Yehuleshet GP Responsibilities

Tewodros Yehuleshet: Medical and Surgical Center

1. In patient care
2. Emergency care

Lideta Yehuleshet: Speciality Clinic

1. NCS
2. LP
3. Emergency
4. MRI Reading (T1, T2, FLAIR,DWI)

Lumbar Puncture

1. Definition of Lumbar Puncture:
2. Common indications
3. Common contraindications to look out for
4. Steps
5. Procedure note template
6. How to do a tough spinal and navigate:
    a.

Nerve Conduction Study (NCS) and ElectroMyoGraphy 101: Simplified for General Practitioners

Learning NCS is a vital part of the process;

Outline

1. The basics
    a. What is NCS?
    b. What are we doing on NCS examination? What are we trying to examine?
    c. Indications and Contraindications for NCS:
        i. Tips:
            1. Metal
            2. Cardiac pacemaker
    d. Common NCS requiring cases
    e. Generals of NCS:
        i. How it works
        ii. What are we doing?
        iii. Motor and Sensory NCS!
        iv. Usage 101:
            1. Parts of the NCS (Receiver, Ground and machine)
            2. Sites for Probe placement (the correct sites)
            3. Values to set on the machine
            4. The different waves and what they mean
                a. Nerve waves
                b. F and H wave

5. Identifying the right Nerve:
    a. Curves, Amplitudes, Latency and Velocity
6. When is it not the right nerve
7. Practical Tips and Tricks
    a. Identifying the right nerve and reducing artifacts
        i. (Tips and tricks)- the Elevator issue
8. Important numbers to keep on hand

f. The Viking Application and how to use it?
    i. Basic functions;
        1. Turning on and OFF
        2. Registering a new patient
        3. Using the system

2. Basic Information:
    a. Anatomy of the Nerves on our body (NCS specific)
    b. Common nerves for NCS
    c. Normal NCS findings and Abnormal findings
    d. Axonal neuropathy vs Demyelinating disease
3. NCS 101
    a. Upper extremity NCS
        i. Indications
        ii. Process
    b. Lower extremity NCS
    c. NCS of the face
    d. Blink Reflex
    e. Special NCS:
        i. Blink Reflex
        ii. Repetitive NCS
        iii. Sympathetic Skin Response (SSR)
4. Reporting NCS
5. Advanced NCS:
    a. Inverting feature
    b.

6. Basic of Electromyography (EMG)

Nerve	**Amplitude**	**Latency**	**Conduction velocity**	**Location with tips and tricks to find the nerve**	**Comments**
Peroneal Motor Nerve with F wave	≧ 2mv			- Finding the belly of EDB: extend their digit A1	- You can do A1 if you find it to be great then do Fwave bezaw
Tibial Motor Nerve	≧ 4mv				
Sural	≧ 6 μV				

Note:

- We only compare and contrast the A1 for Amplitude, and latency (only conduction velocity for the rest of the nerve stimulation sites- A2 and A3)
- The reason why sensory have too many artifact is because they measure in μV (the gain is adjusted that way)
- Memorizing numbers tricks
    - Lower limb-
        - Amplitude: “2,4,6” (peroneal, tibial, and sural)
    - Upper limb
        - 4, 6
    - Fwave
    - Hwave
-

- Finding the muscles;
    -

Notes:

General Tips for Nerve Conduction Studies (NCSs)

Before beginning any nerve conduction study, it is crucial to:

- **Explain the Procedure**: Many patients are anxious, so simple explanations can greatly reduce their anxiety.
- **Perform NCSs First**: Findings on NCSs are needed to adapt and correctly interpret the subsequent needle electromyography (EMG).
- **Understand Anatomy and Physiology**: Knowledge of nerve and muscle anatomy and basic neurophysiology is essential for proper electrode positioning and interpreting findings.
- **Control Temperature**: Temperature is the most important physiological factor. Cooler temperatures can slow conduction velocity (1.5-2.5 m/s per 1°C drop) and prolonged distal latency (approximately 0.2 ms per 1°C). Limbs should be warmed to at least 33°C (91.4°F) for accurate results. It can take 20-40 minutes for underlying nerve temperature to equilibrate in profoundly cool limbs.
- **Achieve Supramaximal Stimulation**: This ensures all nerve fibers are depolarized. Slowly increase the current intensity until the recorded potential's amplitude plateaus, then increase it by an additional 20%-25%. Failing to do so can lead to inaccurate conduction velocity and amplitude measurements.
    - This is what we are looking for when stimulation
        - Normal looking wave and numbers that make sense plus the supramaximal stimulation
- **Optimize Stimulation Site**: Position the stimulator directly over the nerve to achieve the highest Compound Muscle Action Potential (CMAP) amplitude with the least stimulus intensity. This is done by holding the current constant and moving the stimulator slightly laterally and medially until the largest response is found.
- **Proper Electrode Placement**:
    - For motor studies, the active recording electrode (G1) is placed on the center of the muscle (motor point), and the reference electrode (G2) is placed distally over the tendon. Correct placement of G1 results in a characteristic biphasic potential with an initial negative deflection. Misplacement can result in a triphasic potential or only a positive deflection.
    - For sensory studies, a pair of recording electrodes (G1 and G2) are placed in line over the nerve, 2.5–4 cm apart, with G1 closest to the stimulator.
    - For both motor and sensory studies, adjust recording electrode positions to ensure the maximal amplitude is obtained, as minimal movement can significantly affect amplitude and latency measurements.

