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Electroencephalographic findings in normal and idiopathic epileptic dogs

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Abstract
Electroencephalography (EEG) is the non invasive tool to record the spontaneous electrical activity in the cerebral cortex of the brain. The main aim of study was to identify normal EEG patterns in healthy dogs and the interictal epileptiform discharges (ED) in dogs affected with idiopathic epilepsy (IE). Chemical restraint was achieved by intramuscular injection of xylazine in all dogs and recorded with bipolar montage. Normal dog showed alpha rhythm with frequency ranging between 8-13 Hz. The abnormal EEG changes were observed in six dogs with idiopathic epilepsy were spikes and spikes complexes in 4 dogs (66.67%), and sharp and slow waves in 2 dogs (33.33%). All the 6 dogs had generalized seizures and showed bilateral changes in electroencephalographic study with bipolar montage.

Keywords: Electroencephalography (EEG), idiopathic epilepsy (IE), epileptiform discharges, spikes and spike complexes, sharp and slow waves

Introduction
Epilepsy is the most common chronic neurological disease in dogs that adversely affects the quality of life of affected dogs. An epileptic seizure is "a transient occurrence of signs due to abnormal excessive or synchronous neuronal activity in the brain" which may manifests in different ways and caused by a number of underlying etiologies. Epilepsy is a disease of the brain distinguished by an enduring susceptibility to generate epileptic seizures [6]. Electroencephalography (EEG) is a useful and non-invasive examination method for diagnosis of functional central nervous system (CNS) disturbances. German psychiatrist, Hans Berger performed the first single channel EEG recording in human medicine in 1929 [2]. In early sixties the pioneers like Croft, Redding and Holliday used electroencephalography as a tool for diagnosis of neurological diseases in veterinary medicine [5, 8, 16]. Though epilepsy is the common neurological problem in veterinary medicine, EEG not used as a routine examination in assessment of epileptic patients. EEG is the most specific tool to determine the epileptogenic cortex, it has 80-90 per cent sensitivity and specificity of 0.2-3.5 per cent with false positive rates, however it depends on the various factors like age, recording mode, sleep, hyperventilation and light stimulation [18]. In veterinary medicine there is no standardized techniques of EEG recording about electrode placement, montages and anesthetic protocols. Regarding electrode placement most of veterinary neurophysiologists are following their own medication of human "international 10-20 system" of electrode placement. Epileptiform discharges (Paroxysmal discharges) are the abnormal EEG events during recording like spike, sharp wave, poly spikes and poly sharp waves [11].

Materials and Methods
Dogs: Dogs which were brought to the Department of Veterinary Clinical Complex with history of recurrent seizures. And only dogs with idiopathic epilepsy were selected for EEG study, which were diagnosed based on the criteria of age of onset of seizures between the 6 months to 6 years, normal interictal neurological examination without any other systemic signs, normal study of haematology, serum biochemistry, radiography and ultrasonography. In a total of 21 dogs with idiopathic epilepsy, electroencephalography was performed in six dogs and in six healthy dogs.

Electroencephalography recording technique

Instrumentation

EEG recordings obtained with the help of RMS Polyrite D computerized physiograph (Fig.1), by placing of active and ground stainless steel cup surface electrodes (Fig. 2) on scalp of dog and with five channel bipolar montage [3]. The parameters used for each EEG recordings were; sensitivity 7.5 µV, filter pass down of 70Hz, filter pass up 30Hz, sweep speed 30mm/sec, impedance<10 Ω [19].

Animal restraint

Dog was restrained by administering Xylazine (XYLAXIN, Indian Immunologicals Limited India) at the rate of 1mg/kg intra muscularly [14]. Xylazine was preferred over other sedatives/ anaesthetics as it is α2 adrenergic receptor that has no direct effect over pyramidal cortical neurons.

Terminology and position of recording electrodes

EEG recording was obtained by placing electrodes on the scalp with a conductive paste, after preparing the scalp area by shaving. The electrodes positioned and labeled according to the 10-20 international convention accepted in human medicine with letters and numbers (Fig. 3). The even numbers represents the right side of brain hemispheres, odd numbers represents the left side of brain hemisphere, and electrodes placed at the center letter "z" was added. The reference electrode was placed centrally on the rostral part of nasal bone [19].

