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Optimal timing and differential significance of postoperative awake and sleep EEG to predict seizure outcome after temporal lobectomy

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H I G H L I G H T S

- EEG done on 7th day following temporal lobectomy is not useful in predicting seizure outcome.
- EEG at 3 months and 1 year following surgery has significant value in predicting seizure outcome.
- Sleep recording improves the sensitivity of postoperative EEG by 30% without compromising specificity.

A B S T R A C T

Objective: To evaluate the prognostic value of postoperative EEGs to estimate post anterior temporal lobectomy (ATL) seizure outcome.
Methods: We studied postoperative EEGs in 325 consecutive patients who had minimum five years of post-ATL followup. Interictal epileptiform discharges (IEDs) present only during sleep were classified as sleep IEDs. We defined favorable final-year outcome as no seizures during the final one year and favorable absolute-postoperative outcome as no seizures during the entire postoperative period.
Results: At mean follow-up of 7.3 ± 1.8 years, 281 (86.5%) patients had favorable final-year outcome while 161 (49.5%) had favorable absolute-postoperative outcome. IEDs on three months and one year EEG were associated with unfavorable outcomes while IEDs at 7th day had no association with outcomes. Sleep record increased the yield of IEDs by 30% at each time-point without compromising predictive value. EEG at one year predicted the risk of seizure recurrence on drug withdrawal.
Conclusion: While EEG at three months and at one-year after ATL predicted seizure outcome, EEG at 7th day was not helpful. Sleep record increases the sensitivity of postoperative EEG without compromising specificity.
Significance: Both awake and sleep EEG provide useful information in postoperative period following ATL.

Abbreviations: AEDs, antiepileptic drugs; ATL, anterior temporal lobectomy; EEG, electroencephalogram; IED, interictal epileptiform discharges; MRI, magnetic resonance imaging; MTLE, mesial temporal lobe epilepsy; MTS, mesial temporal sclerosis; VEEG, video–electroencephalography.

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1. Introduction

Postoperative EEG is useful for predicting the seizure outcome and to make decisions about antiepileptic drug (AED) withdrawal following epilepsy surgery (Rathore and Radhakrishnan, 2010; Rathore et al., 2011c). Presence of interictal epileptiform discharges (IEDs) on a single postoperative EEG is associated with an increased risk of unfavorable seizure outcome and a higher risk of seizure recurrence on AED withdrawal following temporal and extratemporal surgeries (Menon et al., 2012; Rathore et al., 2011b, 2011c; Rathore and Radhakrishnan, 2010). Still, a single EEG has relatively lower sensitivity and specificity in predicting seizure outcome following epilepsy surgery. The predictive value of EEG can be further increased by obtaining serial EEGs (Rathore et al., 2011c). In nonsurgical patients, the yield of EEG can also be increased by obtaining a sleep record (Adachi et al., 1998; Leach et al., 2006; Mendez and Brenner, 2006). Whether the prognostic yield of EEG in the postoperative period can also be increased by obtaining a sleep record and if yes, then up to what extent, has not been previously studied. Similarly, it is not clear whether the IEDs in the awake and sleep states have the same prognostic value in the postoperative period.

The optimal timing of postoperative EEG is also not certain. Ideally an EEG should be obtained at earliest time following surgery to have the best information about seizure outcome and to make decisions about AED withdrawal. Whether an EEG during the early postoperative period has the same significance as EEG done at later times is not certain (Rathore and Radhakrishnan, 2010). We undertook this study to ascertain the optimal timing of postoperative EEG and the significance of postoperative sleep EEG in a uniform group of patients who underwent anterior temporal lobectomy (ATL) for mesial temporal lobe epilepsy (MTLE).