- **Maintain Consistent Settings**: Both sweep speed and sensitivity can influence latency measurements. All measurements for a nerve conduction study should be made using the same sensitivity and sweep speed to avoid calculation errors.
- **Utilize Side-to-Side Comparisons**: Comparing results with the contralateral (asymptomatic) side is often more useful than relying solely on normal value tables, especially for nerves where responses can be small or difficult to obtain in healthy individuals (e.g., some sensory nerves in older adults). **A 50% side-to-side amplitude difference is generally considered abnormal.**
- **Normal wave forms:**
    - **Median:** Dome shaped
    - Ulnar: notched
    - Radial and Tibial: have a downward dip
- EMG information:
    - The Deltoid has >25% Polyphasic (i.e.> 4 turns over the isoelectric line) normally (for the rest above 25% is PPP +1 above 50% is +2)
    - Short duration waves that are small amplitude are Myopathic changes
    - Large duration waves that have large amplitudes are Neuropathic changes

General Mnemonics:

- Upper limb:
    - 7cm for A1 motors- “7 invert it and it looks like a gun and you hold a gun with your hands”
    - Amplitudes: “4 then 6” (Median then ulnar)
    - Conduction Velocities: $\geqq$ 50 m/s (Hi five)- it is 49 technically but still
    - Distal latency: $\leq$ 4.5 ms and $\leq$ 3.3 ms (Median and then Ulnar)
    - Sensory distance:
        - 11cm for Ulnar you can make a U with 11
        - 13 cm for Median nerve invert the m and it becomes a 3
    - Latencies:
        - Less than 4 generally speaking (median surely less than 4 but ulnar wetat silehone give it 3.3 they have to be quicker)
        - For sensory always less than 3.5 ms they have to be quicker than motor (as always ulnar is 3.1ms)
    - Sensory is faster so less distal latency (note: ulnar is more faster)
- Lower limb:

    - 9cm - Peroneal, and 9 just rotate sideways
    - Velocity ≧ 40m/s- “4 legs”
    - Amplitudes: “2-4-6” peroneal, tibial and then sural (note the sural is μV)
    - Latencies: “6.5, 5.8 and 4.5ms” -leg latencies are less than 6ms but sural is sensory so it has to be less than 4.5
- Generally A2 to A3 is 10 cm
- Fwave: ≤ 31 ms Upper limb because it is closer to the spinal cord; and ≤ 56 ms for lower limb
- Hwave: ≤34 ms- “you can make a 4 from H- if you rearrange it”
- The weirds:
    - Median sensory amplitude 20 μV- “20 median age”
    - Ulnar sensory amplitude 17 μV- “under 17!!”

Upper Extremity Nerves

- **Median Motor Study (Abductor Pollicis Brevis - APB)**

    - **Recording Site**: **G1** (black) over the muscle belly of the APB (lateral thenar eminence); **G2** (red) over the first metacarpal-phalangeal joint.
    - **Stimulation Sites**:
        - **Wrist**: Slightly lateral to the mid-wrist, between the tendons to the flexor carpi radialis and palmaris longus.
            - To locate the palmaris longus tendon, have the patient touch their thumb to their little finger and slightly flex their wrist. If present, the tendon will appear as a prominent structure in the midline of the anterior (front) of the wrist, between the flexor carpi radialis and flexor carpi ulnaris tendons
            - To locate the flexor carpi radialis tendon, flex your wrist while keeping your forearm relaxed. The tendon will be visible as a prominent structure on the radial (thumb) side of your wrist, just proximal to the crease. It is the tendon closest to the thumb and is often more visible with resisted wrist flexion
        - **Antecubital Fossa**: Just medial to the brachial artery pulse. Palpating the biceps tendon with 30 degrees of elbow flexion can make this easier.
    - **Distal Distance**: 7 cm. (then measure the distance between A1 and A2)
    - **Normal Values**:
        - Amplitude: **≥4.0 mV**.
        - Conduction Velocity: **≥49 m/s**.
        - Distal Latency: **≤4.4 ms**.