Electrode terminology for recording canine electroencephalograms as follows

F3 and F4	Left and right frontal electrodes
O1 and O2	Left and right occipital electrode
Cz	Central vertex electrode
Ground electrode	Dorsum of nose

Recording

The standard recording was made by employing bipolar montages and minimum recording time was 30 minutes, dog placed on sternal recumbency (Fig. 4) [14]. With the help of integrated software program Fast Fourier Transform (FFT) in Polyrite D Physiograph calculated and averaged background activity (frequency; Hz) for each channel, with same attainment

Normal EEG Brain Rhythms

- **Alpha rhythm:** EEG activity with frequency between 8-13 Hz that is prominent in the occipital regions of normal, relaxed adults whose eyes are closed.
- **Beta rhythm:** EEG activity with frequency exceeding 13 Hz that is most commonly seen in the frontal and central regions, but may also be generalized.
- **Theta rhythm:** EEG activity with frequency between 4-7 Hz; this activity is abnormal in awake adults, but commonly observed in sleep.
- **Delta rhythm:** The delta rhythm exhibits a frequency below 4 Hz and amplitudes that exceed those of all other rhythms.
- **Mu rhythm:** The mu rhythm is EEG activity with frequency between 7-11Hz that is most prominently exhibited in the central region.
- **Lambda waves:** Transient sharp waves lasts for duration of approximately 0.25 seconds that occur in the occipital region whenever an adult scans a visual field with horizontal eye movement.
- **Sleep-spindles, K-complexes, and vertex Waves:** These are unique waveforms observed only during the different stages of sleep.

Abnormal EEG Brain Rhythms: (spikes, poly-spikes, sharp slow waves, wave spike complexes, bursts of slow waves and spikes)

- **Spike waves:** Spike waves are transients with pointed peaks exhibiting durations between 20-70 milliseconds; the main component is normally negative. Variation in the amplitude.
- **Sharp waves:** These are similar to spike waves, but exhibit longer durations typically between 70-200 milliseconds, actually main component is negative.
- **Spike and slow wave complexes:** Occurs at irregular, apparently random intervals or in bursts where they are rhythmical at a fixed time and pattern with a spike followed by slow wave.
- **Polyspikes and polysharp waves:** These waves are exhibited as combination of multiple spikes and sharp waves.
- **Periodic epileptiform discharges:** Periodic discharges refer to time-limited bursts that are repeated at a certain rate; bursts may exhibit a variety of durations, frequencies, amplitudes, morphologies, and localizations.
- **Bursts of rhythmically repeating paroxysmal discharge:** Consists of presumably generalized multiple spike and slow wave complexes or multiple spikes.
- **Rhythmic hyper synchrony:** Rhythmic hyper synchrony refers to rhythmic activity emerging from a quiescent background and exhibiting unusual frequency, amplitude, morphology and localization of any degree; rhythmic activity may either be continuous or intermittent.
- **Electro cerebral inactivity:** Electro cerebral inactivity refers to a variable length period not caused by instrumental or physiological artifacts that exhibits extreme attenuation of the EEG relative to a patient specific baseline.

Results and Discussion

In apparently healthy dogs, normal EEG pattern of alpha rhythm with frequency of 8-13 Hz were observed when the dog under sedation with xylazine (Fig. 5). Interictal EEG was performed in 6 dogs with idiopathic epileptic dogs to identify epileptiform discharges (EDs). Abnormal EEG patterns out of 6 idiopathic epileptic dogs included spike and spike complexes in 4 dogs (66.67%) (Fig. 6 and 7), 2 dogs (33.33%) had sharp and slow waves (Fig. 8). The EEG changes identified were bilateral spikes and polyspikes with 20-70 ms time and frequency of 4-5 Hz, sharp and slow waves (high voltage, duration of 80-200 ms). All of 6 dogs had generalized seizures and showed bilateral changes in EEG pattern with bipolar montage.

In this study six dogs with idiopathic epilepsy were submitted to EEG recordings in the interictal period. EEG was helpful in detect the abnormality based on the type of seizures, thus indicating that EEG is a valuable diagnostic tool to confirm the diagnosis of epilepsy in dogs (Berendt *et al.*,1999) [1]. Physiological artifacts (e.g. eye movements, blinking, masticatory muscle activity, heart beat and panting) and non physiological artifacts (e.g. instrumental, environmental and electrode related) often obscure and interfere with the recordings (Platt and Olby, 2014) [15]. The dogs were sedated

with xylazine for achieving a recording free of artifacts (Pelligrino and Sica, 2004) [14].

