Original Article

Video-EEG Long Term Monitoring as a new service at Mater Dei Hospital

Gilbert Gravino, Bernard Galea, Doriette Soler, Norbert Vella, Josanne Aquilina

Abstract

Introduction: Video-EEG long-term monitoring (LTM) was introduced into Mater Dei Hospital (MDH) in May 2012. The audit aims to evaluate LTM in terms of diagnostic outcomes and impact on patient management.

Methods: Analysis was carried out after retrospective review of 30 inpatients who underwent LTM at MDH between May 2012 and May 2014. 31 LTM sessions were performed. Referrals were made by 3 consultant neurologists. LTM and medical records were compared to evaluate whether LTM determined a change in diagnosis and how this affected management outcomes.

Results: Patient ages ranged from 3 months to 73 years (35.5% paediatric cases) (16 male , 15 female studies). The most common indication was for uncontrolled seizures (54.8%), followed by suspected non-epileptic seizures (NES) (29%). The average hospital stay was 2 days for paediatric patients and 5 for adult cases. Major monitoring interruptions were recorded in 5 paediatric and 1 adult case. Comparing pre- with post-LTM diagnosis showed that the investigation changed or identified a new diagnosis in 38.7%, confirmed the diagnosis in 29%, and was inconclusive in 32.3% (inconclusive in 45.5% of paediatric cohort and 25% of adult cohort). It led to medication optimisation in 38.7% and neuropsychiatry referrals in 22.6%. The remaining were unchanged, not followed up or referred for other tests. None were referred for surgery.

Conclusion: LTM is an important tool which influenced patient management through changes in medication or referrals in 64.5% of cases. Continuous evaluation of the techniques used and resources available is recommended to increase the yield of conclusive LTM studies.

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epileptic seizures, non-epileptic seizures, video-EEG monitoring.

Introduction

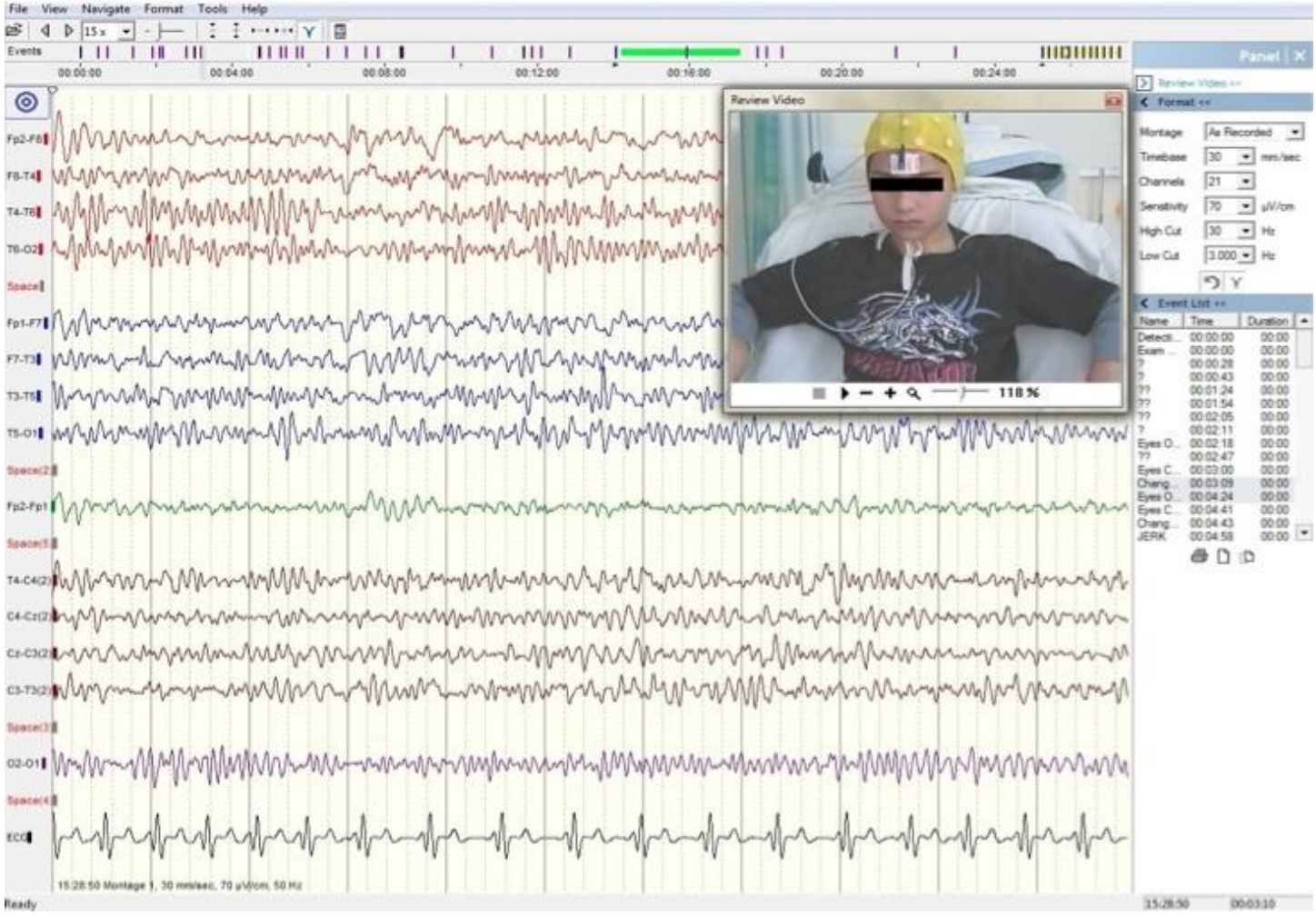
Long term Video-Electroencephalography (EEG) Telemetry Monitoring (LTM) combines two investigative approaches, video imaging and EEG recording, which are viewed simultaneously and in synchrony (Figure 1). This technique was initially used exclusively in specialised units and only reserved for specific circumstances. However, advancements lead to more readily available equipment allowing its introduction into different clinical settings which now include tertiary hospitals, general hospitals, and outpatient clinics.[1] The practice has also been introduced into Mater

