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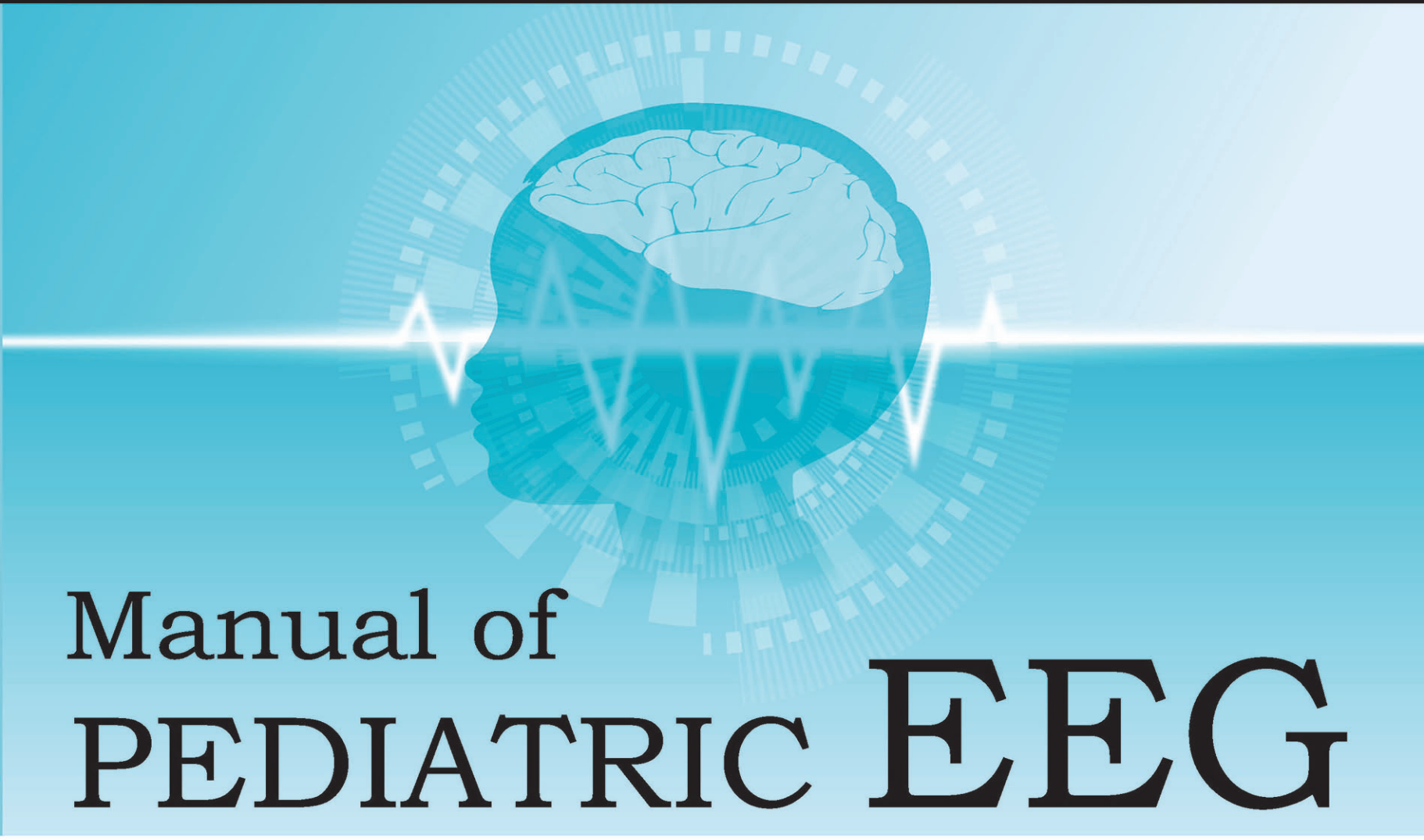

Manual of PEDIATRIC EEG

Praveen Kumar

JAYPEE

Contents

1. **Introduction** 1
2. **Technique** 4
3. **Normal Waveforms** 18
4. **Abnormal Waveforms** 28
5. **Artifacts** 44
6. **Electroencephalography in Focal Epilepsy and Generalized Epilepsy** 50
7. **Electroencephalography in Different Epileptic Syndromes** 57
8. **Benign Electroencephalography Variants** 67
9. **Electroencephalography in Electrographic Seizures** 72
10. **Electroencephalography in Coma and Brain Death** 78
11. **Electroencephalography in Neonates** 86
12. **Sample Electroencephalography for Revision and Practice** 95

Guide to Interpret EEG *101*

Suggested Reading *102*

CHAPTER

2 Technique

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Electroencephalography (EEG) measures voltage difference between neighboring electrodes over scalp. The excitatory and inhibitory postsynaptic potentials generated by pyramidal cells in cerebral cortex and modified by subcortical structures contribute to voltage over scalp. Synchronized discharges from at least 10 cm^2 of cortex is needed to create voltage which can be detected by scalp EEG. A basic knowledge about EEG machine, various techniques of placing electrodes, mechanism of electrical wave generation is essential to understand EEG. Common terminologies to characterize EEG waves, e.g., sensitivity, frequency should be understood. In this chapter we will learn in brief about same.

