

Current Practice and Recommendations in UK Epilepsy Monitoring Units. Report of a national survey and workshop.

Authors: Khalid Hamandi, Sandor Beniczky, Beate Diehl, Rosalind H Kandler, Ronit M Pressler, Arjune Sen, Juliet Solomon, Matthew C Walker, Manny Bagary, with ILAE British Chapter Workshop Attendees.

Affiliations:

Khalid Hamandi, The Welsh Epilepsy Centre, University Hospital of Wales, and Cardiff University Brain Research Imaging Centre, Cardiff, UK.

Sandor Beniczky, Department of Clinical Neurophysiology. Nørrebrogade 44. 8000 Aarhus C, Denmark.

Beate Diehl, Institute of Neurology, University College London and National Hospital Neurology and Neurosurgery, Queen Square, London, UK.

Rosalind H Kandler, Sheffield, Teaching Hospitals, Sheffield, UK.

Ronit M Pressler, Great Ormond Street Hospital for Children NHS Foundation Trust London, UK.

Arjune Sen, Oxford Epilepsy Research Group, NIHR Biomedical Research Centre, Nuffield Department of Clinical Neurosciences, John Radcliffe Hospital, Oxford, UK.

Juliet Solomon, Executive Director, International League Against Epilepsy British Chapter, Institute of Neurology, Queen Square, London, UK.

Matthew C Walker, Institute of Neurology, University College London and National Hospital Neurology and Neurosurgery, Queen Square, London, UK.

Manny Bagary, Regional Complex Epilepsy and Sleep Service, Barberry Centre, BSMHFT, Birmingham, UK.

Word count: 3627

Tables and figures: 3

References: 45

Abstract

Purpose. Inpatient video-EEG monitoring (VEM) is an important investigation in patients with seizures or blackouts and in the pre-surgical workup of patients with epilepsy. There has been an expansion in the number of Epilepsy Monitoring Units (EMU) in the UK offering VEM with a necessary increase in attention on quality and safety. Previous surveys have shown variation across centres on issues including consent and patient monitoring.

Method. In an effort to bring together healthcare professionals in the UK managing patients on EMU, we conducted an online survey of current VEM practice and held a one-day workshop convened under the auspices of the British Chapter of the ILAE. The survey and workshop aimed to cover all aspects of VEM, including pre-admission, consent procedures, patient safety, drug reduction and reinstatement, seizure management, staffing levels, ictal testing and good data recording practice.

Results. This paper reports on the findings of the survey, the workshop presentations and workshop discussions. 32 centres took part in the survey and there were representatives from 22 centres at the workshop. There was variation in protocols, procedures and consent processes between units, and levels of observation of monitored patients. Nevertheless, the workshop discussion found broad areas of agreement on points.

Conclusion. A survey and workshop of UK epilepsy monitoring units found that some variability in practice is inevitable due to different local arrangements and patient groups under investigation. However, there were areas of clear consensus particularly in relation to consent and patient safety that can be applied to most units and form a basis for setting minimum standards.

Introduction

Long term inpatient video-EEG monitoring (VEM) is an essential investigation in tertiary epilepsy centres [1, 2]. VEM involves the recording of continuous and simultaneous video, EEG and ECG with a view to capturing clinical events of interest. The recording is typically carried out over 2 – 5 days, but can be longer according to the clinical situation. The referring clinician should be clear about the indication for VEM along with the expected outcome of the test. These include 1) differential diagnosis of paroxysmal events, most commonly epileptic seizures versus non-epileptic attacks, 2) differentiation between nocturnal epilepsy and parasomnias 3) characterisation of seizure types and electro-clinical syndromes 4) quantification of seizures or sub-clinical EEG discharges and 5) as part of the pre-surgical evaluation for seizure localization or lateralization [3].

VEM, whilst clinically effective, is labour intensive and often a limited resource [4-6]. VEM units require staff with clinical expertise in epilepsy. Ward based nursing staff need to be trained and experienced in recognizing and safely managing seizures, and interact with patients during seizures in a way that supports the diagnostic process [7]. Neurophysiology technical staff are needed to ensure continuous high quality data recording. Patient safety is paramount, particularly where anti-epileptic drugs (AED) are reduced or withdrawn to increase the chance of capturing a seizure during the monitoring period.

Technological advances, the ready availability of commercial systems, increasing demand for accurate diagnostic facilities and the recognition of the value of VEM have led to an expansion in the number of Epilepsy Monitoring Units (EMU) in the UK. Given the growth of EMU and a desire to share knowledge between units, a one-

day workshop was convened under the auspices of the British Chapter of the ILAE in September 2016. The day was preceded by an online survey of current VEM practice. The workshop comprised a morning of presentations by invited expert speakers followed by three breakout focus group sessions in the afternoon. The survey and workshop aimed to cover all aspects of VEM, including pre-admission, consent procedures, patient safety, drug reduction and reinstatement, seizure management, staffing levels, ictal testing and good data recording practice. This paper reports on the findings of the survey, the workshop presentations and workshop discussions.

Survey findings

A survey was developed by two of the authors (MB and KH) adapted from the recently published European survey on current practices in epilepsy monitoring units [8]. The survey was sent to all British Chapter ILAE members in March 2016 with subsequent reminders and additional personal emails to sites known to have an Epilepsy Monitoring Unit (EMU) in the UK. The survey closed in August 2016.