Dei Hospital, Malta since May 2012, where inpatient LTM is being used by the neurologists for diagnostic purposes.

The consensus definition by the International League Against Epilepsy (ILAE) and the International Bureau for Epilepsy (IBE) explains that an epileptic seizure (ES) is the "transient occurrence of signs and/or symptoms due to abnormal excessive or synchronous neuronal activity in the brain".[2] NES refer to paroxysmal changes in behaviour mimicking true epileptic seizures, but have no electrophysiological correlate (not associated with abnormal electrical discharges in the brain) or clinical evidence for epilepsy.[3-6] These can either be due to organic causes or due to psychogenic causes. Organic causes of NES include syncope, motor tics, transient ischaemic attacks, narcolepsy, hemiplegic migraine, paroxysmal vertigo, cardiac arrhythmias and hypoglycaemia.[7] Psychogenic NES (PNES) are known as such due to their emotional and psychological nature.[6]

Video-EEG LTM can potentially help in the prevention of misdiagnoses and therefore also prevent inappropriate treatment regimens. This study aims to evaluate the usefulness of LTM in terms of its indications, its diagnostic outcomes and its role in influencing patient management. It is also intended to help establish the extent to which LTM is achieving its expected outcomes.

Figure 1: *Video -EEG Long Term Monitoring Software*



Methods

Video-EEG LTM Protocol

After an LTM referral to MDH, both adult and paediatric patients are admitted to the neuromedical ward (NMW) which has the necessary facilities. During their stay they are attended continuously by family members and nursing staff. Upon admission each patient undergoes a detailed neurological examination. The patient is placed in a single room where the LTM equipment is set up. Viasys Healthcare system is used for neurophysiological monitoring and NicVue is the software that enables processing of data. Equipment includes the wall mounted cameras which are connected to a central server and EEG monitoring using the 10-20 international system for electrode placement. The video and EEG signals are displayed simultaneously for online observation. All data is recorded in a digitally referential format and then the montage is reformatted for later review. Automated computer detection software allows identification of interictal epileptiform discharges, which greatly reduces the amount of raw data that need to be reviewed for reporting purposes. The patient is also given an event button to activate when an event is experienced. This helps notify medical staff so that they can witness the live event and ensures video-EEG review of that episode.

During recording some patients are subjected to potential epileptic triggers which are also used in conventional EEG monitoring. These include hyperventilation, photic stimulation and sleep deprivation. Tapering of anticonvulsant medication is used in very few cases and placebo drug administration has never been used locally.