The spikes and spike complexes in 66.67% of the dogs and sharp and slow waves in 33.33% commensurate with Jeserevics *et al.* (2007), Pakozdy *et al.* (2012) and Stanciu *et al.* (2015a) [10, 13, 18] who have reported that the common epileptiform abnormalities were single spike, spike complexes (typical or atypical), sharp and slow waves whereas Croft (1970) [4] reported that spikes, spike complexes and slow waves were rarely observed abnormal EEG patterns. Contrary to our findings, Brauer *et al.* (2012) [3] also concluded that short time EEG recordings in epileptic dogs could detect interictal epileptic activity in less than one third of dogs with seizures and was not a useful screening method.

Fig 1: Physiogram unit for Electroencephalography recording

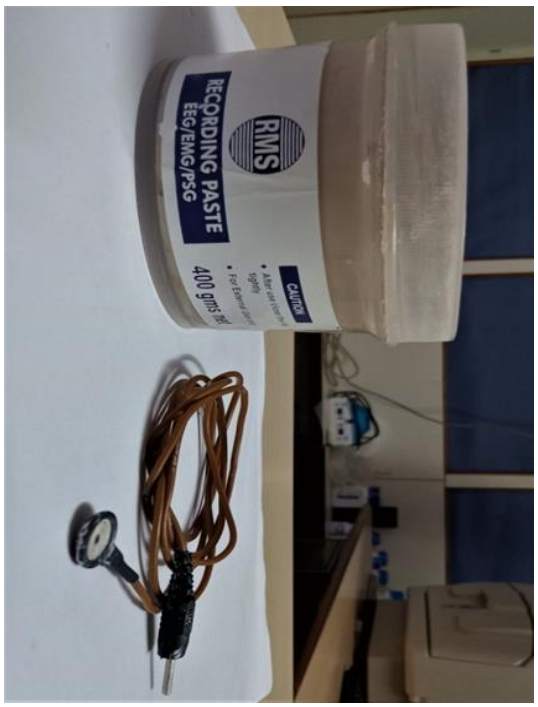

Fig 2: EEG recording paste and silver chloride cup electrode.

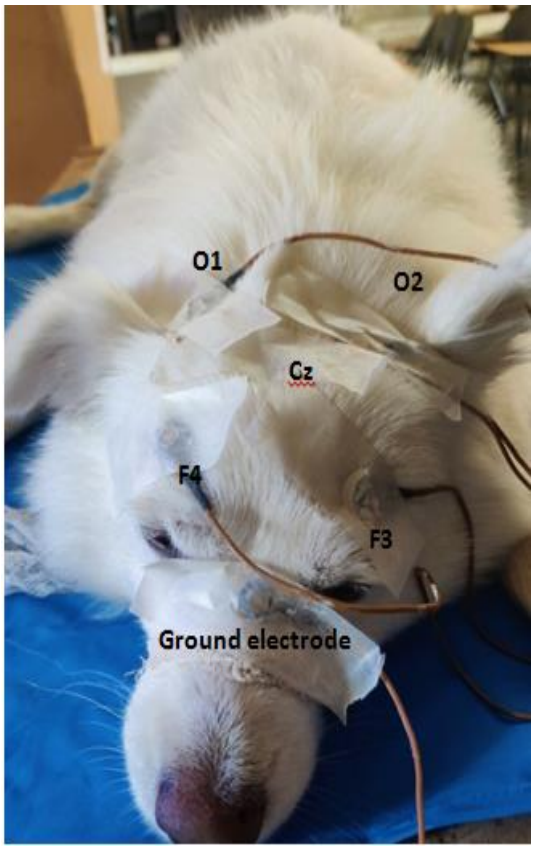

Fig 3: Placing of 5-channel montage electrodes on scalp of idiopathic epileptic dog on sternal recumbency (F3,F4,O1,O2,Cz and Ground electrode).