Responses were received from 32 centres: 22 adult, 7 paediatric and 3 that had EMUs for both. Most EMUs were located in hospital neurology wards (25), others were on the neurosurgery ward (1), neurology and neurosurgery ward (1), self-contained 2 bed unit in a epilepsy service hosted in a neuropsychiatry service (1), dedicated ward in the hospital (1), stand-alone epilepsy assessment centre (1), children's ward (1), children's HDU (1). The number of beds per unit varied from one to seven with a median of 2 (figure 1). The number of adult admissions per year per unit are also shown in figure 1. Ten centres undertook invasive intracranial monitoring. Full survey questions and responses are shown in table 2. A standard

protocol for pre-admission screening is used by 16 (64% of units). Signed informed consent is required by 18 (72%) though only 12 (48%) included risk of AED reduction in their consent process. 9 (36%) had standardized protocols for AED drug reduction and 17 (68%) for reinstating AEDs and rescue AEDs after seizures. 14 (56%) used continuous observation, compared to 11 (44%) with intermittent observation. The type of staff differed in that those with continuous observation were more likely to use healthcare professionals as opposed to qualified staff nurses (figure 2).

Results in table 1 show that wide variation exists and few questions received a consistent response from all centres. Previous surveys have had similar findings with variability between units in areas of practice [8-10]. Most recently a 60-item web-based survey to 27 EMUs in 25 centres across Europe had similar findings to ours [11]. The variability between centres will, at least in part reflect that there is no 'one size fits all' approach, and centres will adapt to their local needs and resources. Nevertheless, seeking consensus and setting standards of practice are important; recent quality indicators have been developed to standardize measurement and report on quality and safety of care on the EMU [12, 13].

Workshop presentations and discussions

Safety in the EMU.

Safety in the EMU is centered around the risks and consequences of epileptic seizures. This is of particular importance when AEDs are withdrawn to increase the chance of capturing seizures during the recording period. Adverse events on the EMU have been addressed in recent publications of local and multicenter surveys [14-19]. Adverse events fall into the following key areas: injuries and falls, cardiac

arrhythmias, psychosis, status epilepticus, and in rare cases, Sudden Unexpected Death in Epilepsy (SUDEP) (Ryvlin et al, 2013).

There was clear consensus in the following areas. All patients should have written information prior to the admission for VEM and pre-screening at a recent clinic, or telephone assessment before admission, with documentation of seizure type, epilepsy syndrome, seizure frequency and whether the patient experiences seizure clusters, history of generalised tonic clonic seizure (GTCS), previous episodes of psychosis, co-morbidity, learning difficulties, previous injuries, and results of previous investigations. Signed consent is needed for VEM (for use in medical records and separately for teaching and case presentations). A specific signed consent is needed for AED reduction. Information should be given on the risks of GTCS, seizure clusters, status epilepticus, possible admission to intensive care unit, post ictal psychosis and SUDEP. The MORTMEUS study, an international survey and detailed review of VEM data from monitored SUDEP cases, reported on 16 SUDEP and 9 near SUDEP from a total of 147 units who responded; 14 of 16 SUDEP cases occurred at night. The reported time to cardiopulmonary resuscitation (CPR) from seizure end (where known) in the SUDEP cases was 13 minutes in one, and considerably longer or not at all in the other SUDEP cases, compared to <1 minute to CPR in most of the near SUDEP cases [20]. It is not possible, on available evidence to quantify a SUDEP risk on the EMU in an appropriately monitored and responded case. The emphasis therefore should be on close supervision and monitoring with prompt seizure interventions. Staffing ratios for continuous monitoring in cases where medication is withdrawn should ideally be no more than 2 patients to 1 appropriately qualified and trained staff member. Padded cot sides, a low bed or a

mattress on the floor should be considered to reduce risk of injury, particularly in cases with known hypermotor seizures. Patients who are undergoing drug reduction, should have an intravenous cannula (flushed regularly) for emergency drug interventions, remain in bed and be in view of the camera at all times. Restrictions around movement from the bed are necessary according to local arrangements and policies.

A view from the CESS (Children's Epilepsy Surgery Service)

Around 30% of children with epilepsy do not respond to antiepileptic medication and may be candidates for a surgical approach. There is increasing evidence that children should be considered for surgery earlier rather than later, in view of the consequence of on-going seizures on brain development [21]. Using data from a recent prospective study in the USA [22] it can be estimated that in the UK over 700 children should be evaluated per year of which half should proceed to surgery. A recent audit [23] demonstrated that only a third of eligible children had surgery within 2 years of the onset of symptoms.

To improve this situation, in 2012 NHS England designated and commissioned four centres across the nation to form the Children's Epilepsy Surgery Service (CESS) which include the following centres: Birmingham Children's Hospital, Bristol Royal Hospital for Children, Liverpool's Alder Hey with Royal Manchester Children's Hospitals, and Great Ormond Street Hospital (GOSH) with King's Health Partners [24]. Although there are a few recommendations and guidelines available [2, 25-27], none of these are specifically for paediatric VEM despite the fact that considerable risks have been described in recent surveys [8, 18, 20, 28]. Therefore, the CESS

Neurophysiology working group has developed consensus guidelines for VEM in children using a modified Delphi process. Building on current recommendations the following key areas were identified: indications, referral pathways, equipment standards, recording techniques (with specific emphasis on safety of VEM), AED withdrawal protocol, protocol for behavioural testing and data storage, in addition to guidelines for writing factual reports and conclusions [29]. Although these guidelines were specifically developed for pre-surgical evaluation in children with epilepsy, it is believed that guidelines are transferable to paediatric VEM in general.

What should we be monitoring and how

Electronically recorded information should include the patient's name, date of birth, date on which the test was performed, name of test and relevant patient identification numbers. Calibration signals should be recorded at the beginning of each recording. Automated recording of technical parameters such as impedance values, sampling frequency, filter settings, gain, and montage selections should be available. The EEG signal is a reflection of a series of variables. These include the activation of neural networks; the localisation, orientation and source of the dipole and propagation through the brain. Despite attempts to automate some aspects of EEG monitoring such as spike detection algorithms, the innate complexity of EEG signal necessitates assessment and interpretation by trained experts.