For the recording of EEG, we need:

- *Electrodes*—to pick up the brain electrical wave activity and their attached wire to connect with the EEG machines
- *Amplifiers*—to amplify these microvolts amplitude waves
- *Filters*—to filter out unwanted (noncerebral, artifacts) waves
- *Writing units*—to record these waves on paper

Electrodes usually consist of a flat disk or cup (often gold or silver) connected to a silver wire. In modern digital EEG machine amplifiers, filters and writing unit are within the computerized system.

In simplest term each amplifier is connected with two neighboring electrode as input 1 and input 2. When input 1 is negative as compared to input 2 there is upward deflection (negative) of pen while if input 1 is relatively positive to input 2 there is downward deflection (positive).

POSITION OF ELECTRODES

Head size is measured and electrodes are placed as per 10-20 system of electrode placement. 10-20 International System of Electrode Placement, where each electrode is 10-20% away from a neighboring electrode, is mostly used. The numbers 10 and 20 simply mean that distance between neighboring electrodes is either 10% or 20% of the total anteroposterior or right–left distance of the skull. It allows standardized electrode placement as it is internationally recognized.

If a child has head bandages and head wounds, standard electrode placement may not be possible. If a change in electrode placement in one hemisphere is required, the same change in corresponding electrode placement on the opposite hemisphere should be done to maintain same interelectrode distance between homologous electrode location and also to maintain anatomical location.

By convention electrodes placed on the left side of cerebral hemisphere are given odd numbers (e.g., Fp1 and T3) while right-sided electrodes have even numbers (e.g., Fp2 and T4). The name includes the first letter of the general area of skull where electrode is placed and reveals lobe of the brain being recorded.

- Fp1,2—prefrontal
- F3,4—frontal, C3,4—central, P3,4—parietal, O1,2—occipital
- F7,8—anterior temporal (records activity from anterior temporal region but placed on frontal bone)
- T3,4—midtemporal, T5,6—posterior temporal, A1,2—ear
- Fz—front vertex
- Cz—central vertex
- Pz—parietal vertex (z = zero)

MEASUREMENT FOR INTERNATIONAL 10-20 SYSTEM OF ELECTRODE PLACEMENT

Four skull landmarks are used in the 10-20 system.

The nasion—a point just above nasal bridge, inion—prominent part of occiput and right and left preauricular points, indentations just above tragus **(Figs. 1 and 2)**.

NEONATAL ELECTRODE PLACEMENT

- In neonates, less number of electrodes are used due to small head size. Frontal and parietal channels are usually omitted. EEG head caps based on 10-20 system are also available and routinely used in neonatal intensive care unit (ICU) **(Figs. 3A and B)**.

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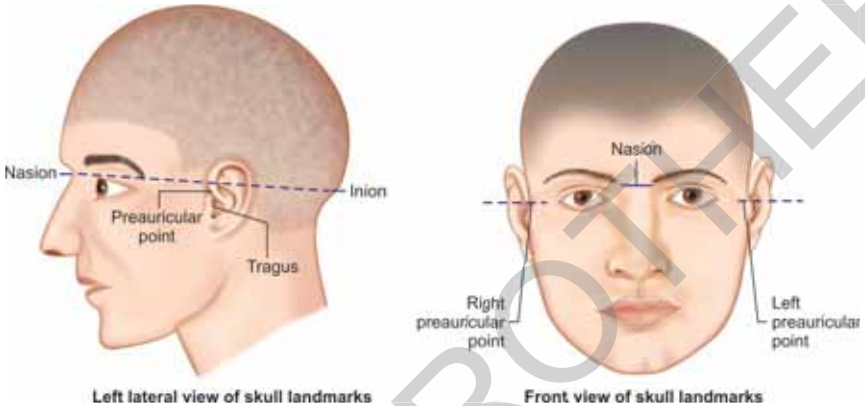

Fig. 1: Nasion—a point just above nasal bridge, inion—prominent part of occiput and right and left preauricular points.