- **Median Sensory Study (Digit 2 or 3)**
    - **Recording Site**: Ring electrode on the metacarpophalangeal (MCP) joint of digit 2 or 3 (G1), with the reference (G2) 3-4 cm distal to G1.
    - **Stimulation Site**: Proximal to the wrist crease, between the flexor carpi radialis and palmaris longus tendons.
    - **Distal Distance**: 13 cm or 14 cm.
    - **Normal Values**:
        - Amplitude: **≥20 µV** (for digit 2).
        - Conduction Velocity: **≥50 m/s**.
        - Peak Latency: **≤3.5 ms** (for digit 2).
    - **Tips**: Be aware of motor artifact, which can obscure or be mistaken for the sensory response. Recording at digit 4 may be even more sensitive to carpal tunnel compression.
- **Ulnar Motor Study (Abductor Digiti Minimi - ADM)**
    - **Recording Site**: **G1** over the muscle belly of the ADM (medial hypothenar eminence); **G2** over the fifth metacarpal-phalangeal joint. (have the crease in between G1 and G2)
    - **Stimulation Sites**:
        - **Wrist**: Medial wrist, adjacent to the flexor carpi ulnaris tendon.
            - To locate the flexor carpi ulnaris (FCU) tendon, you can find it on the anterior (palmar) surface of the forearm, near the wrist. It's the most medial (pinky-side) of the tendons visible there, just before the wrist joint.
        - **Below Elbow**: 3-4 cm distal to the medial epicondyle.
        - **Above Elbow**: Over the medial humerus, between the biceps and triceps muscles, 10-12 cm from the below-elbow site.
        - **Axilla (Optional)**: In the proximal axilla, medial to the biceps over the axillary pulse.
    - **Distal Distance**: 7 cm.
    - **Normal Values**:
        - Amplitude: **≥6.0 mV** (or >7.9 mV).
        - Conduction Velocity: **≥49 m/s** (or >50 m/s).
        - Distal Latency: **≤3.3 ms** (or <3.7 ms).
        - F-wave Latency: **≤32 ms** (or <31.5 ms).

    - **Tips**: Optimal elbow position is flexed 90-135 degrees; straight elbow can cause factitious slowing. Always perform wrist, below-elbow, and above-elbow stimulations to avoid missing focal slowing across the elbow.
- **Ulnar Sensory Study (Digit 5)**
    - **Recording Site**: Ring electrode on the fifth digit (little finger); **G1** over the MCP joint, **G2** 3-4 cm distally over the DIP joint.
    - **Stimulation Site**: Wrist: Medial wrist, adjacent to the flexor carpi ulnaris tendon.
    - **Distal Distance**: 11 cm.
    - **Normal Values**:
        - Amplitude: **≥17 µV** (or >6 µV).
        - Conduction Velocity: **≥50 m/s**.
        - Peak Latency: **≤3.1 ms** (or <4.0 ms).
- **Dorsal Ulnar Cutaneous Sensory Study**
    - **Recording Site**: Dorsal hand: **G1** over the web space between the little and ring fingers; **G2** 3-4 cm distally over the little finger.
    - **Stimulation Site**: Slightly proximal and inferior to the ulnar styloid with the elbow straight.
    - **Distal Distance**: 8 cm.
    - **Normal Values**:
        - Amplitude: **≥8 µV** (or >5 µV).
        - Conduction Velocity: **≥50 m/s**.
        - Peak Latency: **≤2.5 ms** (or <2.9 ms).
    - **Tips**: This nerve typically arises proximal to the wrist (5-8 cm). It is usually spared in ulnar nerve lesions at Guyon's canal (wrist) but can be abnormal if there is axonal loss from an ulnar neuropathy at the elbow.
- **Radial Motor Study (Extensor Indicis Proprius - EIP)**
    - **Recording Site**: **G1** over the muscle belly of the EIP (with hand pronated, two fingerbreadths proximal to the ulnar styloid); **G2** over the ulnar styloid.
    - **Stimulation Sites**:
        - **Forearm**: Over the ulna 4-6 cm proximal to G1.
        - **Elbow**: In the groove between the biceps and brachioradialis muscles.
        - **Below Spiral Groove** and **Above Spiral Groove**.