Continuous surveillance during VEM by dedicated healthcare professionals is recommended through direct observation of the patient(s) supplemented with the use of video monitors and nurse alarms [18]. Healthcare professionals should be trained to recognise seizures, and major disturbances of cardiac rhythms, and

engage appropriately with patients during seizures and instigate necessary treatment measures.

Video and EEG should be reviewed by trained neurophysiology staff within 24 hours to mitigate against the consequences of unnoticed or subclinical seizures and plan any AED changes for the subsequent 24 hours. A minimum staffing ratio of 1 dedicated HCP to 4 patients has been recommended [18]. However, if AED tapering or other forms of provocation are being utilised a higher staffing ratio of 1 HCP to 2 patients is preferred, particularly if intracranial investigations are performed in one or more patients. Daily multidisciplinary ward rounds were recommended to improve communication, manage risks and maximise outcomes.

Capturing a single habitual event, confirmed by patient and family may be sufficient for diagnostics or seizure classification. Stereotypy for ≥ 2 habitual events is necessary for seizures without clear time-locked epileptiform changes such as some extratemporal seizures. There was no clear consensus regarding the minimum number seizures that must be recorded for optimal patient selection for epilepsy surgery. This will necessarily be dependent on the individual's clinical characteristics, imaging findings and interictal EEG abnormalities [30, 31] A recent review concluded VEM findings failed to predict outcome at 6 months, 1 year and 2 years in temporal lobe epilepsy when corrected for routine EEG and MRI findings [32], and markers other than VEM findings, such as imaging may be more reliable in predicting post-operative seizure remission [33]. In pre-surgical planning VEM data must be reviewed in an epilepsy surgery MDT alongside all clinical information, imaging and neuropsychology.

Audiovisual data

The following were recommended standard requirements for all units. For the audiovisual signal an omnidirectional audio microphone (that picks up sound with equal gain from all sides or directions) eliminating the need for directional readjustment. Video should be acquired through 2 high density remote pan/tilt cameras that keep patients in view minimising the chance of obstruction and with an infrared facility for low ambient light conditions. The camera(s) should always be focused on the patient.

Electrophysiological signals

The EEG signal should be recorded with a 10:20 montage as a minimum. An additional bilateral 3 electrode inferior temporal array that covers the 19 standard 10-20 electrodes plus 6 inferior temporal electrodes can have advantages in localising temporal lobe seizures [34], and higher density EEG (10:10) for presumed extratemporal lobe epilepsy [35]. A minimum sampling rate of 256 Hz i.e. three times the high frequency filter setting of 70 Hz. Higher rates, such as 512 Hz, are preferable to prevent aliasing on modern high-resolution computer screens [36]. Much higher sampling would be needed for detecting high frequency oscillations in intracranial EEG, but this highly specialised area [37] was not discussed further at the workshop. The onset, propagation, postictal clinical and EEG features of electroclinical events should be noted with comments on whether the event constitutes a habitual episode and any delay between clinical and electrographic onset. Software to support standardised EEG reporting has been developed, the Standardised Computer-based Organised Reporting of EEG (SCORE) [38], though individual practice in the use of this or similar software was not assessed here.

Continuous ECG display during VEM with alarms for bradycardia and tachycardia were recommended as a minimum standard. Muscle artefact may obscure the detection of ictal arrhythmias with a single lead ECG. Use of a 3 lead ECG [39] in VEM may provide more reliable ECG data. EMG channels can be utilised to determine laterality of seizure semiology. Bilateral deltoid leads were considered the minimum requirement. Surface EMG recording from antagonistic muscle groups was recommended to distinguish between tonic and atonic seizures (both can cause head-drop and falls). Other EMG leads should be individually tailored during VEM. Bilateral EOG and submentalis leads to differentiate exclusively nocturnal seizures from sleep disorders were also considered to be a minimum requirement. Measurement of oxygen saturation using pulse oximetry was also recommended, particularly at night.

Attending seizures and ictal testing

Patient safety is of the highest priority. All staff working on the EMU should receive training in recognising and managing ictal and postictal patients. Patients with convulsive seizures should be positioned in the lateral decubitus position postictally; oxygen should be applied and suction provided. Staff should remain with the patient until he/she has regained awareness. In cases of administration of benzodiazepines and postictal sleep, further vital sign monitoring using pulse oximetry should be considered. Clear protocols must be in place for the management of seizure clusters, status epilepticus and challenging postictal behaviour to ensure patient and staff safety. Patients should also be monitored for signs of postictal psychosis.

Testing of cognitive, behavioural, sensory and motor functions in the ictal and postictal period allows clinically relevant semiology to be determined. Most EMUs perform ictal or postictal testing, although standardisation between EMUs is lacking [8]. A consensus procedure for ictal testing or ictal testing battery (ITB) has recently been developed by a joint taskforce of the ILAE - Commission on European Affairs and the European Epilepsy Monitoring Unit Association [7]; it would be of interest in future surveys and workshops to assess the uptake of this or other standardised procedures. The ITB was prospectively evaluated on 250 seizures in 10 centres to assess feasibility. The ITB was found to be feasible in 93% of the included seizures. Difficulty in implementation related to short seizures (myoclonus; brief absence; and brief focal seizures). The ITB provides information on subtle features of semiology including autonomic features; responsiveness to verbal command and/or touch; comprehension; orientation; verbal and visual memory. Clinical examination is suggested to assess for tone, Todd's paresis and Babinski reflex. The ITB is dynamic and adjusted according to the seizure and takes 2-9 minutes to complete. It is recommended that local protocols should be developed using the most salient features of the ITB. Training for EMU staff, laminated version of the local ITB in the EMU and a pocket version would be helpful prompts. In patients with suspected dissociative seizures, nursing staff may be asked to check whether eyes are closed and if eye opening is resisted during the clinical event. Resistance to opening can be a useful indicator of non-organic clinical events.