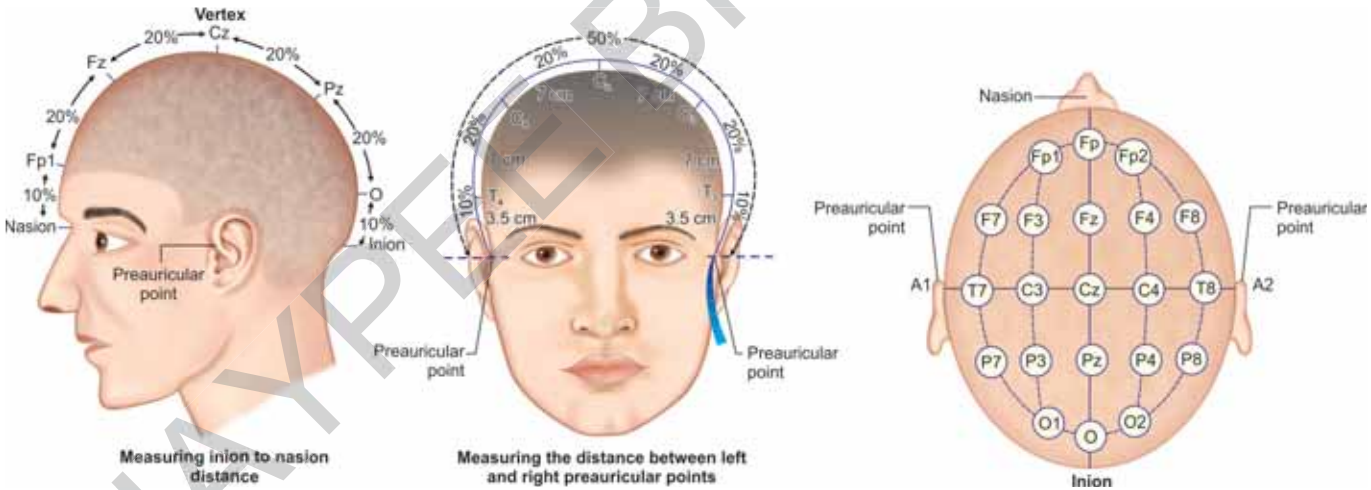

Fig. 2: International 10-20 system of electrode placement.

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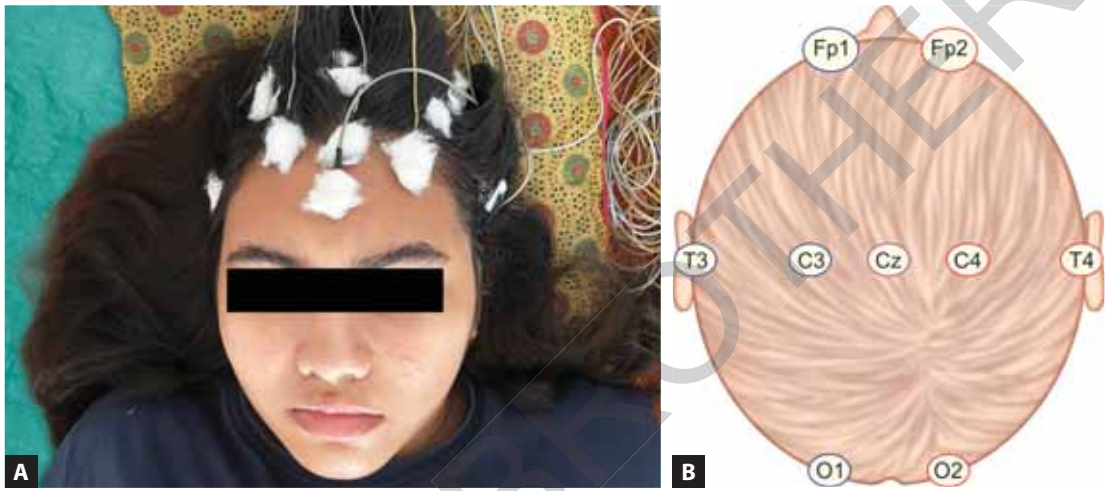

Figs. 3A and B: Pediatric and neonatal electrode placement.

- Extension of 10-20 system, as 10-10 system and 10-5 system can be done for more localized waveforms. It requires additional electrodes.
- There are excellent videos on the internet displaying 10-20 measurement steps. Readers are requested to view them.

Montages

The EEG records brain electrical potential by recording the difference between the activity picked up by two electrodes. Montage refers to the different ways to connect electrodes.

Commonly two types of montages are used:

1. Referential (monopolar) **(Fig. 4)**
2. *Bipolar* **(Fig. 5)**:
   Referential montage: It involves recording the difference between an active electrode on the scalp and an inactive electrode placed over ear or nose or chin (called reference electrodes).

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Bipolar montage: It involves recording the difference between two active scalp electrodes. Each channel of the EEG machine is connected to two different electrodes and the difference in activity picked up by each of these two electrodes is recorded on that one channel.

Montages aids in localization of abnormal discharges. In reference montage site of maximum involvement is where greatest voltage is found means with greatest amplitude, provided reference is inactive like ear.

