EEG Basics

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Introduction to EEG

Terminology

We use the 10-20 international system for placing electrodes. There are 4 points used -

- Nasion
- Inion
- 2 pre-auricular points

Measurements are made from/between -

- Nasion to inion
- 2 pre-auricular points
- Circumference of head
- Parasagital points
- Transverse points

Electrode naming -

- Odd electrodes are placed on the left, even on the right
- F - frontal; C - central; P - parietal
- Lower numbers are closer to the midline
- Midline electrodes are labelled z (for zero)

How EEGs are recorded

We use a differential amplifier where 2 inputs are taken and the resulting output is a difference of the two.

EEG Display

There are 2 different types of displaying EEG recordings -

1. Bipolar montage - We record the difference of recordings between 2 electrodes (known as a channel/derivation.) A string of channels is called a chain. It's a versatile montage however, it's not good at recording focal/diffused discharges.
2. Common Average Reference Montage - We record the difference of recordings of a single electrode and the average of the rest (except the electrodes near the eye because it would disrupt the

accuracy of our findings.) It's very versatile.

Common EEG Patterns

- Eye blinks - The retina is negatively charge whereas the cornea is positive. This creates a large polarity difference. When the eye blinks, Bell's phenomenon occurs where the eyeball moves upwards. This creates a lot of deflection in the EEG recording.
- Alpha rhythm - It's a normal rhythm that occurs when the eyes are closed during wakefulness. The range of frequency is 10 Hz or so.
- Focal epileptiform discharge - This occurs when the brain is capable of producing seizures. It's diagnostically very useful.
- Generalized epileptiform discharge - This is shown in the whole head.

Diagnostic Yield of EEG

Detecting epileptiform discharges -

- within 24 hours - 50%
- after 24 hours - 20-55%
- 24 hour EEG - 80-90%
- 4/more routine EEGs - 80-90%
  Epileptiform discharges aren't picked up sometimes. This could happen if -
- The region of abnormality is smaller than 10-20 cm^2 of area.
- The abnormality is located in a deeper section of the brain.

Polarity Rules

- Upward deflection in channel - Input 1 is negative w.r.t to Input 2.
- Downward deflection in channel - Input 1 is positive w.r.t to Input 2.
- If 2 inputs show negative deflection in 2 different recordings, it's known as phase reversal. This is a region of maximal negativity.
- If 2 inputs show no deflection, they're isoelectric.

Eye Movements on EEG

Eye Blinks

Seen previously.

Horizontal eye movements

If we consider the eye moving to the left -

- Electrode near the cornea will be positively charged.
- Electrode near the retina will be negatively charged.

- The rest will be neutral.
- Then we check for deflections between two nearby electrodes.
- Before deflection, we see a small negative deflection called a lateral rectus spike caused by the movement of the lateral rectus muscle in the eye. Sometimes it's mistaken for an epileptiform discharge.

EEG Montages

We need to read EEGs with multiple montages, not just one, and compare to get accurate findings.

Bipolar Montage

Seen previously.

Common Reference Montage

In this, we compare all the electrodes to a single reference electrode. It's useful for detecting broad abnormalities, but not focal discharges. There are a few common types -

- Cz Reference Montage (w.r.t Cz electrode)
- Ipsilateral Mastoid Reference Montage (w.r.t Ipsilateral Mastoid electrode)
- Contralateral Mastoid Reference Montage (w.r.t Contralateral Mastoid electrode)

Common Average Reference Montage

Seen previously.

Reference Contamination

If there are more negative electrodes, then one electrode will appear to be positive even if it's not. This phenomenon is called reference contamination and it's seen in Common Average Reference Montages.

Laplacian Montage

In this, we compare one electrode with the average of its nearest neighbours thus reducing the chances of Reference Contamination. It's very good at detecting focal discharges but not broad abnormalities. We can't use this montage with broad electric fields.

K-complex

For broad electric fields, we should choose a reference electrode far from that area. Then, a sharp K-complex will be observed.

Technical Issues in EEG

Delta waveforms

Range of frequency < 4 Hz.

Alpha waveforms

Range of frequency: 4-7 Hz.

Beta waveforms

Range of frequency: 8-13 Hz.

Gamma waveforms

Range of frequency > 30 Hz.

Low frequency filter

While plotting a graph of activity seen (amplitude of output) vs frequency input, if we see at high frequencies, more activity is seen then it is called a low frequency filter/high pass filter (as high frequencies are allowed to pass.)

High frequency filter

While plotting a graph of activity seen (amplitude of output) vs frequency input, if we see at low frequencies, more activity is seen then it is called a high frequency filter/low pass filter (as low frequencies are allowed to pass.)

60 Hz notch filter

Electronic devices can mess with EEG recordings. If the electrode is poorly attached to the head, their influence can add a 60 Hz frequency. The 60 Hz notch filter helps remove the frequencies near 60 Hz.

Sensitivity

- Sensitivity is a way of representing true amplitudes on the computer screen.
- Decreasing sensitivity results in a larger waveform.
- Increasing sensitivity results in a smaller waveform.
- However, absolute amplitude always remains the same.
- Default sensitivity is 7 microvolts/mm.
  Timebase should also be checked for accurate findings.

Normal Awake EEG

We look at artifact-free epochs.

Technical Aspects of EEG

We set the -

- Low frequency filter at 1 Hz.
- High frequency filter at 70 Hz.

- Notch filter off.
- Sensitivity at 7 microvolts/mm.
- Timebase such that 10 seconds exist in a single epoch.

Montage

We use the anterior-posterior bipolar montage.
Features noticed -

- Myogenic artifact (due to facial muscle movement)
- Alpha rhythm in first and last sections (eyes closed), at higher voltage
- Blink artifact (due to Bell's phenomenon), at lower voltage

Characterisitics of an alpha rhythm

- Reactivity: It's the tendency of a rhythm to augment with closed eyes and attenuate with open ones.
- Frequency should be around 8.5-12 Hz. We find it by checking an artifact-free region in 1 s.
- Normal amplitude is around 20-50 microvolts (by using a reference scale.) Referential montage is better than bipolar for calculation of amplitude.
- Left and right amplitudes should be symmetrical. Normal asymmetric is <50% difference between both and usually right is found to be higher than left.
- Distribution is such that alpha rhythm is maximal in occipital region. That's why alpha rhythm is also called posterior dominant rhythm.
- Its frequency is fairly constant throughout the lifetime. It gets a bit slower in old age and when you're sleepy.
- Frequency increases during the childhood and reaches the peak in brink of adulthood/adoloscence.

Common normal variants

- Alpha squeak - In the transition from eyes open to eyes closed, a high frequency is observed that's twice as fast called the alpha squeak.
- Lambda waves - They're diphasic waves that resemble the shape of lambda, hence the name. Their distribution is maximum in the occipital region. They are observed when complex visual patterns are being seen. They're blocked by closed eyes.
- Mu rhythm - They appear in the parasagital region and are arch-shaped (like mu, hence the name.) They have frequencies around 8-12 Hz. They're prominent when limbs are at rest and are blocked by movement/thought of movement of contralateral limbs. They're visible during open eyes (alpha rhythm blocks it.)