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Research Paper

Diagnostic utility of prolonged ambulatory video-electroencephalography monitoring

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ABSTRACT

Objectives: Ambulatory video-electroencephalography (video-EEG) represents a low-cost, convenient and accessible alternative to inpatient video-EEG monitoring, however few studies have examined their diagnostic yield. In this large-scale retrospective study conducted in Australia, we evaluated the efficacy of prolonged ambulatory video-EEG recordings in capturing diagnostic events and resolving the referring question.

Methods: Sequential adult and paediatric ambulatory video-EEG reports from April 2020 to June 2021 were reviewed retrospectively. Data collection included patient demographics, clinical information, and details of events and EEG abnormalities. Clinical utility was assessed by examining i) time to first diagnostic event, and ii) ability to resolve the referring questions – seizure *localisation*, *quantification*, *classification*, and *differentiation* (differentiating seizures from non-epileptic events).

Results: Of the 600 reports analysed, 49 % captured at least one event, and 45 % captured interictal abnormalities (epileptiform or non-epileptiform). Seizures, probable psychogenic events (mostly non-convulsive), and other non-epileptic events occurred in 13 %, 23 % and 21 % of recordings respectively, with overlap. Unreported events were captured in 53 (9 %) recordings, and unreported seizures represented more than half of all seizures captured (51 %, 392/773). Nine percent of events were missing clinical, video or electrographic data. A diagnostic event occurred in 244 (41 %) recordings, of which 14 % were captured between the fifth and eighth day of recording. Reported event frequency $\geq$ 1/week was the only significant predictor of diagnostic event capture. In recordings with both seizures and psychogenic events, unrecognized seizures were frequent, and seizures may be missed if recording is terminated early. The referring question was resolved in 85 % of reports with at least one event, and 53 % of all reports. Specifically, this represented 46 % of reports (235/512) for *differentiation* of events, and 75 % of reports (27/36) for *classification* of seizures.

Conclusion: Ambulatory video-EEG recordings are of high diagnostic value in capturing clinically relevant events and resolving the referring clinical questions.

1. Introduction

Prolonged video-electroencephalography (video-EEG) monitoring is a valuable diagnostic tool in the evaluation of epilepsy and other paroxysmal disorders [1,2]. Traditionally, prolonged video-EEG monitoring is performed in the inpatient setting. With recent advances in technology and equipment, ambulatory video-EEG monitoring has become more readily available as an alternative [2].

A primary indication for ambulatory video-EEG monitoring is capturing habitual events and interictal epileptiform discharges (IEDs) to aid diagnosis of epilepsy and non-epileptic disorders. Compared with inpatient video-EEG monitoring, ambulatory studies use fewer resources and are less labour intensive [3]. Prolonged monitoring in the community may also be less disruptive for the patient, and occurs in the patient's usual home environment, with natural sleep and circadian changes improving diagnostic yield [2].

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Limitations of ambulatory video-EEG monitoring can be technical or practical. In the unsupervised home environment with unrestricted movement, there is concern that fewer events may be captured on video, and increased artefacts could affect EEG quality. Some studies suggest these concerns may be less significant than assumed, with similar rates of off-camera events and uninterpretable EEG data in ambulatory versus inpatient video-EEG monitoring [4,5]. Provocative measures are also limited, as anti-seizure medication withdrawal or sleep deprivation are considered unsafe in the outpatient setting.

Most studies of ambulatory EEG monitoring to-date have been without video recording and report variable rates of event and IED capture, likely due to study heterogeneity [2]. While the addition of synchronous video aids the interpretation of ambulatory EEG recordings [6], the clinical utility of ambulatory video-EEG has yet to be studied in-depth. This study aimed to examine the utility of prolonged ambulatory video-EEG monitoring, particularly with respect to capturing diagnostic events and addressing the referring question.

2. Methods

This study was approved by the St Vincent's Hospital Melbourne Human Research Ethics Committee (Project ID 57392, Reference number 165/19).

2.1. Data source

Six hundred sequential adult and paediatric ambulatory video-EEG reports were provided by Seer Medical (Seer Medical Pty Ltd; Melbourne, Australia), a commercial diagnostic home-based video-EEG monitoring service. Reports were generated from April 2020 to June 2021, and provided de-identified to the research team for this study. The reporting process involved initial scientist review of the recording assisted by spike and seizure detection software [7,8] to flag specific epochs. The reporting neurologist then examined the flagged epochs, reported events, unreported events (discovered on review of the recording), and any additional events later reported by witnesses including family and carers.

2.2. Data collection

Data extraction was performed by two neurologists (A.H. and U.S.) and a neurology registrar (M.L.) using an electronic data collection tool (Figure S1) in Microsoft Access (Microsoft Corporation, Redmond, WA, USA).