    - **Distal Distance**: 4-6 cm.
    - **Normal Values**:
        - Amplitude: **≥2.0 mV** (range 1.7-11.1 mV).
        - Conduction Velocity: **≥49 m/s** (range 60.2-79.2 m/s).
        - Distal Latency: **≤2.9 ms** (or <2.1 ms).
        - F-wave Latency: Range 16.2-24.1 ms.
    - **Tips**: A possible initial positive deflection of CMAP may occur due to volume conduction from other nearby radial-innervated muscles. Accurate surface distance measurements can be difficult as the radial nerve winds around the humerus; using obstetric calipers may help.
- **Radial Sensory Study (Snuffbox)**
    - **Recording Site**: Over the superficial radial nerve with **G1** near the extensor tendons of the thumb (snuffbox); **G2** 4 cm distal to G1 over a bony prominence near the 1st MCP joint.
    - **Stimulation Site**: Dorsal radius 10 cm proximal to G1.
    - **Distal Distance**: 10 cm.
    - **Normal Values**:
        - Amplitude: **≥15 µV** (or >7 µV).
        - Conduction Velocity: **≥50 m/s**.
        - Peak Latency: **≤2.9 ms** (or <2.8 ms).
    - **Tips**: The superficial radial nerve can often be palpated as it runs over the extensor pollicis longus tendon. This study is spared in posterior interosseous neuropathy.
- **Lateral Antebrachial Cutaneous Sensory Study**
    - **Recording Site**: Lateral forearm: **G1** 12 cm distal to the stimulation site, in line with the radial pulse; **G2** 4 cm distal to G1.
    - **Stimulation Site**: Antecubital fossa lateral to the biceps tendon.
    - **Distal Distance**: 12 cm.
    - **Normal Values**:
        - Amplitude: **≥10 µV** (or >5 µV).
        - Conduction Velocity: **≥55 m/s**.
        - Peak Latency: **≤3.0 ms** (or <2.5 ms).

    - **Tips**: Easy to perform. The nerve is quite superficial, so low stimulation intensities are usually sufficient. Repositioning electrodes slightly medially or laterally can maximize the response.
- **Medial Antebrachial Cutaneous Sensory Study**
    - **Recording Site**: Medial forearm: **G1** 12 cm distal to the stimulation site, on a line drawn between the stimulation site and the ulnar wrist; **G2** 3-4 cm distally.
    - **Stimulation Site**: Medial elbow: At the midpoint between the biceps tendon and medial epicondyle.
    - **Distal Distance**: 12 cm.
    - **Normal Values**:
        - Amplitude: **≥5 µV** (or >4 µV).
        - Conduction Velocity: **≥50 m/s**.
        - Peak Latency: **≤3.2 ms** (or <2.6 ms).
    - **Tips**: Typically absent or very low in true neurogenic thoracic outlet syndrome. Side-to-side comparisons of amplitude and latency are often helpful.
- **Axillary Motor Study (Deltoid)**
    - **Recording Site**: Over the deltoid muscle (G1 on muscle belly, G2 distally over tendon). The medial head is easiest to study.
    - **Stimulation Sites**: Axilla or Erb's point (just posterior to the sternocleidomastoid muscle in the supraclavicular fossa).
    - **Distal Distance**: 15-21 cm (for Erb's point to deltoid).
    - **Normal Values (Erb's Point)**: Latency: **≤4.9 ms** (or <5.4 ms).
    - **Tips**: Technically difficult to perform, especially achieving maximal stimulus. Side-to-side comparisons are recommended to assess axonal loss.
- **Musculocutaneous Motor Study (Biceps Brachii)**
    - **Recording Site**: At the midpoint between the biceps tendon and the anterior shoulder (G1 on muscle belly, G2 distally over tendon).
    - **Stimulation Sites**: Axilla or Erb's point.
    - **Distal Distance**: 23-29 cm (for Erb's point to biceps).
    - **Normal Values (Erb's Point)**: Latency: **≤5.7 ms** (or <5.6 ms).
    - **Tips**: The biceps brachii is the most accessible muscle innervated by the musculocutaneous nerve. Similar technical difficulties and utility as axillary motor studies.

- **Spinal Accessory Motor Study (Upper Trapezius)**

    - **Recording Site**: **G1** over the upper trapezius; **G2** over the shoulder.
    - **Stimulation Site**: Just posterior to the midpoint of the sternocleidomastoid (SCM) muscle.
    - **Tips**: The nerve is quite superficial and usually can be supramaximally stimulated with low current (e.g., 15-25 mA). Apply firm pressure when holding the stimulator. Ensure correct placement to avoid mistakenly stimulating the brachial plexus (causing shoulder movement).

