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Clinical Study

Optimal duration of video-electroencephalographic monitoring to capture seizures

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ABSTRACT

We aimed to find the optimal duration of long-term video-electroencephalographic monitoring (VEM) to capture seizures in patients with epileptic seizures (ES) and psychogenic non-epileptic seizures (PNES) by evaluating the time to first clinical event and the diagnostic yield of clinical events and positive cases in each day of VEM. Patients aged ⩾18 years who underwent VEM from May 2009 to June 2014 were studied retrospectively. Demographic, clinical and VEM data (including total monitoring length, type and time to first event, total number of ES/PNES) were collected. The difference in time to the first event between ES and PNES was analysed with Mann–Whitney U test. Of 207 VEM studies performed during the 5 year period, 108 recordings captured seizures (ES and PNES) (52.2%). Median times to the first ES and PNES were 19.7 and 23.4 hours, respectively (p = 0.99). A small majority (53.7%) of event-positive patients had their first event on the first day of monitoring. By the end of the fifth day, 98% of all clinical events were captured and 99% of all positive cases were diagnosed. In conclusion, in a patient monitoring program where a diagnosis is reached by capturing seizures, 5 days is probably sufficient to capture the greatest number of events and diagnose 99% of those patients.

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1. Introduction

Video electroencephalographic monitoring (VEM) is regarded as the gold standard diagnostic tool for confirming the diagnosis of seizure disorders, classifying seizure types and evaluating surgical candidates with intractable epilepsy [1–4]. Prolonged inpatient VEM is considered superior in its yield of detecting seizures compared with routine electroencephalography (EEG) (50–70% *versus* 2.5–7%) [1]. Additionally, both the sensitivity and the specificity of EEG recordings with clinical events are far superior to EEG measurements without events [1]. As such, inpatient VEM is especially useful in patients who have recurrent seizures or seizure mimickers, as trained clinicians can draw accurate conclusions based on captured clinical events and EEG correlates. One study involving 131 patients showed VEM helped to change the diagnosis in 58% and alter management in 73% [4]. Improved seizure control has been reported in up to 70% of patients as a result of VEM [5].

However, the use of prolonged VEM is limited by cost and the need for added resources and trained personnel [2,4,6–8]. Therefore, it remains an investigation confined to specialised centres. Given the limitations, finding the optimum duration of VEM with adequate diagnostic yield is an important aspect of pre-admission planning in epilepsy monitoring units. Several studies have attempted to answer this question through various measures, such as the latency to the first interictal epileptiform activity [9,10] or the first clinical event [2,10–18]. However, few studies have been conducted to compare the optimum duration of VEM for epileptic seizures (ES) and psychogenic non-epileptic seizures (PNES) in patients admitted to the same epilepsy monitoring unit.

Against this backdrop, the current study was conducted to evaluate the optimal duration of VEM for patients with ES and PNES attending the same centre using two parameters: the time to first clinical event (ES and PNES) and the diagnostic yield of clinical events and positive cases in each day of monitoring.

2. Method

2.1. Study setting and VEM technique

This study was conducted at Monash Medical Centre in Victoria, Australia, and the video-EEG were recorded in the epilepsy monitoring unit with one monitoring bed. Patients typically fell into two categories: diagnostic clarification of paroxysmal clinical

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events and classification of seizures to tailor management or pre-surgical evaluation of medically refractory epilepsy.

The standard protocol was to admit patients for VEM on Monday morning and discharge on Friday afternoon. However, duration of monitoring was shortened if sufficient clinical events were captured early, or if patients elected to terminate VEM prematurely. Conversely, in selected patients, VEM was extended if no clinical events were captured in the allocated time, or if capturing multiple events was ideal, for example in pre-surgical cases, provided patients tolerated the procedure and were willing to continue. Hence, the duration of VEM was decided on an individual basis, depending on several factors including capturing clinical events and tolerability of the test by patients.

The standard VEM setup was the international 10-20 system of scalp electrodes. Patients were provided with a manually-activated seizure alarm button to allow correlation of perceived events and EEG findings. Antiepileptic drug tapering and sleep deprivation were routinely done. Antiepileptic drugs were rapidly weaned off over 3 days, with the exception of slower and more cautious tapering of benzodiazepines, phenytoin and phenobarbitone and in those patients with a history of status epilepticus. Hyperventilation and intermittent photic stimulation were not routine and used for selected patients with a high clinical suspicion of genetic (idiopathic) generalised epilepsy. Provoking techniques such as placebo injections were not used to induce PNES. The final diagnosis was established by the consensus opinion of epileptologists, taking into account the clinical history, examination findings, investigation results and VEM findings.

