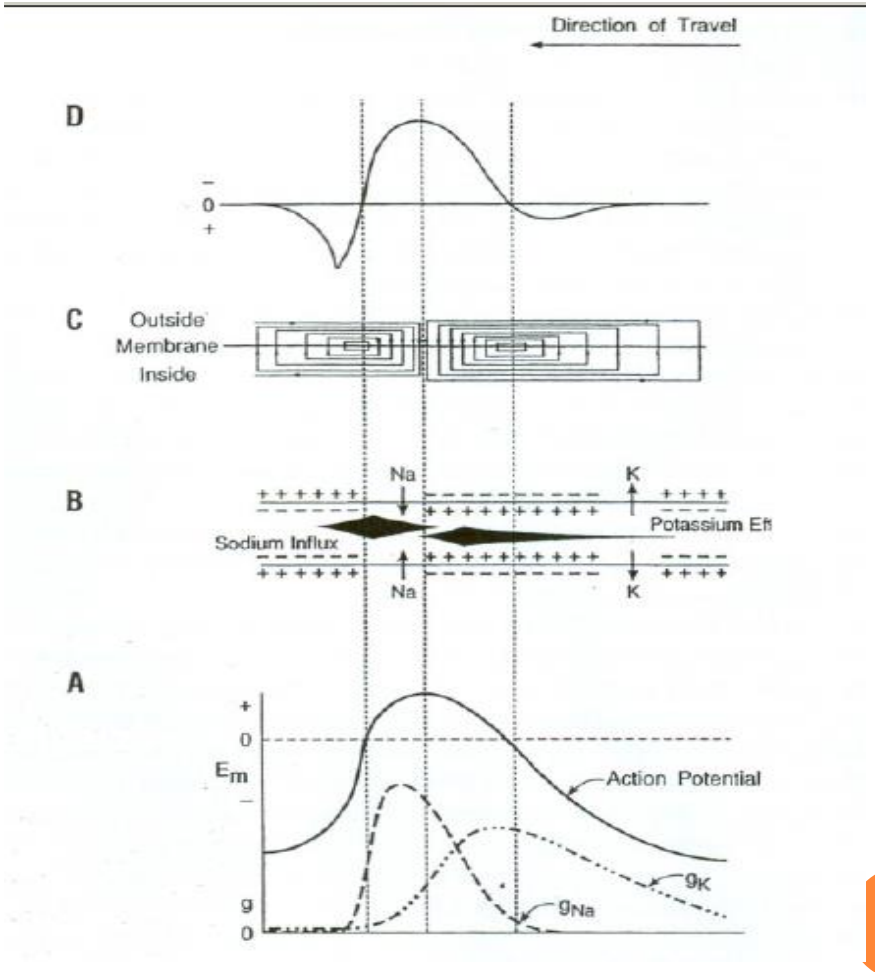
Information synthesis
Impression formulation

- needle EMG is a dynamic process and it is not similar to reading a ECG in isolation from patient.
- sometimes one simple result: CTS
- Sometimes combined result: neuropathy and radiculopathy
- at end: provide some recommendations about prognosis or treatment options if requested

ELECTROPHYSIOLOGY

ACTION POTENTIAL GENERATION

- Membrane potential depolarized from -80 mV to -50 to -60 mV (threshold)
  - Voltage gated Na channel activated 0.5 ms
- Then depolarization to +40 mV
  - Delayed increased K permeability with inactivation of Na channel 2.0 ms



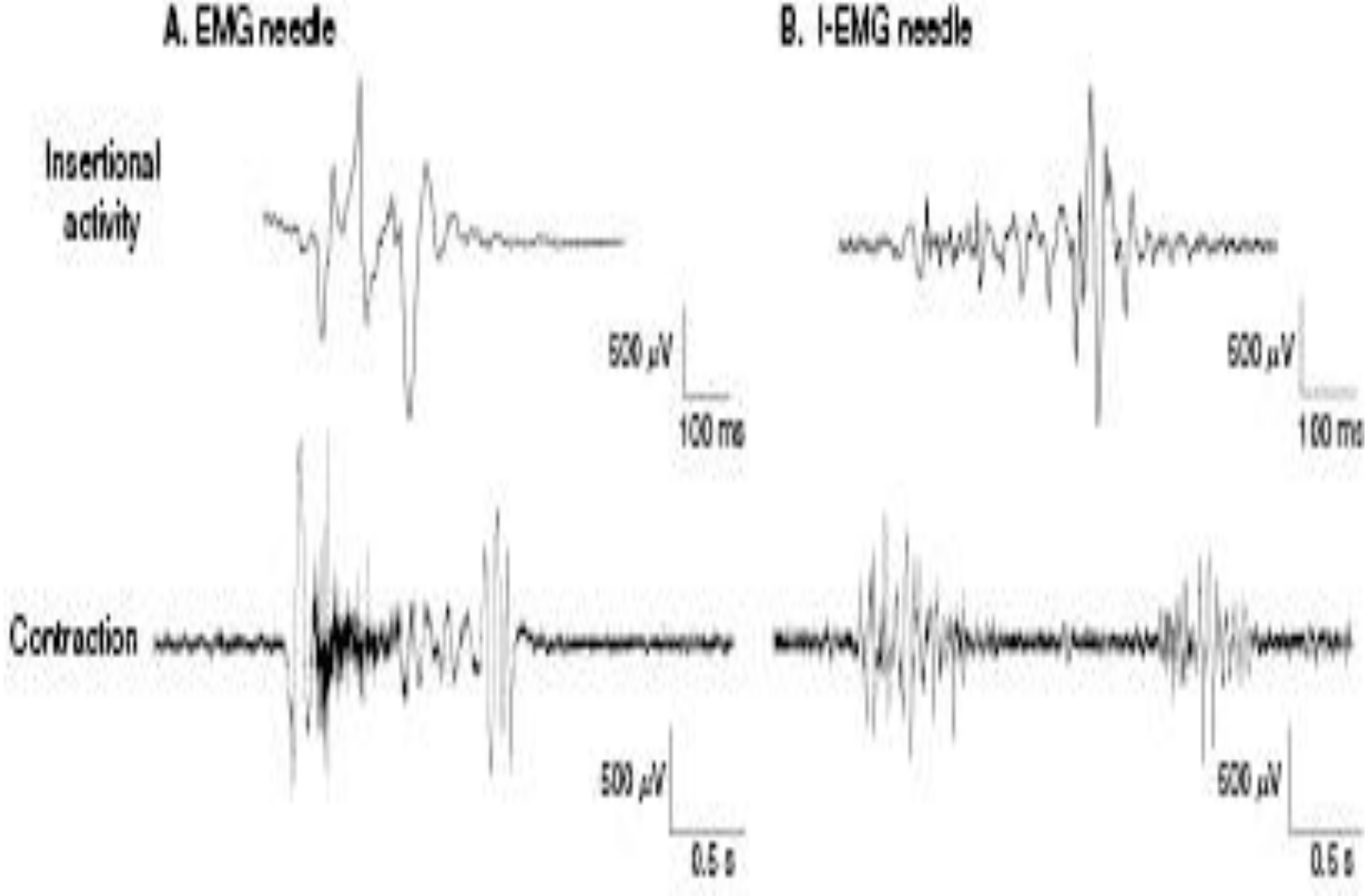
Electrical potentials

- spontaneous activity
- Muscle generator
- fasciculation's
- Fibrillation/psw
- Myotonia
- CRD

- spontaneous activity
- neural generator
- fasciculation's
- Myocymic discharges
- cramp
- Multiplet
- continues motor unit activity

Insertional activity

- Monopolar :
  - Total time of activity: < 230 ms
  - After needle cessation 48+/- 18 ms
- Concentric
  - Total time(from insertion until needle cessation) :<300 ms
- In animal after denervation: PSW then Fib
- Snap crackle and pop :
  - Normal in young men in GCS.
  - Variable length of time persisted
- Another normal variant:
  - Run of PSW with few Fib
  - AD inheritance
- So Fib & PSW are not always pathologic


A. EMG needle
B. I-EMG needle
Insertional activity
500 µV
100 ms
Contraction
500 µV
0.5 s

Needle insertional activity

Table 7-2. Insertional Activity[154]

Type	Duration	Shape	Etiology
Normal	< 300 ms	Spikes	Muscle depolarization
Increased	> 300–500 ms	Spikes	Normal variant
		Positive waves	Normal variant
			Denervation
			Myopathy
Decreased	Absent or < 300 ms	Absent/spikes	Fat
			Fibrosis
			Periodic paralysis

Insertional activity

- Decreased I.A :
  - Fibrosis
  - Sub Q
  - Attack of periodic paralysis
  - Improper electrode connection
- Increased IA:
  - Muscle denervation
  - Other membrane instability

- IA or sustained or unsustained spontaneous activity

SPONTANEOUS ACTIVITY

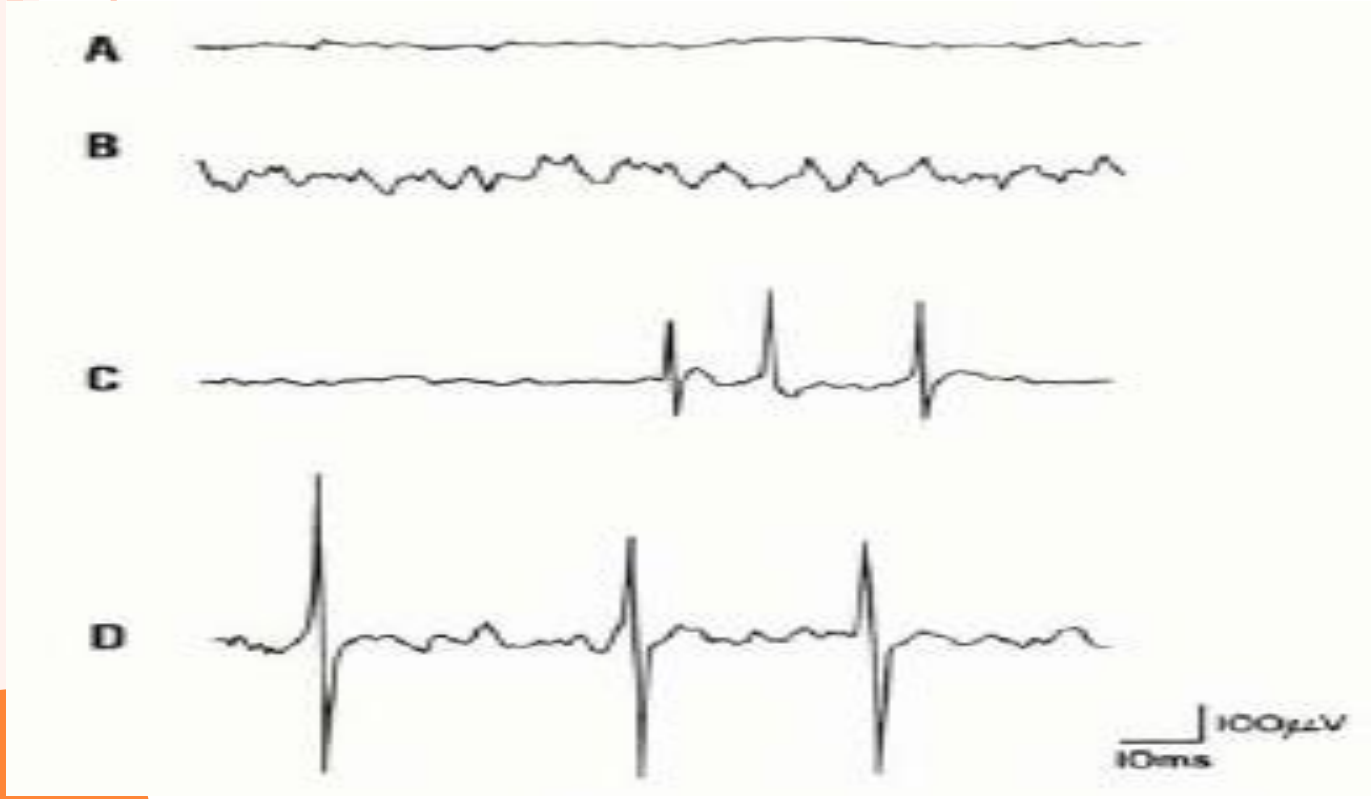
Placing a needle in healthy muscle tissue at rest usually results in complete electrical silence, provided the needle is not located in the endplate region. The endplate is that specialized portion of a single muscle fiber where the terminal axon and muscle fiber form a neuromuscular junction. Two waveforms, miniature endplate potentials (MEPPs) and endplate spikes, may be concomitantly or independently observed with a needle electrode in the endplate portion of muscle tissue.

2.Spontaneous activity

- After placing a needle into **endplate**
  - **Miniature endplate potential (MEPPs)**
  - **Endplate spike**

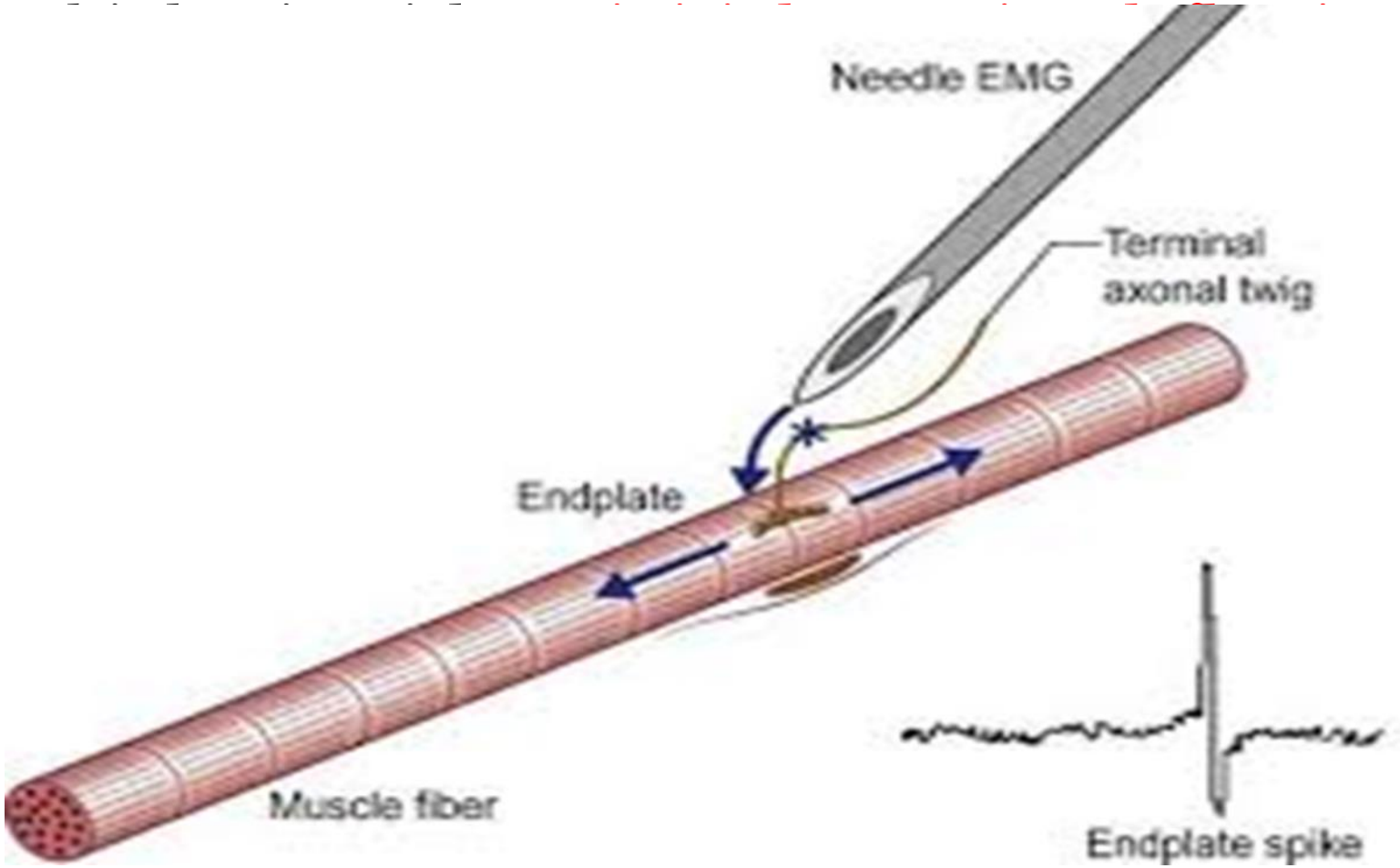
Miniature Endplate Potentials

- ✓ Short duration (0.5-2 ms)
- ✓ Irregularly
- ✓ Small (10-40)μv
- ✓ 20-40Hz
- ✓ Monophasic negative waveform
- ✓ high-pitched noise or seashell murmur
- ➢ spontaneous random release of acetylcholine (ACh) from the presynaptic nerve terminal
- ➢ subtreshold depolarization
- ➢ Following complete denervation of muscle tissue, it disappear because endplate degeneration



اگر 8-10روز بعد از قطع عصب همچنانMEPP برقرار باشد یعنی عصب کاملا دنروه نشده است.