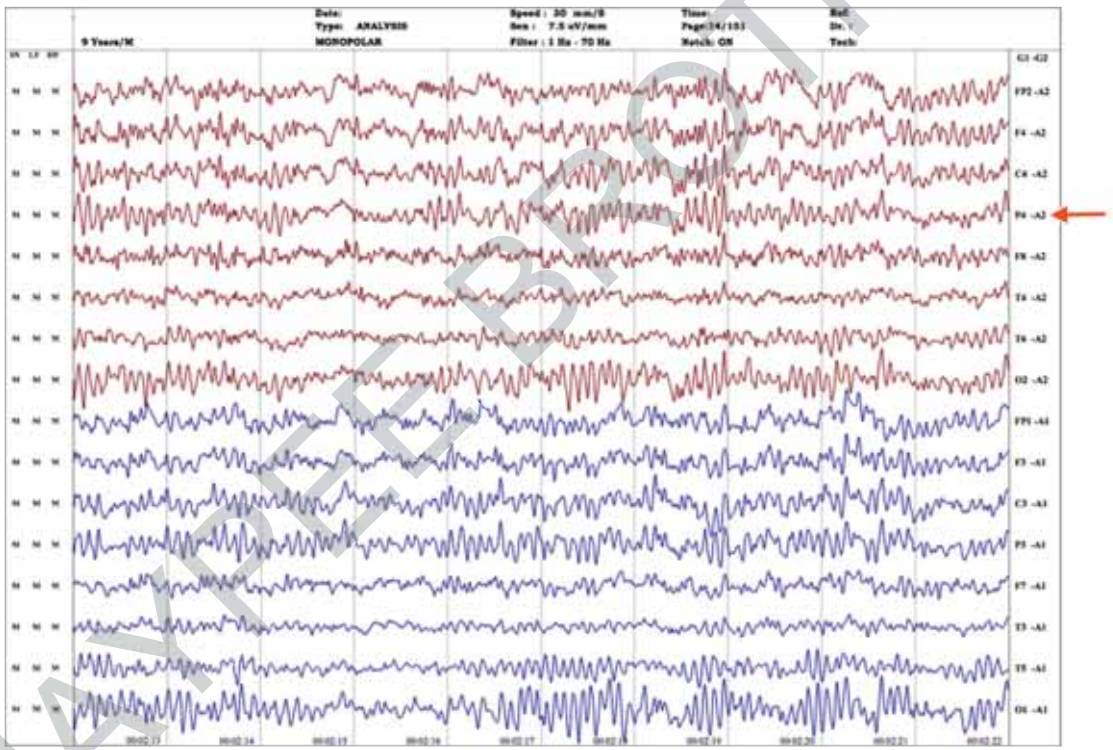

Fig. 4: Monopolar montage.

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While in bipolar montage phase reversal is point of localization. Phase reversal means opposite simultaneous deflection of pens in channels with common electrode.

While localization site of maximum discharge it is important to look at bipolar montage also and not to only at highest amplitude in referential montage. Now with digital EEG machines we have the advantage of reviewing each part of graph in different montage even if technologist has recorded graph in one montage say bipolar. It enhances the accuracy of EEG interpretation.

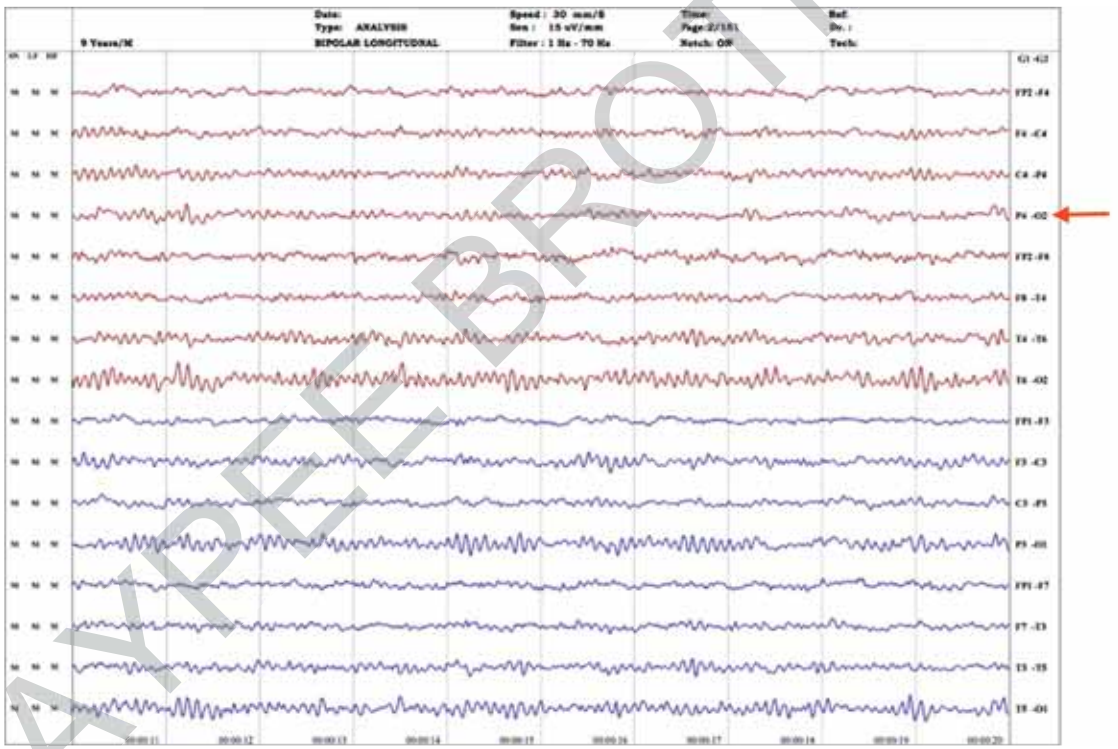

Fig. 5: Bipolar montage.

