Timing of first event in inpatient long-term video-EEG monitoring for diagnostic purposes

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A B S T R A C T

Background: Long-term video-EEG monitoring (LTM) aims to record the habitual event and is a useful diagnostic tool for neurological paroxysmal clinical events. In our epilepsy monitoring unit (EMU) setting, admissions are usually planned to last up to five days. We ascertained time taken for the recording of a first event and determined correlations between different clinical characteristics and timings.

Methods: We retrospectively reviewed diagnostic and classification LTM recording performed at a tertiary epilepsy centre.

Results: Sixty-three recordings were reviewed. Most subjects (89%) had events at least once a week prior to admission. In 40 (63%) a habitual event was recorded, mostly (93%) within the first two days. No events were recorded on day four or five. A few characteristics were associated with a trend for events occurring earlier (events more than once a week vs less than once a week, motor symptoms compared with aura or dyscognitive events, and reduction of antiepileptic drugs versus no reduction).

Conclusions: Our finding suggests that, for diagnostic event recording in people with epilepsy or PNEA, a maximum recording time of three days is sufficient in two thirds of them, if event frequency is at least once a week. In the remaining third, prolonged recording up to five days did not result in capturing a clinical event. For these individuals, shorter admission could be planned, for example for 2 days rather than 5 days.

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1. Introduction

Long-term video-EEG monitoring (LTM) is a useful tool in different clinical settings, including diagnosis of unclear clinical paroxysmal events, seizure classification and presurgical evaluation. Recording of an event is required for optimal outcome of the investigation (for example, whether events are epileptic or non-epileptic). The diagnostic yield of these recordings has been previously demonstrated (Alving and Beniczky, 2009; Ghougassian et al., 2004). LTM is expensive but an incorrect diagnosis can lead to unnecessary costs and inappropriate treatment. To optimize LTM duration for diagnostics and to reduce costs, understanding the timings of a first recorded event and its determinants are required. It is preferable from a cost perspective, that admissions are as short as possible.

Previous retrospective studies report mean time to a first recorded events ranging from 0.6 to 2.3 days (Eisenman et al., 2005; Lobello et al., 2006; Rose et al., 2003; Seneviratne et al., 2011; Spritzer et al., 2014). These differences can be explained by heterogeneous populations (diagnostic/classification/presurgical pooled together). The success rate of recording a habitual event varies between 69 and 83% (Alving and Beniczky, 2009; Eisenman et al., 2005; Ghougassian et al., 2004; Lobello et al., 2006; Spritzer et al., 2014), which is probably also a result of different diagnostic groups and differences in recording duration. No assessment of possible determinants such as individual characteristics or the contribution of provocative measures of a successful recording has been reported. One study suggested that psychogenic non-epileptic attacks (PNEA) are likely to occur significantly earlier than epileptic seizures (Rose et al., 2003), but others did not find this (Lobello et al., 2006; Spritzer et al., 2014).

As part of our service evaluation, we ascertained the time to the first habitual clinical event during long-term EMU video-EEG recordings performed for diagnostic purposes and classification. We attempted to correlate clinical characteristics and timing of events.

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2. Material and methods

We retrospectively reviewed reports of all people older than 12 years admitted between June 2013 and February 2015 for multi-day continuous LTM at our tertiary epilepsy centre. Only those who were admitted for diagnostic clarification or seizure classification were selected for further analysis. Presurgical cases were excluded. We selected all LTM recordings that were initially planned for five days (standard practice for this diagnostic question in that time period), but which could be terminated earlier (e.g. if the question was clarified or the subject requested it). All had standard provocative measures (3 min hyperventilation and intermittent photic stimulation). The protocol in reviewing the results of the video EEG was the following: patient or visitors of patients could report an event and in addition clients were monitored by nursing staff 24 h a day. A technician reviewed the whole EEG, with special interest to reported events by clients and/or nursing staff. A team of 5 experienced clinical neurophysiologists reviewed the selected EEG fragments and video’s and made a final diagnosis concerning the recorded events. In case of doubt a consensus was made by reviewing the recording by more than one clinical neurophysiologist. We reviewed case notes and extracted data, including gender, age at recording, start of first paroxysmal event, usual frequency of events, main semiological feature of events, use of antiepileptic drugs (AED) and whether AEDs were lowered during the admission. From the LTM the following information was recorded: number of recorded habitual events, time and timing of first recorded event, events triggered by provocative measures, total recording duration and post-recording diagnosis. Admission day was defined as day 1; subsequent days were defined as starting at 9 a.m. of the relevant days.

Statistics: descriptive measures are presented as median with minimum and maximum values. The chi square test with Yates’ correction for continuity where appropriate and Mann Whitney U tests were used to explore possible differences between those having an event and those not. The Kruskal-Wallis test was performed to compare the duration to first event between different subgroups based on the documented clinical characteristics. A goodness of fit test was performed to see whether the occurrence of events in the four quarters of the day was different from that expected. Statistical analyses were carried out with SPSS for Windows 23 (SPSS Inc, Chicago, IL).