Patient and report details were collected, including age, sex, and duration of monitoring. Interictal EEG abnormalities were categorised into one or more of the following: "generalised" epileptiform abnormalities, "focal" epileptiform abnormalities, and "non-epileptiform" changes. To assess recording quality, the presence of any events with no video data, no EEG data, or patient off camera was also documented.

Reported and unreported events were categorised as either "epileptic" or "non-epileptic". Non-epileptic events were further categorised as "probable psychogenic" events – defined as paroxysmal time-limited alterations in motor, sensory, autonomic or cognitive signs and symptoms not caused by ictal epileptiform activity [9], or "other" events – defined as any other miscellaneous symptom or behaviour the patient or caregiver decides to report. Each event was categorised based on the scientist description of the event on video, the patient's reported phenomenology at the time, and any associated electrographic changes. Events unable to be categorised (e.g. events missing video or EEG data, and off-camera events) were labelled "unclassified" events.

Based on the clinical history and indication for monitoring, reports were categorised into one or more of four pre-determined referring questions:

Differentiation of epileptic versus non-epileptic events.
Classification of seizure type or epilepsy type.
Quantification of seizures or IEDs.
Localisation of seizure focus.

For each report, the relevant clinical questions were then classified as either "resolved" or "not resolved", based on whether representative events or interictal abnormalities were captured to sufficiently address the question (see Figure S1). Reasons for not resolving the referring question were also examined.

The date and onset time of the first diagnostic event was recorded, if applicable. This was defined as the first representative event that sufficiently resolved the relevant clinical question(s). We also examined whether successful capture of a diagnostic event was predicted by variables including age, sex, duration of recording, interictal abnormalities (epileptiform or non-epileptiform), past history of epilepsy (if known), and reported event frequency $\geq$ 1/week (if indicated by the referrer).

2.3. Data analysis

Statistical analysis was performed using IBM SPSS Statistics version 29.0.1.0 (IBM Corp., Armonk, NY, USA). Univariable and multivariable logistic regression were used to assess whether any clinical variables predicted diagnostic event capture. Two-tailed p-values were generated, with significance defined as $p < 0.05$. GraphPad Prism version 9 (GraphPad Software, San Diego, CA, USA) was used to generate graphical figures.

3. Results

3.1. Patients and reports

The 600 ambulatory video-EEG reports described 598 unique patients, with demographics outlined in Table 1. Recording duration ranged from one to ten days, with a mean of 5.7 days (Figure S2). Quality of the recordings was high, with very few (16/600, 2.7 %) capturing only events that were off-camera or without video or EEG data (see Table 1). The most common clinical question was differentiation (512/600, 85 %), followed by quantification (106/600, 18 %), then classification (36/600, 6.0 %), with some reports including more than one clinical question. No referrers requested localisation of seizure focus.

Table 1
Summary of patient demographics and report findings.

Patients (n = 598)	
Sex, n (%) patients	
Female	351 (58 %)
Male	215 (36 %)
Other/Unknown	34 (5.7 %)
Age, mean ± SD	36.6 ± 19.9 years
Paediatric (age < 18 years), n (%) patients	109 (18 %)
Known history of epilepsy	234 (39 %)
Reports (n = 600)	
Recording duration, mean ± SD	5.7 ± 2.2 days
Quality control, n (%) reports	
Off-camera events	91 (15 %)
Events without video	15 (2.5 %)
Events without EEG	54 (9.0 %)
Report findings	
Electrographic abnormalities, n (%) reports	274 (46 %)
Seizures	75 (13 %)
Interictal abnormalities	269 (45 %)
Epileptiform discharges (generalised or focal)	208 (35 %)
Non-epileptiform abnormalities (e.g. focal slowing, non-specific changes)	76 (13 %)
Seizures AND interictal abnormalities	71 (12 %)
Clinically significant cardiac abnormalities, n (%) reports	3 (0.5 %)
≥1 event, n (%) reports	295 (49 %)
≥1 diagnostic event, n (%) reports	244 (41 %)
≥1 unreported event, n (%) reports	53 (8.8 %)

3.2. Events and interictal abnormalities

Events were captured in 295 (49 %) recordings, comprising 2646 events in total (Table 2). This included events reported by the patient or caregiver (2004/2646, 76 %), unreported events discovered on review of the recording (411/2646, 16 %), and events unable to be classified due to being off-camera or missing associated video or EEG data (231/2646, 8.7 %). Probable psychogenic (convulsive or non-convulsive) events were most frequent (921/2646, 35 %), followed by seizures (773/2646, 29 %), and other non-epileptic events (717/2646, 27 %). Electrographic abnormalities were described in 46 % (274/600) of reports (Table 1), including seizures (75/600, 13 %), interictal epileptiform discharges (208/600, 35 %), and interictal non-epileptiform abnormalities (76/600, 13 %). Clinically significant cardiac abnormalities were described in three reports, namely interictal and ictal bradyarrhythmias.

