

EEG: Anesthetic Drug Effects

Anesthetic Pearls: Effect of Anesthetic Drugs on the EEG

The EEG in standard recording fashion measures voltage as a function of time. Scalp surface potentials are measured using either a unipolar or a bipolar system. In the unipolar system, one electrode is on the surface of the scalp and another electrode placed elsewhere on the body to serve as a ground. In the bipolar system, the difference in electrical potential is measured between two points on the scalp. EEG waves are weak signals in comparison to those seen on the EKG. Generally, brain waves have a voltage in the range of 20-200 μV and can be divided into four categories.

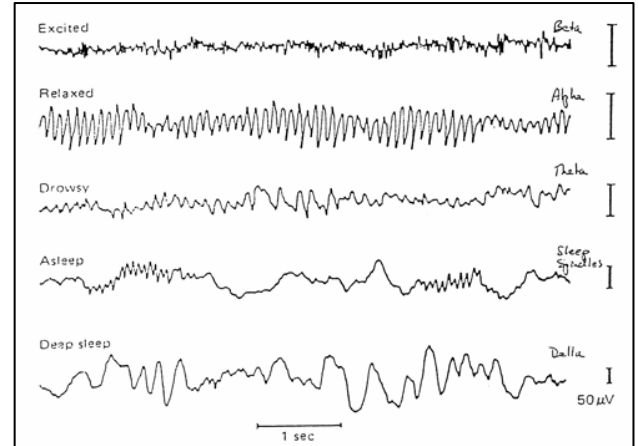
1. **Delta Waves** (< 4 Hz) – seen in infants & sleeping adults.
2. **Theta Waves** (4-7 Hz) –
3. **Alpha Waves** (8-13 Hz) – are in the same regions of the brain as theta waves, are augmented by relaxation, and reduced during visual or mental activity (synchronous & symmetrical).
4. **Beta Waves** (13-25 Hz) – are symmetrical & asynchronous.

Three aspects of the EEG are most important:

1. **Frequency** (change in frequency)
2. **Amplitude** (change of amplitude)
3. **Symmetry** (loss of symmetry)

General pattern of EEG during stages of general anesthesia:

- A. Induction of anesthesia: increase frequency from alpha to beta rhythm.
- B. Deepening of anesthesia: decrease frequency to theta and delta.
- C. Further deepening: near maximal depression of cerebral metabolism (burst suppression).
- D. Profound levels of anesthesia: isoelectric EEG.



Factors That Change the EEG:

1. **Increased Frequency**
Hyperoxia, hypercarbia, initially with hypoxia, seizure
Light anesthesia, ketamine, barbiturate
2. **Decreased Frequency & Increased Amplitude**
Mild hypoxia, mild to moderate hypocarbia, mild hypothermia
Benzodiazepines, etomidate, narcotics, deepen anesthesia (1.5 MAC)
3. **Decreased Frequency & Decreased Amplitude**
Severe hypoxia / hypercarbia / hypotension / hypoglycemia, moderate to profound hypothermia
High dose barbiturates, inhalational anesthesia >1.5 MAC
4. **Electrical Silence**
Brain death, severe hypoxia, profound hypothermia
High dose barbiturates/propofol, high dose inhalation anesthesia

Anesthetic Effects on the EEG:

1. Barbiturates & Propofol:
Initially fast wave pattern
As accumulated dose increases, spindle-shaped bursts superimposed on fast activity (coincides with loss of consciousness).
Greater dosage --> decline in spindle bursts to polymorphic wave
Even higher dosage --> burst suppression
2. Etomidate – initially increased activity in all frequencies with transient neuronal excitation.
3. Narcotics:
Low dose narcotics have little effect on the EEG.
High induction doses causes high amplitude / slow wave activity and can lead to isoelectric pattern.
4. Ketamine – high amplitude theta activity with secondary pattern of beta activity at surgical anesthesia.
5. Benzodiazepines – initial increase in amplitude with theta waves.
6. Inhalational agents & N_2O – as described above for barbiturates. (Enflurane may cause seizures)