Lower Extremity Nerves

- **Peroneal Motor Study (Extensor Digitorum Brevis - EDB)**

    - **Recording Site**: **G1** over the muscle belly of the EDB (dorsal lateral foot); **G2** over the metatarsal-phalangeal joint of the little toe.
    - **Stimulation Sites**:
        - **Ankle**: Anterior ankle, slightly lateral to the tibialis anterior (TA) tendon.
        - **Below Fibular Head**: Lateral calf, one to two fingerbreadths inferior to the fibular head.
        - **Lateral Popliteal Fossa (Above Fibular Neck)**: Lateral knee, adjacent to lateral hamstring tendons, 10-12 cm from the below-fibular head site.
    - **Distal Distance**: 9 cm.
    - **Normal Values**:
        - Amplitude: **≥2.0 mV** (or >1.3 mV).
        - Conduction Velocity: **≥44 m/s** (or >38 m/s).
        - Distal Latency: **≤6.5 ms**.
        - F-wave Latency: **≤56 ms** (or <61.2 ms).
    - **Tips**: Higher stimulation currents are needed at the below-fibular head site as the nerve lies deep there. Always perform all three stimulations (ankle, below-fibular neck, above-fibular neck) to avoid missing slowing across the fibular neck. If CMAP amplitude is higher at proximal sites compared to the ankle, consider an accessory peroneal nerve. Avoid overstimulating at the lateral popliteal fossa, as this may co-stimulate the tibial nerve.
- **Peroneal Motor Study (Tibialis Anterior - TA)**

    - **Recording Site**: **G1** over the muscle belly of the TA (mid leg lateral to the tibia); **G2** 3-4 cm distally over the anterior ankle.
    - **Stimulation Sites**: Below fibular head; Popliteal fossa.
    - **Distal Distance**: Variable (5-10 cm).
    - **Normal Values**:
        - Amplitude: **≥3.0 mV** (or >1.7 mV).
        - Conduction Velocity: **≥44 m/s** (or >43 m/s).
        - Distal Latency: **≤6.7 ms** (or <4.9 ms).
    - **Tips**: This study is especially valuable in patients where no or only a small response is obtained from recording at the EDB. May require higher stimulation currents due to the nerve lying deep.
- **Sural Sensory Study**
    - **Recording Site**: **G1** over the posterior ankle; **G2** 3-4 cm distally.
    - **Stimulation Site**: Calf (midline between the gastrocnemius muscles).- go posteriorly and slightly angle your probe anteriorly
    - **Distal Distance**: 14 cm.
    - **Normal Values**:
        - Amplitude: **≥6 µV** (or >4 µV).
        - Conduction Velocity: **≥40 m/s**.
        - Peak Latency: **≤4.4 ms** (or <4.5 ms).
    - **Tips**: Often used as a representative pure sensory nerve for generalized polyneuropathy assessment. Responses can be small or absent in normal individuals, especially those over 40 years old; side-to-side comparison is necessary.
- **Superficial Peroneal Sensory Study**
    - **Recording Site**: Lateral ankle: **G1** placed between the TA tendon and lateral malleolus; **G2** 3-4 cm distally.
    - **Stimulation Site**: Lateral calf (in the groove between the extensor digitorum longus and peroneus longus/brevis muscles).
    - **Distal Distance**: 14 cm (standard), but shorter distances (e.g., 10-12 cm, 7-9 cm) may be easier for eliciting a response.
    - **Normal Values**:
        - Amplitude: **≥6 µV** (or >7.7 µV).
        - Conduction Velocity: **≥40 m/s**.