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Montages should be arranged in an orderly sequence. Like for referential montage, anteriorly placed electrodes are placed on the first channel and the posteriorly placed electrodes on the later channel. Bipolar montages have electrodes in chains usually from front to back (anteroposterior, Fp1-O1, Fp2-O2, double banana) or side to side (transverse), from one electrode to its neighbor and then onto the next one, etc.

Paper Speed

- It is also called as time scale. The paper speed generally adopted for EEG recording is 30 mm/s **(Fig. 6)**. With this paper speed usually there are 10 seconds per page of EEG (time scale). However, this can be compressed (many seconds per page) or expanded (less number of seconds per page) for better visualization of EEG changes as mentioned below.
- Slow paper speed of 15 mm/s (compressed time scale—many seconds on one page) is used for **(Fig. 7)**:
  - Monitoring repetitive activity (periodic discharges in subacute sclerosing panencephalitis—SSPE)
  - Periods of attenuation/rhythmicity
  - Premature infants—slow paper speed of 15 mm/s compresses the record and facilitates visual recognition of dominant delta frequency of neonates
- *Faster paper speed of 60 mm/s (expanded time scale-less seconds on one page) for*:
  - Study of asymmetrical onset of seemingly synchronous activity

Changing paper speed does not change the waveforms it only enhances the visual image on the page.

FILTER

A circuit which permits only the necessary signal to pass by varying the frequency response of an electric current is called filter. It is a review setting in modern EEG machine. It excludes very slow and very fast activity and select the spectrum of frequencies which has the greatest clinical significance. Filters should be used in such a way that they do not eliminate spike/sharp wave activity. It should not be used to clean up the artifacts and produce a pretty record. Usually, a low frequency is set at 1 Hz and high frequency filter at 70 Hz also known as LFF-low frequency filter and HFF-high frequency filter (so it does not allow waves below 1 Hz and above 70 Hz to pass through it). Most cortical activity of clinical importance falls in the frequency of 1–30 Hz. Muscle artifacts are of higher frequencies, so HFF may be set to 35 Hz to reduce artifacts. However, changing filters may also change appearance of existing cerebral waveforms, e.g., decreasing HFF to 35 Hz may make spikes look sharp and reducing LFF to 0.5 Hz may miss slower waves than 1 Hz.

Notch filter is used to reduce artifact due to environmental AC current. It is kept at 60 Hz in Indian settings. Before starting to read EEG you must look at filter setting usually mentioned on top of recording.

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SENSITIVITY

This is also termed as gain and amplification and is measured in microvolt/mm. It is a kind of review setting in EEG to better visualize the waveforms in vertical display. Generally, sensitivity in pediatric EEG is kept at 10 μV/mm **(Fig. 8)** [or 7.5 μV/mm **(Fig. 9)** in neonates and adults]. Sensitivity of 10 μV/mm means 10 μV is needed to make pen move 1 mm while sensitivity of 2 μV/mm means only 2 μV of electrical energy will deflect pen to 1 mm. Higher numbers of sensitivity causes small amplitude waves. For example, if waveforms are of