Data Storage

All EEG data should be reviewed prior to any clipping and archiving of data. As a minimum, the consensus was that archiving should include clipped EEG data labelled as sleep; wake; interictal sections and ictal recordings with relevant clipped video to demonstrate associated semiology. Data should be stored on a server system to facilitate long term back up and review as needed. This minimises the risk of data loss by incorporating built-in data storage redundancy and regular data backup [36]. EEG recording formats should be able to store the EEG signal data and technologist's comments. EEG recording systems should be able to input and output publicly available data formats such as European Data Format (EDF) or EDF-plus [40] for storage of EEG and video data [41]. Manufacturers are encouraged to provide a method for outputting studies in a format with a standalone viewer so that a user can view the recording on any computer. The stored digital information should allow data recovery in an accessible format in addition to providing information about those who have accessed the record, as required by the Care Records Guarantees. Information governance and data protection guidance has recently been updated in the UK [42].

Provocation procedures, drug reduction and rescue protocols

All attendees agreed that provocation procedures and AED reduction need to be individualized to each patient and no standard protocol could cover the varied local facilities, patient characteristics and treatment regimens. Nevertheless, general recommendations and similarities in practice were observed. The main provocation procedure in the EMU is AED reduction. Additional provocation included sleep

deprivation and less commonly exercise or specific stimuli in reflex seizures.

Hyperventilation can also enhance diagnostic yield in the EMU and may be helpful in provoking both epileptiform activity and non-epileptic attacks.

The workshop consensus was that AED reduction should not be implemented prior to admission, and that the risk of beginning AED reduction in an unsupervised environment is not offset by a potential gain in capturing seizures earlier in the admission to the EMU. The rate of drug reduction, and which drug to withdraw first in those on polytherapy, is an individualized process, taking into account the AEDs in question, the frequency and severity of seizures and risk/benefit to the patient.

Nevertheless, the practice of most units where AED reduction is needed, is to reduce AEDs by 50% on day 1, and by 75% day on day 2, and tailor further reduction, stopping one or all AEDs thereafter until the desired number of events are recorded.

AEDs should be reinstated to full dose at least 24 hours prior to discharge. In addition, a 'loading' dose of AED was recommended by some, or consideration of a temporary course of benzodiazepine, for example Clobazam, over a few days. Again, there was consensus that this was an individualized decision based on type and severity of seizures and patients' home circumstances, namely the presence of adult family members or a carer. For rescue medication, all centres have a protocol for status epilepticus that can be applied to the EMU. A further consideration for rescue medication is oral, buccal or iv benzodiazepines following a generalized tonic clonic seizure, seizures lasting >5minutes, or multiple or increasing seizures, along with reinstating full AEDs.

All patients need daily review by the EMU designated consultant or competent designee to supervise AED tapering and each EMU should have its own protocols for

AED tapering appropriate for their environment and patients. At the end of the admission unaccompanied discharge should be avoided but if contingencies fail and the patient lives alone risks could be mitigated by earlier reinstatement of AEDs; and/or cover with short term benzodiazepines. Any local protocol needs to be sufficiently simple and robust to be followed by junior members of the team and out of hours on call staff.

There was recognition that there was little published literature and a need for a better evidence base to inform AED reduction decisions on the EMU. In a study of 158 patients with rapid withdrawal of AEDs, most discontinued within 24 hours of admission, showed similar complication rates to studies with slower withdrawal [43]. A recently published retrospective study of 79 patients stratified to fast or slow AED reduction, and complete or incomplete withdrawal found that complete AED discontinuation was associated with three times increased likelihood of receiving rescue therapy and double the rate of having GTCS compared to the group partially discontinued, though discontinuation rate did not affect complication rates [44]. Future work would help evaluate different AEDs, rates of reduction and impact on seizure threshold based on the AEDs half-life and other concomitant medication.

It was notable that amongst all the workshop attendees all adult EMUs except one in a major centre operate a Monday to Friday monitoring period only, unless undertaking an intracranial recording when additional provision is made to cover Saturday and Sunday. This is primarily due to staffing reasons. This may influence AED withdrawal regimens and diagnostic yield from each admission. A study is currently underway across EMUs in France assessing the impact of a standardized

protocol of AED withdrawal against current practices as the control, due to complete in 2019[45].

Concluding remarks

VEM is a gold standard test in making a diagnosis of epilepsy versus non-epileptic attacks, classifying epileptic seizures and syndromes and in the pre-surgical evaluation of patients with epilepsy. Our workshop showed the breadth and scope of procedural, technical and staffing factors that need to be in place for the necessary safety and quality on VEM units. We hope that we have identified and highlighted areas where there is clear consensus for good practice and areas for future work. The latter includes a better evidence based guidance on AED reduction, the number of seizures needed for surgical planning and methods for data display.

Acknowledgements We are grateful to the International League Against Epilepsy – British Chapter for support in funding and convening the meeting and Hannah Stapley for survey and meeting coordination, and manuscript formatting.