Endplate Spikes



B) Endplate spike

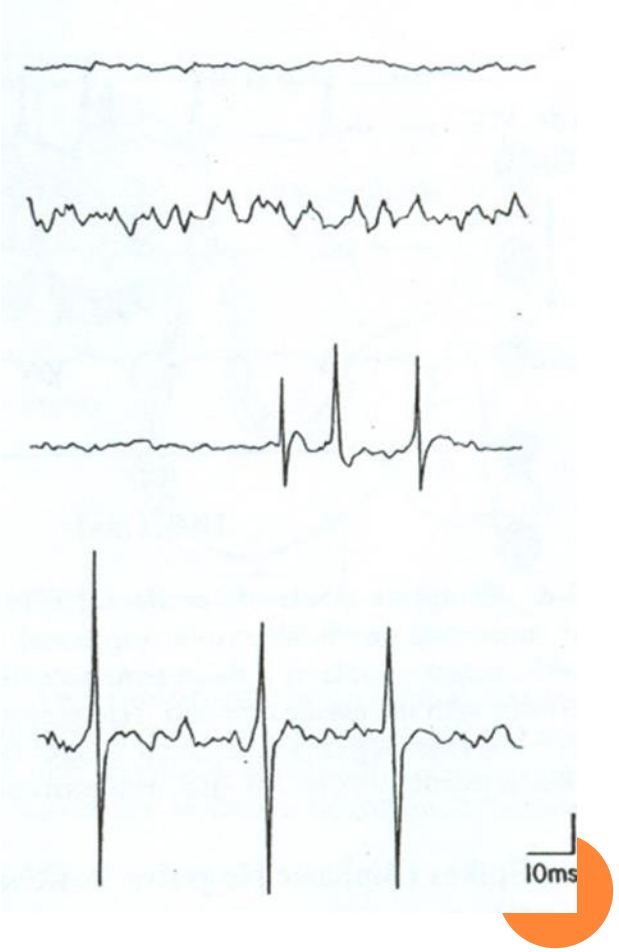
- Longer duration (3-5ms)
- Moderate amp (100-200 mic v)
- Irregular
- Shape:
  - Biphasic with + initial : mistaken with PSW
  - Triphasic with + initial : mistaken with Fib
  - But endplate spike is highly irregular
- Some believed it arise from intrafusal muscle fiber
- Crackling sound

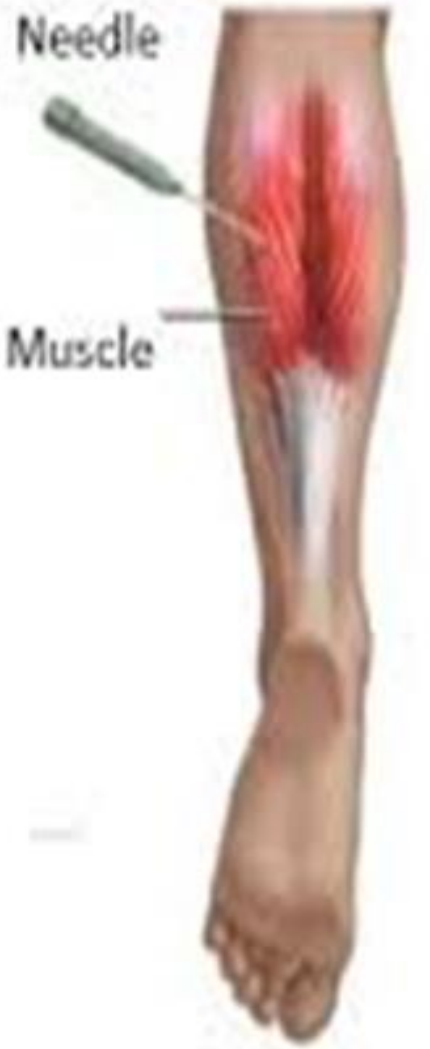
Difference between MEEPs and endplates

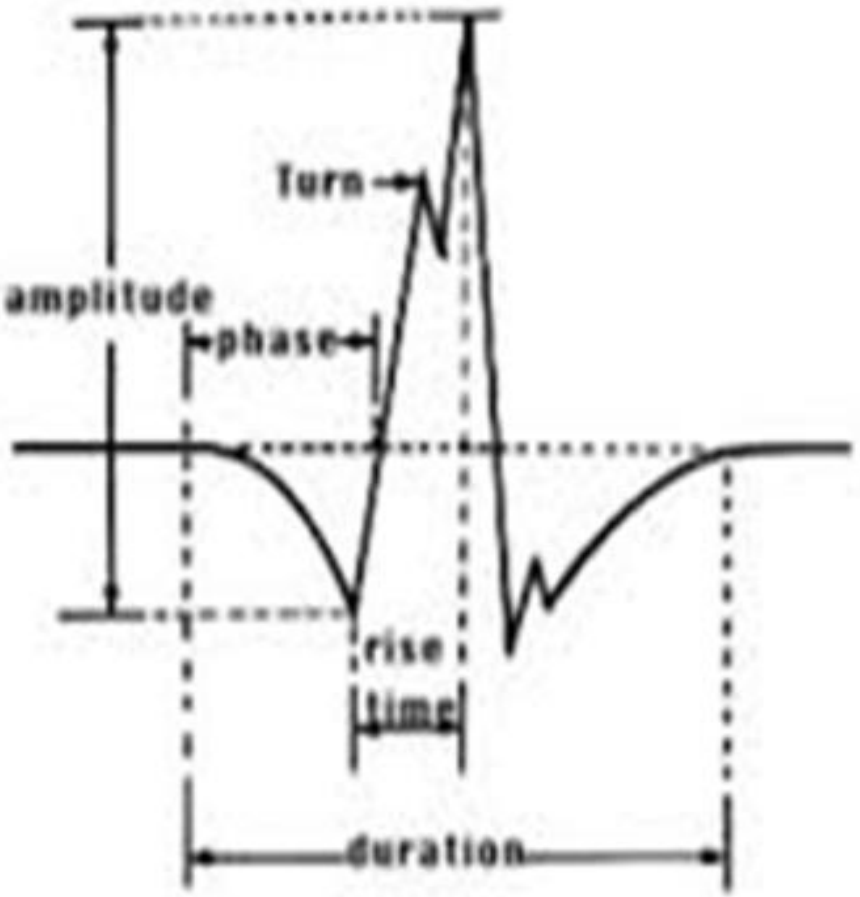
Table 7-3. Endplate: Normal Spontaneous Activity

	MEPPs	Endplate Spikes
Morphology	Monophasic negative	Biphasic negative/positive
Firing pattern	Irregular	Irregular
Amplitude	10–50 μV	100–200 μV
Duration	0.5–2.0 ms	3.0–4.0 ms
Origin site	Endplate	Single muscle fiber depolarization from needle electrode generating a suprathreshold endplate potential
Denervation	Disappear	Disappear

Modified after Brown[21]

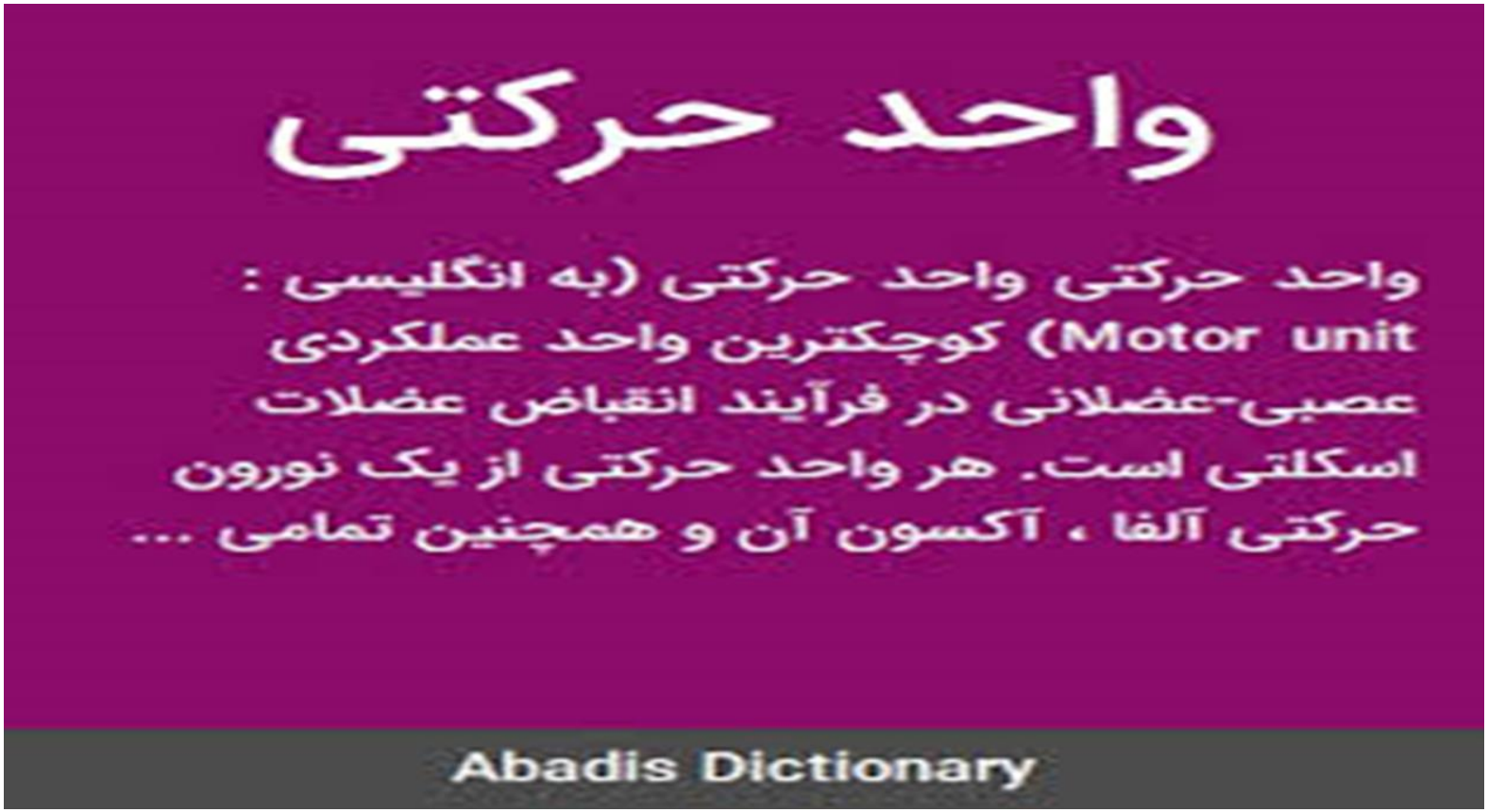






EMG Test Report (Electromyogram)

- یک single muscle fiber A.P یک پتانسیل تری فازیک ابتدا پازتیو بعد نگاتیو هست به سه دلیل تبدیل میشود به موج بیفازیک:
- موج سوم پازتیو ان در نویز بیس لاین محو شده باشد
- از ناحیه تاندون رکورد شده باشد
- ناحیه کانولا در end plateقرار گرفته و موج اولیه نگاتیو/پازتیو را به حالت پازتیو /نگاتیو کانورت(invert) می کند.


واحد حرکتی
واحد حرکتی واحد حرکتی (به انگلیسی : Motor unit) کوچکترین واحد عملکردی عصبی-عضلانی در فرآیند انقباض عضلات اسکلتی است. هر واحد حرکتی از یک نورون حرکتی آلفا ، آکسون آن و همچنین تمامی ...
Abadis Dictionary

MUAPs

Anatomy

- Motor unit definition
- Types:
  - Alpha: skeletomotor
  - Beta : skeletofusimotor
  - Gamma: fusiomotor
- Alpha situated in ventrolateral horn
  - Limbs motor units located laterally in comparison with neck and trunk muscle.
  - They have axon collateral to synapse with Renshaw interneourons and other alpha motor neurons
- One MU may be distributed over 100 muscle fiber
  - MUs dos not extended between 2 muscle
  - One single fiber innerveted by only one MN
  - Sometimes 2 NMJ seen but its from one MN

What is the Motor Unit?

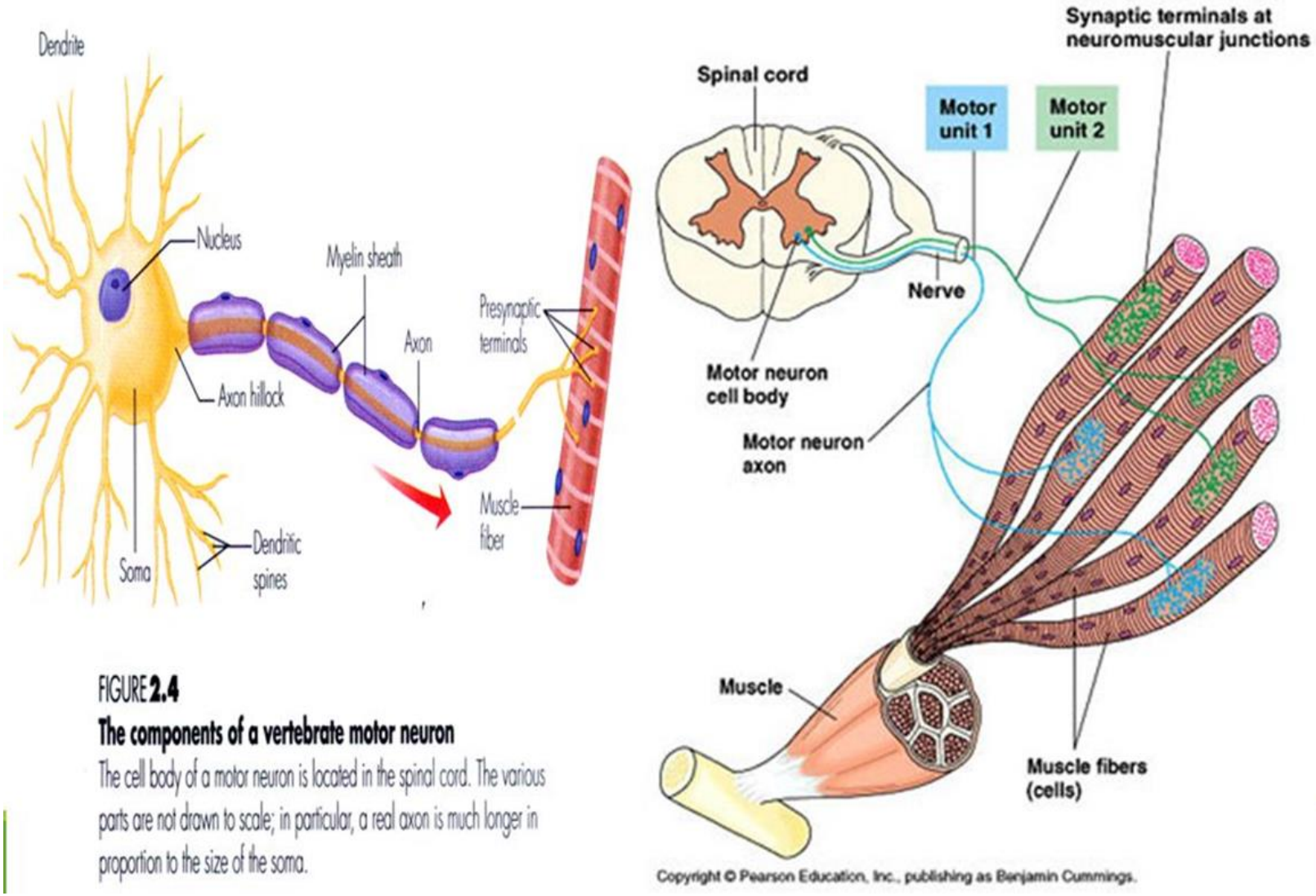


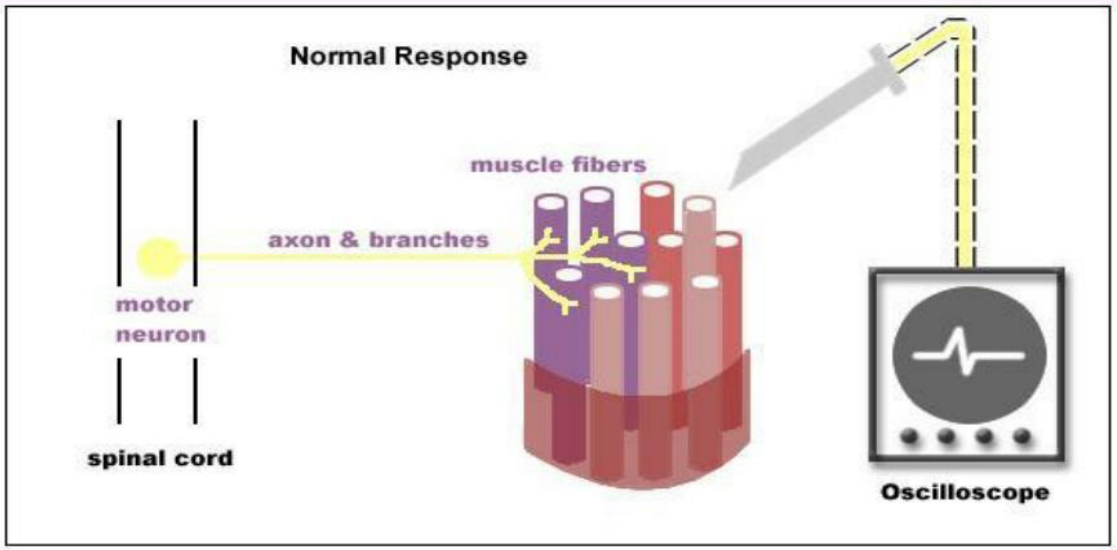
FIGURE **2.4**

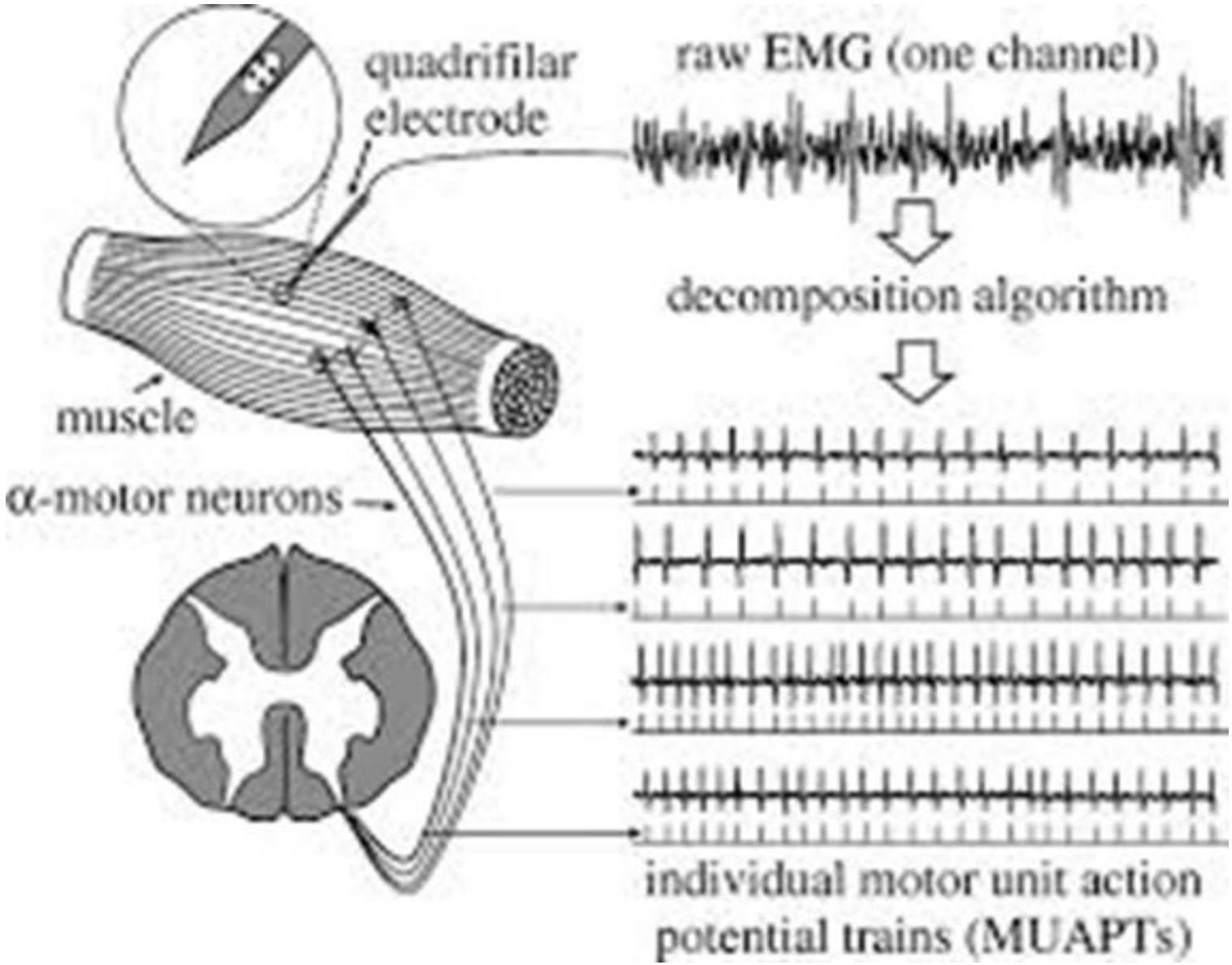
The components of a vertebrate motor neuron

The cell body of a motor neuron is located in the spinal cord. The various parts are not drawn to scale; in particular, a real axon is much longer in proportion to the size of the soma.