Unreported events were almost exclusively seizures (392/411, 95 %), with almost half of all captured seizures being unreported by the patient or caregiver (392/773, 51 %). Specifically, unreported seizures occurred in 57 % (43/75) of recordings with seizures, with a mean time to first unreported seizure of 1.6 days. Unreported seizures were generalised in 18 recordings, focal in 22 recordings, and poorly localised or lateralised in three recordings. The 22 recordings with unreported focal seizures included onset localised to hemisphere (right = 2, left = 2), anterior quadrant (right = 4, left = 6), temporal (right = 2, left = 1), or extra-temporal (right = 5, left = 0) regions.

Few recordings (n = 12) captured both seizures and probable psychogenic events (Table S1). Among this subgroup, unreported seizures were frequent (10/12 recordings), and in six recordings all seizures were exclusively unreported. The first seizure tended to occur after the first psychogenic event (8/12 recordings), with variable latency (up to 145 hours). Additionally, recordings with both seizures and probable psychogenic events invariably had interictal epileptiform abnormalities.

Fig. 1 illustrates the overlap between event types and interictal abnormalities, and Fig. 2 illustrates the distribution of focal epileptiform, generalised epileptiform, and non-epileptiform interictal abnormalities. Of note, interictal epileptiform activity occurred in all recordings with generalised seizures (27/27), and most recordings with focal seizures (42/48). Indeed, for events occurring in the context of a normal interictal trace (n = 879 excluding unclassified events), the vast majority were non-epileptic (869/879, 99 %), a small number were focal seizures (10/879, 1.1 %), and none were generalised seizures.

Table 2
Types of events recorded.

Event type	Reports, n (%)	Reported events, n	Unreported events, n	Total events, n
Seizures	75 (13 %)	381	392	773
Probable psychogenic [a]	137 (23 %)	907	14	921
Other non-epileptic [b]	126 (21 %)	713	4[c]	717
Cardiac (clinically significant)	3 (0.5 %)	3[d]	1[e]	4
Unclassified [f]	83 (14 %)	–	–	231
Any type	295 (49 %)	2004	411	2646

[a] Mostly non-convulsive, with only 22 reports (3.7%) capturing *convulsive* psychogenic non-epileptic events.
[b] Heterogenous mix of events including (but not limited to) behavioural events, migraine symptoms, non-neurological symptoms, and symptom hypervigilance or over-zealous reporting.
[c] Four vocal/motor tics reported in one recording.
[d] Ictal bradycardia and ictal asystole in one recording, and sinus bradycardia/pause in another recording.
[e] Sinus pause of 6.8 s.
[f] Events not classified due to being off-camera or missing video or EEG data.

3.3. Diagnostic event capture and its determinants

A "diagnostic" event was captured in 41 % of recordings (246/600). Excluding eight reports where events were not time-stamped, Fig. 3 graphs the absolute and cumulative frequency of capturing a first diagnostic event on each day of consecutive recording. The mean time to diagnostic event was 1.5 days, and 86 % (204/238) of first diagnostic events occurred by the end of the fourth day of recording. Each subsequent day of recording continues to add diagnostic value, up until the end of the eighth day (Day 5: +6.7 %, Day 6: +3.4 %, Day 7: +2.9 %, Day 8: +1.3 % increase in cumulative frequency of diagnostic event capture).

Among demographic and clinical variables, reported event frequency ≥ 1/week was the only significant determinant of diagnostic event capture in both univariable (odds ratio 4.15, 95 % CI: 2.17 – 8.15) and multivariable (odds ratio 4.83, 95 % CI: 2.18 – 11.4) analysis. Age, sex, duration of recording, interictal abnormalities (epileptiform or non-epileptiform), and past history of epilepsy did not predict recording a diagnostic event in both univariate and multivariate analysis.

3.4. Yield in addressing the referring question

The clinical questions asked by the referrer were resolved in 53 % (317/600) of reports overall. This increased to 85 % (252/295) for reports capturing at least one event. Fig. 4 illustrates the diagnostic yield for each clinical question, and Table 3 describes the reasons for resolving and not resolving the differentiation and classification questions.

Diagnostic yield for event differentiation was 46 % (235/512). Where this question was resolved by event capture, the events were mostly non-epileptic (178/235, 76 %) rather than epileptic (39/235, 17 %). A number of studies were still able to resolve the question without capturing events (15/235, 6.4 %) by capturing interictal epileptiform activity alone in the correct clinical context. Seizure classification was achieved in 75 % (27/36) of recordings referred for this indication. Of note, over a quarter (10/27, 28 %) of recordings resolved the classification question with interictal epileptiform activity alone, without capturing any events. Quantification studies (n = 106) were not categorised, given the video-EEG report invariably resolves the referring question by either capturing or not capturing electrographic abnormalities.