The referential video-EEG montage is reviewed and reported by the referring consultant neurologists.

Data Collection

The study was approved by the ethics committee at MDH. A retrospective review of 30 inpatients who underwent LTM at MDH between May 2012 and May 2014 was carried out. Over this 2 year period, 31 VEM sessions were performed, with one patient having done the LTM twice. All patients were referred for monitoring by 3 consultant neurologists at MDH; 2 consultant adult neurologists and 1 consultant paediatric neurologist. The Video-EEG results and medical records were used to collect data on a structured proforma for comprehensive data collection. The data was evaluated using descriptive statistical analysis and the results are expressed as absolute numbers and percentages.

The outcomes were classified as 'conclusive' (successfully diagnosing ES or NES) or 'inconclusive' (uneventful sessions or those with inability to clarify the nature of events).

Results and discussion

Adding videography to EEG is advantageous since it allows correlation between clinical events and EEG activity. The simultaneous recordings and playback of the EEG and clinical events facilitates review and specialist discussions, thereby yielding better diagnostic outcomes.[8] LTM has also been regarded as 'an important auxiliary diagnostic instrument in epilepsy'.[9] However, this method of evaluating patients is resource intensive and also has its disadvantages which must be recognised in order to avoid its unnecessary use. These include the high costs associated with hospital admission, patient discomfort, the fact that it is highly time consuming and the need of highly trained staff to manage the equipment during the procedure.[10-11]

This audit included a total of 30 patients. One patient had the LTM study performed twice for different indications. 64.5% (n=20) of LTMs were performed on adults and the other 35.5% (n=11) were paediatric patients (< 18 years). The age ranged from a 3 month infant to 73 years. In total, 16 male studies and 15 female studies were performed. In many of the previous study reports, women constituted the majority of the patient population undergoing LTM.[12-17] Lobello et al. (2006) suggested that this may represent a selection bias on the part of clinicians, such that more women are suspected of having PNES and are therefore monitored for this purpose.[12] However, data collection from this audit is not in keeping with this observation since there was one more male LTM study than female study. In fact, the patient having the LTM done twice was male, which makes the actual male to female patient ratio 1:1.

Reduction of anticonvulsant therapy

The reduction of anticonvulsant therapy was only implemented in two LTM studies (6.5%). One was a 27 year old patient known to suffer from complex partial seizures which had increased in frequency and was on Sodium Valproate,

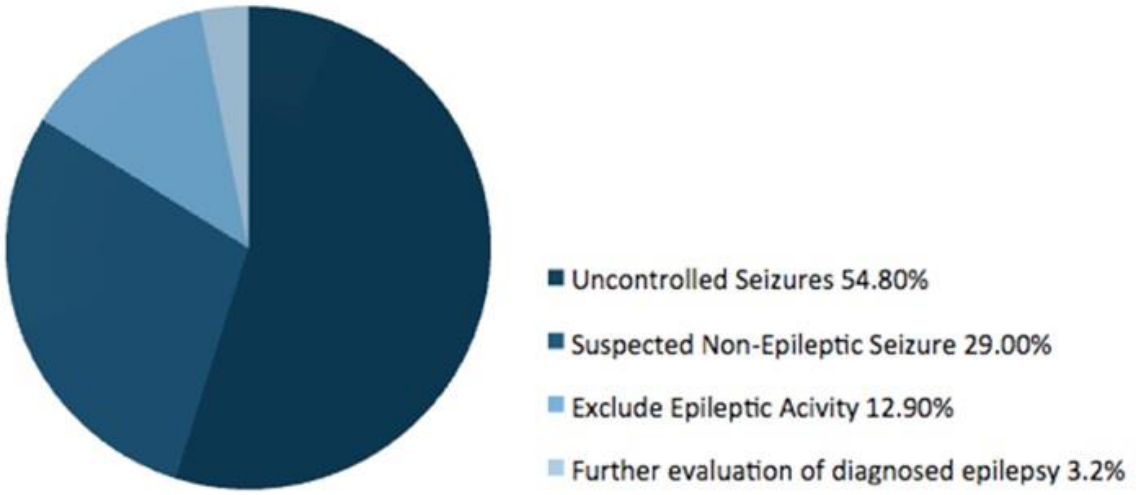
Topiramate, Levetiracetam, and Pregabalin. The latter was stopped on days 3 to 5. This patient had a habitual clinical event after withdrawal but was diagnosed with NES. The other was a 21 year old patient with uncontrolled seizures who was on Sodium Valproate and Methylphenidate. The former was stopped on days 4 to 5. This patient also had a clinical event after drug withdrawal but no significant EEG changes were recorded and the LTM outcome was inconclusive.