2.2. Subjects and clinical events

We retrospectively studied patients who had inpatient VEM in the 5 year period from May 2009 to June 2014. Only adult patients ($\geqslant$18 years) who had monitoring for a minimum of 24 hours were included. In our study, clinical events were defined as either ES or PNES. Other non-epileptic paroxysmal events such as syncope and sleep disorders were excluded from the analysis.

2.3. Data collection and analysis

Demographic (age, sex), clinical (indication for VEM, pre-test frequency of events, pre and post-test diagnoses and classification, antiepileptic drug therapy) and VEM (total monitoring length, type of first event, time to first event, total number and spread of ES/PNES during each day of monitoring, seizure type) data were collated from medical records and VEM reports. The video-EEG recordings were reviewed for additional information.

Descriptive statistics included frequencies and percentages for categorical variables and means, medians and standard deviations for continuous variables. The significance of difference in time to the first clinical event between different groups was analysed with the Mann–Whitney U test. We first studied the differences between ES and PNES. Patients with a post-test diagnosis of epilepsy were further categorised as shown in Figure 1. This allowed further analysis of the difference in time to first clinical event between generalised epilepsy and focal epilepsy and finally, temporal lobe epilepsy and extratemporal lobe epilepsy.

Statistical significance was defined as a p value of <0.05. The diagnostic yield was defined as the number of positive cases based on at least one clinical event divided by the total number of cases monitored, expressed as a percentage. The data analyses were performed with the Statistical Package for the Social Sciences version 21 (IBM, Armonk, NY, USA). This study was approved by the Human Research Ethics Committee of Monash Health.

3. Results

Of the 207 VEM studies performed during the 5 year period, 108 recordings captured seizures (52.2%). The characteristics of these patients are summarised in Table 1. Of 108 positive recordings, 91 patients (84.3%) underwent VEM for diagnostic clarification and 17 patients (15.7%) for pre-surgical evaluation. ES alone were captured from 52 patients (48.1%), PNES alone in 53 patients (49.1%) and both ES and PNES in three patients (2.8%). A mixed diagnosis of co-existing epilepsy and PNES was made in 11 patients; either through occurrence of both types of events during monitoring (n = 3) or by capturing PNES in patients with previously-confirmed epilepsy (n = 8). The mean duration of monitoring in the total cohort was 3.7 ± 1.5 days (range 1.1–7.3).

3.1. Time to first clinical event

Median time to first event was 22.3 hours (mean 30.9 ± 29.9 hours, range 0.3–156.6 hours). Median time to first ES was 19.7 hours (mean 33.0 ± 33.6 hours, range 0.8–156.6 hours), whereas median time to first PNES was 23.4 hours (mean 29.5 ± 26.7 hours, range 0.3–116.3 hours). However, there was no significant difference between the median time to first ES and PNES (p = 0.99). We also did not find significant differences in the median times to first event between generalised epilepsy and focal epilepsy (p = 0.16) as well as temporal lobe epilepsy and extratemporal lobe epilepsy (p = 0.17).

3.2. Diagnostic yield during monitoring

Table 2, 3 highlight the yield of diagnostic events across each day of monitoring in terms of positive cases and clinical events (ES, PNES) respectively.

As shown in Table 2 and Figure 2, the highest overall diagnostic yield of new cases occurred on the first day of monitoring. Clinical events were captured in 58 of the total 207 patients monitored (28%), equating to 54% of all positive cases. The yield of new positive cases decreased with each passing day as illustrated in Figure 2. Seventy-seven percent of all positive cases were diagnosed by the end of the second day, 89% by the end of the third day and 96% by the end of the fourth day. PNES tended to present earlier during monitoring than ES, taking 4 days to diagnose 98% of the PNES patients and 5 days to diagnose the equivalent proportion of ES patients.

Table 3 and Figure 3 illustrate that the majority of clinical events (98%) were captured by the end of the fifth day. The most common events overall were focal dyscognitive seizures, followed by PNES. As highlighted in Table 3, PNES were captured earlier than ES, taking 4 days to record 96.6% of all PNES compared with 5 days to record a similar proportion of ES.

4. Discussion

VEM is a crucial tool for diagnosing epilepsy and PNES, helping to guide medical and surgical management of epileptic patients, [6] and avoiding antiepileptic drug exposure in PNES patients [16]. In order to evaluate the optimal duration for VEM for appropriate allocation of this valuable resource, our study approached the topic using two parameters: the time to first clinical event and the yield of events and positive cases across monitoring days. A key finding from this study is that the highest yield occurs during the first day of VEM. The first clinical event, either ES or PNES, tends to occur within the first day of monitoring (median 19.7 hours and 23.4 hours respectively, p = 0.99). As for overall yield, PNES occurs earlier during VEM than ES. Lastly, our results

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