Some reports may provide useful information for the referrer, even without strictly resolving the clinical question. For example, 39 studies had a reported event frequency ≥ 1/week (including some with multiple events per day), but did not capture any habitual events. Another subset of 22 studies referred for event differentiation captured interictal epileptiform activity, but were classified "not resolved" as the significance of the interictal abnormalities was unclear because the referrer provided minimal or no information about the patient's habitual events.

There were no significant differences between the adult and paediatric subgroups with respect to report findings and diagnostic yield (Table S2).

4. Discussion

4.1. Key findings

This study retrospectively examined a large series of ambulatory video-EEG reports, finding an event capture rate of 49 %, which in most cases (83 %) included a diagnostic event that resolved the referring question. Recording quality was high, with only 2.7 % of event-containing recordings having no on-camera events with both video and EEG data. Overall, 53 % of recordings resolved the clinical question, with yield varying based on the indication for monitoring. Event differentiation was resolved for 46 % of referral requests, with most

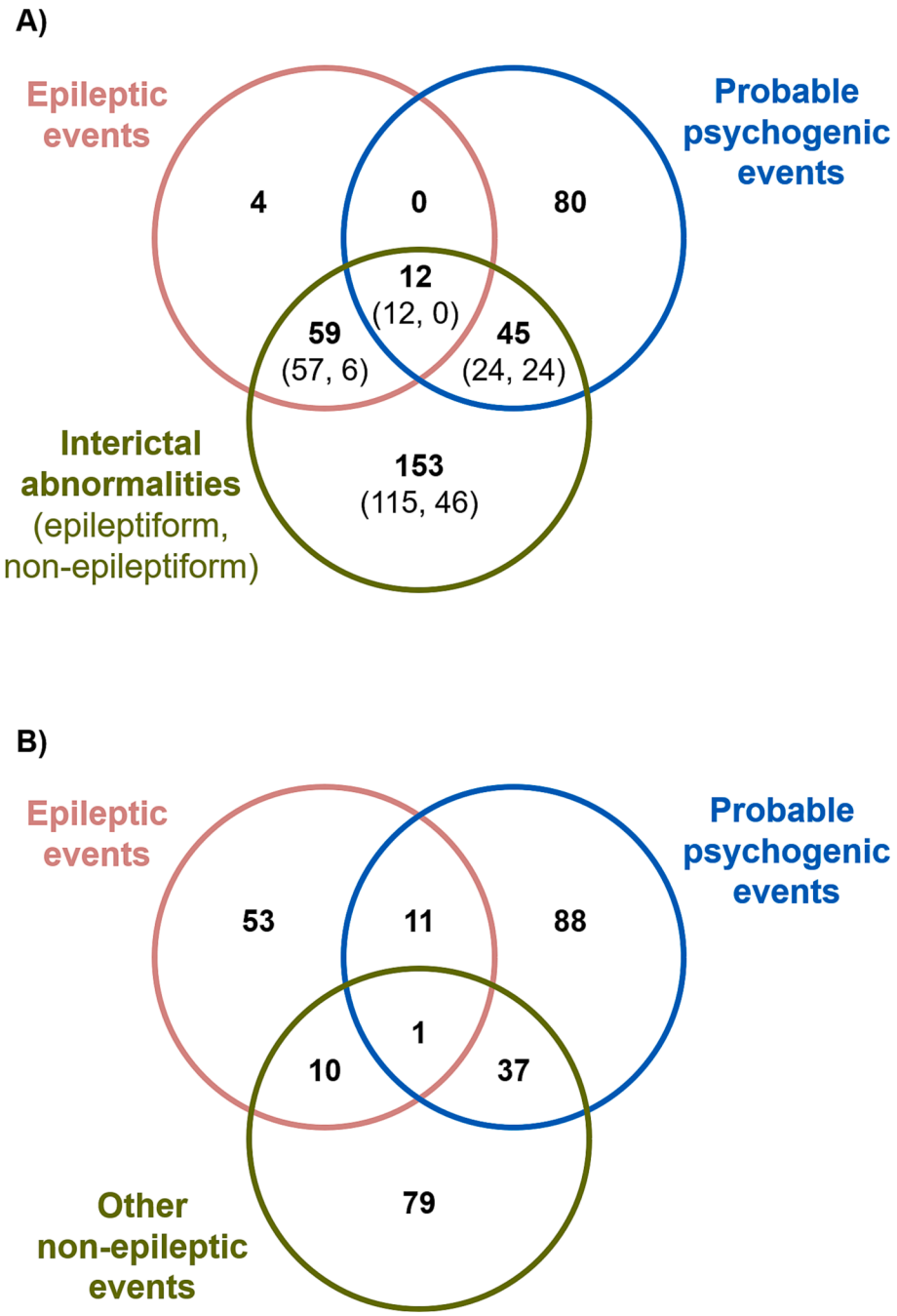

Fig. 1. EVENTS AND INTERICTAL ABNORMALITIES. A) Venn diagram illustrating the concurrent capture of interictal abnormalities among recordings with seizures, probable psychogenic non-epileptic events (convulsive and non-convulsive) or both. For the paired values in brackets indicating interictal abnormalities, the first value denotes number of reports with epileptiform discharges, and the second value denotes number of reports with non-epileptiform abnormalities. B) Venn diagram illustrating the distribution and overlap of the three different event types. Values denote number of ambulatory video-EEG reports in each subset. 