A study by Risvi et al. (2014) reported that combined sleep deprivation and protocol driven withdrawal of antiepileptic medication is a safe and effective investigative technique with no adverse long-term sequelae. However, some other LTM studies reported no improvement in recoded events when withdrawing drugs.[18] Chen et. Al (1995) reported that there was no statistical difference in the rate of capturing habitual events between children with and without antiepileptic drugs withdrawn.[19]

Indications for LTM studies (Figure 2)

The most common indication for LTM in this audit was uncontrolled seizures (54.8%, *n*=17), followed by suspected NES (29%, *n*=9). The remaining 16.1% (*n*=5) of LTMs were indicated for other purposes; 'exclude epileptic activity' (12.9%, *n*=4) and to acquire a baseline for frequency and duration of seizures before starting a new treatment (3.2%, *n*=1).

Figure 2: *Indications for Video -EEG Long Term Monitoring*



As the availability of this diagnostic tool became more widespread, indications for its use have also increased. Generally, studies report that the most common indications are the diagnoses of epilepsy syndrome, identifying the nature of other paroxysmal events and diagnose non-epileptic causes, quantifying the frequency and duration of seizures, and identifying candidates for surgery.[1,20] The majority of indications in many centres are in fact intended to differentiate between true epileptic seizures due to epilepsy syndrome ES and NES.[13]

No patients at MDH were referred for LTM as potential surgical candidates since this service is not available locally. However, this is a major indication in other institutions for highly selected patients with intractable epilepsy where they may also be investigated with intracranial telemetry.[21] Intracranial telemetry is performed for localization of the ictal onset zone or functional mapping.[22] The rationale for surgical treatment is excision of the epileptic zone (EZ).

Duration of LTM studies

The length of stay (LOS) in hospital for the LTM studies ranged from a minimum of 1 day to a maximum of 5 days. All adult cases were at least 3 days long. 5 day studies were performed in a total of 19 (61.3%) LTMs, including both adults and paediatric cases. The estimated average LOS for all the cohort was 4 days. It was 2 days for paediatric patients alone and 5 days for adult cases. Major monitoring interruptions (defined by the patient having to leave the hospital and then return to continue the monitoring) were recorded in 6 cases, 5 of which were paediatric cases.

These results are in keeping with the LOS

reported by other studies. In many centres the average LOS for children (adolescents aside) is 1.2–1.5 days, whereas 3–4 days are more typical LOS for adults (including the elderly).[1] Given the shorter hospital stay for paediatric cases, several centres have reported on the utility of using Video-EEG in the outpatient setting.[11,23] Nordli (2006) suggests that adding a brief video to a routine EEG can increase the diagnostic yield, particularly when there are frequent paroxysmal events.[1]

Capturing events

Overall, 80.6% (*n*=25/31) of LTMs recorded some sort of event (clinical event or significant EEG changes). In turn, only 32% (*n*=8/25) of these showed both clinical changes and abnormal EEG findings. Some clinical phenomena occurred without any EEG changes and *vice versa*. In fact, 71% (*n*=22/31) of cases reported a clinical event during the LTM and only 35.5% (*n*=11/31) recorded an actual EEG event. The rate of capturing seizures or clinical habitual events varies between studies. An adult study by Lobello et el. (2006) reported an overall capturing rate of 83.9%, whereas capturing rates in paediatric studies range from 53% to over 80%.[1,11,19,24-26] The difference in reported rates may be attributed to multiple factors such as frequency of the habitual events and adjustment of anti-epileptic medications.[24] In paediatric studies it has been suggested that selection of children with daily seizures is an important factor associated with a high chance of capturing habitual events.[11,19]

Overall, 64% (*n*=16/25) of patients who had an event did so during the first 2 days of admission. 48% (*n*=12/25) had their first event on day 1 and 16% (*n*=4/25) had their first event on day 2. This is comparatively lower to the results in a study by Lobello et al. (2006) which reported 87.7% of LTMs having their first event in the first 2 days of admission.[1]