- واحد حرکتی (motor unit) شامل جسم سلولی نورون حرکتی
- آکسون نورون حرکتی
- فیبر های عضلانی هستند که از آن اکسون عصب گیری میشوند.

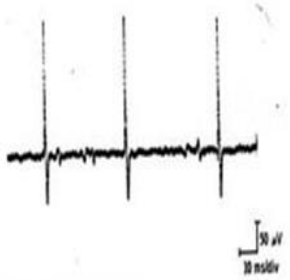
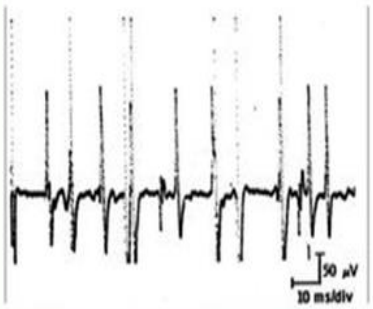
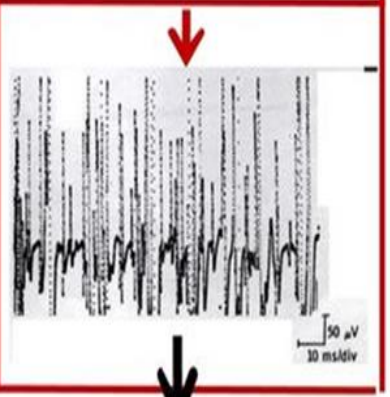
NORMAL EMG




quadrifilar
electrode
raw EMG (one channel)
decomposition algorithm
muscle
α-motor neurons
individual motor unit action
potential trains (MUAPTs)

Motor Unit Potentials (MUPs) (Normal MUP)

- (MUPs): is the potentials recorded (on volitional effort) in needle EMG are derived from motor units of the muscle.

At Rest: silent	During Mild Effort	During Moderate Effort → note recruitment of additional motoneurons	During Full Voluntary Effort . There is full recruitment (you can not see the baseline)
			

- (MUPs) Abnormalities:
  - In nerve diseases: Giant MUPs due to re-innervation > 5 mV.
  - In muscle disease: Small MUPs < 300μV.

Max contraction →
Full interference pattern

Innervation ratio:

Total number of muscle fibers in a particular muscle dividing by the number of large motor axons innervating that muscle.

به عنوان مثال در رکتوس فوقانی چشم 23 فیبر به ازای هر موتور یونیت هست
در عضله گاستروکنمیوس 1934 فیبر به ازای هر موتور یونیت هست.

Physiology

- MU classifications
- Fast twitch
- More force innervated by fact conductive neurons
- Slow twitch
- Small force by slow conductive neurons
- Speed of contraction
- Specific contractile proteins
- Rate of calcium uptake
- Fast twitches have
- More extensive sarcoplasmic reticulum
- Richer in Ca-Mg ATPase

Motor units classification

- Fast fatigue (FF)
- Readily fatigue
- High tetanus tension
- Fast contraction time
- Slow (s)
- Low tetanus tension
- Long contraction time
- Resistant to fatigue
- Third group
- Moderate tetanic tension
- Fast twitch time
- Relatively fatigue resistant (FR)

Muscle Fibre Types

Long Distance

Type 1

Slow twitch

400m / 800m

Type 2A

Fast twitch oxydative

Short Sprints

Type 2B

Fast twitch glycolytic

Low → High

Fatigue rate

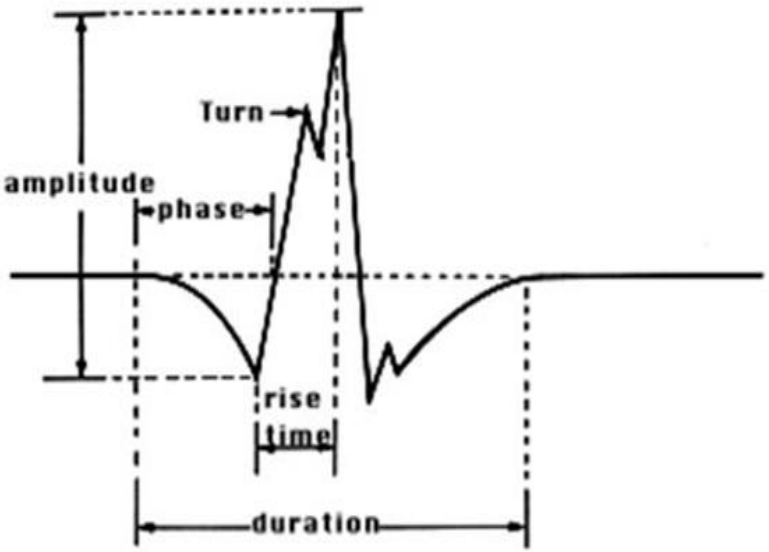
Histochemical technique

- Fatigue resistant: higher activity of
- Mitochondrial enzymes
- Succinate dehydrogenase

- Fatigue sensitive: higher activity in
- Phosphorylase activity (myosin ATPase)

Electromyography (EMG) Parameters Recorded

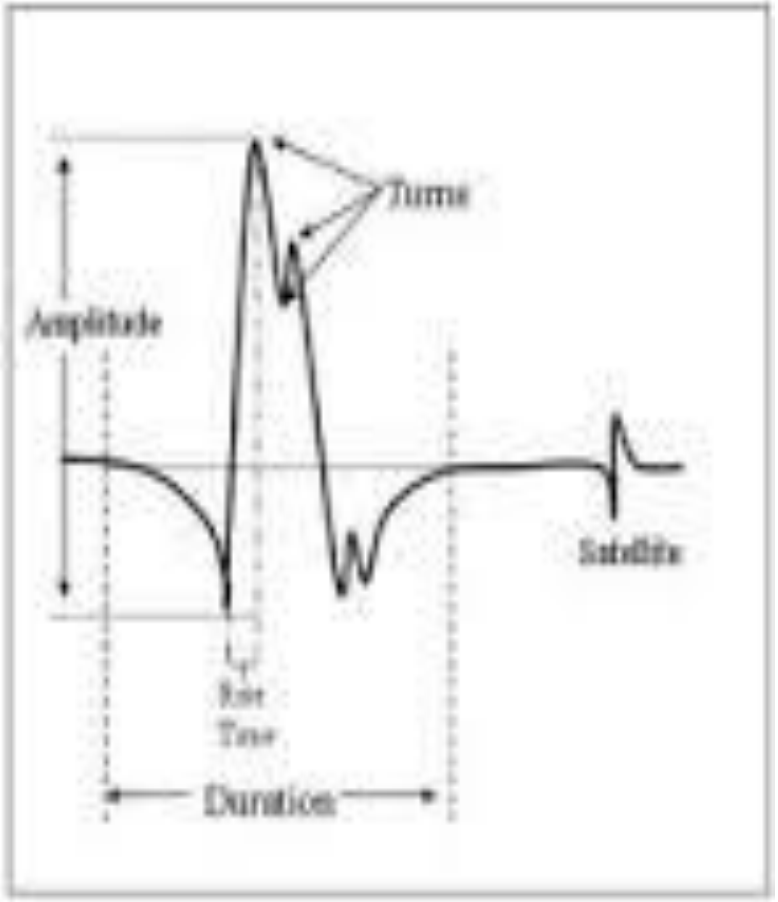
- Amplitude = negative peak to positive peak
- Duration = time from first deflection of the baseline to the last return to baseline
- Number of phases = number of times the components of the motor unit potential cross the baseline plus one
- Rise time = elapsed time between the peak of the initial positive (down) deflection to the peak of the highest negative (up) deflection



Note: the number of fibers contained in a motor unit and their degree of synchrony affect these characteristics

Motor Unit Potential Parameters

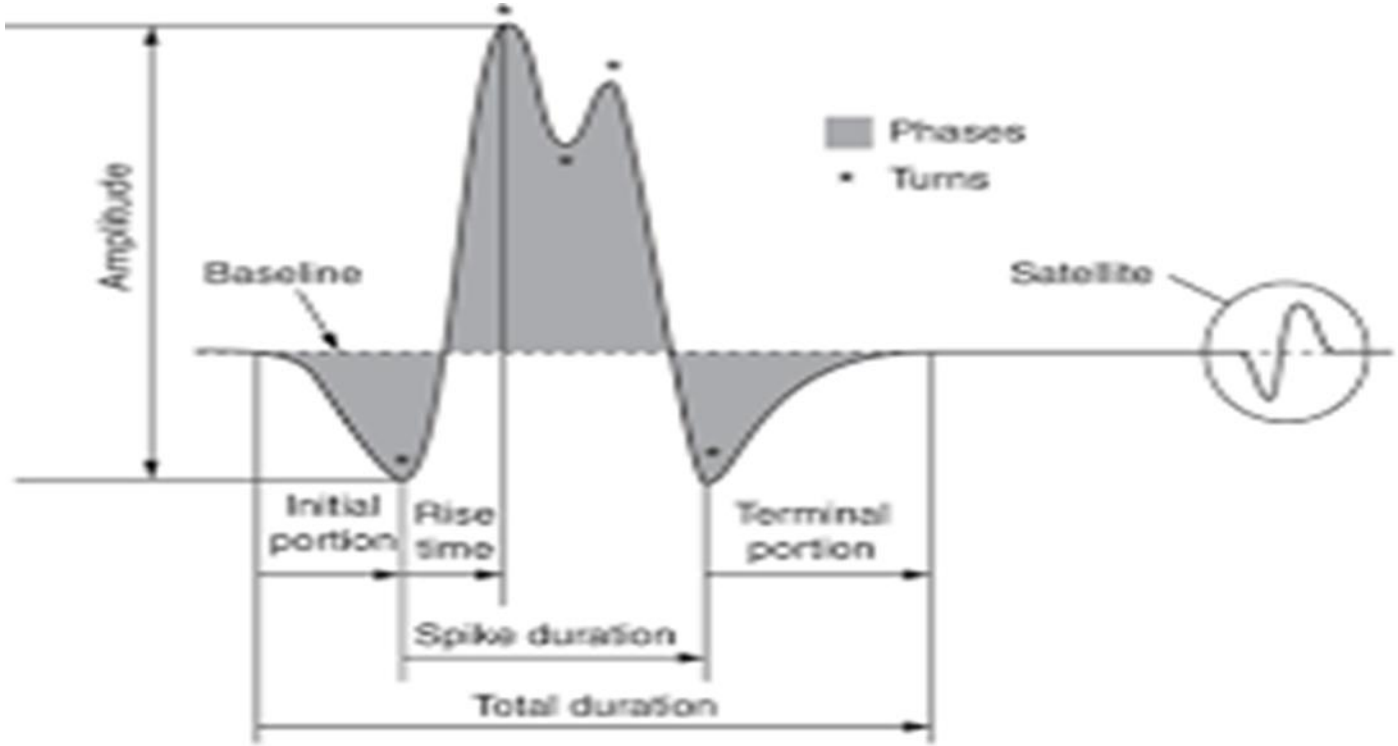
- Rise time
  - Distance from generator
- Spikes, turns, phases
  - Number of fibers
- Duration
  - Size and synchrony
- Amplitude
- Stability
  - Junction or terminal