305 reports captured no events, and 16 reports captured only unclassified events (events missing video or EEG data, and off-camera events).

patients (76 %) being diagnosed with non-epileptic events. Three-quarters of ambulatory video-EEG recordings successfully classified the seizure type or syndrome, when requested. Unreported seizures comprised around half (51 %) of all seizures captured, highlighting the issue of seizure unawareness and the value of ambulatory video-EEG monitoring in quantifying ictal (and interictal) activity. Yield was greatest in the first few days of recording, with each subsequent day continuing to add diagnostic value until the end of the eighth day.

4.2. Diagnostic yield

Diagnostic yield for event differentiation in our study was similar to previous studies with more than 100 participants. A recent prospective study found that 46 % of ambulatory video-EEG recordings referred for differentiation captured a typical event or epileptiform activity [10]; and others reported typical events in 47 % [11] and 56 % [12] of recordings. Event differentiation was the most common clinical question in our study, reflecting the difficulty in diagnosing epilepsy versus non-epileptic paroxysmal disorders. Indeed, 26 % of patients referred to a tertiary epilepsy clinic in Montreal had a final diagnosis other than

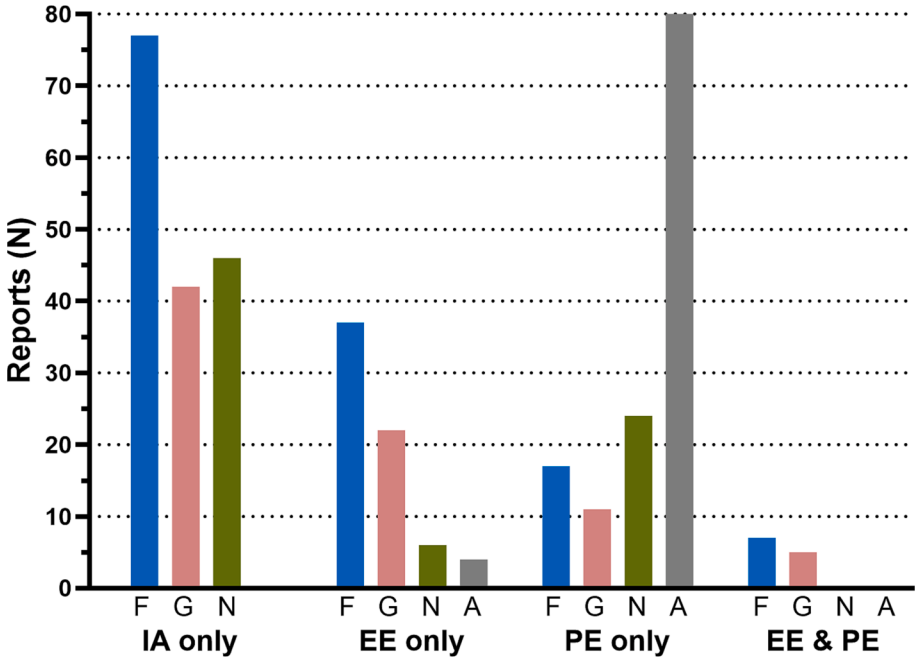

Fig. 2. DISTRIBUTION OF INTERICTAL ABNORMALITIES AMONG SUBGROUPS. F = focal, G = generalised, N = non-epileptiform, A = absent, IA = interictal abnormalities, EE = epileptic events, PE = probable psychogenic non-epileptic events.