References

- [1] Alsaadi, T.M., Thieman, C., Shatzel, A. and Farias, S. Video-EEG telemetry can be a crucial tool for neurologists experienced in epilepsy when diagnosing seizure disorders. *Seizure* 2004; **13**:32-34.
- [2] Velis, D., Plouin, P., Gotman, J., da Silva, F.L. and Neurophysiology, I.D.S.o. Recommendations regarding the requirements and applications for long-term recordings in epilepsy. *Epilepsia* 2007; **48**:379-384.
- [3] Cascino, G.D. Clinical indications and diagnostic yield of video-electroencephalographic monitoring in patients with seizures and spells. *Mayo Clin Proc* 2002; **77**:1111-1120.
- [4] Ghougassian, D.F., d'Souza, W., Cook, M.J. and O'Brien, T.J. Evaluating the utility of inpatient video-EEG monitoring. *Epilepsia* 2004; **45**:928-932.
- [5] Yogarajah, M., Powell, H.W., Heaney, D., Smith, S.J., Duncan, J.S. and Sisodiya, S.M. Long term monitoring in refractory epilepsy: the Gowers Unit experience. *J Neurol Neurosurg Psychiatry* 2009; **80**:305-310.
- [6] Kumar-Pelayo, M., Oller-Cramsie, M., Mihu, N. and Harden, C. Utility of video-EEG monitoring in a tertiary care epilepsy center. *Epilepsy Behav* 2013; **28**:501-503.
- [7] Beniczky, S., Neufeld, M., Diehl, B., Dobesberger, J., Trinka, E., Mameniskiene, R., Rheims, S., Gil-Nagel, A., Craiu, D., Pressler, R., Krysl, D., Lebedinsky, A., Tassi, L., Rubboli, G. and Ryvlin, P. Testing patients during seizures: A European consensus procedure developed by a joint taskforce of the ILAE - Commission on European Affairs and the European Epilepsy Monitoring Unit Association. *Epilepsia* 2016; **57**:1363-1368.
- [8] Rubboli, G., Beniczky, S., Claus, S., Canevini, M.P., Kahane, P., Stefan, H., van Emde Boas, W., Velis, D., Reus, E., Gil-Nagel, A., Steinhoff, B.J., Trinka, E. and Ryvlin, P. A European survey on current practices in epilepsy monitoring units and implications for patients' safety. *Epilepsy Behav* 2015; **44**:179-184.
- [9] Fitzsimons, M., Browne, G., Kirker, J. and Staunton, H. An international survey of long-term video/EEG services. *J Clin Neurophysiol* 2000; **17**:59-67.
- [10] Buelow, J.M., Privitera, M., Levisohn, P. and Barkley, G.L. A description of current practice in epilepsy monitoring units. *Epilepsy Behav* 2009; **15**:308-313.
- [11] Kobulashvili, T., Hofler, J., Dobesberger, J., Ernst, F., Ryvlin, P., Cross, J.H., Braun, K., Dimova, P., Francione, S., Hecimovic, H., Helmstaedter, C., Kimiskidis, V.K., Lossius, M.I., Malmgren, K., Marusic, P., Steinhoff, B.J., Boon, P., Craiu, D., Delanty, N., Fabo, D., Gil-Nagel, A., Guekht, A., Hirsch, E., Kalviainen, R., Mameniskiene, R., Ozkara, C., Seeck, M., Rubboli, G., Krsek, P., Rheims, S. and Trinka, E. Current practices in long-term video-EEG monitoring services: A survey among partners of

the E-PILEPSY pilot network of reference for refractory epilepsy and epilepsy surgery. *Seizure* 2016; **38**:38-45.

[12] Sauro, K.M., Wiebe, N., Macrodimitris, S., Wiebe, S., Lukmanji, S. and Jette, N. Quality and safety in adult epilepsy monitoring units: A systematic review and meta-analysis. *Epilepsia* 2016.

[13] Sauro, K.M., Wiebe, S., Macrodimitris, S., Jette, N. and Team, E.M.U.Q.I. Quality indicators for the adult epilepsy monitoring unit. *Epilepsia* 2016.

[14] Noe, K.H. and Drazkowski, J.F. Safety of long-term video-electroencephalographic monitoring for evaluation of epilepsy. *Mayo Clin Proc* 2009; **84**:495-500.

[15] Dobesberger, J., Walser, G., Unterberger, I., Seppi, K., Kuchukhidze, G., Larch, J., Bauer, G., Bodner, T., Falkenstetter, T., Ortler, M., Luef, G. and Trinkka, E. Video-EEG monitoring: safety and adverse events in 507 consecutive patients. *Epilepsia* 2011; **52**:443-452.

[16] Shafer, P.O., Buelow, J., Ficker, D.M., Pugh, M.J., Kanner, A.M., Dean, P. and Levisohn, P. Risk of adverse events on epilepsy monitoring units: a survey of epilepsy professionals. *Epilepsy Behav* 2011; **20**:502-505.

[17] Atkinson, M., Hari, K., Schaefer, K. and Shah, A. Improving safety outcomes in the epilepsy monitoring unit. *Seizure* 2012; **21**:124-127.

[18] Kandler, R., Lai, M., Ponnusamy, A., Bland, J. and Pang, C. The safety of UK video telemetry units: results of a national service evaluation. *Seizure* 2013; **22**:872-876.

[19] Sauro, K.M., Macrodimitris, S., Krassman, C., Wiebe, S., Pillay, N., Federico, P., Murphy, W., Jette, N. and Epilepsy Monitoring Unit Quality Improvement, T. Quality indicators in an epilepsy monitoring unit. *Epilepsy Behav* 2014; **33**:7-11.

[20] Ryvlin, P., Nashef, L., Lhatoo, S.D., Bateman, L.M., Bird, J., Bleasel, A., Boon, P., Crespel, A., Dworetzky, B.A., Hogenhaven, H., Lerche, H., Maillard, L., Malter, M.P., Marchal, C., Murthy, J.M., Nitsche, M., Patariaia, E., Rabben, T., Rheims, S., Sadzot, B., Schulze-Bonhage, A., Seyal, M., So, E.L., Spitz, M., Szucs, A., Tan, M., Tao, J.X. and Tomson, T. Incidence and mechanisms of cardiorespiratory arrests in epilepsy monitoring units (MORTEMUS): a retrospective study. *Lancet Neurol* 2013; **12**:966-977.