Fig 4: An electroencephalographic (EEG) unit for EEG recording technique in a 4 yr old Spitz dog with idiopathic epilepsy. The dog was placed on sternal recumbency after sedated with intramuscular injection of xylazine

EEG is an essential tool in the differentiation of seizure disorders from other paroxysmal events that impair consciousness, psychological events, metabolic/toxic events, and movement disorders look similar to status epilepticus (Golubovic and Rossmeisl, 2017) [7]. Electroencephalography is the main diagnostic technique for the diagnosis of various neurological diseases such as epilepsy, coma, encephalopathies and brain death which measures voltage fluctuations resulting from ionic current flows with in neuron of brain (Shashi *et al.* 2020) [17].

Conclusion

EEG gives valuable information about parameters and the severity of changes induced by idiopathic epilepsy and is the main aid to prove the presence of an epileptic focus even

when the clinical signs are absent. Concomitant use of visual and quantitative analysis of EEG in epileptic patients is advised as complementary information can be achieved.

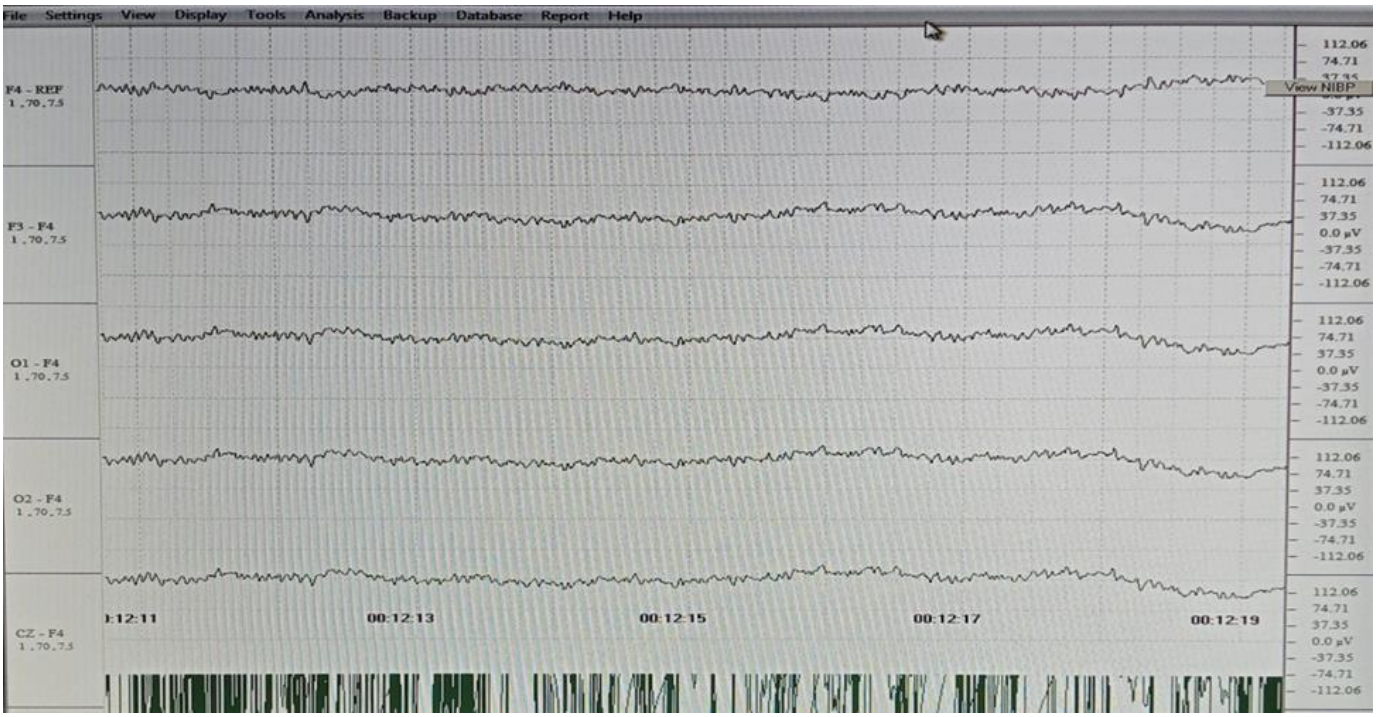

Fig 5: Alpha rhythm with frequency of 8-13Hz, traced from the healthy control dog from bipolar montage.