        - Peak Latency: **≤4.4 ms** (or <4.2 ms).
    - **Tips**: If using a shorter distance, determine normality by the calculated conduction velocity (based on onset latency and distance) rather than peak latency. Response can be small or absent in normal controls, especially over age 40; side-to-side comparison is crucial.
- **Saphenous Sensory Study**
    - **Recording Site**: Medial/anterior ankle: **G1** placed halfway between the tibialis anterior tendon and the medial malleolus; **G2** 3-4 cm distally.
    - **Stimulation Site**: Medial calf (in the groove between the medial gastrocnemius and tibia), 10-14 cm proximal to the recording electrodes.
    - **Distal Distance**: 14 cm (standard), but 10 cm may be easier.
    - **Normal Values**:
        - Amplitude: **≥4 µV** (or >2 µV).
        - Conduction Velocity: **≥40 m/s**.
        - Peak Latency: **≤4.4 ms**.
    - **Tips**: Side-to-side comparison is useful, especially if symptoms are limited to one side. This study is helpful for differentiating femoral neuropathy or lumbar plexopathy from an L2-L4 radiculopathy.
- **Medial Plantar Sensory Study**
    - **Recording Site**: Medial ankle: **G1** above and posterior to the medial malleolus; **G2** 3-4 cm proximal to G1.
    - **Stimulation Site**: Great toe.
    - **Normal Values**:
        - Amplitude: **10-30 µV**.
        - Peak Latency: **<3.68 ms**.
    - **Tips**: This is an orthodromic study. Useful for evaluating possible tarsal tunnel syndrome. Use firm pressure on the stimulator, as plantar skin can be thick.
- **Lateral Plantar Sensory Study**
    - **Recording Site**: Medial ankle: **G1** above and posterior to the medial malleolus; **G2** 3-4 cm proximal to G1.
    - **Stimulation Site**: Fifth toe.
    - **Normal Values**:
        - Amplitude: **8-20 µV**.

        - Peak Latency: **<3.65 ms**.
    - **Tips**: This is an orthodromic study.
- **Tibial Motor Study (Abductor Hallucis Brevis - AHB)**
    - **Recording Site**: **G1** over the muscle belly of the AHB (medial foot, at the midpoint between the heel and the ball of the foot); **G2** over the metatarsal-phalangeal joint of the great toe.
    - **Stimulation Sites**:
        - **Ankle**: Slightly proximal and posterior to the medial malleolus.
        - **Popliteal Fossa**: Lateral to the medial hamstring tendons, 10-12 cm from the ankle site.
    - **Distal Distance**: 9 cm.
    - **Normal Values**:
        - Amplitude: **≥4.0 mV** (or >4.4 mV).
        - Conduction Velocity: **≥41 m/s** (or >39 m/s).
        - Distal Latency: **≤5.8 ms** (or <6.1 ms).
        - F-wave Latency: **≤56 ms** (or <61.4 ms).
    - **Tips**: The AHB is often difficult to activate and can be painful to sample. The CMAP often has an initial positive deflection. Useful for evaluating tarsal tunnel syndrome.
- **Femoral Motor Study (Rectus Femoris)**
    - **Recording Site**: **G1** over the muscle belly of the rectus femoris (mid-anterior thigh); **G2** distally over the patella.
    - **Stimulation Site**: Groin (1-2 fingerbreadths inferior to the inguinal ligament, 1-2 fingerbreadths lateral to the femoral artery).
    - **Normal Values**:
        - Amplitude: **≥3.0 mV** (range 0.2-11 mV).
        - Distal Latency: **≤7.0 ms** (or <7.4 ms).
    - **Tips**: Comparison of CMAP amplitudes to the contralateral side helps assess axonal loss.

Craniobulbar Nerves

- **Facial Motor Study (Nasalis, Orbicularis Oculi)**
    - **Recording Site**:

        - **Nasalis**: Standard disk electrode placed on the skin over the nasalis muscle. Reference electrode over the contralateral nasalis muscle.
        - **Orbicularis Oculi**: **G1** below the eye socket over the orbicularis oculi muscle; **G2** over the inactive lateral canthus of the eyes.
    - **Stimulation Site**: Over the angle of the jaw or anterior to the tragus (in front of the ear).
    - **Normal Values**:
        - **Nasalis**: Amplitude **≥1.0 mV**, Distal Latency **≤4.2 ms**.
        - **Orbicularis Oculi**: Amplitude **≥1.0 mV**, Distal Latency **≤3.1 ms**.
    - **Tips**: Always perform bilateral studies for comparison. Motor unit action potential (MUAP) duration is normally briefer in craniobulbar muscles compared to limb muscles. Needle should be inserted tangentially for thin facial muscles like Orbicularis Oculi.
- **Blink Reflex (Trigeminal and Facial Nerves)**

    - **Recording Site**: Bilateral orbicularis oculi muscles: **G1** below the eye socket over the orbicularis oculi muscle; **G2** over the inactive lateral canthus of the eyes.
    - **Stimulation Site**: Supraorbital nerve over the mid eyebrow, at the supraorbital notch.
    - **Normal Values**:
        - **R1 (ipsilateral)**: Latency **≤13 ms**, side-to-side difference **≤1.2 ms**.
        - **R2 (ipsilateral)**: Latency **≤41 ms**, side-to-side difference **≤5 ms**.
        - **R2 (contralateral)**: Latency **≤44 ms**, side-to-side difference **≤7 ms**.
    - **Tips**: Use two channels with four electrodes to record both ipsilateral and contralateral sides. Low current is typically required for supramaximal stimulation.

