Physiology 439

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Nerve conduction studies and EMG

Editing file

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Red: Important
Black: In Male & Female slides
Blue: In male slides
Pink: In female slides
Gray: Notes & extra information

Objectives

1. Define nerve conduction study (NCS) and electromyography (EMG).
2. Explain the procedure of NCS.
3. Define the normal conduction velocity in upper limb and lower limb nerves.
4. Define the motor unit potentials (MUPs) and how they are changed in muscle and nerve diseases.

Nerve Conduction studies

Nerve Conduction Study (NCS)

Is a test commonly used to evaluate the function, especially the ability of electrical conduction, of the motor and sensory nerves of the human body.
Sensory and motor nerve conduction studies involve analysis of specific parameters, including latency, conduction velocity, and amplitude.

Nerve Conduction Velocity (NCV)

is a common measurement made during this test.

NCS اختبار يقيس قدرة توصيل الكهرباء للأعصاب ال sensory و ال motor, و ال NCV هي القياس الشائع لهذا الاختبار.

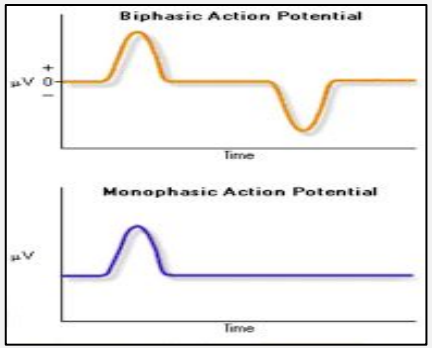
Motor Conduction Studies (MCS)

01

The recorded potential, known as the compound muscle action potential (CMAP) , represents the summation of all underlying individual muscle fiber action potentials.

02

CMAP is a biphasic potential with an initial upward deflection from the baseline.



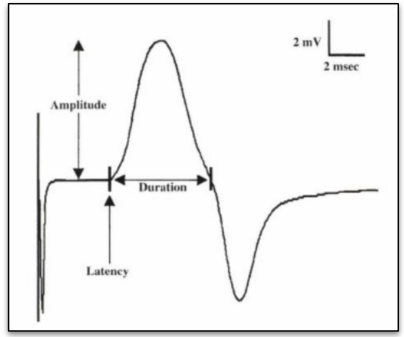
03

A motor conduction velocity can be calculated after two sites of stimulation, one distal and one proximal.

04

For each stimulation site:
- latency
- amplitude
- duration

of the CMAP are measured.



MCS Procedure

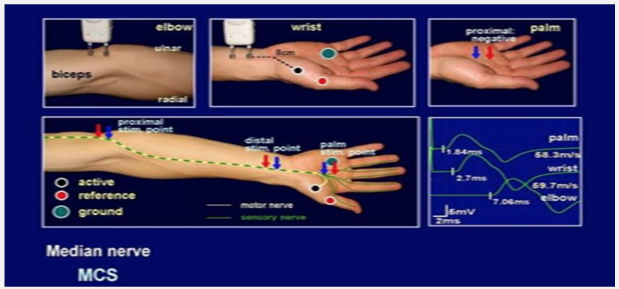
The **active recording electrode** is placed on the center of the muscle belly (over the motor endplate), and the **reference electrode** is placed distally about 3-4 cm (will be converted to millimeters (mm) later).

The stimulator then is placed over the nerve that supplies the muscle.

As current is slowly increased from a baseline: more of the underlying nerve fibers are brought to action potential, and subsequently more muscle fiber action potentials are generated.

Most nerves require a current in the range from **20 to 50 mA** to achieve supramaximal stimulation.

When the current is increased to the point that the CMAP no longer increases in size, one presumes that all nerve fibers have been excited and that supramaximal stimulation has been achieved. The current then is increased by another 20% to ensure supramaximal stimulation.



