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Development, evaluation and implementation of video-EEG telemetry at home

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ABSTRACT

Purpose: To describe the development and implementation of video EEG telemetry (VT) in the patient's home (home video telemetry, HVT) in a single centre.

Methods: HVT met the UK Medical Research Council definition of a complex intervention, and we used its guidance to evaluate the process of piloting, evaluating, developing and implementing this new clinical service. The first phase was a feasibility study, comparing inpatient VT (IVT) with HVT in a test–retest design ($n = 5$), to assess data quality and yield of clinically relevant events. The second phase was a pre-implementation study ($n = 8$), to examine acceptability and satisfaction as well as the costs of IVT and HVT. Subsequently, we implemented the service, and reviewed the outcomes of the first 34 patients.

Results: The feasibility study found no difference in the quality of recording or clinical yield between IVT and HVT. The pre-implementation study showed excellent patient satisfaction. We also discuss the findings of the main stakeholder survey (consultants and technicians). Our economic modelling demonstrates a clear financial superiority of HVT over IVT.

Conclusion: Our findings show that diagnostic HVT for seizure classification and polysomnographies can be carried out safely in the patients' home and poses no security risks for staff. HVT can be effectively integrated into an existing tertiary care service as a routine home or community-based procedure. We hope to encourage other clinical neurophysiology departments and epilepsy centres to take advantage of our experience and consider adopting and implementing HVT, with the aim of a nationwide coverage.

1. Introduction

EEG is a key component of the evaluation of epilepsy and sleep disorder. Long-term monitoring (LTM) in an Epilepsy Monitoring Unit (EMU) or Sleep Unit is often needed to capture events which have not been captured during routine outpatient EEG, and which remain diagnostically uncertain. Inpatient LTM is expensive, and takes the patient out of their natural environment, which may diminish the likelihood that events will be captured,[1] or significantly alter their nature. A natural extension of inpatient LTM is to undertake LTM outside the hospital setting, in the patient's natural environment. Routine outpatient EEG and LTM on an EMU routinely include continuous video, and often include other modalities of continuous data collection. Continuous multimodal data collection outside the hospital environment has many challenges.

Provision of expert inpatient video-EEG telemetry (IVT) is geographically variable even within well-resourced settings. Furthermore, the ability of some patient groups to access inpatient diagnostic services is sometimes limited by co-morbid illness such as severe behavioural or psychiatric disorders. We examine in this study whether conducting video-EEG telemetry in the patient's own home might be a satisfactory alternative solution in some instances. Specifically we examine home video telemetry (HVT) in the context of the UK NHS. As its implementation impacts on conventional clinical practice and clinician behaviour, a careful analysis of our approach is provided which may prove helpful for future service providers.

Monitoring seizures at home is of course not a new concept. An alternative approach to recording video and EEG related to seizures occurring at night is to use motion detectors placed beneath the patient's mattress. A study of such a device found only 62.5% sensitivity and en extremely high false detection rate of 0.18 per hour.[2] Extended periods of EEG and video monitoring in the patient's home for epilepsy has been surprisingly little reported. An innovative study 30 years ago used radiotelemetry to collect

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EEG in the patient's home and transmission of data over a conventional telephone line to the epilepsy centre, showing the future potential of remote monitoring.[3,4] In another study, simple improvisation was used to combine a conventional ambulatory EEG system with a portable video camera set up in the patient's home, with offline combining of the EEG and video for simultaneous viewing.[5] A case study reported the benefit of home recording for monitoring the patient's treatment.[6] Probably the best-established system combines EEG and video into a single portable unit taken by the patient to their home, after EEG connection in the clinic[7]; however, this system differs from our described here in that it is "unattended" – that is, there is no professional staff involvement in the patient's home, whereas we describe here an "attended" system, with professionals visiting the patient's home during monitoring.

Despite these several attempts and approaches to video-EEG monitoring a home, there is very little reported data describing the implementation and evaluation of video-EEG telemetry carried out in the patient's home. When our work began no dedicated HVT recording system was available, hence we not only needed to develop a process for HVT, but devise a recording device to be both robust in the domestic environment and simple enough for quick and easy assembly.