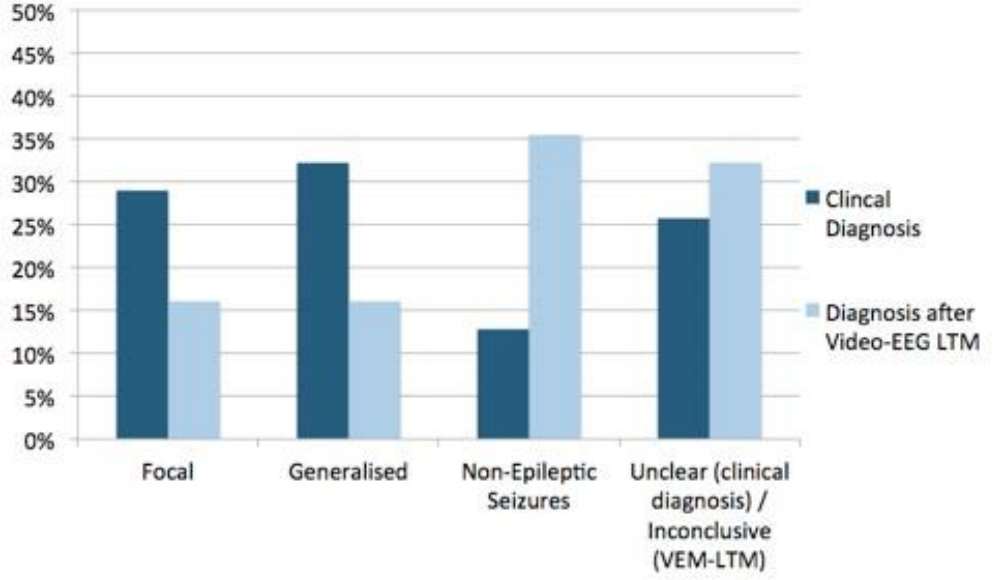
Imaging and routine EEG findings

The routine EEGs against which LTMs were compared showed that 64.5%(*n*=20) were normal and 32.3% (*n*=10) were abnormal. In one case the routine EEG was not found in the patient's records. Imaging studies in the form of either a CT scan or MRI scan was found to be normal in 80.6% (*n*=25), abnormal in 9.7% (*n*=3), and 9.7% (*n*=3) did not have any imaging done.

Diagnosis

The clinical diagnosis for the audited cases (i.e. before LTM investigation) were 29% focal onset epilepsy, 32.3% generalised epilepsy, 12.9% NES and 25.8% were unclear. The LTM studies rendered changes, with the diagnoses becoming 16.1% focal, 16.1% generalised, 35.5% NES and 32.3% remained inconclusive (Figure 3). In the paediatric cohort 45.5% of LTMs were inconclusive, whereas a 25% inconclusive rate was recorded in the adult cohort.

Figure 3: *Diagnoses pre- and post- Video-EEG Long Term Monitoring*



Overall, this translates into the LTM studies changing or identifying a new diagnosis in 38.7% (*n*=12), confirming the diagnosis in 29% (*n*=9), and inconclusive in 32.3% (*n*=10) (Figure 4).

These LTM results led to medication optimisation in 38.7% and neuropsychiatry referrals in 22.6%. In 19.4% there was no management change and 16.1% had no follow up recorded (Figure 5). One case (3.2%) was simply referred for further cardiovascular investigation with 24 hour blood pressure and Holter ECG monitoring. None were referred for surgery. The results are comparatively better than the results in a study (including all age groups) by Alsaadi et al. (2004) which reported a change in diagnosis in 24% after LTM.[27] Elderly LTM studies by Keranen, Rainesalo & Peltola (2002) and Lancman et al. (1996) reported the change in either diagnosis or treatment as 38.9% and 55% respectively.[14-15]

Further analysis of the 21 patients with conclusive outcomes revealed that the most prevalent diagnosis was NES in 52.4% and ES followed with 47.6%. The higher prevalence of NES has also been reported in other previous studies.[13-14] The cohort diagnosed with true epileptic seizure after LTM was made up of 60% (*n*=6/10) male and 40% (*n*=4/10) female, whereas those diagnosed with NES were 27.3% (*n*=3/11) male and 72.7% (*n*=8/11) female. This higher prevalence of NES in females is in keeping with other studies.[1]