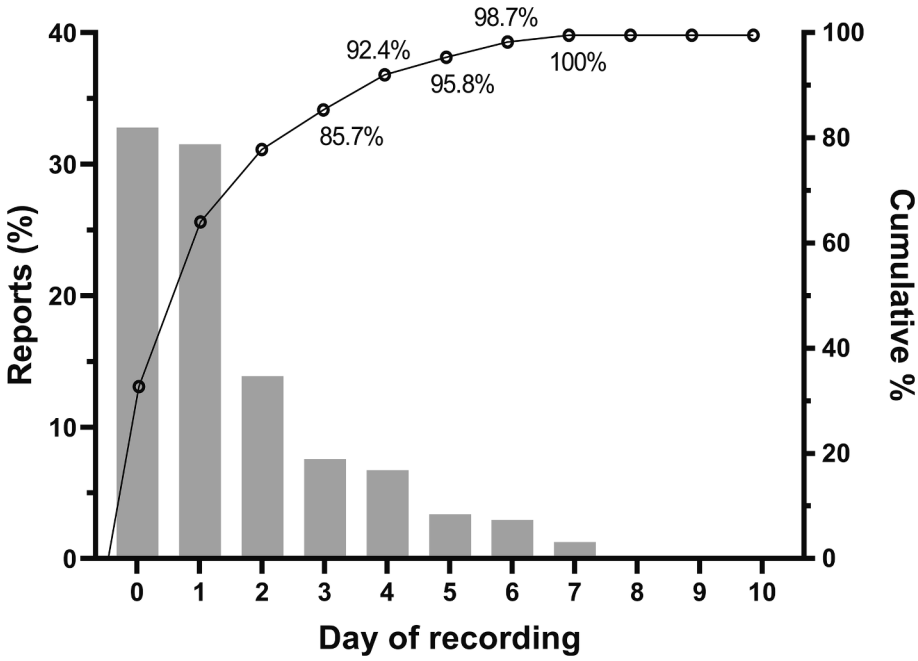

Fig. 3. TIME TO FIRST DIAGNOSTIC EVENT. Frequency (left Y-axis) and cumulative frequency (right Y-axis) of first diagnostic event (i.e. habitual event resolving the referring question) by day of recording. Each subsequent day of recording adds diagnostic value, up until the end of the seventh day.

epilepsy [13], and others have documented misdiagnosis rates for epilepsy as high as 30 % [14]. Therefore, ambulatory video-EEG monitoring serves a valuable tool in interrogating events that remain undifferentiated despite clinic assessment and prior EEG.

Other indications for ambulatory video-EEG monitoring are less well studied. Six percent of reports in this study requested seizure classification, with a yield of 75 %. This was comparable to the 85 % yield documented by an early study of 34 patients re-directed to ambulatory video-EEG from an inpatient video-EEG waitlist, who were mostly referred for seizure classification [15]. Quantification of seizure activity was requested in 17 % of reports in this study, however no referrers requested localisation of seizure focus. This may be because referrals for prolonged video-EEG monitoring for localisation typically occur in the pre-surgical context, where ictal SPECT imaging and provocative measures are often indicated but restricted to the inpatient setting. Indeed, very few have attempted using ambulatory video-EEG monitoring in the evaluation for epilepsy surgery [16,17].

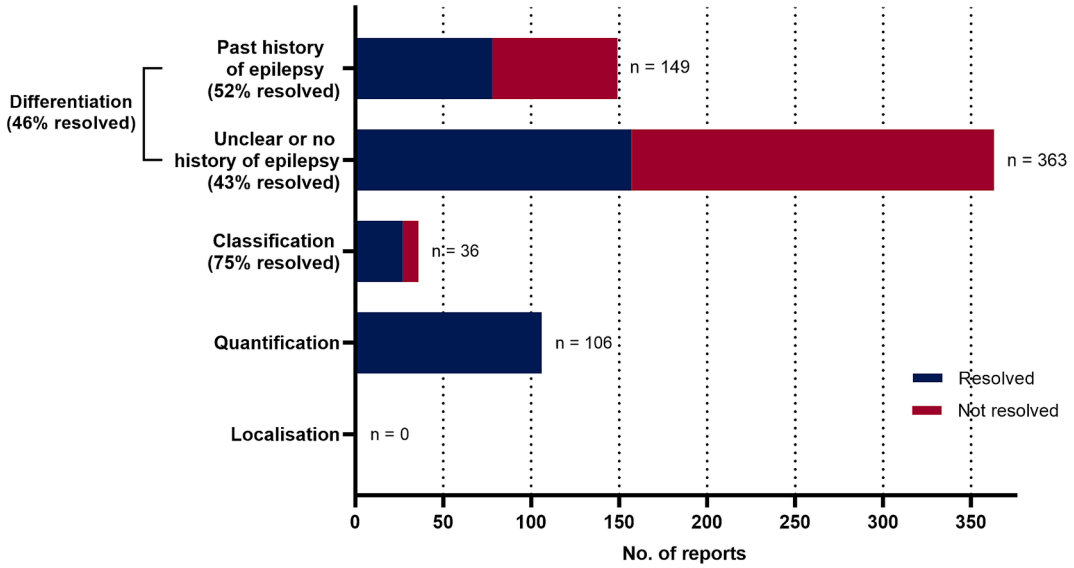

Fig. 4. DIAGNOSTIC YIELD. Diagnostic yield with respect to resolving each referring clinical question. Quantification was not categorised, given the video-EEG report invariably resolves the referring question by either capturing or excluding seizures and epileptiform activity. No reports requested localisation of seizure focus.