2. Methods

2.1. Study setting and patient selection

This study was carried out at Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum, Kerala, India. We have previously described our methods of patient selection for ATL for MTLE and the subsequent postoperative protocols (Chemmanam et al., 2009; Lachhwani and Radhakrishnan, 2008; Rathore et al., 2011a; Sylaja et al., 2004). From a prospectively maintained database, we included consecutive patients who underwent ATL for MTLE from March 1995 to December 2005 and had completed a minimum of 5 years of postoperative follow-up. To have a uniform group of patients, only those patients with MTLE who had hippocampal sclerosis on MRI or in whom MRI was normal or showed equivocal findings were selected for this study. Hippocampal sclerosis was defined as the presence of hippocampal atrophy and increased hippocampal signal on T2 weighted and fluid attenuated inversion recovery (FLAIR) sequences. Patients with MTLE associated with other lesions such as vascular malformations and benign tumors, patients with dual pathology, and those with bilateral mesial temporal sclerosis were excluded from this analysis. Similarly, patients with extratemporal and temporal neocortical epilepsies were excluded.

The standard presurgical evaluation protocol at our center includes detailed clinical evaluation with special emphasis on seizure semiology, neuropsychological evaluation, long-term video–electroencephalography (VEEG) monitoring for clinical semiology and interictal and ictal EEG data, and 1.5-T high resolution magnetic resonance imaging (MRI) (Chemmanam et al., 2009; Lachhwani and Radhakrishnan, 2008; Rathore et al., 2011a; Sylaja et al., 2004). We made decisions for surgery after thorough discussion in the multidisciplinary patient management conference. The majority of the patients with unilateral hippocampal sclerosis on MRI were selected for surgery on the basis of noninvasive evaluation. Patients with normal or equivocal MRI findings were also selected for ATL on the basis of noninvasive data, if they satisfied all of the following specific criteria: history of febrile seizures, seizure semiology suggestive of mesial temporal origin, unilateral anterior temporal IEDs (defined as $\geq$90% of IEDs lateralized to the side of resection), and well defined ipsilateral temporal ictal onset on EEG. Few patients were subjected to hippocampal depth electrode monitoring before surgery if the noninvasive evaluation data were nonlocalizing or discordant. We performed standard temporal lobectomy for all the patients in which excision of neocortical structures (4.5–5 cm on nondominant side and 3.5 cm on dominant side) was followed by complete excision of amygdala, hippocampus and parahippocampal gyrus. Pathologically, $\geq$30% loss of neurons in the CA1 sector of hippocampal formation was defined as hippocampal sclerosis (Rathore et al., 2011c).

2.2. Postoperative follow-up

After the ATL, all the patients underwent an EEG before discharge which was usually on 7th postoperative day. Subsequently, all the patients came for follow-up at three months, at one year, and then at yearly intervals. At each follow-up, patients were asked about the seizure outcome through the personal interview. Patients were asked to maintain seizure diaries as a standard practice. After five years of postoperative regular follow-up, patients who remained seizure free and had difficulty in yearly visits were followed up through postal or email interview. In case of any seizure recurrence, patients were advised to contact personally or telephonically. For this study, we defined two outcome measures: favorable *final-year outcome* was defined as no seizures or auras during the final one year of follow-up. Those patients who had seizures during the final year of followup were classified to have unfavorable final-year out*come*. Favorable *absolute-postoperative outcome* was defined as no seizures or auras during the entire post-ATL follow-up period. Those patients who had seizure any time during whole followup period were classified as having unfavorable absolute-postoperative outcome.

2.3. Postoperative EEG protocol

We have previously described our protocol for EEG recording and reporting (Rathore et al., 2011c). For all the patients, we tried to obtain EEG at 7th day, at three months and then at one, two and three years of follow-up. As the majority of the patients have seizure recurrence within first year, we included the EEG done at 7th day, three months and at one year for the analysis in this study. We utilized the Mayo system of EEG classification and coding for EEG abnormalities (Mayo Clinic and Mayo Foundation, 1991). Our EEG protocol consists of partial sleep deprivation on previous night and obtaining at least 40 min of EEG record, both in awake and sleep states (Radhakrishnan et al., 1999; Rathore et al., 2011c). We tried to obtain natural sleep in majority of the patients; however, if required, either chloral hydrate or Triclofos were used as hypnotic agents. We performed activation procedures including intermittent photic stimulation and hyperventilation for all the patients except on the 7th day when hyperventilation was not performed. Only definite spikes or sharp waves were classified as IEDs. We classified IEDs as awake IEDs when these were present only during wakefulness, or both during wakefulness and sleep, while sleep IEDs were defined as IEDs present only during sleep.