[21] Cross, J.H. and Duchowny, M. Transition in lesional focal epilepsy, and following epilepsy surgery. *Epilepsia* 2014; **55 Suppl 3**:34-36.

[22] Berg, A.T., Mathern, G.W., Bronen, R.A., Fulbright, R.K., DiMario, F., Testa, F.M. and Levy, S.R. Frequency, prognosis and surgical treatment of structural abnormalities seen with magnetic resonance imaging in childhood epilepsy. *Brain* 2009; **132**:2785-2797.

- [23] Harvey, A.S., Cross, J.H., Shinnar, S., Mathern, G.W., Mathern, B.W. and Taskforce, I.P.E.S.S. Defining the spectrum of international practice in pediatric epilepsy surgery patients. *Epilepsia* 2008; **49**:146-155.
- [24] England, E.A.o.b.o.N. Children's Epilepsy Surgery Service (CESS). Guidelines for children's epilepsy brain surgery referrals in England. In, <https://www.epilepsy.org.uk/sites/epilepsy/files/professionals/cess-practioners-booklet.pdf>, 2013.
- [25] Society, A.C.N. Guideline twelve: guidelines for long-term monitoring for epilepsy. *J Clin Neurophysiol* 2008; **25**:170-180.
- [26] Labiner, D.M., Bagic, A.I., Herman, S.T., Fountain, N.B., Walczak, T.S., Gumnit, R.J. and Centers, N.A.o.E. Essential services, personnel, and facilities in specialized epilepsy centers--revised 2010 guidelines. *Epilepsia* 2010; **51**:2322-2333.
- [27] Shafer, P.O., Buelow, J.M., Noe, K., Shinnar, R., Dewar, S., Levisohn, P.M., Dean, P., Ficker, D., Pugh, M.J. and Barkley, G.L. A consensus-based approach to patient safety in epilepsy monitoring units: recommendations for preferred practices. *Epilepsy Behav* 2012; **25**:449-456.
- [28] McAuley, C.F., Aylett, S., Dunkley, C., Zaiwalla, Z. and McShane, T. Paediatric video-telemetry safety survey. *Arch Dis Child* 2012; **97**:298-299.
- [29] Pressler, R.M., Seri, S., Kane, N., Martland, T., Goyal, S., Iyer, A., Warren, E., Notghi, L., Bill, P., Thornton, R., Appleton, R., Doyle, S., Rushton, S., Worley, A. and Boyd, S.G. Consensus-based guidelines for Video EEG monitoring in the pre-surgical evaluation of children with epilepsy in the UK. *Seizure - European Journal of Epilepsy* **50**:6-11.
- [30] Jobst, B.C. When in Doubt Record More Seizures! *Epilepsy Curr* 2016; **16**:234-235.
- [31] Struck, A.F., Cole, A.J., Cash, S.S. and Westover, M.B. The number of seizures needed in the EMU. *Epilepsia* 2015; **56**:1753-1759.
- [32] Goldenholz, D.M., Jow, A., Khan, O.I., Bagic, A., Sato, S., Auh, S., Kufta, C., Inati, S. and Theodore, W.H. Preoperative prediction of temporal lobe epilepsy surgery outcome. *Epilepsy Res* 2016; **127**:331-338.
- [33] Tellez-Zenteno, J.F., Dhar, R. and Wiebe, S. Long-term seizure outcomes following epilepsy surgery: a systematic review and meta-analysis. *Brain* 2005; **128**:1188-1198.
- [34] Rosenzweig, I., Fogarasi, A., Johnsen, B., Alving, J., Fabricius, M.E., Scherg, M., Neufeld, M.Y., Pressler, R., Kjaer, T.W., van Emde Boas, W. and Beniczky, S. Beyond the double banana: improved recognition of temporal lobe seizures in long-term EEG. *J Clin Neurophysiol* 2014; **31**:1-9.

- [35] Feyissa, A.M., Britton, J.W., Van Gompel, J., Lagerlund, T.L., So, E., Wong-Kisiel, L.C., Cascino, G.C., Brinkman, B.H., Nelson, C.L., Watson, R. and Worrell, G.A. High density scalp EEG in frontal lobe epilepsy. *Epilepsy Res* 2017; **129**:157-161.
- [36] Halford, J.J., Sabau, D., Drislane, F.W., Tsuchida, T.N. and Sinha, S.R. American Clinical Neurophysiology Society Guideline 4: Recording Clinical EEG on Digital Media. *J Clin Neurophysiol* 2016; **33**:317-319.
- [37] Gliske, S.V., Irwin, Z.T., Chestek, C. and Stacey, W.C. Effect of sampling rate and filter settings on High Frequency Oscillation detections. *Clin Neurophysiol* 2016; **127**:3042-3050.
- [38] Beniczky, S., Aurlien, H., Brogger, J.C., Fuglsang-Frederiksen, A., Martins-da-Silva, A., Trinka, E., Visser, G., Rubboli, G., Hjalgrim, H., Stefan, H., Rosen, I., Zarubova, J., Dobesberger, J., Alving, J., Andersen, K.V., Fabricius, M., Atkins, M.D., Neufeld, M., Plouin, P., Marusic, P., Pressler, R., Mameniskiene, R., Hopfengartner, R., van Emde Boas, W. and Wolf, P. Standardized computer-based organized reporting of EEG: SCORE. *Epilepsia* 2013; **54**:1112-1124.
- [39] Antonicelli, R., Ripa, C., Abbatecola, A.M., Capparuccia, C.A., Ferrara, L. and Spazzafumo, L. Validation of the 3-lead tele-ECG versus the 12-lead tele-ECG and the conventional 12-lead ECG method in older people. *J Telemed Telecare* 2012; **18**:104-108.
- [40] Kemp, B. and Olivan, J. European data format 'plus' (EDF+), an EDF alike standard format for the exchange of physiological data. *Clin Neurophysiol* 2003; **114**:1755-1761.
- [41] Kemp, B. and Roessen, M. European Data Format Now Supports Video. *Sleep* 2013; **36**:1111.
- [42] Alliance, I.G. <https://digital.nhs.uk/article/402/Information-Governance>. In, 2017.
- [43] Rizvi, S.A., Hernandez-Ronquillo, L., Wu, A. and Tellez Zenteno, J.F. Is rapid withdrawal of anti-epileptic drug therapy during video EEG monitoring safe and efficacious? *Epilepsy Res* 2014; **108**:755-764.
- [44] Guld, A.T., Sabers, A. and Kjaer, T.W. Drug taper during long-term video-EEG monitoring: efficiency and safety. *Acta Neurol Scand* 2016.
- [45] <https://clinicaltrials.gov/ct2/show/NCT02679846>. In, 2016.