Figure 4: *Outcomes of Video-EEG Long Term Monitoring*

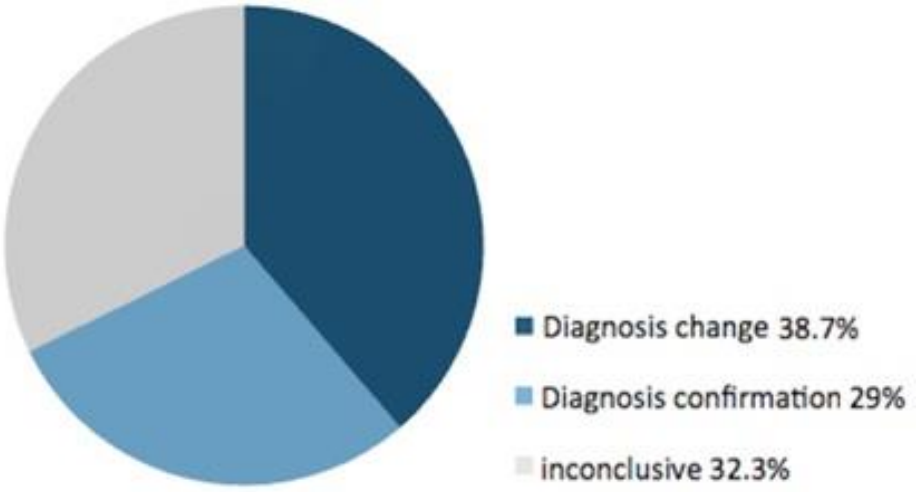
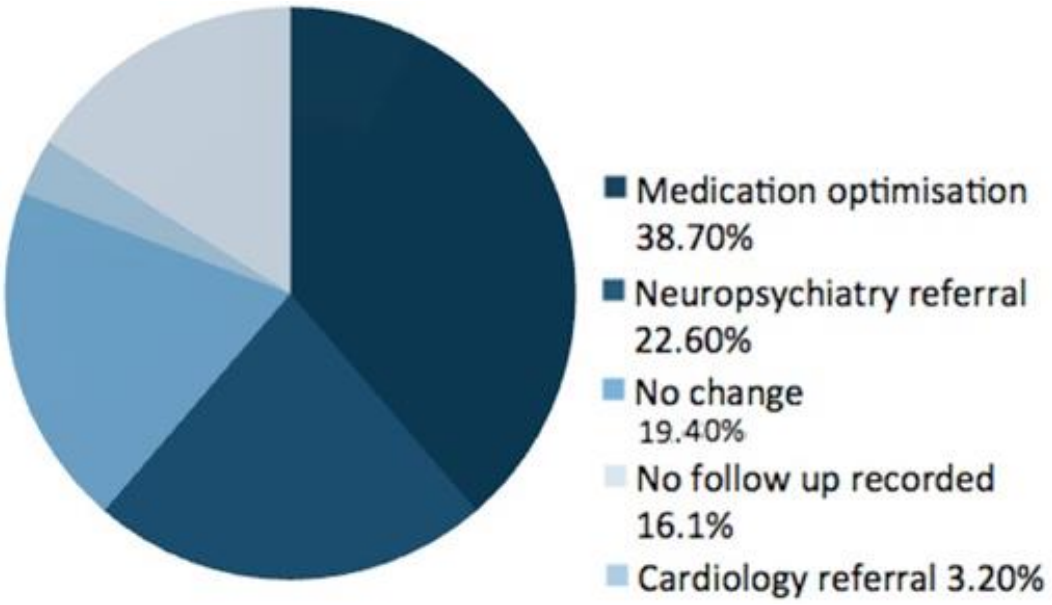


Figure 5: *Management Outcome after Video-EEG Long Term Monitoring*



Differentiating Epilepsy Syndrome from Non-Epileptic Seizures

Differentiation between ES and NES, particularly PNES, is a major problem. In fact, discriminating between ES and PNES can be difficult even for experienced physicians.[27] Without LTM clinicians cannot witness the seizures and therefore are forced to make the diagnosis based on the history and the witness' descriptions and routine EEG. Descriptions can often be misleading due to inaccuracy, and EEG has been reported to show normal activity on initial testing in 40% of true epileptic patients.[28] Moreover, If no EEG paroxysms become evident during a seizure it does not completely exclude the possibility of a true epileptic seizure since deep cerebral discharges may not be detected by surface electrodes.[29-30]