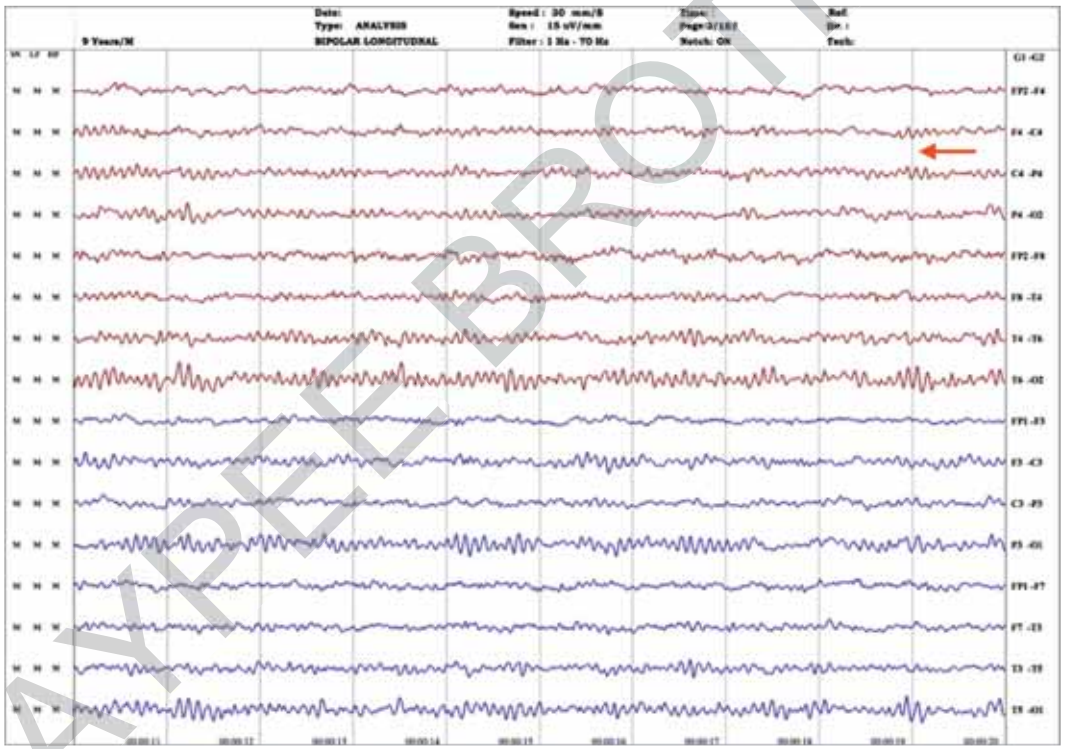

Fig. 6: EEG at paper speed of 30 mm/s (also note 10 seconds on 1 page—1 horizontal line is 1 second).

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high amplitude like in hypsarrhythmia sensitivity numerical value may need to be changed to higher 15 μV/mm or 20 μV/mm to decipher morphology of waves clearly. While in cases of brain death, a lower numeric value of sensitivity is kept 2 μV/mm to see the smallest detectable EEG activity. EEG at sensitivity of 20 μV/mm, and 2 μV/mm is shown in **Figures 10 and 11**. Higher numeric value of sensitivity means lower sensitivity and vice versa.

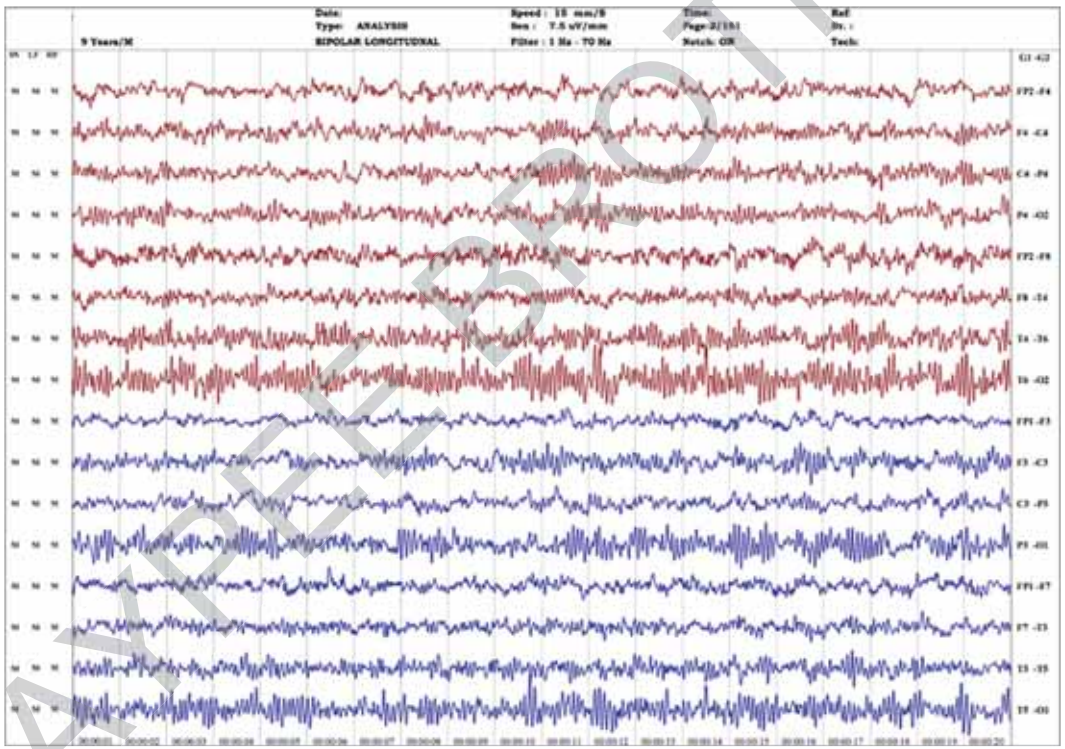

Fig. 7: EEG at paper speed of 15 mm/s (note compressed time scale 20 seconds on 1 page).

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Activation Procedures

Activation procedures are used to enhance epileptiform activity in recording. These are routinely used in day-to-day EEG recording. Child's cooperation is required especially for effective hyperventilation. Caution is required while performing EEG in lab as activation procedures can induce seizures.