Table 3
Reasons the clinical question was resolved or not resolved – event differentiation and seizure classification.

DIFFERENTIATION			n = 512
	Past history of epilepsy?		*Reports, n (%)*
	Yes, n (%) (n = 149)	*Unclear/No, n (%) (n = 363)*	
Resolved	78 (52 %)	157 (43 %)	235 (46 %)
Reason resolved			–
Seizure(s) captured	21 (14 %)	18 (5 %)	39 (8 %)
Non-epileptic event(s) captured	53 (36 %)	125 (34 %)	178 (35 %)
Diagnostic IEDs in correct clinical context	4 (3 %) [a]	11 (3 %)	15 (3 %)
Cardiac event(s) captured	0 (0 %)	3 (1 %)	3 (1 %)
Not resolved			277 (54 %)
Reason not resolved			–
No events captured			235 (45 %)
Event(s) captured but not representative			24 (5 %)
Event(s) captured but unclear if representative			13 (3 %)
Event(s) captured but missing event data			5 (1 %)
CLASSIFICATION			n = 36
			Reports, n (%)
Resolved			27 (75 %)
Reason resolved			–
Seizure(s) captured			17 (46 %)
Diagnostic IEDs			10 (28 %)
Not resolved			9 (25 %)
Reason not resolved			–
No events captured			9 (25 %)

[a] Patients with a past history of epilepsy referred for monitoring to confirm their events were epileptic.

4.3. Event capture

Approximately half of all recordings in this study captured at least one event, slightly lower than the 55–85 % event capture rate reported across other ambulatory video-EEG studies [5,6,10–12,15,18,19]. This may be attributed to selection criteria, with higher capture rates observed in studies of patients reporting at least two events per week [18], or patients selected for suitability by the referring neurologist [5]. It is perhaps unsurprising that our data and a recently published study both showed that reported event frequency predicts capturing typical events during ambulatory video-EEG monitoring [20]. With respect to the timing of habitual events that resolved the referring question, 92 % occurred by the end of the fifth day of recording, comparable to previous inpatient video-EEG studies [21,22].

When examining patterns of event capture and interictal abnormalities, there were some notable observations. Firstly, among events occurring amidst a normal interictal trace, only a small number (~1%) were focal seizures and the remainder were non-epileptic events. Therefore, a habitual event occurring in the context of a normal prolonged ambulatory trace may carry a high negative predictive value for epilepsy. For patients with focal seizures, one in six did not have IEDs on scalp EEG when monitored in an inpatient video-EEG unit for at least three days [23], comparable to the rate (one in eight) seen in this study. Secondly, the first seizure was more likely to follow the first probable psychogenic event among recordings with both event types. Thus, it is important to not assume a diagnosis is made by the first event, and to continue monitoring for the planned duration to maximise the chance of capturing all different habitual events experienced by the patient.

4.4. High rate of unreported seizures

This study observed that unreported seizures were frequent in the ambulatory setting, occurring in more than half of all recordings with seizures, and accounting for more than half of all seizures captured. Indeed, 95 % of unreported events were seizures, suggesting unreported events may carry a high predictive value for a diagnosis of epilepsy. In the literature, studies show that more than 50 % of seizures are unreported by patients and caregivers [24], and intra-individual and inter-individual variance is high [25,26]. Therefore, ambulatory video-EEG monitoring serves an accessible means of objectively quantifying seizure activity in a population where self-reporting of seizures is known to be unreliable.

Importantly, in patients with epilepsy, the significance of the high rate of unreported seizures with respect to morbidity and mortality outcomes remains unclear. To the best of our knowledge, there are minimal studies correlating unreported seizures with sudden unexpected death in epilepsy or epilepsy-related injuries and accidents [27,28]. Thus, further work is needed to elucidate the role of reported and unreported seizure counts in assessing treatment response.

4.5. Comparison with other forms of prolonged EEG monitoring

Pooled diagnostic yield for ambulatory video-EEG monitoring in this study was 53 %, which compares with 26 % to 89 % for ambulatory EEG without video [2,29–31], and 19 % to 75 % for inpatient video-EEG monitoring [32]. Given these heterogenous results, which likely reflect differences in cohort, methodology, endpoints and indications for monitoring, comparison between different forms of prolonged EEG monitoring is challenging [2]. Nonetheless, high rates of unreported seizures are a consistent finding, with fewer than 50 % (47 % to 63 %) of seizures reported by the patient during inpatient EEG monitoring [24].