This assessment was reviewed by the Medical Ethical Committee of Leiden University Medical Centre and classified as service evaluation and therefore no approval was required.

3. Results

We identified 63 individuals who underwent LTM for diagnostic and classification purposes and reviewed their recording. See Table 1 for clinical and demographic details. Median recording time was four days. Thirty subjects (48%) completed the scheduled 5 day recording; 9 (14%) were recorded for up to two days only, in seven as events were recorded within this period and two at the request of the subject. Forty (63%) had at least one habitual event recorded, with a median of three events per subject. No clinical characteristic was identified that was significantly more common in those who had an event recorded than in those who did not (Table 1).

The median time to the first recorded event was 12 h (IQR 20, minimum 9 min, maximum 56 h). The median day on which the first event appeared was day 1 (IQR 1, minimum 1, maximum 3). Only three (7%) had their first event on day three and all were epileptic seizures with primarily dyscognitive features (Fig. 1).

Post recording diagnoses in those with events were epileptic seizures in 16 (40%), PNEA in 13 (33%) and clinical events of uncertain aetiology (e.g.: subjective feelings without EEG change) in 11 (27%). The event recording happened fairly equally during the different time categories (p = 0.06); 11 (27.5%) between 6 a.m. and 12 noon, 15 (37.5%) between 12 noon and 6 p.m., 11 (27.5%) between 6 p.m. and midnight) and the remainder during the night (3, 7.5% between 0 a.m. and 6 a.m.). The final diagnosis was not dependent on the time of day at which the event happened.

In two individuals with a final diagnosis of PNEA (both with motor symptoms primarily), events happened during hyperventilation (n = 1) or photic stimulation (n = 1).

None of the investigated variables was found to be significantly associated with the timing of the event (p < 0.05). Statistical significance was lacking but some trends were visible (Fig. 2). Related to event frequency in the history, cases with more than 1 event per week had their first event twice as soon as cases with 1 event per week (median 10 vs 19 h, p = 0.24). People with motor symptoms had their first event after a median time of 11 h, compared to 20 and 22 h in those with dyscognitive features and auras respectively (p = 0.22). Decreasing AED resulted in a median time to first event of 6.5 h, compared to 12 h and 19.5 h in people with no AED and no reduction of AED respectively. (p = 0.27).
Table 1
Patient characteristics.

<table>
<thead>
<tr>
<th></th>
<th>Total cohort (N = 63)</th>
<th>Cases with recorded events (N = 40)</th>
<th>Cases without recorded events (N = 23)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>15 (24%)</td>
<td>8 (20%)</td>
<td>7 (30%)</td>
<td>0.53</td>
</tr>
<tr>
<td>Male</td>
<td>48 (76%)</td>
<td>32 (80%)</td>
<td>16 (70%)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years; median [range])</td>
<td>27 [13–74]</td>
<td>31 [15–74]</td>
<td>23 [13–70]</td>
<td>0.22</td>
</tr>
<tr>
<td>Duration of symptoms (years; median [range])</td>
<td>2 [0–35]</td>
<td>1 [0–35]</td>
<td>2 [0–25]</td>
<td>0.62</td>
</tr>
<tr>
<td>Frequency of events</td>
<td>49 (78%)</td>
<td>33 (84%)</td>
<td>16 (70%)</td>
<td>0.38</td>
</tr>
<tr>
<td>&gt;1/week</td>
<td>7 (11%)</td>
<td>5 (12%)</td>
<td>2 (9%)</td>
<td></td>
</tr>
<tr>
<td>1/week</td>
<td>2 (3%)</td>
<td>0 (0%)</td>
<td>2 (9%)</td>
<td></td>
</tr>
<tr>
<td>&gt;1/month</td>
<td>2 (3%)</td>
<td>1 (2%)</td>
<td>1 (4%)</td>
<td></td>
</tr>
<tr>
<td>1/month</td>
<td>2 (3%)</td>
<td>0 (0%)</td>
<td>2 (9%)</td>
<td></td>
</tr>
<tr>
<td>&lt;1/month</td>
<td>1 (2%)</td>
<td>1 (2%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>13 (21%)</td>
<td>11 (27%)</td>
<td>2 (9%)</td>
<td></td>
</tr>
<tr>
<td>Main semiology of event</td>
<td>22 (35%)</td>
<td>12 (30%)</td>
<td>10 (43%)</td>
<td></td>
</tr>
<tr>
<td>Aura</td>
<td>24 (38%)</td>
<td>15 (38%)</td>
<td>9 (39%)</td>
<td></td>
</tr>
<tr>
<td>Motor</td>
<td>2 (3%)</td>
<td>0 (0%)</td>
<td>2 (9%)</td>
<td></td>
</tr>
<tr>
<td>Dyscognitive</td>
<td>2 (3%)</td>
<td>2 (5%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>Tonic/clonic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>3 (5%)</td>
<td>2 (5%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>AED use</td>
<td>22 (35%)</td>
<td>16 (40%)</td>
<td>6 (26%)</td>
<td>0.51</td>
</tr>
<tr>
<td>No AED</td>
<td>11 (17%)</td>
<td>6 (15%)</td>
<td>5 (22%)</td>
<td></td>
</tr>
<tr>
<td>Reduction of AED</td>
<td>30 (48%)</td>
<td>18 (45%)</td>
<td>12 (52%)</td>
<td></td>
</tr>
</tbody>
</table>