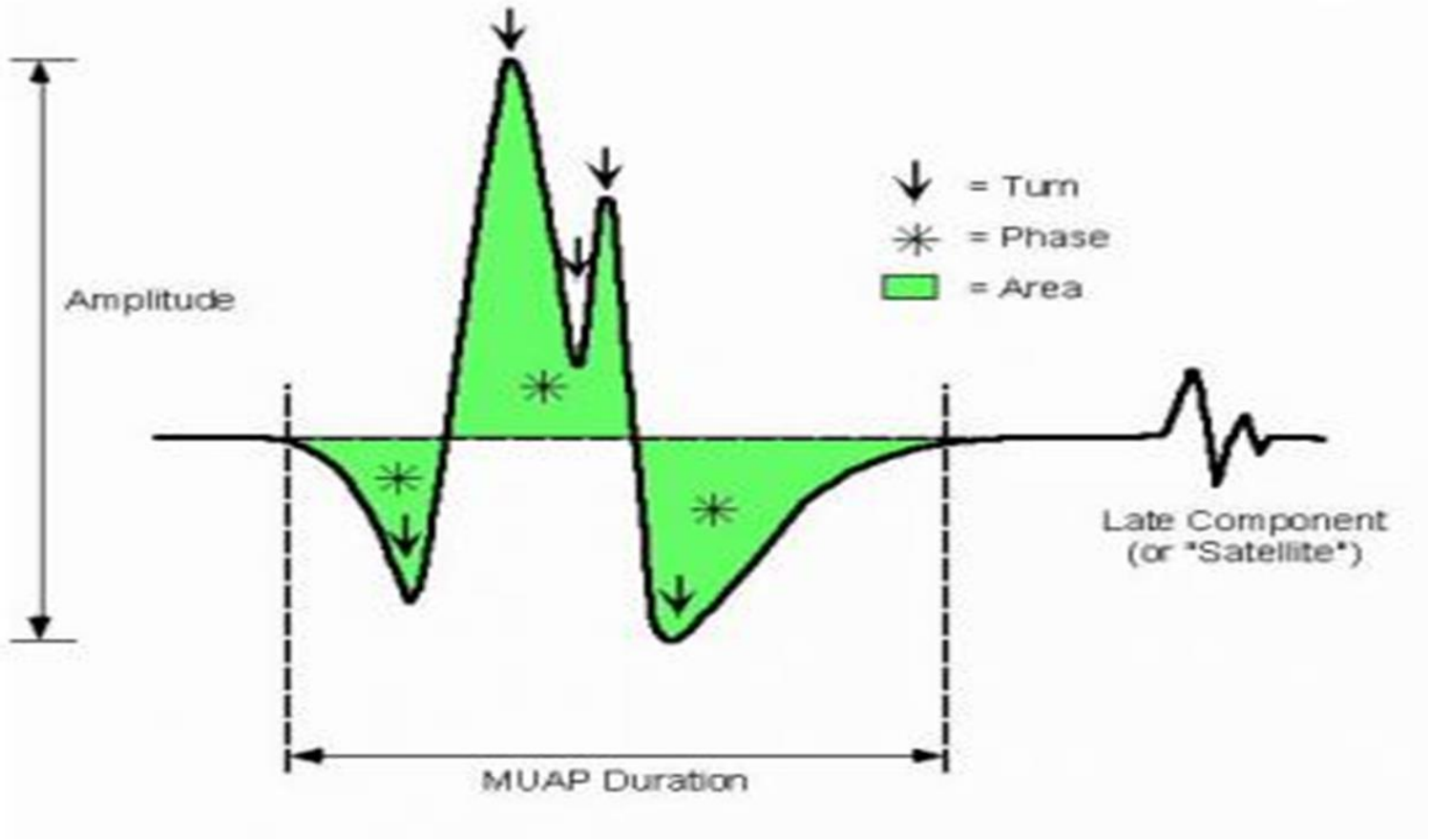
Phase

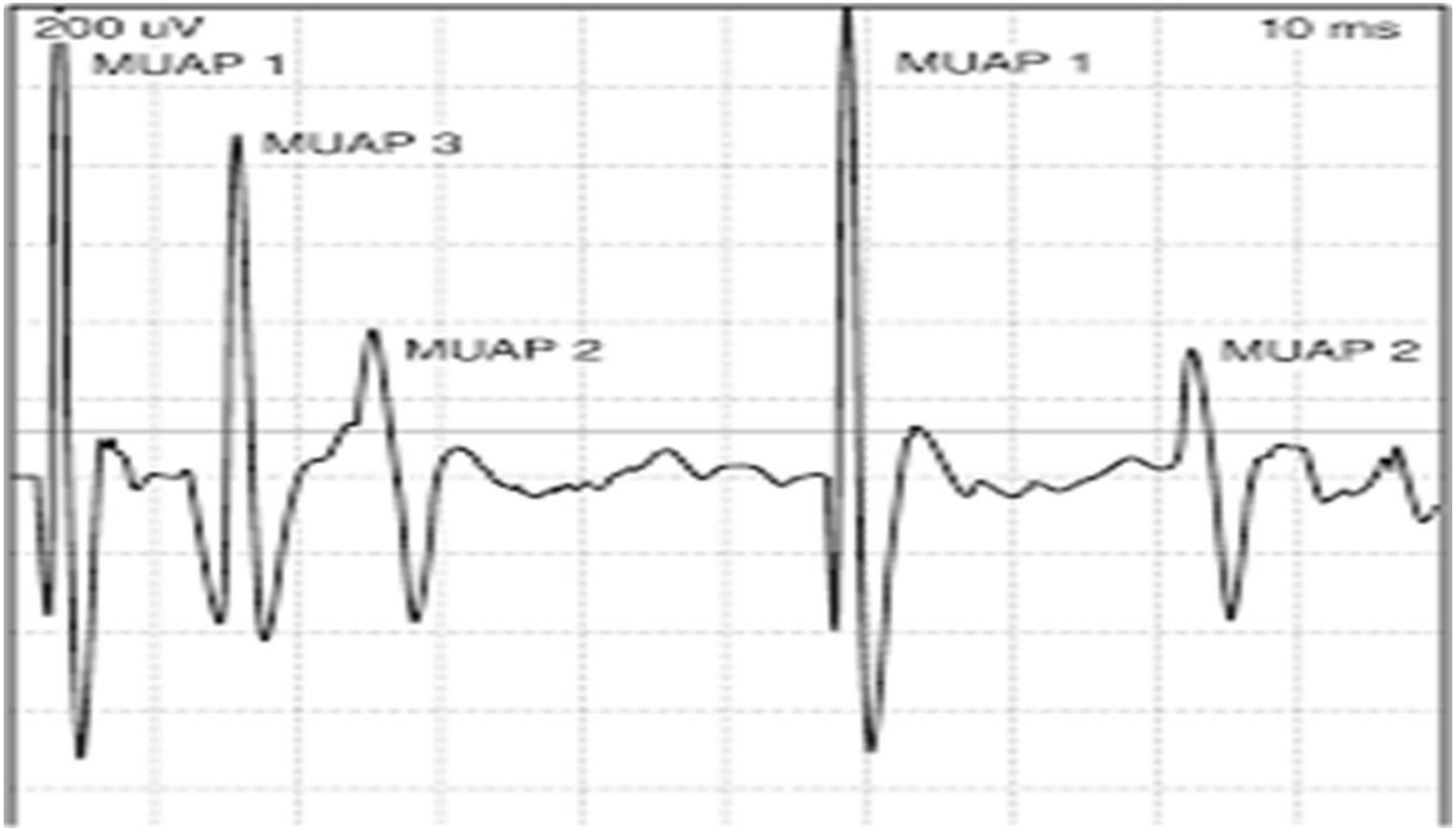
- Polyphasy : 5 or more
- Monopolar: up to 30% nl
- Concentric: up to 15% nl
- Main spike arise from 1-12 near fibers
- Amp or rise time is belonged to 1-12 muscle fiber

  In 300-500 μm distance from recording surface
- Distant muscle tissue :act as low pass filter
- low frequency initial and terminal
- Small negative spike



Source: Ian B. Maitin: Current Diagnosis & Treatment: Physical Medicine & Rehabilitation
www.accessmedicine.com


Amplitude
= Turn
= Phase
= Area
Late Component
(or "Satellite")
MUAP Duration


200 uV
10 ms
MUAP 1
MUAP 3
MUAP 2
MUAP 1
MUAP 2

چه چیزهایی روی اجزا و پارامترهای MUAP اثر میگذارد؟

- پارامترهایmuap

- Amp
- Diuration
- Phase

- عوامل موثر:

- **بیمار** (سن، جنس، ورزشکار؟)
- عوامل **محیطی** (دما)
- **دستگاه** عوامل مربوط به (needle نوع, فرکانس دستگاه)

سرما (کاهش دما):T

- افزایشAmp
- افزایشDiuration
- افزایشPhase

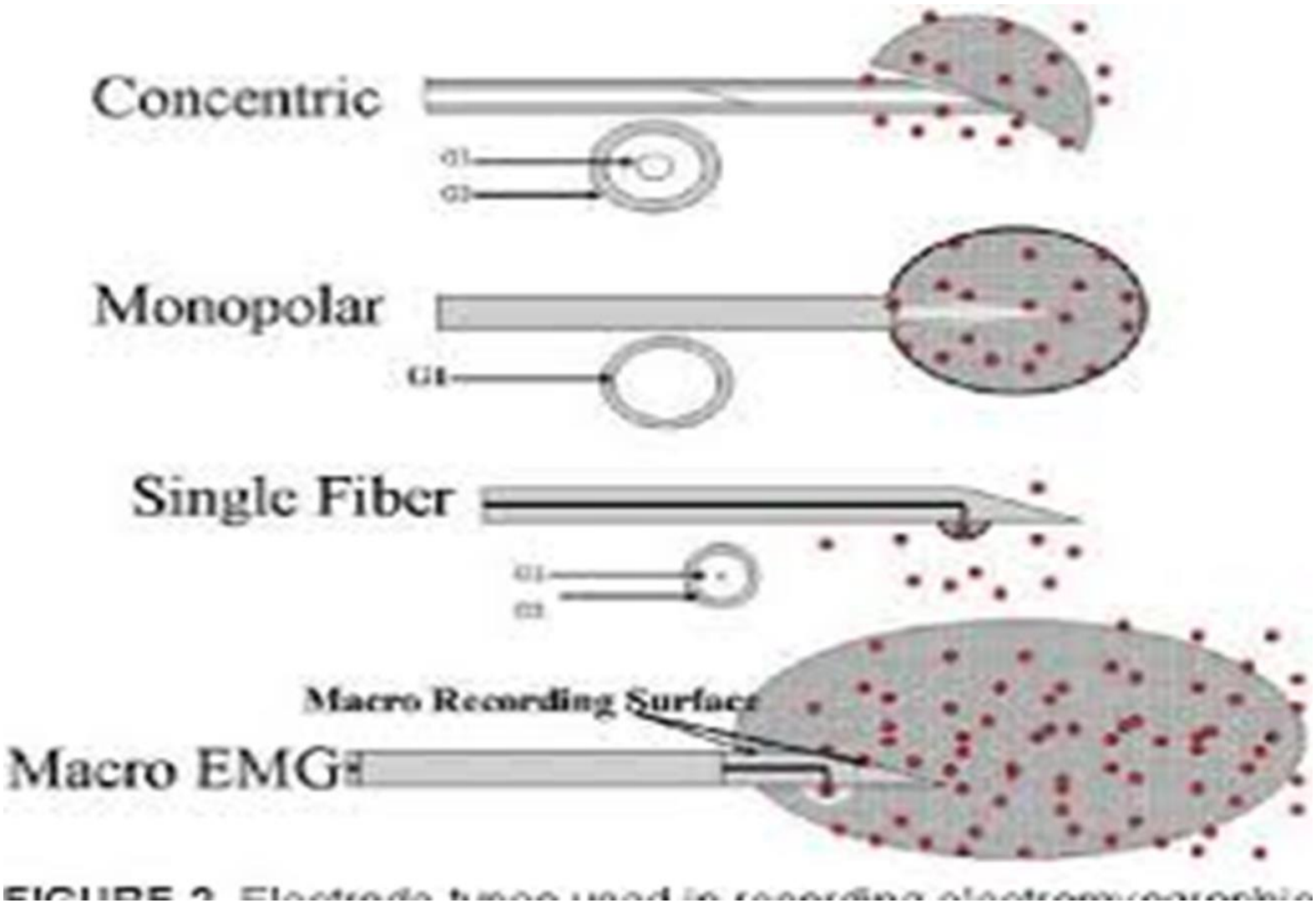
:Concentric

- کاهش Amp
کاهش Diuration
کاهش Phase
و اما افزایش IA !!!

MUAP AMPLITUDE

- **Instrumentation** factor
- Reduction in **MUAP amplitude**
  - Reduced HFF
  - Concentric needle
  - Large electrode lead off surface
  - Rotation on concentric needle
  - Removal of Teflon in concentric
- Effect of **temperature on MUAP**
- Controversial
- Authors opinion:
  - Reduction of temp
    - Increased initially
    - More dec. in temp.: AP failure and MUAP decreased
- **In >65 Y** : MUAP increased

* مقایسه انواع نیدل از نظر آمپلیتود



- Electrophysiologic counting
  - Incremental motor unit counting
    - Max CMAP divided by mean incremental amplitude
- PAS staining
  - Circular region about 20-30% muscle volume
  - Higher density in enter of motor unit
  - Upper limb MU territory: circular to oval 5-7 mm
  - Lower limb MU territory: m7-12 mm

MUAP DURATION

- Duration depend on:
- Width of Endplate Zone
- Lesser: terminal axon conduction velocity
- Inc LFF:Deletion of initial and terminal
- Dec. duration
- **Concentric needle** : Reduced duration
- **Cooling** : Increased duration

MUAP PHASE

- Synchronocity
- **Aging** and **temperature** reducing:
  - Increased phase
- Elevating LFF : inc phasicity
- Monopolar have more polyphasic potential

Recruitment

- Principles:
  - First MUAP : small and slow type I
  - Minimal to moderate force needed
  - Late type II MUAPs in not simple to analyze
  - Subtle pathology my be miss
  - Increasing fire rate of first MUAP with more force
  - Slow and constant contraction is sufficient for analysis

Others

- Equipment :
  - LFF: 10-30
  - HFF: 10,000 or more
  - Sweep speed 20 ms/div
- Techniques :
  - Identify first MUAP and measure firing rate

Recruitment principles

- Henneman size principle
- First MU activated is weakest
- Then large MUs activated
- So contraction in smooth and appropriate to need

Normal recruitment

1st	2nd	3rd	4th
5 Hz			
10 Hz	5 Hz		
15 Hz	10 Hz	5 Hz	
20 Hz	15 Hz	10 Hz	5 Hz

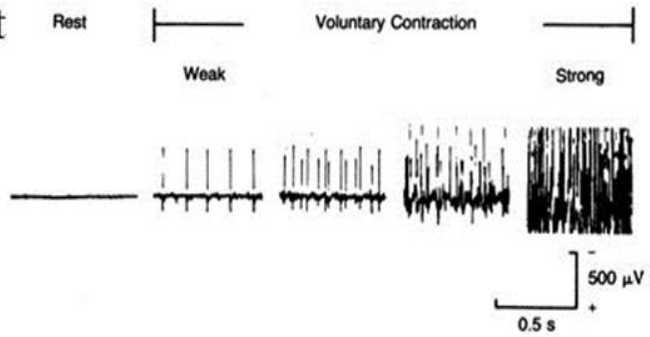
Neurogenic recruitment

- Decreased recruitment
- Recruitment ratio > 5
- Neuroapraxia could mimic that

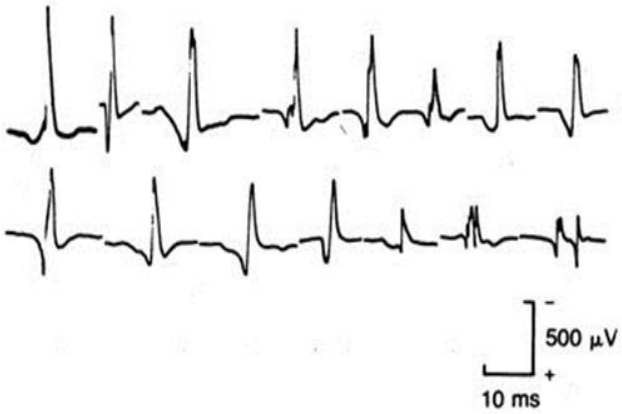
1st	2nd	3rd	4th
20			
25	0	0	
30	0	0	20

Normal EMG Activity

- **Recruitment Pattern:** Recruitment refers to successive activation of the same and new motor units with increasing strength of voluntary muscle contraction.



- **Motor Unit Action Potentials (MUAPs):** Action potentials reflecting the electric activity of a single motor unit. It is a compound action potential of those muscle fibers within the recording range of the electrode.



RECRUITMENT

- Recruitment ***frequency : 10 Hz***
  - ***فرکانس موتور یونیت MUAP A وقتی که MUAP B به خدمت گرفته میشود را رکورتمنت فرکونسی گویند که در عضلات اندام 12-15 هرتز و در عضلات فاسیال حدود 20 هرتز می باشد.***
- Recruitment ***interval : 100ms***
  - ***در عضلات صورت کوتاهتر است اینتروال.***
- Recruitment ***ratio: 5***
  - ***frequency of fastest MUAP/the number of MUAPS firing in CRT***
  - ***به عنوان مثال 20/4 =5 ولی اگر بالای 8 باشد نوروژنیک وزیر 5 باشد میوژنیک خواهد بود.***

Recruitment

- Recruitment ***frequency***:
  - Frequency of MUAP A when MUAP B begin fireing
- Recognition:
  - Observing for second MU to appear
  - Change in sound
- Recruitment ***interval***
  - Distance between 2 peaks of MUAP
- Normal muscle
  - Recruitment frequency: 10 Hz
  - Recruitment interval: 100 ms
  - Facial muscles: short interval and high frequency

* Recruitment ratio?

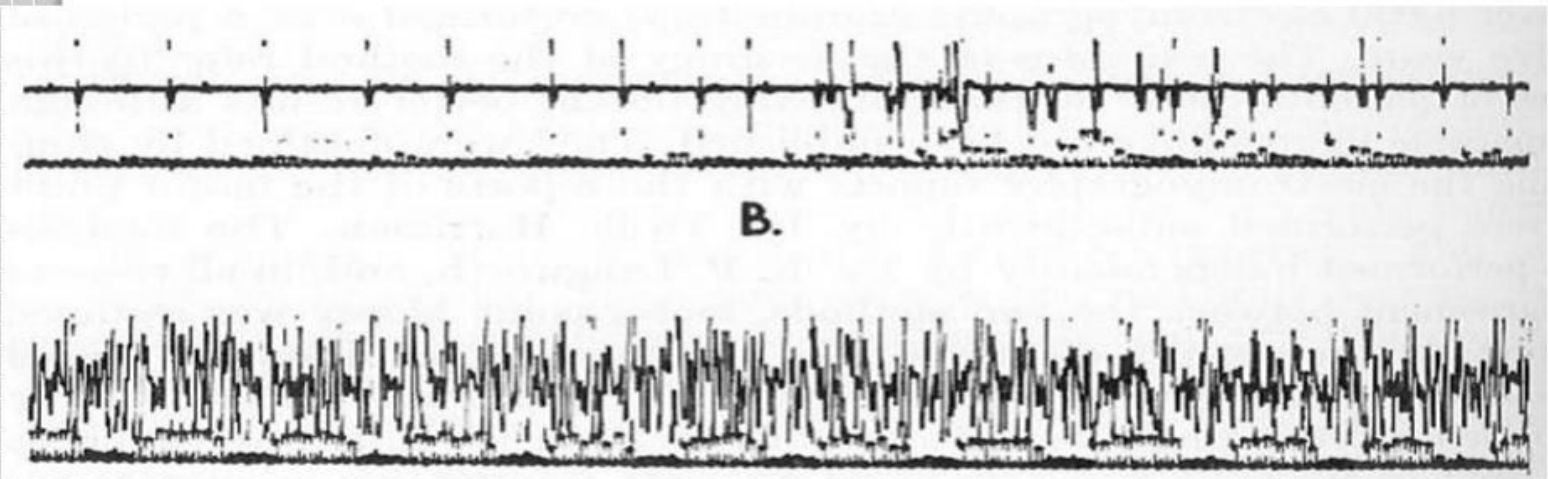
- Recruitment ***ratio:***
  - Frequency of fastest MUAP divided by number of Different MUAP in screen
  - Should be close to **5**
  - If near 10: too few MU presented (neurogenic)
  - If below 4 : too many MU existed (myogenic)

- محاسبه firing frequency
- تناسب می بندیم در 100 msصفحه مثلا دوتا داریم در 1000 ms چقدر؟ میشود 20 هرتز
- 100 را بر خانه های بزرگ بین دو موتور یونیت پشت سرهم تقسیم می کنیم مثلا 100 تقسیم بر 4 میشود: 25 هرتز
- اگر سویپ 100 میلی سکند باشد تعداد موتور یونیت ها ی صحنه را در 10 ضرب می کنیم و اگر سویپ 50 باشد تعداد انها را در 20 ضرب می کنیم. 2*10=20 هرتز