For best practice in the valuation of pre-surgical patients and for the differentiation of epileptic versus non epileptic seizures, IVT has become generally accepted as a gold standard; nonetheless, it has limitations and disadvantages which typically receive limited attention because of the lack of alternatives. Typically IVT is provided in tertiary centres at a distance from the patient's home, and require several days admission; this has obvious disadvantages of travel time and costs, loss of employment income, and often challenging difficulties if the patient is a parent or has other carer responsibilities. This may be compounded for some by the difficulties coping with an unfamiliar hospital environment, and accepting hospital-provided food and restrictions on smoking. In the UK NHS, pre-admission screening for methicillin-resistant *Staphylococcus aureus* (MRSA) may create admission delays, and marked seasonal variation in emergency admission demands regularly result in cancellation of elective admissions (including IVT) at peak demand times. It is our experience that certain particularly vulnerable patients such as children, patients with severe learning difficulties and special needs, elderly patients and patients with mental health problems including challenging behaviour may rarely or never get the benefit of a video EEG assessment.

IVT requires a considerable amount of resources, ranging from specially skilled technical, nursing and medical staff plus administrative. This makes this 3–5 days hospital test an expensive procedure.

Our aim was to develop an alternative procedure outside the hospital of the same or improved quality that is both cost effective and safe, making it potentially better for patients and carers.

2. Method

We model our methods on a widely used framework for the development and evaluation of complex interventions[8] which provides a more flexible and less linear model than is typical of clinical trials. This model emphasises the need to give attention to development and implementation phases as well as evaluation.

2.1. Feasibility study (n = 5)

In the feasibility study we compared the clinical yield and the quality of video-EEG recording of HVT and IVT in the same patients, to test the hypothesis: HVT provides data of comparable quality and clinical yield to IVT. The patients were randomly picked from the waiting list excluding patients awaiting presurgical evaluation and patients living further than 20 miles from the hospital. All patients had both home and inpatient recordings. HVT and IVT were carried out within four weeks to minimise the likelihood that drug changes would be made between sessions. All the home recordings were carried out by one technician and were reported by one consultant. IVT recordings were independently reported by a second consultant who was blinded to the HVT results. The reporting consultant either took the clinical history over the telephone or in a face to face interview.

For HVT we used a portable video-EEG system (Xltek Connex Laptop EEG system, Natus Medical Inc., San Carlos, CA), and for IVT we used Nicolet ONE LTM SYSTEM (Natus Medical Inc., San Carlos, CA). Offline data processing, archiving and reviewing was carried out in the hospital according to our conventional practice, and was identical for IVT and HVT data.

Criteria to evaluate the quality of the EEG and video recording were developed and applied to both datasets. Four EEG quality criteria were defined as follows: (1) Reference electrode functioning correctly and in contact; (2) More than 17 electrodes covering the scalp area of interest (AOI); (3) More than 3 adjacent electrodes over the AOI; (4) Fewer than 5 dysfunctional non-adjacent electrodes. Video quality was judged "good" if the patient was 100% visible; "acceptable" if the view of the patient was partially blocked by persons during ictal assessment, or the patient moved out of view during a seizure; "poor" if the patient was not visible.

To evaluate clinical yield, we assessed whether the following information had been obtained: habitual seizures observed; interictal discharges observed; ictal assessment possible; sleep event captured. We also measured the time to the first relevant diagnostic event.

In this initial feasibility study we examined safety and risks for patients, staff and equipment. We developed a set of risk assessment and process protocols for further refinement in the next phase.

2.2. Pre-implementation Pilot Study (n = 8)

Following successful completion of the initial feasibility study, a number of questions and issues were unresolved which led to the design of the Pre-implementation Pilot Study. With a view to achieving acceptance throughout the clinical team, all 5 EEG specialist physicians and 5 EEG technicians were involved. Our departmental engineer modified an existing a recording system which was both robust enough for the domestic environment and simple to transport and assemble.

An inpatient video-EEG telemetry system, Nicloet ONE LTM (Natus Medical Inc., San Carlos, CA) was used, with modification for portability, transportation, space savings and ease of operation in the home environment. This was housed on a lightweight cart also accommodating camera mounting pole, with adjustable height and angle. All the equipment (uninterruptable power supply, compressed air gun for electrode application, cables, camera, removable hard disc, EEG electrode application accessories, documents) were carried in two wheeled travel suitcases.