There is also difficulty in interpreting EEG findings. True epileptic seizures may sometimes show ictal EEG changes which are not 'epileptiform' and patients diagnsoed with PNES have also been reported to have 'epileptiform' EEGs.[1,31] However, a study by Benbadis and Tatum (2003) evaluated patients diagnosed with PNES and having epileptiform abnormalities reported by neurologists (not epileptologist or electroencephalographers), and identified that none of them had true epileptiform abnormalities.[32] Instead findings included multiple normal variants (wicket spikes, hypnagogic hypersynchrony, and hyperventilation-induced slowing), as well as overreading of simple fluctuations of sharply contoured background rhythms. This explains why epileptologists regard EEG "over-reading" as being more harmful than "under-reading".

Diagnosis may therefore be erratic in three main ways:

1. Diagnosis of PNES despite actual ES
2. Diagnosis of ES despite a psychogenic aetiology
3. Unrecognised coexistent PNES and ES

The latter has been reinforced by studies reporting that PNES and epilepsy coexist in 10-13% of cases.[3,17,33-34] This presents a further diagnostic challenge. All these errors have huge implications on patient management. The correct management plan requires antiepileptic drugs (AED) tailored to each patient's epileptic syndrome and psychological therapy to target any psychosocial factors.[35-36]

Differentiating between ES and PNES is extremely important since unnecessary AED treatment is costly and has potential side effects, and undiagnosed/untreated ES is associated with morbidity and mortality (including sudden unexpected death).[12] In addition, early recognition of PNES is associated with better outcomes.[16] These consequences emphasise the need for a diagnostic tool such as video-EEG LTM which helps to prevent such errors. The tool helps minimise these mistakes but still carries the risk that some patients having both ES and NES can get an incomplete diagnosis if only one of these is captured during LTM.

Paediatric video-EEG LTM

Video-EEG LTM in children, although similar to adult LTM, has been noted to present additional challenges. Reported literature identifies the following difficulties encountered in paediatric LTM[24,37-39]:

- a parent or guardian is almost always required to stay with the patient
- children may not tolerate lengthy admissions
- accurate estimation of seizure frequency (which in turn has been associated with higher chance of capturing habitual event) is difficult when based on the information from the parents alone, since seizures are often very subtle.

Additionally, MDH lacks dedicated facilities for paediatric LTMs (instead, these are performed in the adult NMW which does not provide the desired environment) and is short in nursing staff who can provide dedicated monitoring of children overnight. Therefore, the higher rates of interrupted studies and inconclusive outcomes observed in paediatric cases may be attributed to these limitations. It is very important to consider these shortcomings when evaluating the usefulness of paediatric LTM.

Conclusion and suggestions

Video-EEG LTM at MDH has proved to be an important tool for proper understanding of the problem, and consequently proper handling and management. It helped change or identify a new diagnosis in 38.7% and confirmed the diagnosis in 29%. It also influenced patient management by leading to changes in medication and appropriate referrals in 64.5% of the cases. Knowing the exact diagnosis reassures the patient and the physician, and enables clinicians to choose the most suitable treatment avoiding unnecessary empirical trials with

anticonvulsants. The information from this audit is useful both for the clinical neurologist and the patients in that it provides what can be expected from subsequent video-EEG LTM sessions.

The audit also highlights areas for improvement. There must be continuous evaluation of the techniques used and the resources available in order to increase the yield of conclusive information that LTM studies can provide. The audit led to a number of suggestions:

1. Acquire a base-line EEG on admission to be used for comparison with LTM results, rather than using an older routine EEG.
2. Review the character of each LTM event on video with patient and family so as to ensure that the episode recorded was representative of typical events that had led to the monitoring evaluation.
3. Consider developing dedicated facilities for paediatric LTM and increasing dedicated nursing stuff, both of which may help improve the rate of conclusive paediatric LTM studies.
4. Repeat the audit with more exhaustive data collection and include patient follow-up after LTM diagnosis and management change confirm that the this led to an improvement in patients' well being.
5. Retrospective collection of data for this audit meant that some relevant information was not easily available or not available at all. This includes frequency of seizures, typical duration of each habitual event, accurate dates for symptom onset and routine EEG results. A dedicated proforma for patients undergoing Video-EEG LTM may help with a more comprehensive gathering of data. It would facilitate clinical practice as well as future auditing and research in epilepsy.

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