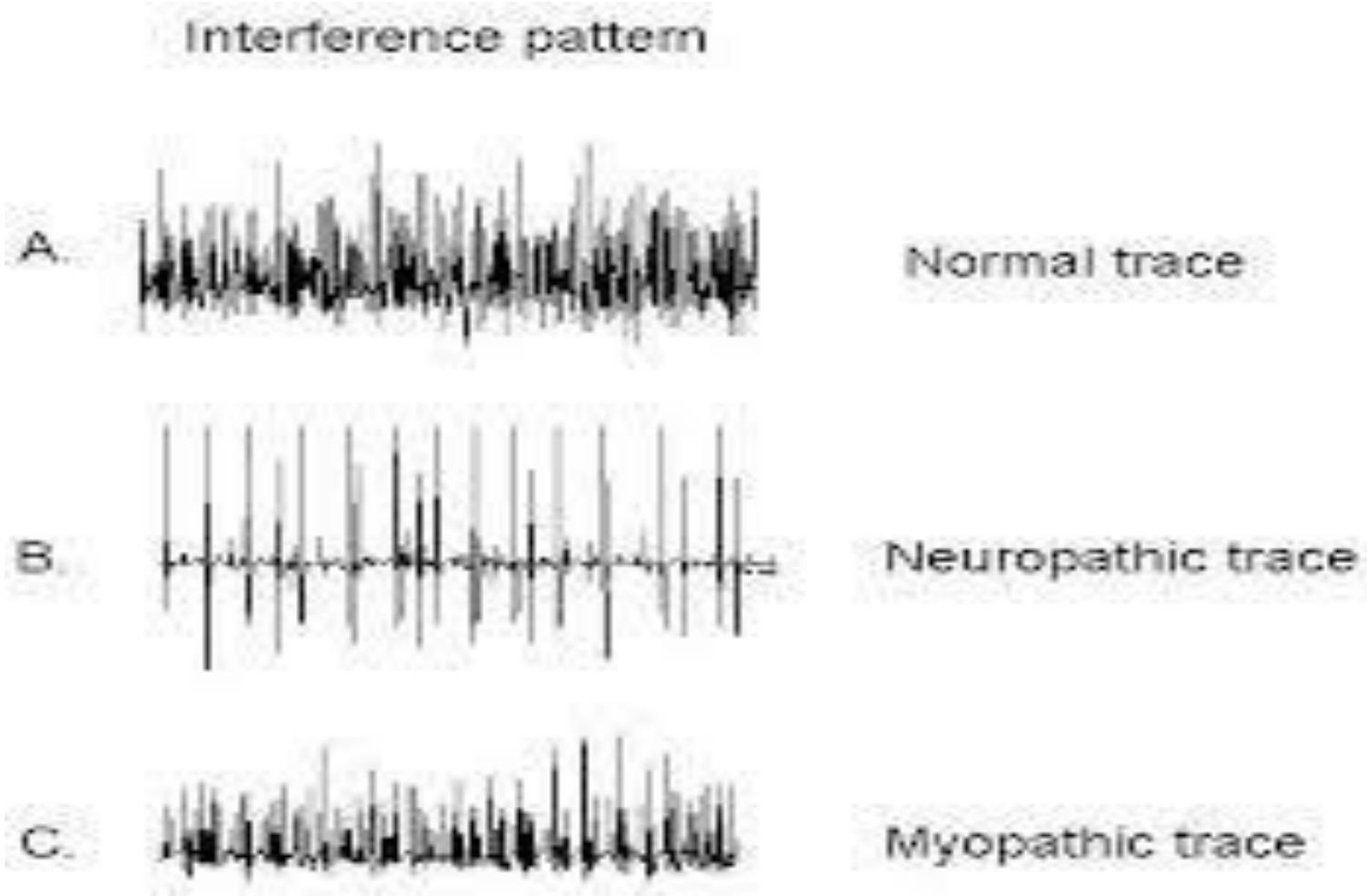
Interference Pattern * تعريف

Interference Pattern

- Normally seen with strong muscular contraction
- Individual potentials are summated with increasing number of motor units firing at higher frequencies



*مفهوم Interference Pattern درصفحه CRT



*مراحل مختلف در بررسی NEEDLE EMG :

IA → REST –→ POWER

Table 7-1. Electrical Potentials

I. Insertional Activity
   A. Normal
   B. Increased
   C. Decreased

II. Spontaneous Activity
   A. Muscle generator
      1. Fasciculation
      2. Fibrillation
      3. Positive sharp wave
      4. Myotonia
      5. Complex repetitive discharge
   B. Neural generator
      1. Fasciculation
      2. Myokymic discharge
      3. Continuous motor unit activity
      4. Cramp
      5. Tremor
      6. Multiplet

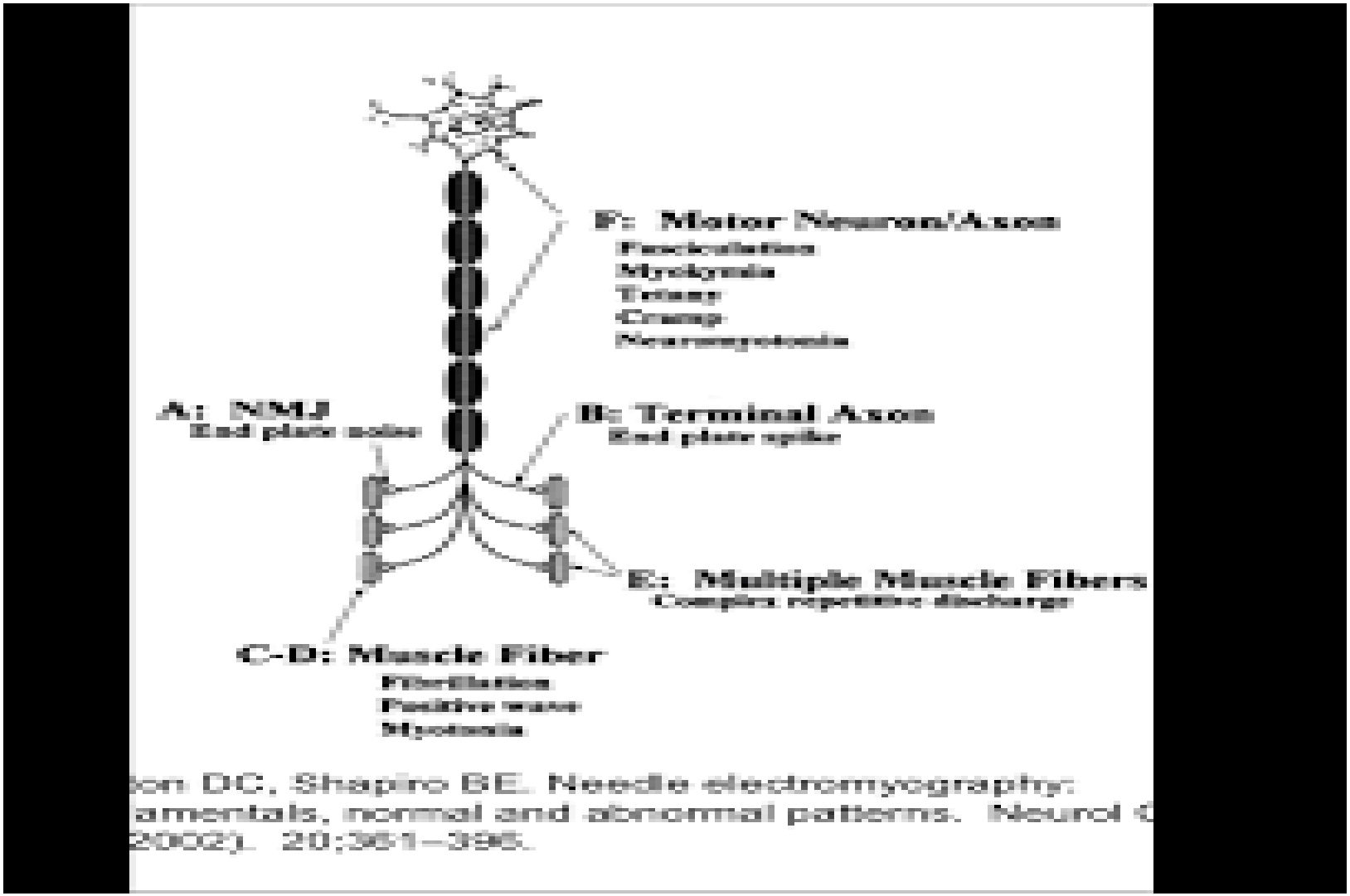
III. Voluntary Activity
   A. Normal MUAPs
   B. Polyphasic MUAPs
   C. MUAPs with increased/decreased duration
   D. MUAPs with increased/decreased amplitude
   E. Multiplet MUAPs
   F. MUAPs with variable amplitudes
   G. Abnormal MUAP recruitment

IA ; ONE POINT

- In increased insertional activity , it is better to state that “sustained” or “unsustained” abnormal spontaneous potentials because duration of depolarization both in denervated and innervated muscle is the same despite significant membrane instability and time period is 50ms.

* شکل شماتیک آناتومیک برای یک **Motor Unit**:

عصب --> آکسون --> NMJ ---> عضله



on DC, Shapiro BE. Needle electromyography:
amentals, normal and abnormal patterns. Neurol
2002). 20:351–395.

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   D. MUAPs with increased/decreased amplitude
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   F. MUAPs with variable amplitudes
   G. Abnormal MUAP recruitment

- **MUSCLE GENERATORS OF**

ABNORMAL SPONTANEOUS POTENTIALS

MUSCLE GENERATORS OF ABNORMAL SPONTANEOUS POTENTIALS

- **SA from Muscle:**
  - IA
  - Fib
  - PSW
  - CRD (BHF or سودومیوتونی)
  - میوتونی

FIBRILLATION POTENTIAL

- Resting membrane potential in denervated muscle fiber approach to less negative level of -60mV compared to normal value of -80mV.
- -80 ⟶ -60 (threshold) ⟶ -75 (hyperpolirezie) ⟶ regular occurring fib in a cyclical pattern
- there is intervals of quiescence muscle this explains why sometimes fibs are abundance and sometimes are absent.
- fib waves
  1. triphasic :pos/neg/pos
  2. biphasic: neg/pos (mainly record from endplate
  3. biphasic: pos/neg(more common) third phase has been lost in baseline noise.

* Fibrillation potential
عوامل موثر در کاهش آن

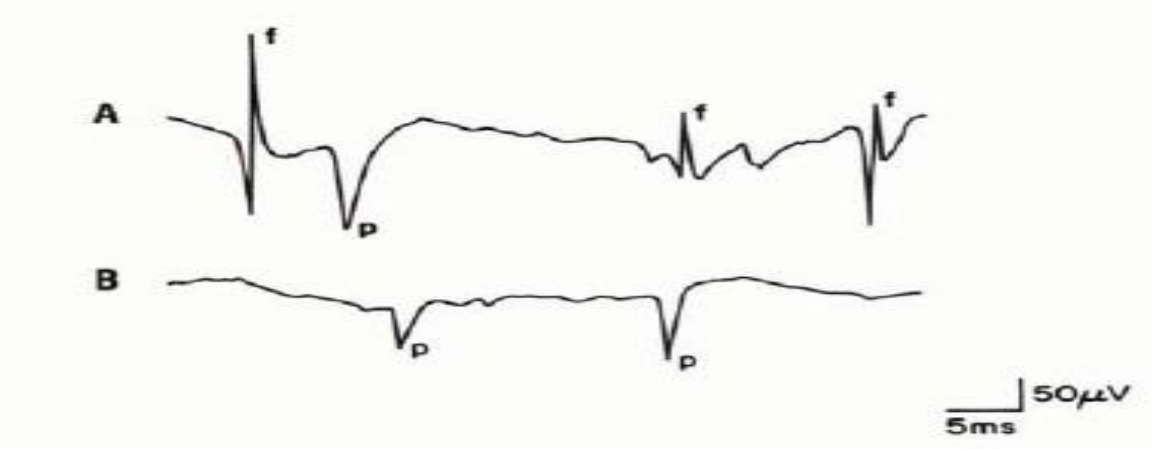
- 4-6 or longer days
- Threshold level and regularly repetition
- Fib are more present in previous endplate region
- **Decreased with:**
  - Decreased temperature
  - Ischemia
  - D-tubocurarine
- 50 % regular
- High pitched: crackling cellophane or rain
- Sound like rain on the roof

Fibrillation Potentials

Table 7-8.	Characteristics of Fibrillation Potentials[154]
Appearance:	a. Biphasic spike 1–5 ms in duration b. Positive wave with negative phase
Rhythm:	Usually regular but can be somewhat irregular
Frequency:	0.5 to 15 Hz
Amplitude:	20 to 1000 μV
Stability:	Stable
Observed in:	a. Muscle disorders Inflammatory myopathies Inclusion body myositis Congenital myopathies Some muscular dystrophies Hyperkalemic periodic paralysis Rhabdomyolysis Muscle trauma following muscle biopsies Trichinosis b. Neurogenic disorders Anterior horn cell disorders Radiculopathies Plexopathies Mononeuropathies Peripheral neuropathies Entrapment neuropathies Upper motor neuron disorders (stroke, head injury, and spinal cord injury) c. Neuromuscular junction disorders Myasthenia gravis Botulism

*Positive sharp wave

- Positive wave terminated to base line
- Monophasic
- Same ethiology
- Purely demyelinatig disease have PSWs but no fibrilation
- PSW appear earlier than fibrillations in muscles of human or animals deprived from nerve supply
- Combination of Fib/PSW
- Sound: dull pop



Clinical findings

- Radiculopathy
  - 7-10 days : paraspinal
  - 21 days: limbs
- Persistent : sequestrated muscles
- Amplitude:
  - First 2 m : 600 micro v
  - End of 3 m: 500 micro v
  - At 6 m: 300 micro v
  - One year: < 100 micro v

- In period paralysis : no fib between attacks

✓ Recorded in both neurogenic and myopathic disease

Clinical Findings

Recorded in both neurogenic and myopathic disease ✓

One to three weeks ✓

The mean Fibrillation amplitude during: ➢

First two months: 600

Third month: 500

6 months: 300

After one year: 100

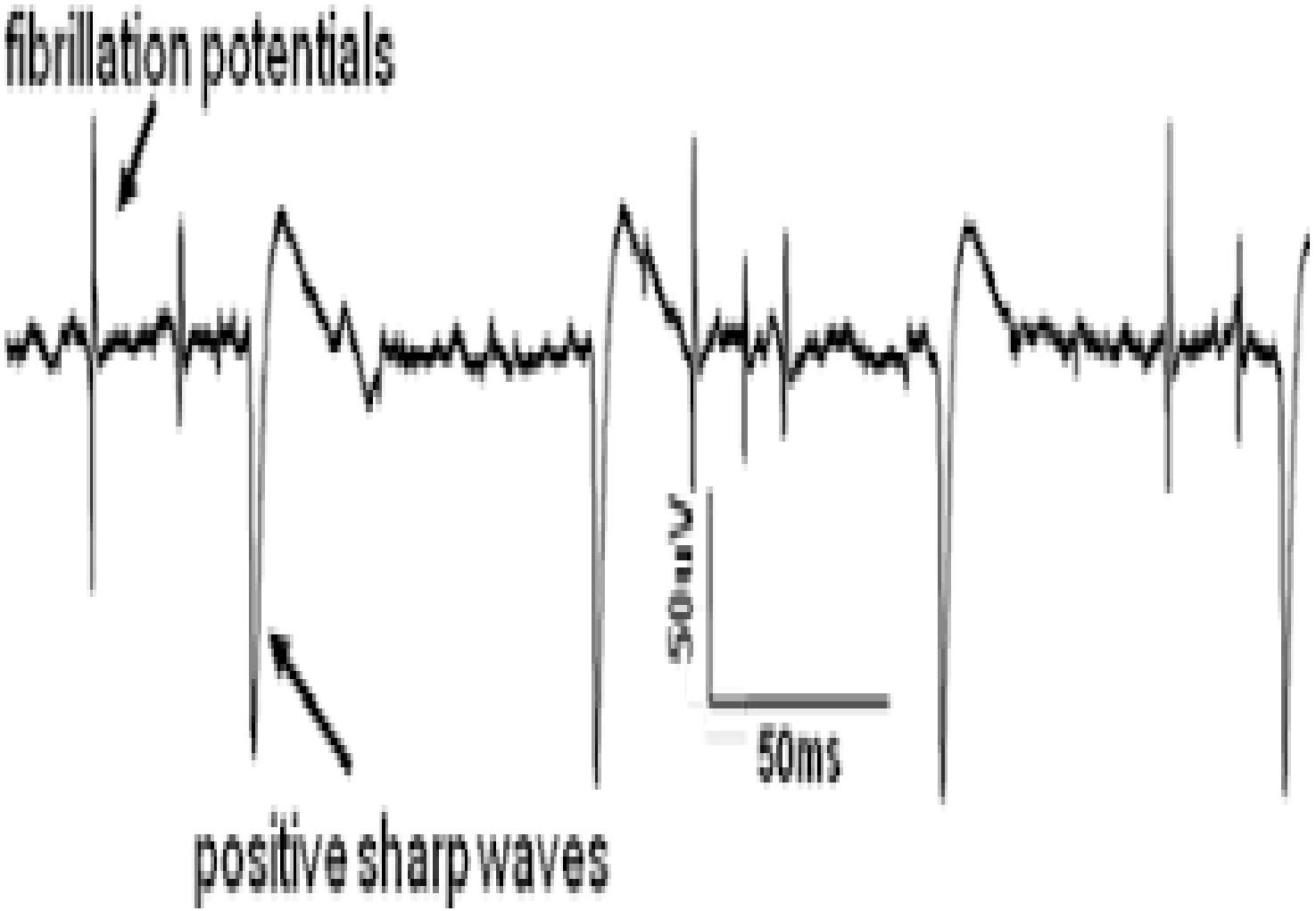
As long as muscle vasculature will be alive fib will be persistent,then will be sequestrated and then over time muscle will be atrophie and amplitudes reduces.

- The incidence of membrane instability was greater in muscle with significant weakness (force < 4) than muscle with a grade of 4+ or more.
- A single investigation has suggested that it is easier to detect Fibrillations potentials and positive sharp waves with a concentric compared to monopolar needle electrode.