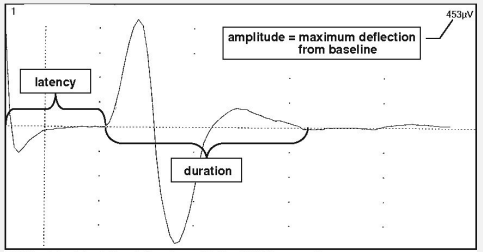
Vectors of NCS/MCS

Conduction Velocity

- It's measurement of the speed of the conducting nerve axons.
- It is calculated by dividing the change in distance (between proximal stimulation site & distal stimulation site in mm) by the change in time (proximal latency in mSec minus distal latency in mSec).
- It's normal values are: 50 to 70 m/sec (in the arm)
  40 to 60 m/sec (in the leg)

Latency

- Latency measurements usually are made in milliseconds (ms) or (mSec).
- The latency is the time from the stimulus to the initial deflection from baseline.



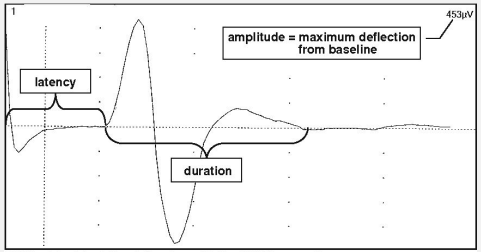
Vectors of NCS/MCS

Duration

- This is measured from the initial deflection from baseline to the final return
- Duration characteristically increases in conditions that result in slowing of some motor fibers (e.g., in a demyelinating lesion).

Amplitude

- it is **most commonly** measured from baseline to the peak (baseline-to-peak) and **less commonly** from the first upward peak to the next downward peak (peak-to-peak).
- CMAP amplitude reflects the number of muscle fibers that depolarize.
- low CMAP amplitudes most often result from loss of axons (as in a typical axonal neuropathy)
- average CMAP amplitude 3 mv

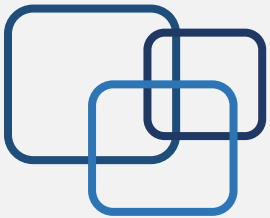


Motor Nerve Conduction Velocity (MNCV)

Based on the nature of conduction abnormalities two principle types of peripheral nerve lesions can be identified: Axonal degeneration and segmental demyelination.

Motor nerve conduction velocity of peripheral nerves may be closely correlated to their functional integrity or to their structural abnormalities.

In the patients of muscular weakness, muscle atrophy, traumatic or metabolic neuropathy, these tests are considered as an extension of the physical examination rather than a simple laboratory procedure.



Motor Nerve Conduction Velocity (MNCV)

Distance = 284 mm

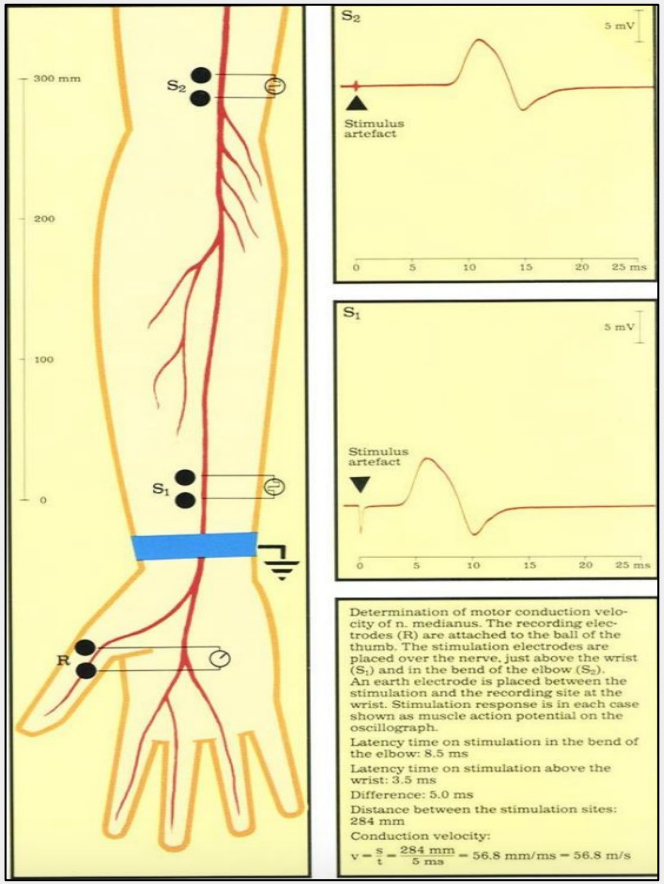
Latency at wrist (distal) ,(L2) = 3.5 ms

Latency at elbow (proximal) ,(L1) = 8.5 ms

MNCV can be calculated by the formula:

$$\text{MNCV(m/Sec)} = \frac{\text{Distance (mm)}}{\text{L1 - L2 (msec)}}$$

* How to measure the latency ?
From the stimulus artefact until the peak of action potential (AP)

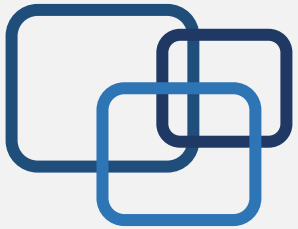


How to measure the MNCV?