The addition of video to ambulatory EEG recording provides the ability to objectively correlate event semiology with the EEG. An early study found that using a take-home camcorder assisted the interpretation of ambulatory EEG in 82 % of patients [6]. In another cohort, a "confident diagnosis" was established in 100 % of ambulatory EEG recordings with an event captured on video, compared to 55 % of recordings with events not on video [18].

Given the relatively resource intensive nature of inpatient video-EEG, patients are often carefully selected and may undergo provocation measures to maximise event capture [33]. Unsurprisingly, inpatient rates of seizure capture were higher among patients with anti-seizure medication reduction, and patients referred for pre-surgical evaluation [34]. In prospective studies comparing ambulatory to inpatient video-EEG monitoring, one found that ambulatory studies captured more events in total but fewer representative events and epileptiform abnormalities [10], whereas another reported similar yield for answering the diagnostic question [5]. Interestingly, ambulatory EEG (without video) contributed to a clinical diagnosis of epileptic or psychogenic events in 48 % of patients even after non-diagnostic inpatient video-EEG monitoring, highlighting the value of prolonged home monitoring [35]. The yield and prevalence of the converse, that is, inpatient video-EEG monitoring *after* ambulatory video-EEG monitoring, is not known from the present study and may be an important question for future work.

4.6. Limitations of this study

Due to its retrospective design, findings from this study should be interpreted carefully. Results may not be entirely generalisable to other populations with different referral patterns or ambulatory video-EEG protocols. We also did not examine whether diagnostic yield varies depending on the referral source (e.g. epileptologist, general neurologist, or non-neurologist). Since reports were analysed rather than raw video or EEG data, misclassification of events and interictal abnormalities may have occurred due to inter-observer variability in EEG interpretation, or bias from the reporting scientist and neurologist. For example, events without electrographic change were classified as psychogenic if the patient and scientist description of the event reasonably satisfied the International League Against Epilepsy definition [9]. However, we were unable to interrogate patients regarding their symptoms, nor view the video or EEG directly, therefore these events were termed "probable psychogenic".

Given the reports were in free-text format, there was an inevitable degree of subjectivity when categorising the referring question and whether it was "resolved". This process was even more difficult in some cases where the referrer provided minimal clinical information. Furthermore, a small number of events labelled "non-epileptic" could in fact be minor focal seizures not captured on scalp EEG, but this was felt unlikely to significantly affect the results.

An innate limitation of our study (and previous studies) is that measuring diagnostic yield does not necessarily reflect the breadth of clinical information a video-EEG recording provides. Prior studies typically used the capture of representative events and IEDs to assess diagnostic yield, whereas this study focussed on whether the referring question was "resolved". However, the clinical information gained from ambulatory video-EEG monitoring is more nuanced than binary outcome measures, and may be useful to the referrer even when the clinical question is "not resolved". For example, some reports herein captured no events despite a clinical history of at least weekly events (n = 38), which may indicate an unreliable historian or perhaps a cyclical event pattern depending on clinical context. When assessing treatment response, an ambulatory video-EEG recording without electrographic abnormalities is also informative, and may guide medication titration. Therefore, this study likely underestimates the utility of ambulatory video-EEG monitoring in practice.

5. Conclusion

Prolonged ambulatory video-EEG recordings were of high quality and diagnostic value in capturing clinically relevant events, and offer a practical alternative to inpatient video-EEG in the appropriate setting. Ambulatory studies are effective at resolving referring questions regarding differentiation of epileptic from other paroxysmal events, seizure classification, and quantification of seizure activity. Patients reporting more frequent events carry a higher pre-test probability for addressing the clinical question. High rates of unreported epileptic seizures were observed. Future studies should examine whether presence or frequency of unreported seizures is associated with outcomes in patients with epilepsy, to determine the optimal treatment target. It will also be worthwhile assessing how ambulatory video-EEG monitoring impacts management beyond the clinical question.

CRediT authorship contribution statement

Michael C. Li: Conceptualization, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Udaya K. Seneviratne:** Investigation, Writing – review & editing. **Ewan S. Nurse:** Conceptualization, Resources. **Mark J. Cook:** Conceptualization, Supervision. **Amy J. Halliday:** Conceptualization, Investigation, Methodology, Writing – review & editing.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Michael Li reports administrative support was provided by Seer Medical Pty Ltd.

Mark Cook & Ewan Nurse reports a relationship with Seer Medical Pty Ltd that includes: board membership.

1. Chief Medical Officer of Seer Medical - M.C.
2. Director of Epilepsy Research at Seer Medical - E.N.

If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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