Table 1. Questions sent to each centre with count of responses.

Figure 1. Summary of the number of the number of beds and reported admissions per centre per year.

Figure 2. Ratio of designated staff observing patients in epilepsy monitoring unit according to whether intermittent or continuous observation is in place.

Workshop Participants

Aline Russell, *Consultant Neurophysiologist, The William Quarriers Scottish Epilepsy Centre*. Anna Cuarentas, *Staff Nurse, UCLH National Hospital for Neurology and Neurosurgery, London*. AP Mocroft, *Consultant Neurologist, Neurophysiology - University Hospitals Birmingham NHS Foundation Trust*. Athi Ponnusamy, *Consultant Neurophysiologist, Sheffield Teaching Hospitals*. Beate Dejneke-Lowe, *EEG Videotelemetry Epilepsy Nurse, UCLH National Hospital for Neurology and Neurosurgery, London*. Brenda McManus, *Neurophysiology Services Manager, NHS Grampian*. Carl-Christian Moor, *Consultant Neurologist, Clinical Lead in Epilepsy, Royal Stoke Hospital*. Caroline Scott, *Senior Healthcare Scientist - Clinical Neurophysiology, Birmingham Children's Hospital*. Cecilia Blomberg, *Consultant Clinical Neurophysiologist, St Georges' Hospital, London*. Colin Shirley, *Consultant Clinical Neurophysiologist, Queen Elizabeth Hospital, Birmingham*. Daniel Konn, *Consultant Clinical Neurophysiologist, University Hospital Southampton NHS Foundation Trust*. Darren Lamb, *Healthcare Scientist (Neuro), Birmingham Children's Hospital*. David Rollings, *Clinical Physiologist – Neurophysiology, Queen Elizabeth Hospital, Birmingham*. Deivasumathy Muthugovindan, *Consultant Paediatric Neurologist, Royal London Hospital*. Devi Amin, *Lead Technician in Clinical Neurophysiology, King's College Hospital NHS Foundation Trust*. Dora Lozsadi, *Consultant Neurologist, St George's University Hospitals NHS Foundation Trust, London*. Emma Durrant, *Duty Manager & Clinical Physiologist- neurophysiology, Poole Hospital NHS Foundation Trust*. Fahmida Chowdhury, *Consultant Neurologist, St George's University Hospitals NHS Foundation Trust, London*. Heather Angus-Leppan, *Consultant Neurologist, Royal Free London NHS Foundation Trust, London*. Jane Adcock, *Consultant Neurologist, John Radcliff Hospital, Oxford*. Judith Dunne, *Clinical Physiologist, University Hospitals Coventry and Warwickshire*. Linda Gerrie, *Consultant Neurologist, Aberdeen Royal Infirmary, NHS Grampian*. Mary O'Regan, *Consultant Paediatric Neurologist, Royal Hospital for Sick Children, Glasgow*. Munni Ray, *Consultant Paediatric Neurology and Neurophysiology, Leeds Teaching Hospital NHS Trust, Leeds*. Nandini Mullatti, *Epileptologist and Clinical Neurophysiologist, King's College Hospital NHS Foundation Trust*. Naseeb Akhtar, *ST6 in Clinical Neurophysiology, The Queen Elizabeth University Hospital, Glasgow*. Paul Cooper, *Consultant Neurologist, Salford Royal NHS Foundation Trust*. Peter Muthinji, *Specialised Clinical Physiologist, King's College Hospital NHS Foundation Trust*. Rajiv Mohanraj, *Consultant Neurologist, Salford Royal NHS Foundation Trust*. Robert Elwes, *Consultant Neurologist, King's College Hospital NHS Foundation Trust*. Satinder Bhath, *Neurophysiology Manager, Queen Elizabeth Hospital, Birmingham*. Sean Slaght, *Consultant Neurologist, Wessex Neurological Centre, Southampton*. Tejal Mitchell, *Consultant Neurologist, Addenbrooke's Hospital, Cambridge*. Tim Wehner, *Consultant Clinical Neurophysiologist and Neurologist at the National Hospital for Neurology and Neurosurgery, London*. Vivian Tagalan, *Nurse, UCLH National Hospital for Neurology and Neurosurgery, London*.