01 Measure the distance from elbow to wrist with a measuring tape.

02 Measure the latency in first CMAP & in the next CMAP.

03 Enter the distance between the elbow and wrist to the machine.

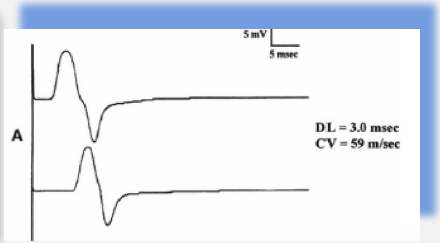


Patterns of Nerve Conduction

01 Normal study of Median Nerve

(Most common for NCS)

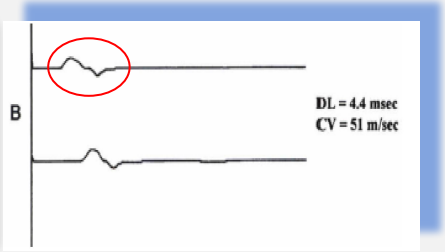
- Note the normal median distal latency (DL) 3 ms, amplitude >4 m V, and conduction velocity (CV) >49 mls.
- Dome-shaped



02 Axonal Loss

Ex: **Axonal Degeneration Neuropathy**

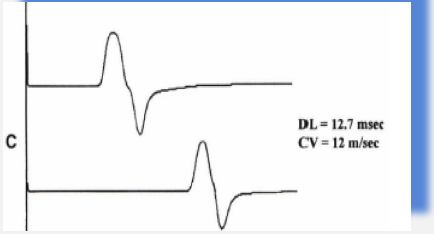
- Amplitudes decrease
- CV is normal or slightly slowed.
- DL is normal or slightly prolonged.
- The morphology of the potential does not change between proximal and distal sites.



03 Demyelination associated with inherited disorders

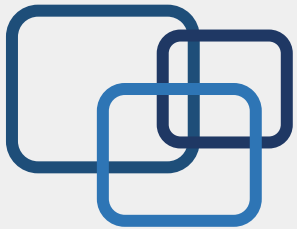
Ex: **Demyelinating Neuropathy**

- CV is markedly slowed < 75% lower limit of normal).
- DL is markedly prolonged (>130% upper limit of normal).
- Usually there is no change in configuration between proximal and distal stimulation.



Nerve conduction comparison

(Axonal Loss) Axonal degeneration neuropathy features	(Demyelination) Demyelinating Neuropathy features
Low amplitudes	Normal amplitudes
Normal / slight delay in latency	Significant delay in latency
Normal / slightly low conduction velocity	Significantly low conduction velocity



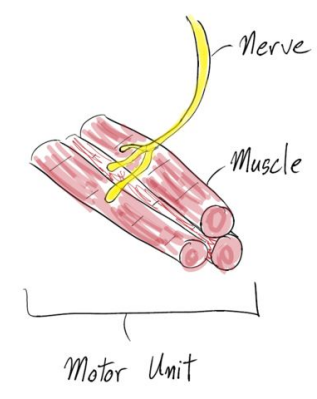
Electromyography (EMG)

Definition

It's a recording of **electrical activity of the muscle** by inserting **needle electrode** in the belly of the muscles or by applying the surface electrodes.

Motor Unit

one motor neuron and all of the muscle fibers it innervates.



Motor Unit Potentials (MUP)

The potentials recorded on volitional effort are derived from motor units of the muscle

Mechanism of EMG: It is a recording of electrical activity of the muscle by inserting needle electrode in the belly of the muscles (needle EMG) or by applying the surface electrodes (surface EMG).