Late Responses

- **F-Wave**

    - **Mechanism**: The F-wave is a late motor response resulting from antidromic travel of an action potential up the nerve to the anterior horn cell in the spinal cord, followed by backfiring of some anterior horn cells and orthodromic travel back down the nerve to the muscle.
    - **Stimulation**: Any routine motor nerve can be used. Supramaximal stimulation is required, with the cathode pointing proximally. Obtain at least 10 F responses as each varies slightly in latency, configuration, and amplitude.

    - **Normal Values (Minimal F-Latency)**:
        - **Upper Extremity**: Median **≤31 ms**, Ulnar **≤32 ms**.
        - **Lower Extremity**: Peroneal **≤56 ms**, Tibial **≤56 ms**.
    - **Tips**: F-wave persistence (number of F waves per stimulations) is normally 80%-100% and always above 50% (except for peroneal responses). F-wave chronodispersion (difference between minimal and maximal latency) is normally up to 4 ms in the upper extremities. If F-waves are difficult to elicit, the Jendrassik maneuver (e.g., patient clenching teeth or making a fist with the contralateral hand) can help "prime" the anterior horn cells.
- **H-Reflex**

    - **Mechanism**: The H-reflex is a monosynaptic reflex (involves a single synapse in the spinal cord), reflecting conduction along sensory afferent fibers to the spinal cord and motor efferent fibers back to the muscle.
    - **Stimulation**: Typically elicited in the soleus muscle by stimulating the tibial nerve in the popliteal fossa with a submaximal, long-duration pulse (1 ms).
    - **Normal Values (Minimal H-Latency)**: Tibial (Soleus) **≤34 ms**. Normal H-reflex latencies are based on patient height.
    - **Tips**: As stimulation intensity increases, the H-reflex amplitude initially increases and then decreases, while the direct motor (M) potential increases. Side-to-side latency difference greater than 1.5 ms is considered abnormal.

Electrophysiological studies, such as nerve conduction studies (NCSs), use electrical stimulation to assess nerve function. The intensity of this stimulation and specific techniques for assessing nerves across the carpal tunnel are critical for obtaining accurate diagnostic information.

Stimulation Intensity for Each Nerve

The fundamental principle for all nerve conduction studies is to use **supramaximal stimulation**. This means increasing the current intensity until the amplitude of the recorded potential (Compound Muscle Action Potential (CMAP) for motor nerves or Sensory Nerve Action Potential (SNAP) for sensory nerves) reaches a plateau, and then increasing it by an additional 20%-25% to ensure all nerve fibers are depolarized. This is crucial because without supramaximal stimulation, the true conduction velocity and amplitude cannot be accurately determined.

Here's a breakdown of typical stimulation intensities:

- **General Motor Studies:** Most normal motor nerves usually require a current in the range of **20–50 mA** to achieve supramaximal stimulation.
- **General Sensory Studies:** Most normal sensory nerves typically require less current, in the range of **5–30 mA**, as sensory fibers generally have a lower threshold to stimulation than motor fibers.
- **Specific Nerves:**
    - **Ulnar Nerve (below elbow):** Higher current intensity is usually needed to achieve supramaximal stimulation at the below-elbow site compared to the wrist and above-elbow sites because the nerve lies deep to the flexor carpi ulnaris muscle at this location. The current needed above the elbow is typically about half of that needed at the below-elbow site.
    - **Tibial Nerve (popliteal fossa):** High stimulation intensities are often required at the popliteal fossa to ensure supramaximal stimulation because the nerve can be deep.
    - **Femoral Motor Study:** High currents are typically needed, especially in obese individuals (e.g., >50 mA).
    - **Dorsal Ulnar Cutaneous Sensory:** Supramaximal stimulation can usually be achieved with low intensities, such as **5–15 mA**, as this nerve is quite superficial.
    - **Medial Antebrachial Cutaneous Sensory:** Similar to the dorsal ulnar cutaneous, low intensities (e.g., **5–15 mA**) are often sufficient due to the nerve's superficial location.
    - **Lateral Antebrachial Cutaneous Sensory:** This superficial nerve also typically requires low stimulation intensities (e.g., **5–15 mA**) for supramaximal stimulation.
    - **Superficial Peroneal, Sural, and Saphenous Sensory:** Supramaximal stimulation can usually be achieved with low intensities, typically **5–25 mA**.
    - **Lateral Femoral Cutaneous Sensory:** This study can be difficult to perform in obese individuals and may require high currents.
    - **Blink Reflex (Supraorbital Nerve):** Supramaximal stimulation can be achieved with low currents, typically **10–15 mA**.
- **Optimizing Stimulation:** Placing the stimulator optimally directly over the nerve significantly reduces the current needed to achieve supramaximal stimulation, which also minimizes patient discomfort and technical errors like co-stimulation of adjacent nerves. Currents exceeding **50 mA** with a 0.2 ms pulse duration can often lead to co-stimulation of adjacent nerves, so careful attention to muscle twitch and waveform morphology is advised.