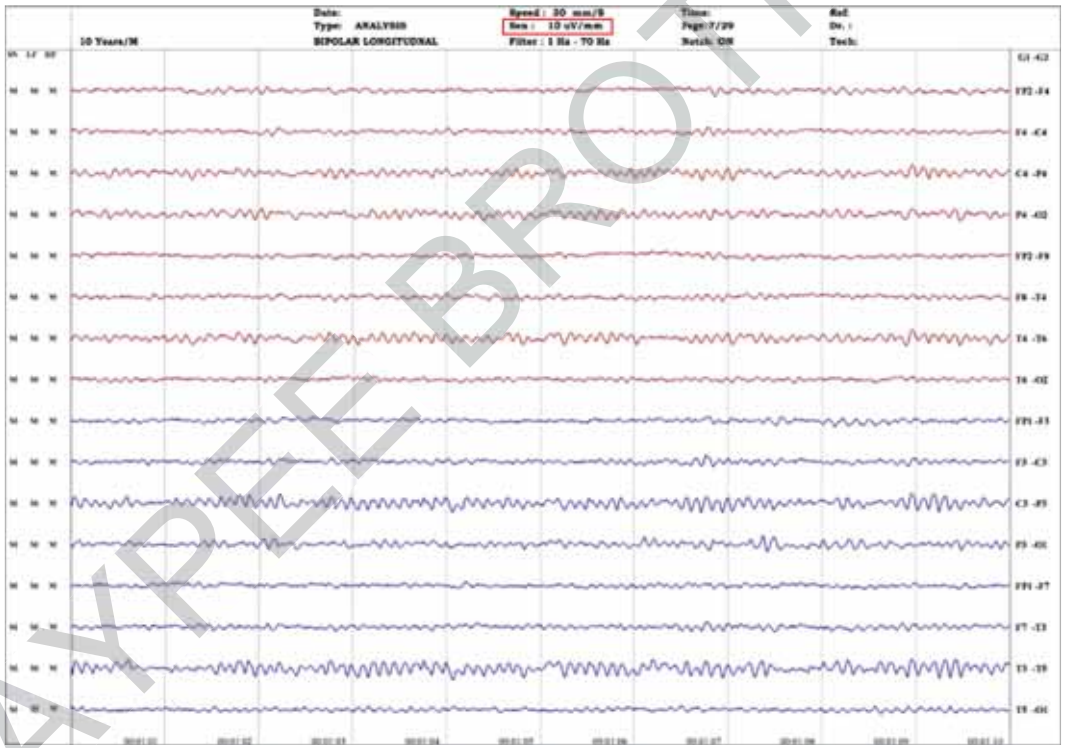

Fig. 8: Sensitivity of 10 μV/mm.

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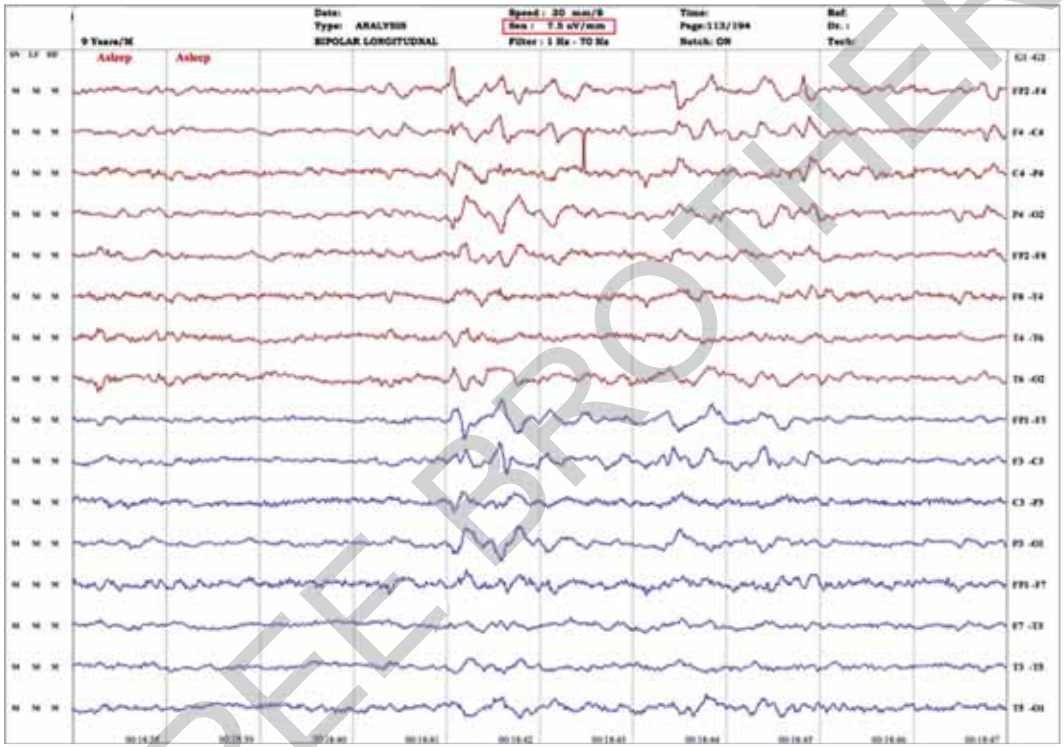

Fig. 9: Sensitivity of 7.5 μV/mm.