EMG analysis

EMG is used to analyze:

01 Insertional activity

The electrical activity present as the electrode is passed through muscle
cells. These are discharge potentials provoked by the disruption of the cell membrane itself.
-decreased in atrophied muscle or fatty tissue.
- increased in many abnormal conditions that cause membrane instability, such as neuropathies, radiculopathies, and inflammatory myopathies.

02 Spontaneous activity

The skeletal muscle is silent at rest, hence spontaneous activity is absent.

Normal MUPs

Duration

3-5 mSec

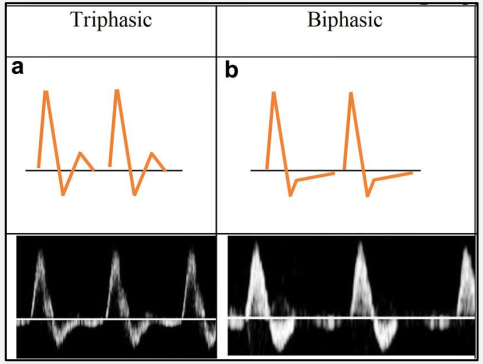
Morphology

Bi-phasic

Tri-phasic

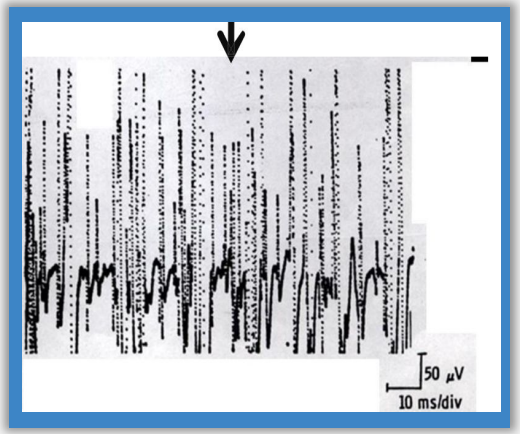
Amplitude

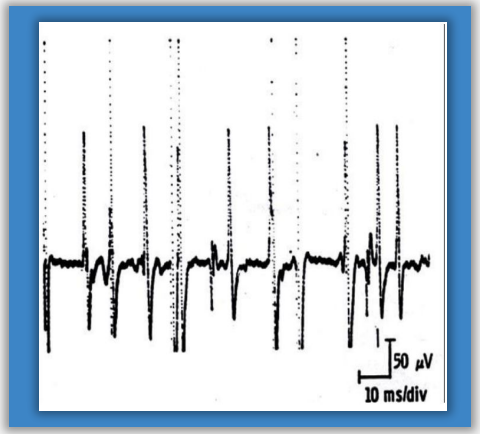
300μV-5000μV(5mV)



During Full Voluntary Effort

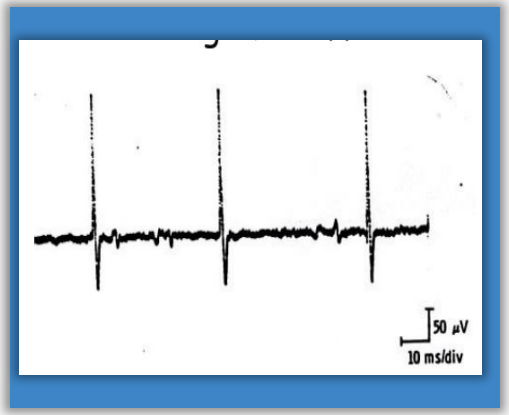
There is full recruitment
(you can't see the baseline)





During Moderate Effort

note recruitment of additional
motoneurons



During Mild Effort

The muscle is at rest (silent)

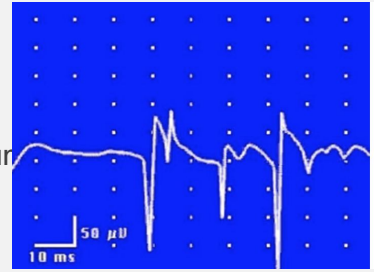
Abnormal MUPs

(Abnormal resting activity)

01

Positive sharp wave:

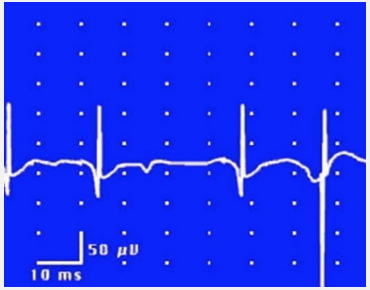
-A small potential of **50 to 100 µV, 5 to 10 msec** duration with **abrupt onset and slow outset**. It is the earliest manifestation of **axonal denervation**.
-Fibrillations are not found exclusively in neurogenic disease, however; they also occur in inflammatory and dystrophic muscle disease.
-**Not visible through the skin**



02

Fibrillation potential:

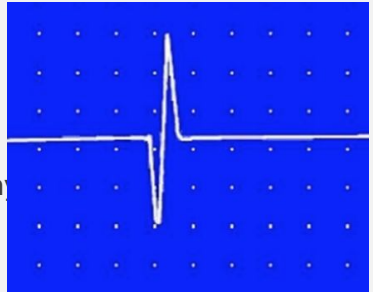
-These are **randomly occurring small amplitude potentials** or may appear in runs. The audioamplifier gives sounds,as if somebody listen **sounds of rains in a tin shade** house. These potentials are generated from the single muscle fiber of a **denervated muscle**, possibly due to denervation hypersensitivity to acetyl choline.
-**Not visible through the skin**



03

Fasciculation potentials:

-These are **high voltage, polyphasic, long duration potentials appear spontaneously** associated with visible contraction of the muscle.
-May be benign and they occur in **motor neuron disease**, radiculopathy and neuropathy
-**Visible through the skin**

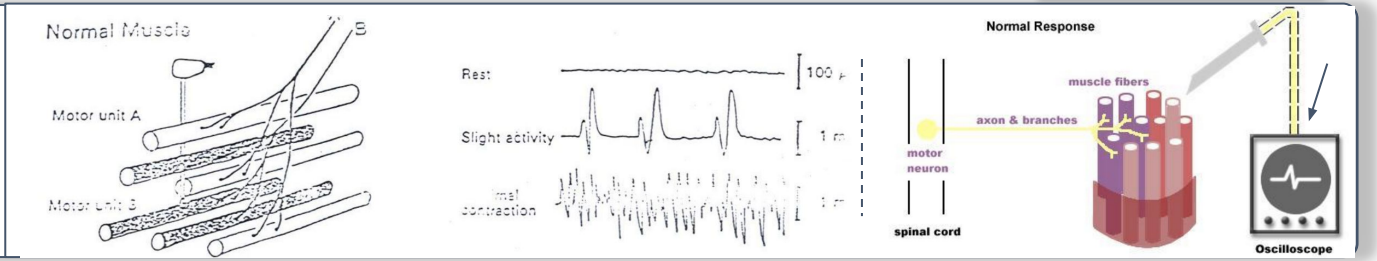


Neuro/Myopathy

We see **Giant unit** when there is a damaged neuron and another neuron is supplying both of his fibers and the fibers of damaged neuron