Table 7-9. Grading of Fibrillation Potentials[41]

Grading	Characteristics
0	No fibrillation potentials
1+	Persistent/unsustained single trains in at least two muscle regions
2+	Moderate numbers in three or more muscle areas
3+	Many in all muscle regions
4+	CRT baseline obliterated with fibrillation potentials in all areas of muscle examined

*شکل FIB & PSW و مقایسه ی آنها در صفحه CRT



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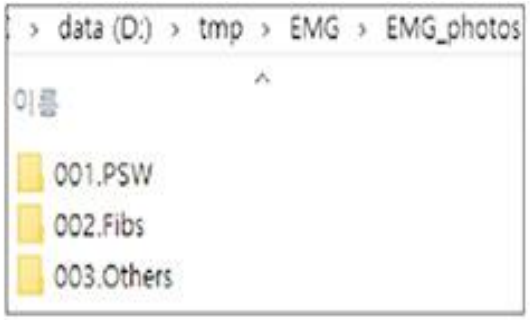
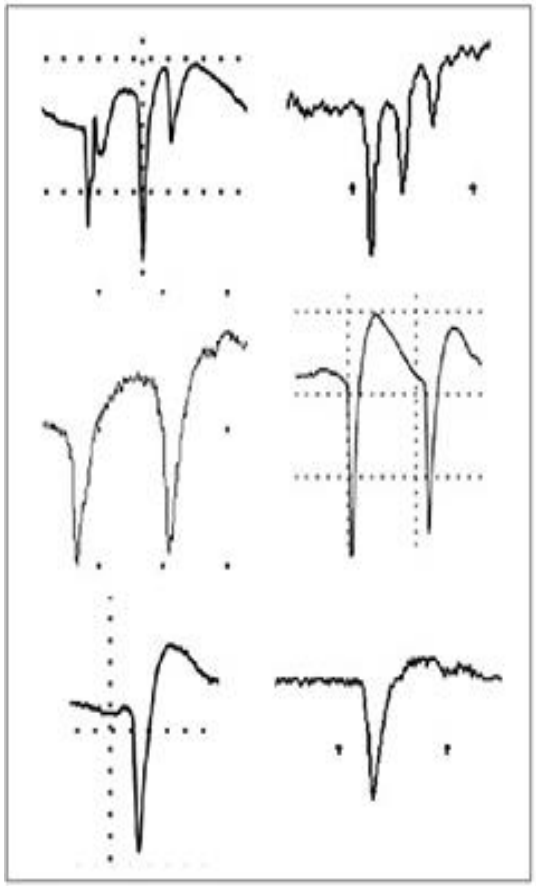
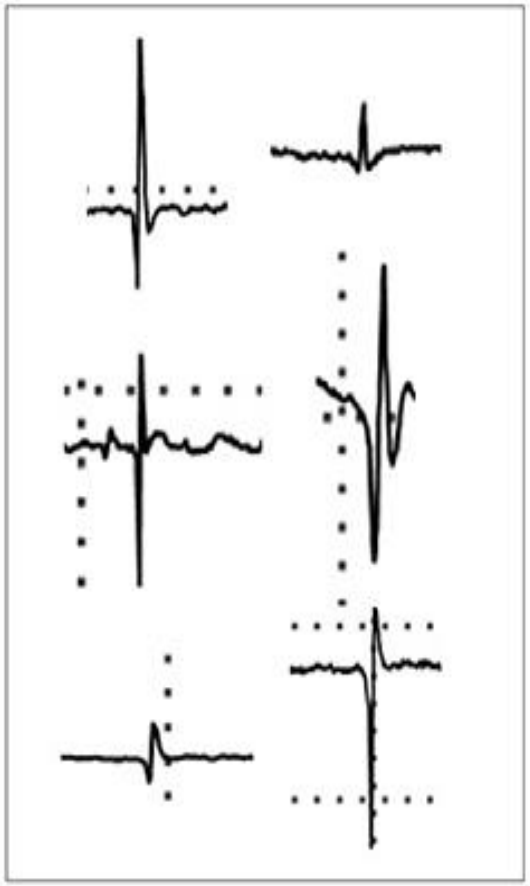


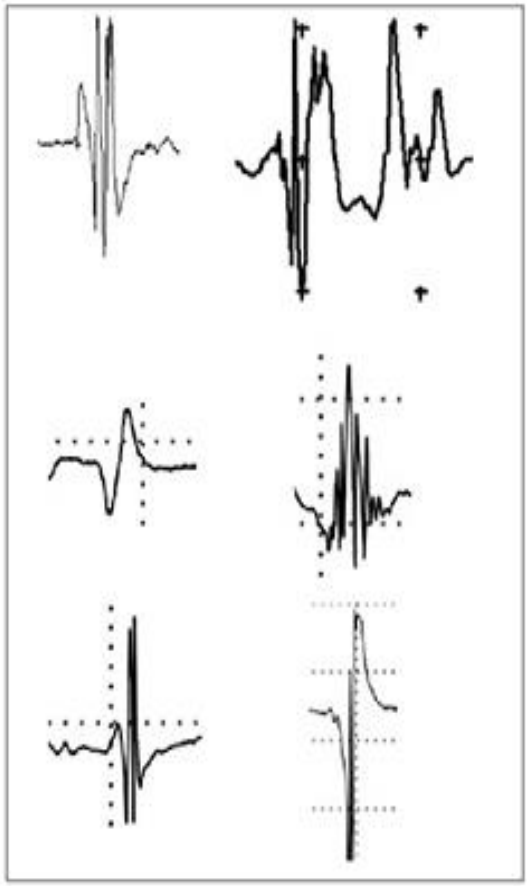
A Folders



B PSW



C Fibs



D Others

* COMPLEX REPETITIVE DISCHARGES
مشخصات آن در نیدل

- CRD
- Bizarre high frequency discharges (**BHF**) or **pseudomyotonic**
- **Hallmark : start and stop abruptly**
- **Not stop with nerve block or curare** (originate in muscle tissue)
- **Frequency: 0.3-150Hz**
- Ephaptical pathway
- Pace maker and copaceaker
- Sound: Heavy machinery or idling motorcycle

Complex Repetitive Discharge

Bizarre high frequency discharges or pseudomyotonic discharges ✓

Regularly repeat at 0.3-150 Hz ✓

Heavy machinery or an idling motorcycle ✓

A hallmark of these waveforms is that they start and stop abruptly ✓

Nerve block and curare do not abolish (originate in muscle tissue) ✓

- Myopathy :

Polymyositis

Various forms of muscular dystrophy

- Chronic denervation:

Motor neuron disease

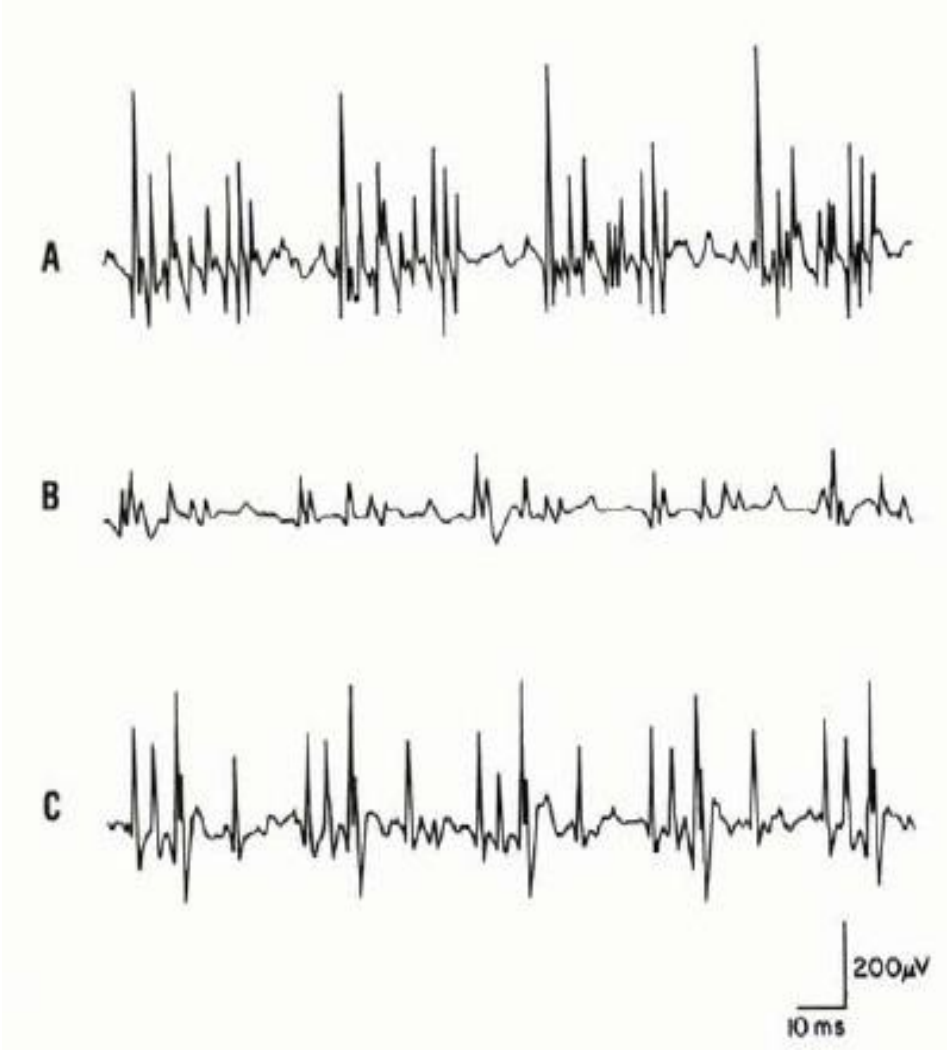
Radiculopathy

Polyneuropathy

- Normal:

IP

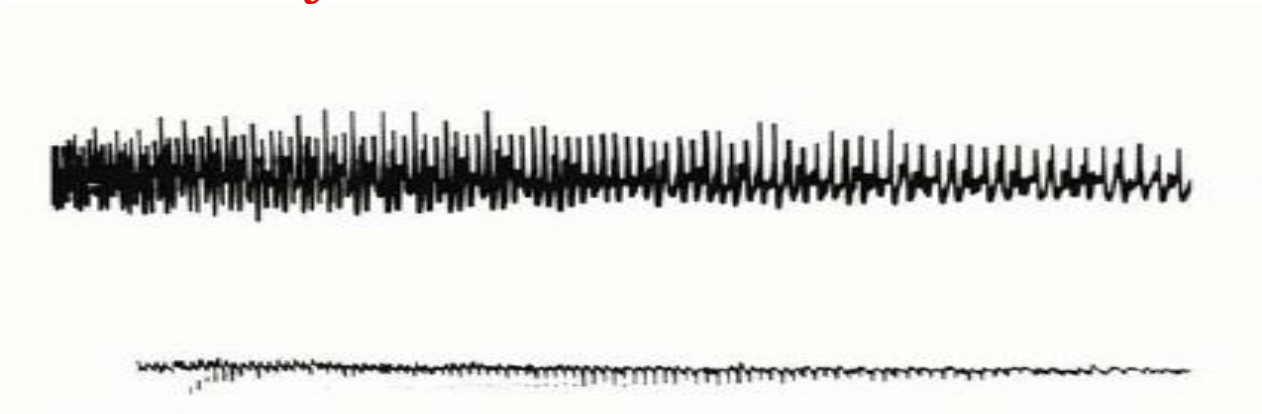
Biceps



Myotonic Discharge

- The phenomenon of delayed muscle relaxation following muscle contraction is referred to as myotonia or action myotonia

- The finding of delayed muscle relaxation after reflex activation or induced by striking the muscle belly with a reflex hammer is called percussion myotonia.



- Sound likened to a dive bomber
- Waxing and waning firing pattern

Table 7-12. Characteristics of Myotonic Discharges[154]

Appearance:	Brief spikes/positive waveform
Rhythm:	Wax and wane
Frequency:	20 to 100 Hz
Amplitude:	Variable (20μV to 1 mV)
Stability:	Firing rate alterations
Observed in:	a. Myopathies Myotonic dystrophy Myotonia congenita Paramyotonia Polymyositis Acid maltase deficiency Hyperkalemic periodic paralysis b. Other Chronic radiculopathy Chronic peripheral neuropathy

Quantitative description of myotoni discharges

I+: discharges should last at least 500 ms and be obtained in 3 regions outside of the endplate zone ✓

2+: myotonic discharges found in greater than one-half of all needle sites ✓

3+: myotonic discharges noted in all areas examined secondary to needle movement ✓

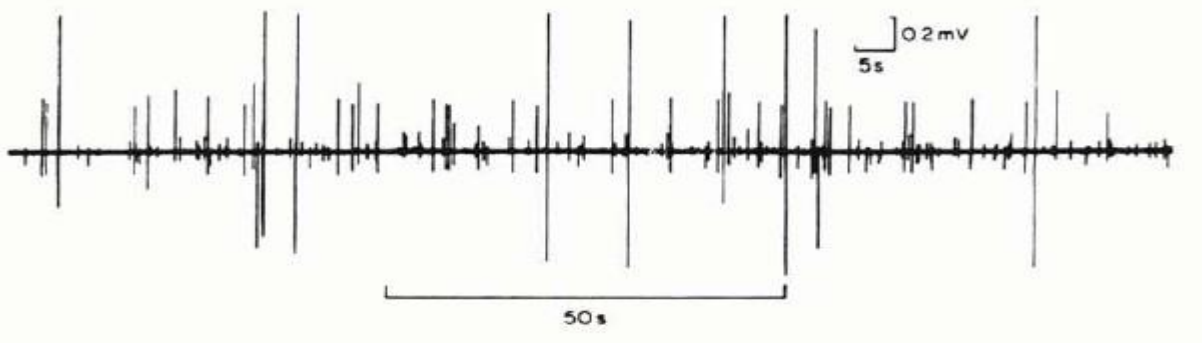
These potentials persist after nerve block, neuromuscular block and so they originate muscle membrane itself ➢

NEURAL GENERATORS OF ABNORMAL SPONTANEOUS POTENTIALS

FASCICULATION POTENTIALS

Table 7-13. Characteristics of Fasciculation Potentials[154]

Appearance:	Variable: normal or complex MUAPs
Rhythm:	Irregular
Frequency:	0.1 to 10 Hz
Amplitude:	> 300 μV
Stability:	Stable
Observed in:	a. Normal individuals Spontaneous Following exercise b. Lower motor neuron disorders Amyotrophic lateral sclerosis Creutzfeldt-Jakob disease Radiculopathy Peripheral neuropathy Entrapment neuropathy c. Metabolic disorders Thyrotoxicosis Tetany Anticholinesterase medication



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Foot intrinsic muscles or gastroc-soleus muscle ✓

Tension or anxiety ,fatigue ✓

Heavy exercise, coffee, smoking ✓

Motor neuron disorders ✓

Radiculopathies ✓

Entrapment neuropathies ✓

Cervical spondylotic myelopathy ✓

Tetany ✓

Thyrotoxicosis ✓

Anticholinesterase overdoses ✓

* FASCICULATION POTENTIALS

- Fasciculation :
- visible spontaneous contraction of a portion of muscles
- Normal in **foot intrinsic and GCS**
- Arise from anterior horn cell
- Aggravation with:
- Anxiety
- Fatigue
- Heavay exercise
- Coffee and smoking
- ✓ Motor neuron disorders
- ✓ Radiculopathies
- ✓ Entrapment neuropathies
- ✓ Cervical spondylotic myelopathy
- ✓ Tetany
- ✓ Thyrotoxicosis
- ✓ Anticholinesterase overdoses

MYOKYMIC DISCHARGE

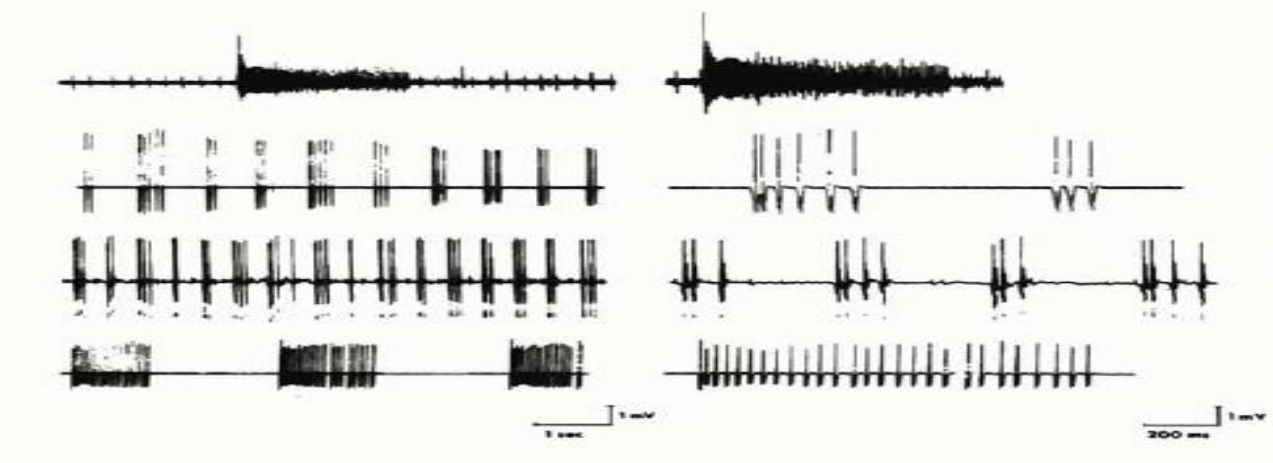
Vermicular (bag of live worms) or continuous rippling movement of the skin ✓

0.1-10 Hz in a semirhythmic pattern (regular) ✓

Two to ten potentials within a single burst may fire at 20-250 Hz ✓

Not affected by voluntary contraction ✓

Low-powered motor boat engine ✓



Orbicularis oculi ➢

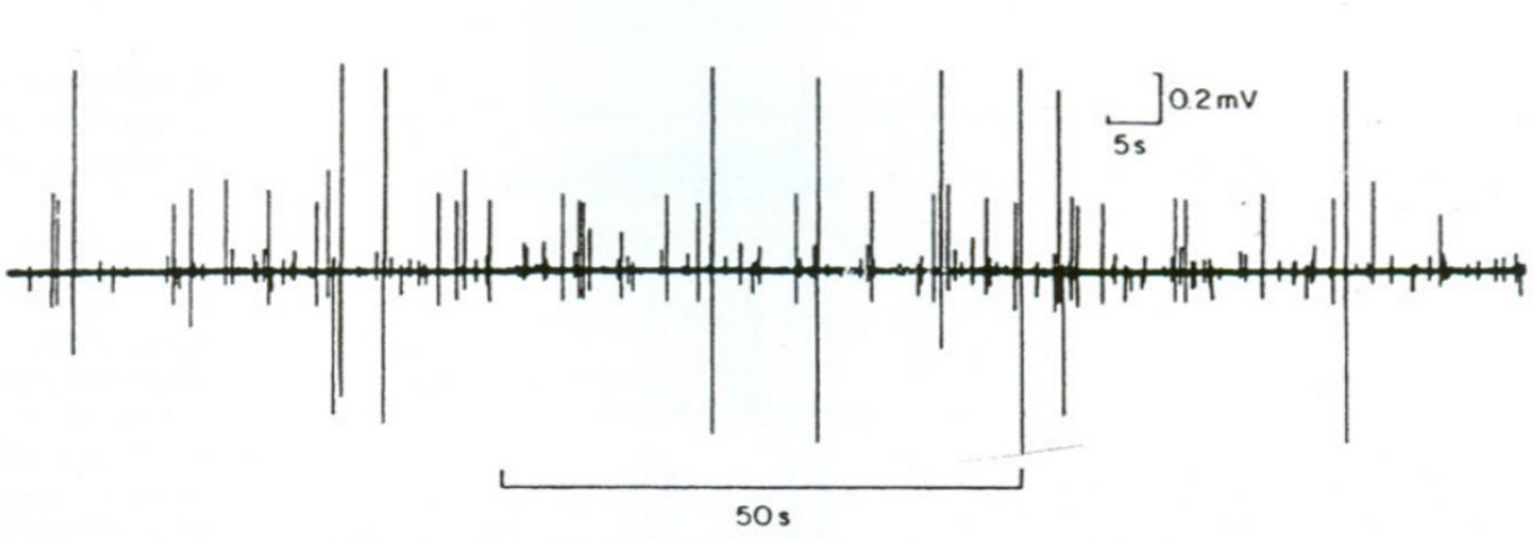
Focal : fatigue, multiple sclerosis or a brainstem neoplasm ✓