AED = antiepileptic drugs.

* P-value calculated between two categories: event frequency more than once a week versus once a week and less.

b Chi-square test for independence not applicable due to sample size.

c drop attacks, respiratory events.

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Fig. 2. Time to first event in hours in categories with different clinical characteristics.
Figure legend: PNEA = psychogenic non-epileptic attack, AED = anti-epileptic drugs.
PNEA events happened somewhat earlier than epileptic seizures and both preceded events in which aetiology could not be determined (subjective feelings without EEG change) (median time to first event 8 vs. 11 vs. 21 h, \( p = 0.39 \)).

4. Discussion

We investigated the occurrence of, and time to, first habitual event in LTM for diagnostic and classification purposes, and whether these were associated with certain clinical characteristics. Overall, in our cohort 63% had at least one habitual episode. This is in line with previously published numbers (Alving and Beniczky, 2009; Eisenman et al., 2005; Ghougassian et al., 2004; Lobello et al., 2006; Spritzer et al., 2014), especially as we excluded those undergoing presurgical evaluation. All events were captured within the first three days, with a median time to the first event of 12 h. We found no variables that were significantly associated with the time required to record a first event, possibly due to lack of power. We did notice, however, that some features showed a trend to a shorter time until the first event was recorded. Events with primarily motor symptoms tended to occur in half the time taken for those with dyscognitive features or auras. Reduction of AEDs also resulted in a tendency to earlier event recording. There are some differences in the time to first event, but in clinical practice the differences are not significant, as LTM is usually planned in days, and not in hours. In our cohort, all events occurred within the first three days of the admission, of which 93% occurred within the first two days. This is in line with a previous study, in which 87.7% of all recorded events occurred on day one or two (Lobello et al., 2006).

Provocative measures such as hyperventilation and intermittent photic stimulation seemed to provoke events in two individuals, in whom the final diagnosis was PNEA. The provocative effect of these measures was described earlier (Benbadis et al., 2000; Mcgonigal et al., 2002) and, especially in PNEA, can be very useful. It is possible that more events would occur if individuals were challenged to hyperventilate for 5 min, as described earlier (Craciun et al., 2015).

We demonstrated that most events occur on day one or two of the recording. Almost all in our cohort had a high frequency of events prior to admission. It is possible that, in those with lower frequencies of events, the time to the first event would be longer than 3 days. An earlier study, however, found no correlation between self-reported seizure frequency and time to first event (Eisenman et al., 2005). In this study, the self-reported frequency of events is also quite high, which is reflected in a mean frequency of events of 2.2 per month in the low frequency group. In practice, individuals with an event frequency of less than once per month are unlikely to have a request for LTM.

In this service evaluation, we ascertained timing of the first event and did not assess clinical relevance of the recording. Twenty-seven percent of individuals in our cohort had no definite diagnosis (clinical event with uncertain significance) after the recording of an event; this is in line with a previous study investigating the diagnostic usefulness of LTM (Alving and Beniczky, 2009); 25% of cases in that study had no definite diagnosis after event recording. We therefore believe that recording more events in those with no definite diagnosis would not have added to the diagnostic gain. Recording more than one event is especially useful in the workup of presurgical patients (Struck et al., 2015).

5. Conclusions

Our evaluation shows that for diagnostic event recording in people with epilepsy or PNEA with an event frequency of at least once a week a maximum recording time of three days is sufficient in two thirds of them. In the other one third, prolonged recording of up to five days does not result in capturing the clinical event. Further specification on clinical characteristics to predetermine the recording time is not possible using our dataset.

Based on this service evaluation it appears to be more efficient and cost-effective to plan to monitor these individuals for less than five days. In our EMU we have now shortened the recording time for this clinical pathway to two days. It remains to be investigated whether a second (short) admission is clinically useful in those without event recording the first time.

Conflicts of interest

The authors have no conflicts of interest to declare

Ethical standards

Our work has been carried out in accordance with the code of ethics of the world medical association for experiments involving humans.

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