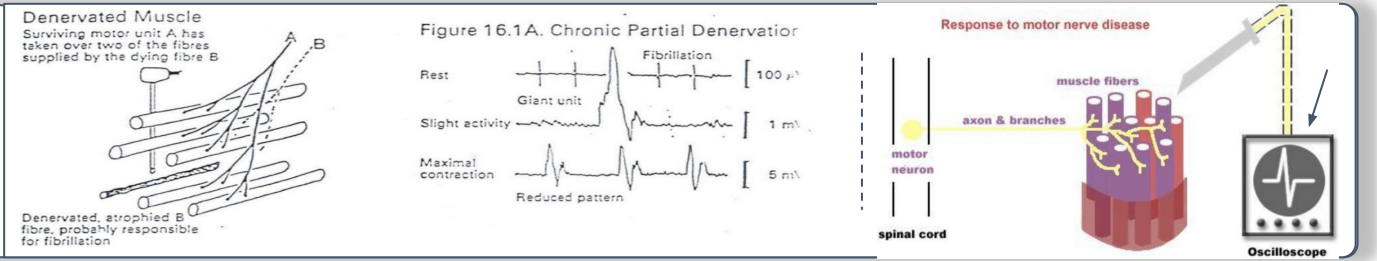
EMG Changes

01 Normal Muscle



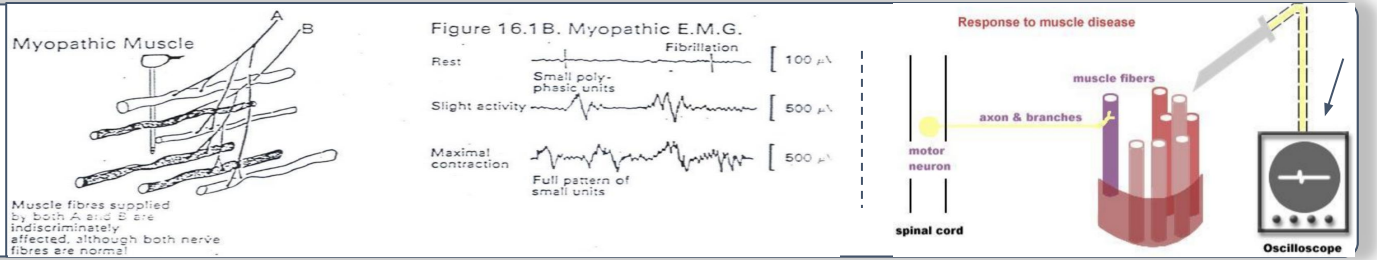
02 Neuropathic Muscle

1-There is a resting activity
2-Polyphasic
3-there is giant unit



03 Myopathic Muscle

1-There is a resting activity
2-Polyphasic



Analysis of a Motor Unit Potential (MUP)

MUP	Normal	Neurogenic	Myopathic
Duration.	3 – 15 msec	longer	Shorter
Amplitude	300 – 5000μV	Larger (giant)	Smaller
Phases	Biphasic /triphasic	Polyphasic	polyphasic
Resting Activity	Absent	Present	Present
Interference pattern	full	partial	Full

Typical MUAP characteristics in myopathic, neuropathic & normal muscle

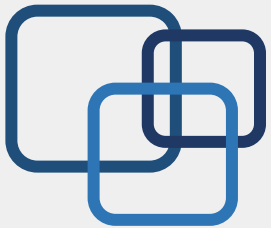
MUP	Myopathy	Normal	Neuropathy
Duration.	< 3 msec	3 – 15 msec	> 15 msec
Amplitude	< 300 μV	300-5000 μV	> 5 mV
configuration	polyphasic	triphasic	Polyphasic

SUMMARY

helpful video helpful video

- The normal conduction velocity at the arm and the lower limb.
- the normal MUPs there is no activity (silent)
- you have to know the amplitude and the duration
- How to differentiate between the normal and abnormal cases (neurogenic and myogenic)

NCS	Normal Values	Axonal Loss	Demyelination
Latency ms	Stimulus to initial deflection	Normal or slightly Prolonged	Prolonged
Duration ms	Initial deflection to find return	N/A	N/A
Velocity m/s	Arm 50 - 70 Leg 40 - 60 Distance/ Latency	Normal	Slow
Amplitude mV	3 mV reflect number of fibers	Decreased	Same
Morphology	Biphasic	Same	Same



QUIZ!

MCQs

Q1: demyelinating neuropathy has a			
A) Normal latency	B) slight delay in latency	C) Normal amplitude	D) slightly low conduction velocity
Q2 : Which of the following has an abnormal conduction velocity?			
A) 40 m/sec in arm	B) 40 m/sec in leg	C) 50 m/sec in arm	D) 50 m/sec in leg
Q3 :CMAP is a ..... potential			
A) Monophasic	B) Aphasic	C) Multiphasic	D) Biphasic
Q4 : Which of the following MUPs abnormalities is **visible** throgh the skin			
A) Positive sharp wave	B) Fasciculation potentials	C) Fibrillation potential	D) None of them
Q5 : The Morphology of **normal** MUPs is			
A) Biphasic	B) Triphasic	C) Polyphasic	D) A&B
Q6 when is the MUP is absent at the resting activity?			
A) Normal state	B) Neurogenic state	C) Myopathic state	D) Both B&C

SAQ

Q1: Fibrillations are found in?

Q2: The duration of the normal MUP?

MCQs key answer :
1) C
2) A
3) D
4) B
5) D
6) A

SAQ answer key :
1)neurogenic disease,inflammatory and dystrophic muscle disease

2) 3- 15 msec

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Physiology 439

THANK YOU

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