- *Hyperventilation*: Child is asked to blow slowly but effectively for 3 minutes at some paper or toy fan while EEG is being recorded. Sitting position is preferred. For 3–5 minutes causes respiratory alkalosis and cerebral vasospasm leading to generalized slowing. Asymmetrical slowing can be seen in intracranial space occupying lesion. It can provoke 3-Hz spike and wave discharges and clinically absence seizures during procedure. In cases of JME, hyperventilation test has been found to enhance the interictal

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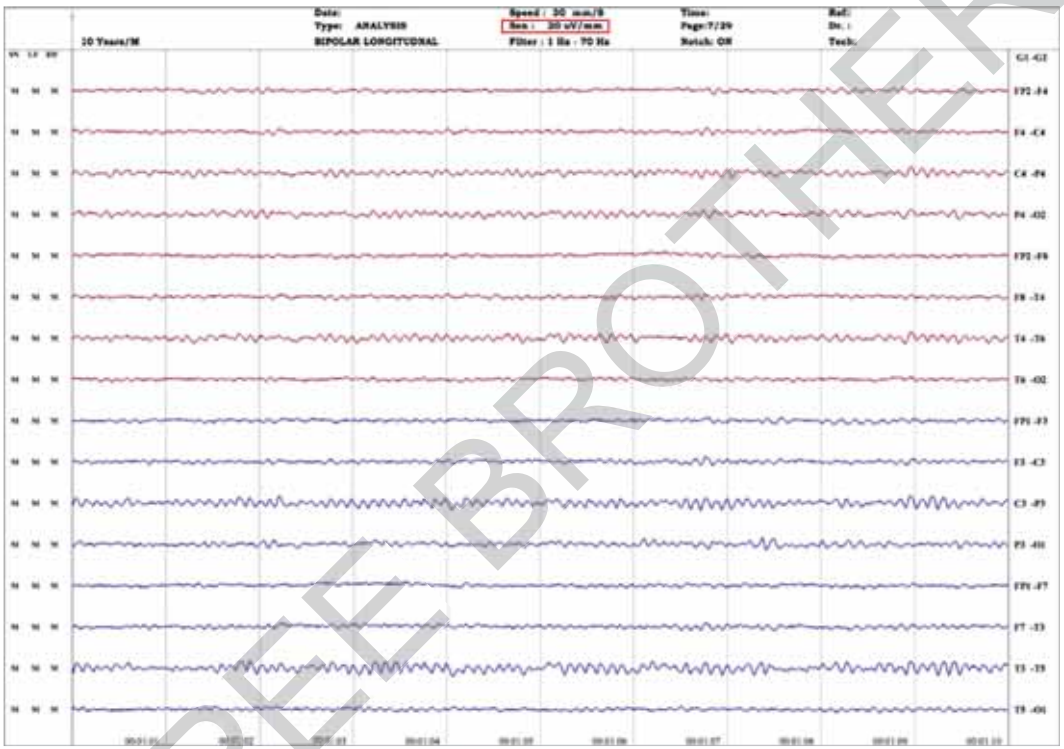

Fig. 10: Sensitivity of 20 μV/mm (waves are appearing smaller).

discharges. It should not be done in patients with significant cardiac and respiratory disease. It is also avoided in patients with Moyamoya disease with cerebral vascular stenosis. Refereeing physician and technician must inquire and mention about potential contraindications of hyperventilation test.

- *Photic stimulation* ***(Fig. 12)***: The photic stimulation (PS) is done with strobe units that flash for 5–10 seconds. It may or may not cause EEG changes especially over occipital leads. Photic driving is rhythmic frequency (of same hertz, twice or half the frequency Hz of PS)

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Manual of PEDIATRIC EEG

Seeing many EEG pages to interpret is frightening in the beginning. *Manual of Pediatric EEG* is a simplified and systematic approach to learn EEG. Chapter on technique is essential to start and then normal and abnormal waveforms, EEG in different epilepsy syndromes and in pediatric intensive care is useful in day-to-day clinical practice. Initiation on the neonatal EEG is done. Sample EEGs and relevant texts are discussed for better understanding. This book will make EEGs easy for you.

Praveen Kumar completed his MBBS from prestigious BJ Medical College, Pune, Maharashtra, India. Thereafter he did his Diploma in Child Health from MLN Medical College, Allahabad, standing first in course, followed by Diplomate of National Board from Tata Main Hospital, Jamshedpur. He trained further in pediatrics with residency from Dr RML Hospital, New Delhi with Best Resident Award. With keen interest in Neurology, he completed his Post-Doctoral Fellowship in Pediatric Neurology from renowned KK Women and Child's Hospital, Singapore. He currently works at the very illustrious Sir Ganga Ram Hospital, New Delhi. He delivers pediatric neurology scientific lectures and conducts workshops including EEG workshops regularly in different parts of the country. He has received Young Achievers' and Most Trusted Pediatric Neurologist awards.



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