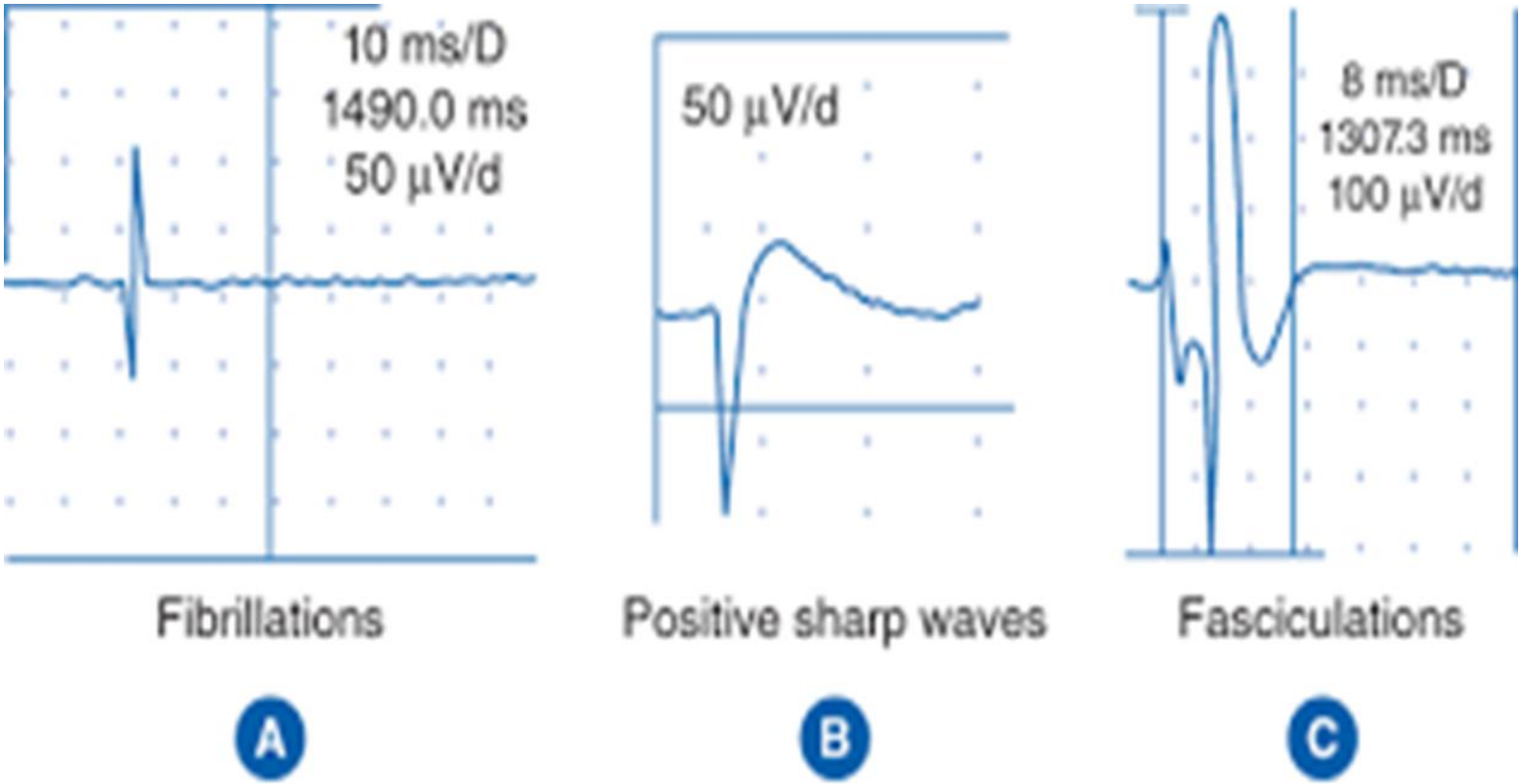
Segmental : syringomyelia or radiculopathies ✓

Generalized : uremia, thyrotoxicosis, inflammatory polyradiculoneuropathy ✓

Limb myokymic discharges: radiation plexopathy ✓

Fasciculation potentials





Source: John C.M. Brust:
CURRENT Diagnosis & Treatment: Neurology, Third Edition

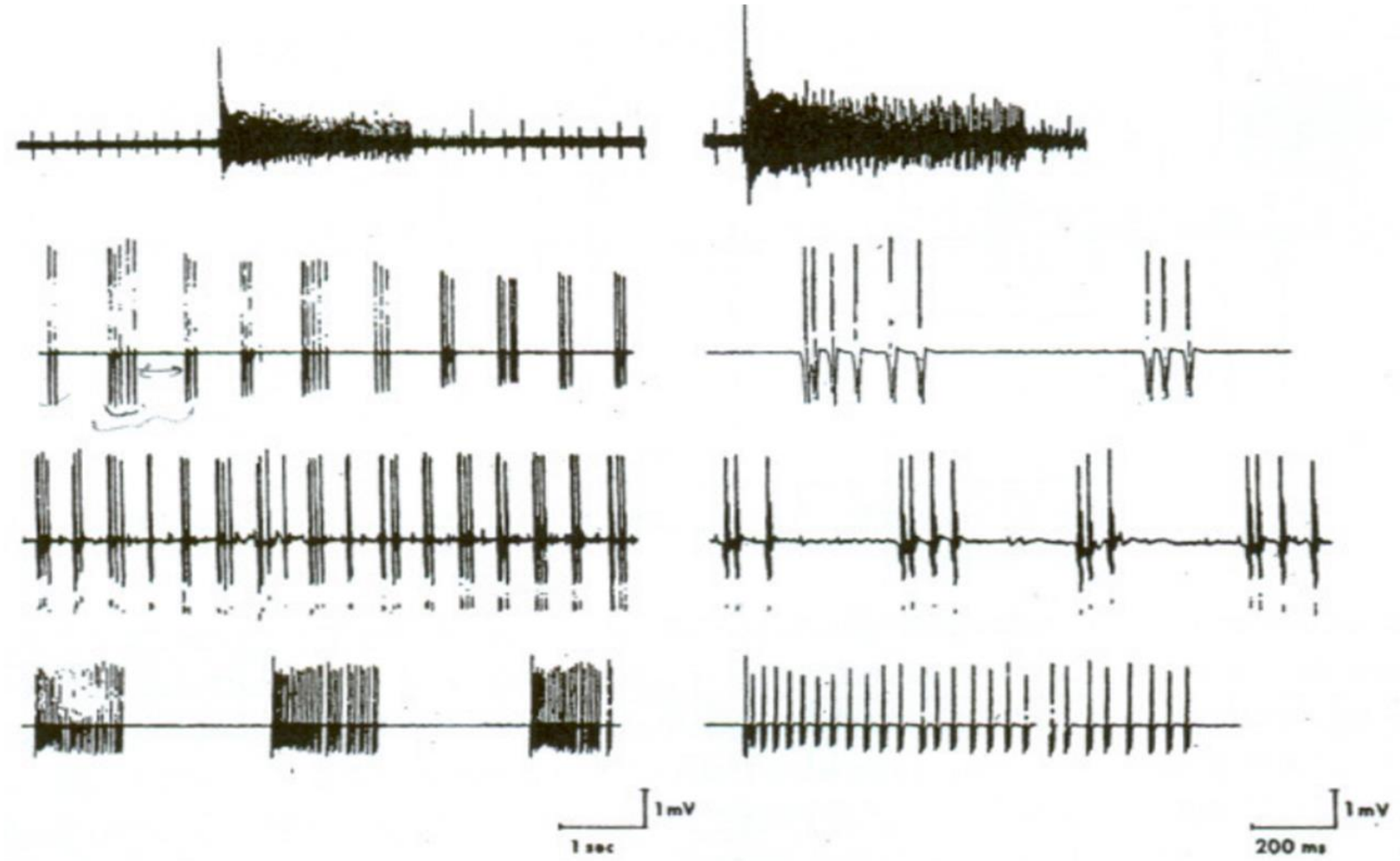
* Myokimic discharge

- Vermicular movement movement
- Mechanisms: trans axonal ephaptic activation
- Burst of normal MUAP with interburst silence
- Sound : low power motor boat engine
- 0.1-10 Hz in a semirhythmic pattern (regular)
- Difference with CRD:
- No regularity in burst of MUs
- No typical start and stop abruptly
- They are group of MU but CRD single muscle fiber
- Normal in orbic. Oculi

* Myokimic discharge

- Focal : fatigue, multiple sclerosis or a brainstem neoplasm
- Segmental : syringomyelia or radiculopathies
- Generalized : uremia, thyrotoxicosis, inflammatory polyradiculoneuropathy
- Limb myokymic discharges: radiation plexopathy

* Myokymic potentials



CONTINUOUS MUSCLE FIBER ACTIVITY

Stiff-man syndrome

- Central nervous system ✓
- Sustained firing of motor units ✓
- Abolished by:Peripheral nerve block, ✓ neuromuscular block, spinal block, general anesthesia, and sleep, diazepam
- But not with :Phenytoin or carbamazepine ✓
- Sustained interference pattern in both the ✓
- ✓ agonists and antagonists
- ✓ Sustained conotraction in chest wall and pharynx causes disability & contracture

Isaacs syndrome

Peripheral nervous system ✓

Abolished only by:Neuromuscular block ✓

Not by:Peripheral nerve block, spinal or general anesthesia, or sleep ✓

Frequencies up to 300 Hz ✓

Characteristic "pinging" sound ✓

Not influenced by voluntary contraction and may be induced by ischemia or electrical nerve stimulation ✓

ISAACS SYNDROME

- antibodies against K-voltage gated channels rendering nerve hyperexitable and prone to repetitive firing
- a rippling muscle disorder associated sweating and muscle pain
- discharges myokimia, doublet , triplet neuromyotonia with 300 hz are seen

CRAMPS

- Sustained ✓
- Painful muscle contractions ✓
- Seconds or minutes ✓
- Calf muscles or other lower limb muscles ✓ following exercise
- Abnormal positioning ✓
- Maintaining a fixed position for a prolonged ✓ period of time

- Hyponatremia ✓
- Hypocalcemia ✓
- Vitamin deficiency ✓
- Ischemia ✓
- Early motor neuron disease and peripheral neuropathies ✓
- Multiple motor units firing synchronously between 40 and 60 Hz and occasionally reaching 200-300 Hz ➢
- Arise from a peripheral portion of the motor unit ➢

MULTIPLET DISCHARGES

A clinical syndrome manifested by spontaneous muscle twitching, cramps and carpo-pedal spasm is known as tetany.

Peripheral and/or central nervous system

Systemic alkalosis ✓

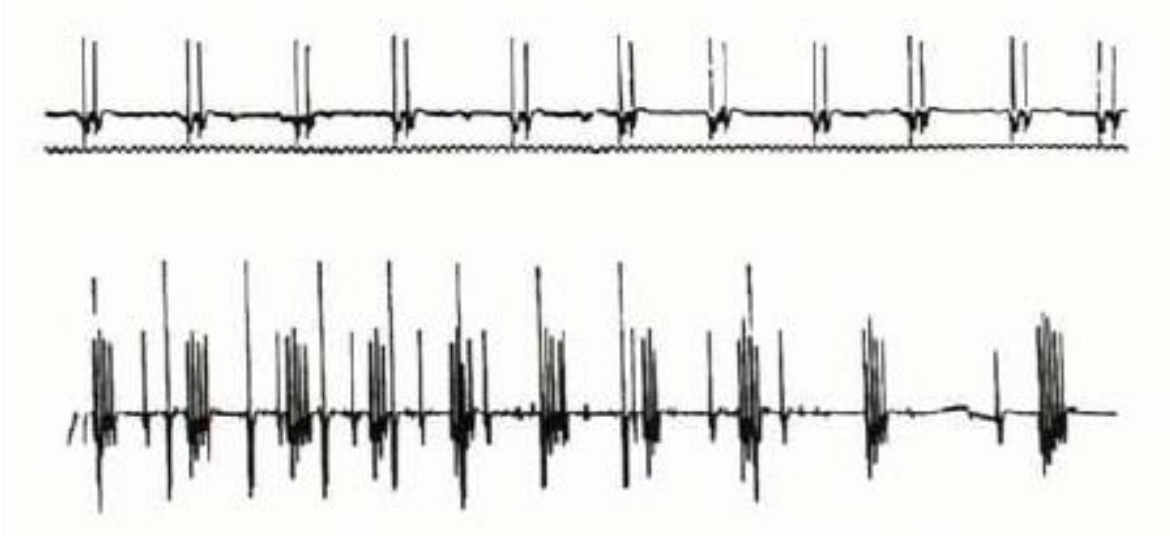
Hypocalcemia ✓

Hyperkalemia ✓

Hypomagnesemia ✓

Local ischemia ✓

- Clinically one may induce tetany by tapping the facial nerve (Chvostek's sign), the peroneal nerve at the fibular head (peroneal sign), and inducing limb ischemia (Trousseau's sign).
- A single motor unit potential may fire rather rapidly with an inter discharge interval of 2-20 ms twice (doublets) or three times (triplets) or more (multiplets).

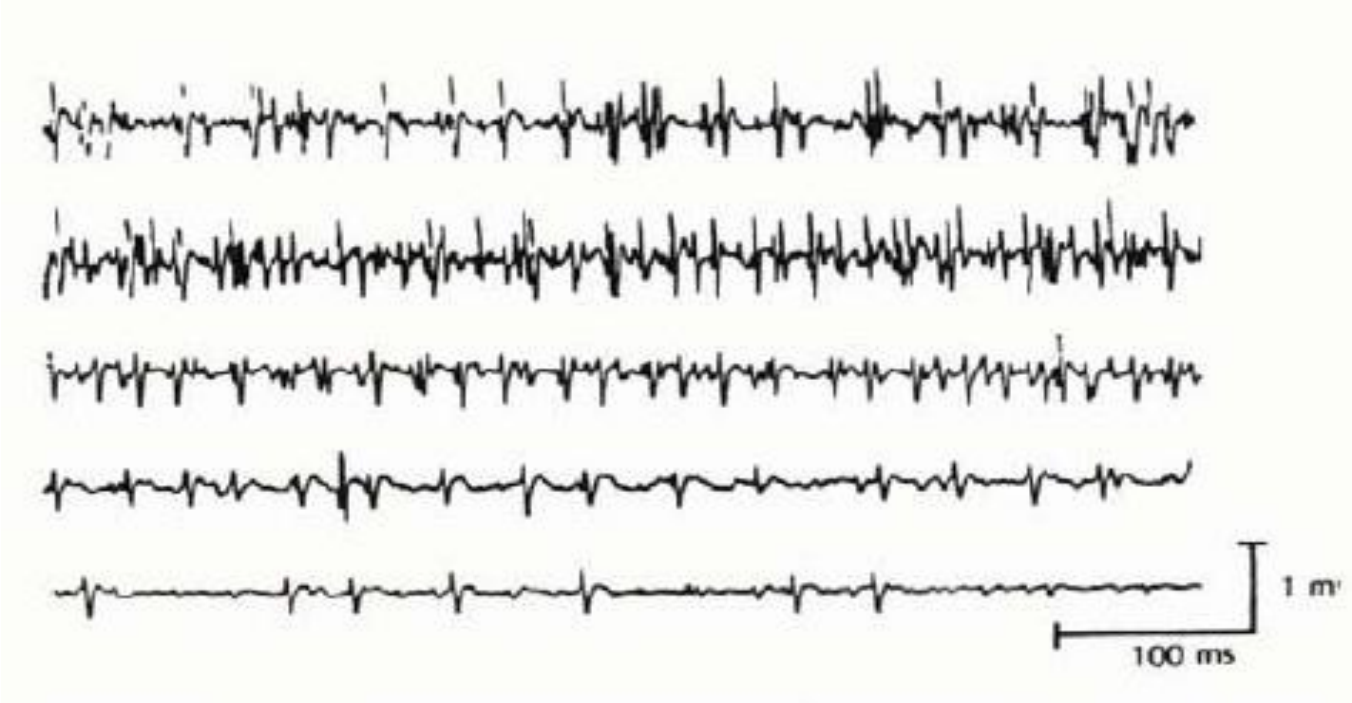


TREMOR

Involuntary activation of multiple motor units ✓

Central nervous system ✓

Semi rhythmic pattern ✓



MOTOR UNIT ACTION POTENTIALS (MUAPS)

The electrical activity typically recorded by a needle electrode placed in a voluntarily contracting muscle is the summation of action potentials resulting from single muscle fibers innervated by one anterior horn cell. This summated electrical activity gives rise to electrical waveforms called motor unit action potentials (MUAPs).

Anatomy

There are three types of motor neurons identified:

alpha (skeletomotor) motor neurons (1

beta (skeletofusimotor) motor neurons (2

gamma (fusimotor) motor neurons (3

NORMAL IN:?