Transcarpal Nerve Conduction Studies

"Transcarpal" studies typically refer to specialized nerve conduction techniques used to evaluate the median nerve as it passes through the carpal tunnel at the wrist, primarily for diagnosing Carpal Tunnel Syndrome (CTS). These studies are often more sensitive than routine median nerve studies, especially in mild or equivocal cases.

Here are the key methods for transcarpal assessment:

1. **Median Sensory Palmar Study (Segmental Sensory Conduction Studies Across the Wrist):**
    - This technique is highly sensitive and compares the sensory conduction velocity of the median nerve over two segments: the **wrist-to-palm** segment and the **palm-to-digit** segment (usually digit 3).
    - **Procedure:** Ring electrodes are placed on the middle finger (G1 over the proximal interphalangeal joint, G2 3–4 cm distally). The median nerve is then stimulated at the wrist (e.g., 14 cm from G1) and in the palm (e.g., 7 cm distal to the wrist site).
    - **Interpretation:** In normal subjects, the wrist-to-palm segment typically conducts at the same velocity or faster than the palm-to-digit segment. In CTS, this pattern reverses, with the wrist-to-palm segment conducting more slowly. A **slowing of more than 10 m/s** between the wrist-to-palm and palm-to-digit segments is considered abnormal. Electronic averaging may be needed for clear onset latency measurement, and anode rotation might be required to reduce stimulus artifact during palm stimulation.
2. **Comparison of CMAP or SNAP Amplitudes with Wrist and Palm Stimulation:**
    - This method is technically easier than inching and provides insights into the underlying pathophysiology, such as conduction block versus axonal loss.
    - **Motor Study:** The median nerve is stimulated at the wrist and in the palm, with recording over the abductor pollicis brevis (APB) muscle. A **palm/wrist CMAP amplitude ratio greater than 1.2** is indicative of conduction block across the wrist. If wrist stimulation results in a low CMAP, a significantly higher amplitude when stimulating the palm (e.g., 200% increase) indicates conduction block, while no change suggests axonal loss.
    - **Sensory Study:** The median nerve is stimulated at the wrist and palm, with recording over digit 2. A **palm/wrist SNAP amplitude ratio greater than 1.6** suggests conduction block across the wrist.
    - **Technical Considerations:** Ensure both stimulations are supramaximal, prevent co-stimulation of adjacent nerves, and ensure a clear baseline for accurate amplitude measurement. Special attention is needed when stimulating the recurrent thenar motor branch in the palm, often requiring the stimulator's anode to be rotated distally to prevent excessive stimulus artifact.

3. **Inching Across the Wrist:**

    - This technique involves stimulating the median nerve at **1-cm increments** across the carpal tunnel.
    - **Procedure:** Stimulation points are marked, typically from 4 cm proximal to the distal wrist crease to 6 cm distal, with recordings from the APB or a median digital SNAP (e.g., digit 3).
    - **Interpretation:** An **abrupt change in latency (e.g., ≥0.5 ms)** or a significant drop in amplitude between successive 1-cm stimulation sites is highly suggestive of focal demyelination. This method can precisely localize the lesion.
    - **Technical Challenges:** This is a very sensitive but technically demanding procedure, as slight errors in measurement are magnified over short distances.

Common Yehuleshet Cases and information

1. Idiopathic Intracranial Hypertension (PseudoTumor Cerebri)
2. Neuropathy: Axonal vs Demyelinating lesions
3. Myelopathy vs Plexopathy vs Radiculopathy
4. Compressive neruopathies:
    a. Carpal Tunnel Syndrome
    b. Tarsal Tunnel Syndrome
    c. Ulnar???
5. Cervical Pain
6. Lower Back Pain
7. Bell's Palsy
8. Neurocognitive Disorders (Dementia)
9. Parkinson's Disease
10. Headache and Migraine
11. Stroke
12. Epilepsy
13. Emergency Cases
    a. Seizure in Adults and Pediatrics
    b. PNES Identification
    c.