Table 1

Survey question	Response (adult)		Responses (children)	
	Yes (%)	No (%)	Yes (%)	No (%)
Do you have standardized protocols for preadmission screening that considers seizure frequency, seizure types, episodes of seizure clusters or status epilepticus, previous injuries, and psychiatric disturbances?	15 (63)	9 (37)	3 (43)	4 (57)
Do you have any preliminary assessment of possible comorbidities (for instance, osteoporosis and cardiorespiratory compromise) that may render seizure provocation potentially harmful?	8 (33)	16 (67)	2 (29)	5 (71)
Do you require a signed informed consent form prior to the video-EEG monitoring procedure?	17 (71)	7 (29)	1 (20)	6 (80)
Does your written consent include risks of AED reduction?	12 (50)	12 (50)	1 (20)	6 (80)
Do you have standardized protocols / practice for AED reduction?	9 (37)	15 (63)	3 (43)	4 (57)
Do you have standardized protocols / practice for reinstating AEDs?	17 (71)	7 (29)	3 (43)	4 (57)
Do you have standardized protocols / practice for rescue AEDs after seizures?	16 (67)	8 (33)	7 (100)	0 (0)
Do you have a standardized protocol to ensure patient safety after being discharged from the EMU?	9 (37)	15 (63)	4 (57)	3 (43)
Intensity and level of observation.	13 (54)	11 (46)	3 (43)	4 (57)
Is diagnostic testing performed on the patient at seizure onset in the ictal and postictal phases?	20 (83)	4 (17)	2 (29)	5 (71)
Do you use automatic systems for detection of ECG abnormalities and for alarming purposes?	6 (25)	18 (75)	2 (29)	5 (71)
Do you use any system for oxygen desaturation detection and for alarming purposes?	10 (42)	14 (58)	5 (71)	2 (29)
Do you use seizure detection systems based on detecting movement while the patient lies in bed?	4 (17)	20 (83)	0 (0)	7 (100)

Figure 1

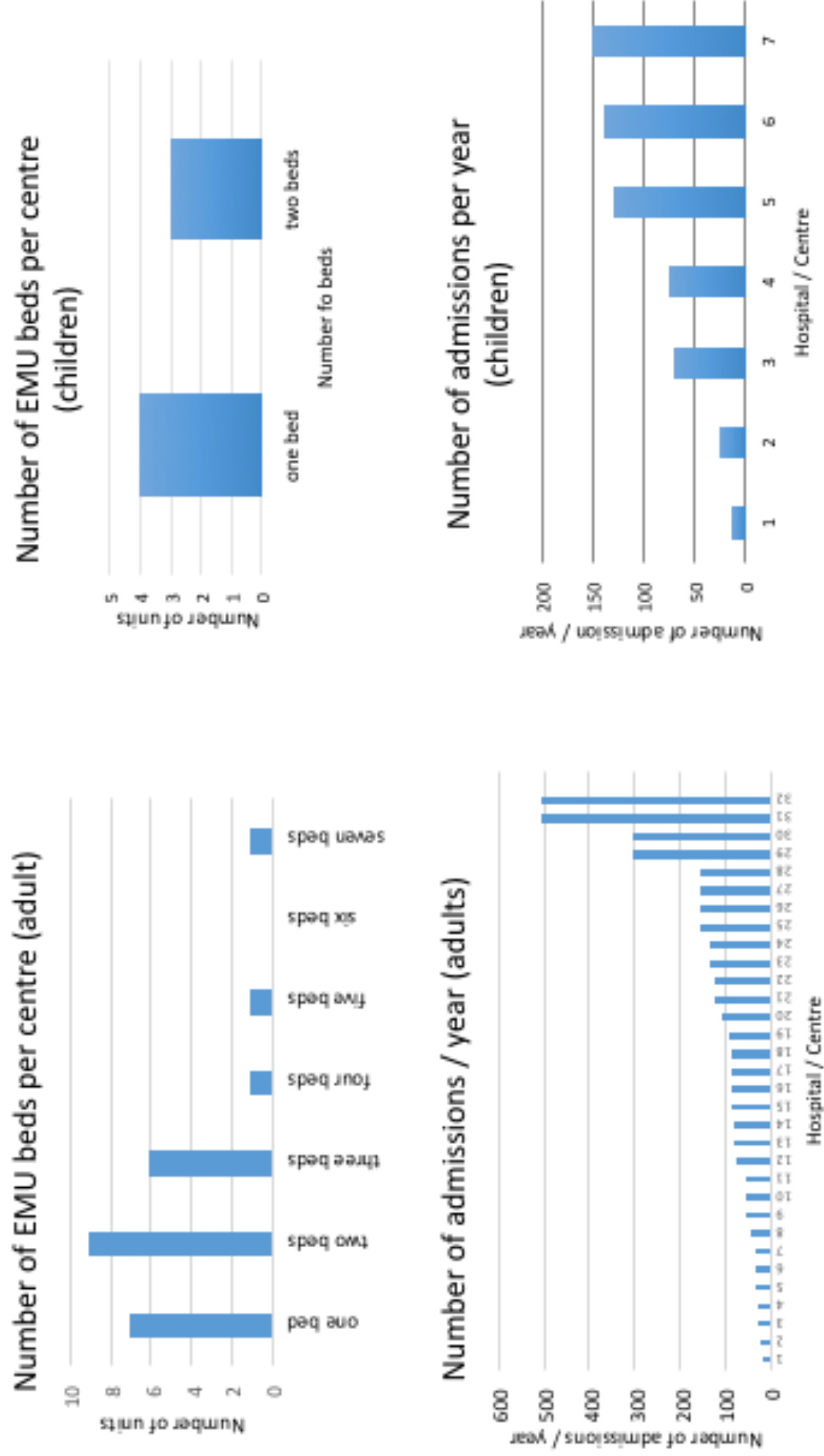


Figure 2