- ***IA*** ---→Young Male GCS & FDL, Run in AD
- ***Fib*** ---→ Intrinsic muscle in foot, Para spinal L5 in older person or Diabet+
- ***CRD*** ---→ BB , IP
- ***Fasic*** ---→ Intrinsic muscle in foot, GCS
- ***Cramp*** ---→ Calf muscles
- ***Myokimic discharge*** ---→orbicularis Oculi & Oris

SOUNDS

- ***MEPPs*** ---→ Seashel murmur
- ***EPS*** ---→ Crackling
- ***Fib*** ---→High pitched: crackling cellophane or rain
  Sound like rain on the roof
- ***PSW*** ---→Dull pop
- ***CRD*** ---→ Heavy machinery or idling motorcycle
- ***Myotonic discharge*** ---→ Drive bomb
- ***Myokimic discharge*** ---→ Motor boat engine, sputtering
- ***Neuromyotony*** ---→ Pinging

* علل مهم

- ***Fib & PSW*** ---→ Acute or Ongoing process in muscle, NMJ or nerve
- ***CRD*** ---→ Chronic process, Schwatz jumple
- ***Myotonic discharge*** ---→ Myotonic dystrophy, Acid maltaz dificiency (pompe), ↑ KPP
- ***Fasi*** ---→ Cervical myelopathy, thyrotoxicosis, Anti colinesteraz
- ***Neuromyotonic discharge*** ---→ SMA, Anti colinesteraz , Ischemia
- ***Cramp*** ---→ ↓ Ca ↓ Na , ↓ Vit, Ischemia, Mac Ardel
- ***Myokimic discharge*** ---→ Radiation plx,
- ***Multiplet*** ---→ ↓ Ca , ↓ Mg , ↑ **K,** ↑ PH, Local Ischemia

زمان مناسب برای انجام EDX:

- در رادیکولوپاتی : 4 هفته یا 1 ماه بعد از شروع درد
- در پلکسوپاتی و ارب : 2 هفته بعد از شروع آسیب اولیه
- در بلز پالزی : 5 روز بعد از شروع
- در ترومای صورت : 6 روز بعد از آسیب
- در ترومای اندام : 3-4 هفته بعد از آسیب

_ Neural loss

- 2 process after denervation:
- Re-growth 2-3 mm/day
- Collateral sprouting
- Point of node of Ranvier
- Bunds of bunger : remaining Schwan cell sheaths
- Each MN : support 4-5 times
- So 20 % remaining could cover others
- Fiber types grouping
- 2 weeks
- MU territory remain unchanged

NEURAL LOSS

If a muscle is completely denervated by a lesion affecting the motor neurons or the peripheral nerve, there will be a complete absence of MUAPs. Fibrillation potentials and PSWs will appear in great abundance following an appropriate period of time.

A partial nerve lesion, however, may result in profuse fibrillations and PSWs, with preservation of some MUAPs.

A muscle that is totally denervated can be reinnervated only by regrowth of the peripheral nerve along its original course.

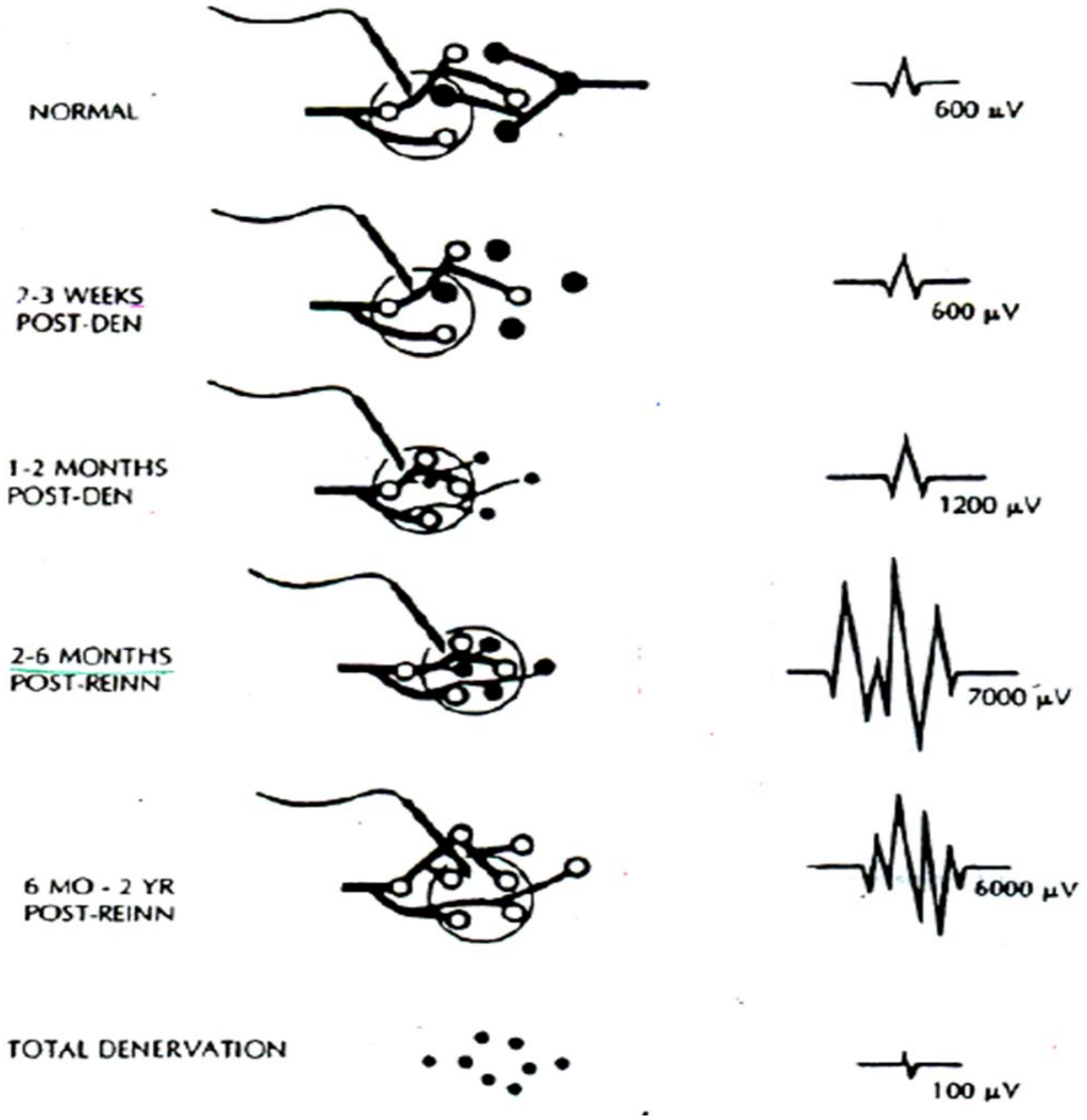
A partially denervated muscle will consist of denervated motor units and intact motor units. The motor units deprived of their innervation may be reinnervated by one of two mechanisms,

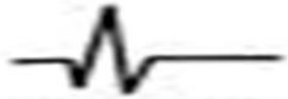
1.The first process involves a regrowth of axons along the previous neural pathways. Neural regrowth occurs at approximately 3-4 mm per day.

2.The second manner in which denervated muscle fibers can be reinnervated is through collateral sprouting.

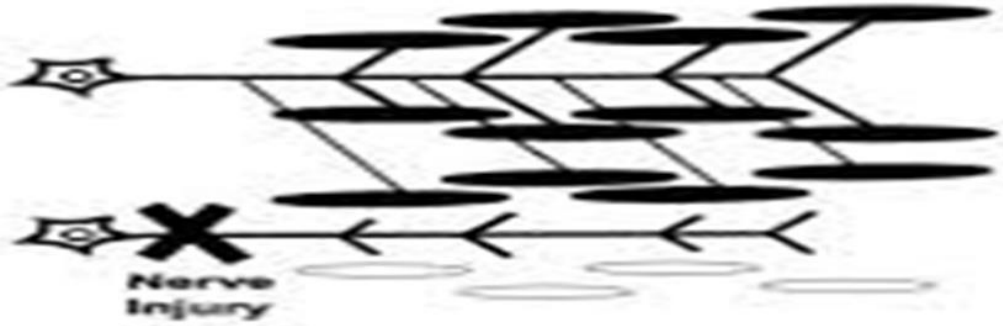
The minimum number of surviving motor units theoretically required to reinnervate the muscle completely, therefore, is 20% (i.e., 80% of motor units lost).

Motor unit Remodeling



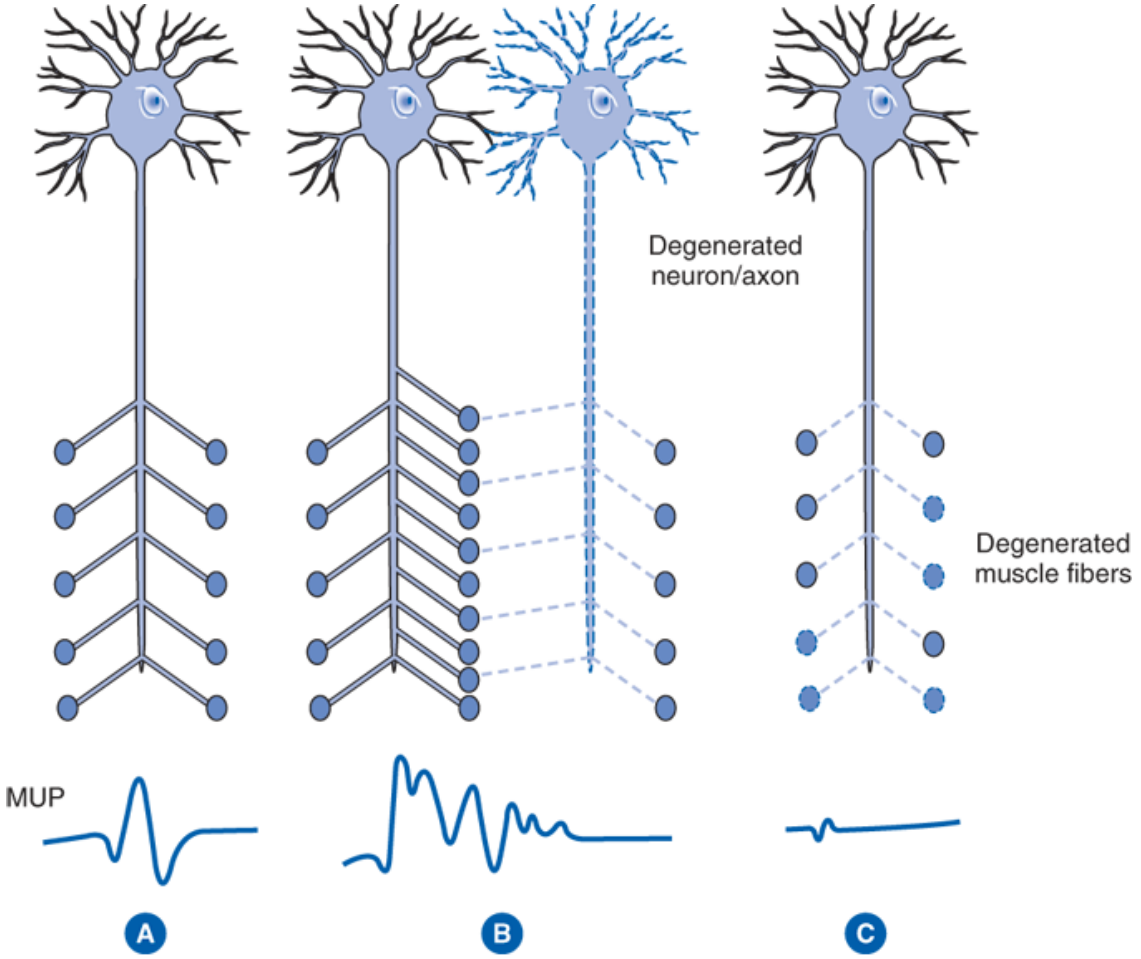


Normal MUAP



Neuropathic MUAP

Myopathic MUAP



Source: John C.M. Brust:
CURRENT Diagnosis & Treatment: Neurology, Third Edition

Neurogenic Recruitment

Table 7-15. Neurogenic Recruitment

	Motor Unit Recruited		
1st (A)	2nd (B)	3rd (C)	4th (D)
A (20 Hz)			
A (25 Hz)	0	0	
A (30 Hz)	0	0	D (20 Hz)

Motor unit A begins firing at 20 Hz because motor units B and C are not present. When motor unit A fires at 30 Hz, motor unit D finally becomes active at 20 Hz. The recruitment pattern is altered, and fewer motor units are firing at higher than anticipated rates.

MUSCLE LOSS

A number of primary muscle diseases are characterized by a disease process that randomly affects muscle fibers throughout the muscle as a whole. The effect is to reduce the number of muscle fibers comprising each motor unit. Muscle fibers still innervated also demonstrate an increase in variation of muscle fiber diameter. The loss of muscle fibers combined with fiber size changes may lead to a reduced motor unit territory.

_ Muscle loss

- Muscle fiber loss
- Muscle fibers approximated but no electrical summation
- Fiber type grouping also occur

MUAP FINDINGS IN MUSCLE DISEASE

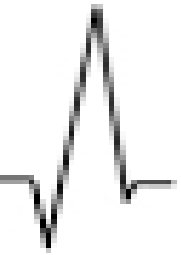
- MUAP duration decreased
- Increase number of phase
- Fiber splitting and slow conduction:
  - Satellite potential
    - 10% in normal
    - 12 % in neuropathy
    - 45 % in myopathy
    - Responsible for abnormal long duration 60 ms
- Large MUAP: needle near hypertrophic fibers
- Segmental necrosis : Fib/PSW

Myogenic recruitment

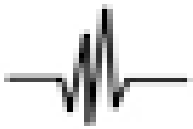
- Increased MU firing
- Early or increased recruitment
- Recruitment ratio < 3

1st	2nd	3rd	4th	5th
15	15	15	15	15

Normal

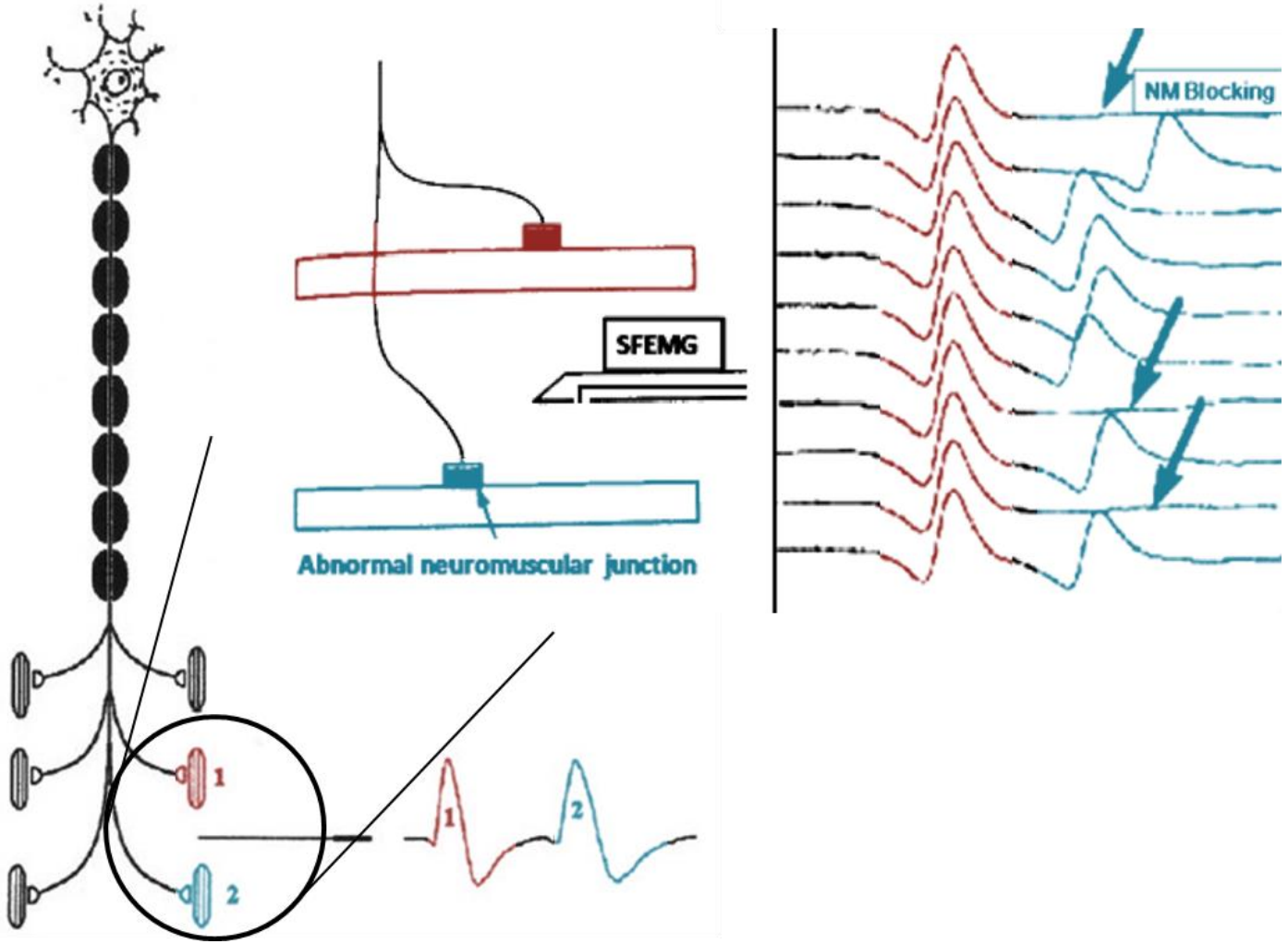


Myopathy



MUAP IN NMJ

- Presynapthic
  - Botulism
  - Lambert-Eaton syndrome show
- Synaptic space:
  - Organophosphate
  - Congenital disorders
- Postsynaptic
  - Medication ,
  - MG
- 1&2 : MU variability


SFEMG
Abnormal neuromuscular junction
NM Blocking
1
2
1
2

Other entity

- CVA
  - First MU 7-8 firing rate
  - Second MU 10-15
  - diminished degree of voluntary control

- Additional waveforms:
- 50-60 Hz
- EKG 1Hz
- Pacemaker

- Several points:
- The most painful muscles in needle exam:
- 1. cervical paraspianls
- 2. lumboscaral paraspinals
- 3.hand interniscic muscles
- Relative contraindications for needle exam:
- platelet count < 50000
- PT>1.5-2 times a control value
- heparin therapy and PTT>1.5-2 times a control value
- in hemophilia initially factors optimized then
- In lymphadema it should be limited.

EMG in Myopathies

- **During Voluntary activity** motor unit potentials (**MUP**) ie. are recorded and **MUP phase** are studied
- ≥5, phases are called polyphasic.
- Acute myopathy: MUP are small in amplitude, short duration and polyphasic.
- Chronic myopathy: MUP are large and of longer duration.

THANK YOU FOR YOUR ATTENTION