Fig 6; EEG tracing from the dog idiopathic epilepsy and having generalized seizures, shows bilateral spikes (changes in all channels from the skull) with frequency of 4-5 Hz and with duration (t) of 20-50 ms.

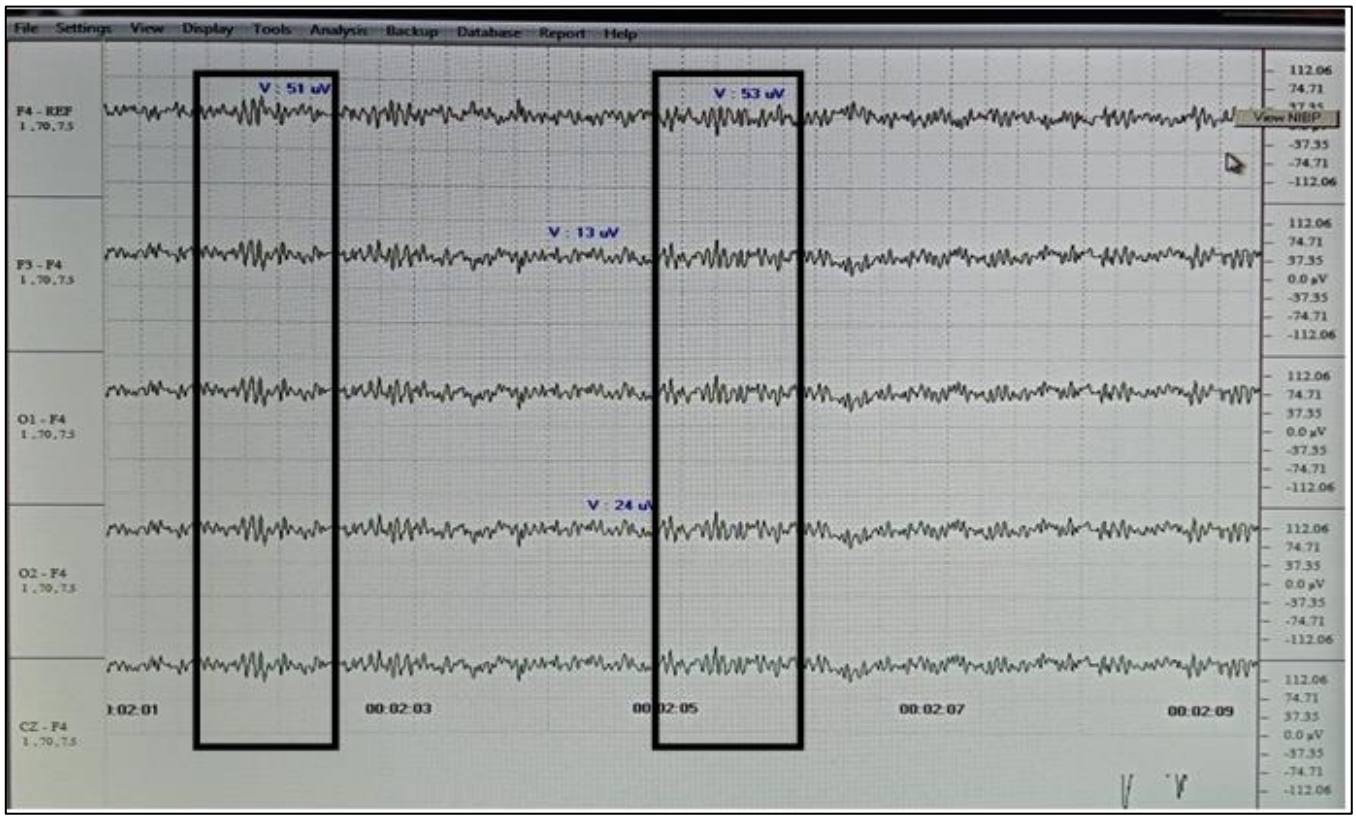

Fig 7: EEG abnormality with bilateral spikes and poly spikes/ spike complexes (frequency of 3-4 Hz and duration of 20-70ms) traced from the idiopathic epileptic dog had generalized tonic-clonic convulsion from 6 months.

Fig 8: EEG recording from the 3.5 yr old, male Labrador retriever had generalized seizures exhibited the sharp waves (duration of 80-200ms) and spikes with slow waves (high voltage) bilaterally

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