The patients were again randomly chosen from the VT waiting list excluding patients awaiting presurgical evaluation and any patients living further than 20 miles from the hospital.

We collected the following data: duration of recording; total technician time required; distance from hospital to patient's home; travel costs for technician and equipment; how initial clinical history was taken (telephone, outpatient visit to hospital, or in the patient's home); whether relevant clinical events were captured during recording. A patient, parent and carer satisfaction questionnaire was included. The questionnaire for patients, parents and carers included the following six items:

- What would have been the personal consequences had the monitoring not happened this week?
- What would be your preference and why: Monitoring in the hospital or at home?
- What would have been the advantages for you or your child had the VT monitoring been carried out in the hospital?
- Were you dissatisfied, satisfied or very satisfied with the service provided?
- Do you have any general comments and suggestions regarding our HVT service?
- In what way could HVT be improved?

Given that changes in clinical practice were involved, we used questionnaires to survey the principle stakeholders (consultants and technicians), to explore how HVT was perceived. The questionnaire for technicians consisted of the following items:

- Quality of the recording compared to IVT (scored 1–5, 5 best)
- Workflow compared with IVT (each item scored 1–5):
  - Electrode application
  - Telephone assessment
  - Downloading data
  - Review at base hospital
  - Call outs
  - Installation of equipment
  - Transport booking
  - Transport in general
- Any major advantages? (free text)
- Disadvantages? (free text)
- Technician opinion of the service (free text)
- Patient/carer/patient opinion (free text)

The questionnaire for doctors consisted of the following items:

- Quality of the recording compared to IVT (scored 1–5, 5 best)
- Workflow compared with IVT (each item scored 1–5):
  - Reporting, patient interview
  - History taking
  - Review with tech
- Any major advantages? (free text)
- Disadvantages? (free text)
- What percentage of the adult and paediatric diagnostic VT cases could be done with HVT?
- Doctor opinion of the service (free text)
- Patient/carer/patient opinion (free text)

In this pre-implementation phase, a simple economic model of costs of IVT and HVT was developed.

2.3. Implementation and evaluation of consecutive case series (n = 34)

Following Feasibility and Pilot Studies, we implemented HVT as a new clinical service offered by the hospital. We followed the following protocol:

- Referrals for video-EEG telemetry vetted for suitability for HVT by medical staff. We particularly selected patients with seizures and severe learning difficulties and patients that had declined hospital admissions in the past. Patients awaiting presurgical evaluation were excluded.
- Referral registered on hospital electronic patient management system by administrative staff.
- Pre-HVT telephone assessment was undertaken by a technician.
- Information leaflet was sent to the patient with the appointment letter.
- Outpatient appointments to obtain the clinical history were given to ambulant patients but a consultant home visit or telephone call was organised for patients where travel to the hospital was not possible.
- HVT day 1: electrode placement either during the outpatient visit or at home; consenting to video monitoring; and first home visit with installation of recording equipment.
- HVT day 2: technician visits home to download data and optimise recording, reviews clinical events in question with patient or family.
- Relevant data epochs selected, archived and reviewed at hospital during routine multidisciplinary review meeting.
- HVT day 3 (and subsequent days as required) home visit by technician to download data, optimise recording and review events in question.
- HVT last day: termination of recording, disassembling of recording system and return to hospital for full data review.
- Consultant reports HVT data, results entered on hospital electronic patient record system.

We anticipated that following the feasibility, pre-implementation and implementation phases, we would be able to address a range of questions regarding HVT, including: clinical effectiveness, resource use, costs, limitations and risks; accessibility to patients with learning difficulties, behavioural problems and other factors restricting access to IVT; acceptability to patients; acceptability to clinicians.

We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

3. Results

3.1. Feasibility study

5 patients were included in the feasibility study (Table 1). The EEG recording quality of IVT was rated as good in 24/24 (100%) of all recorded seizures compared to 34/36 (93%) in HVT. The video quality was acceptable in 19/24 (79%) in the IVT and 30/36 (83%) in HVT. No difference was found in the incidence of habitual seizures, the interictal assessment, or the ictal assessment. Both HVT and IVT produced conclusive findings in 4/5 patients (80%).

Risks for staff, patients and equipment were examined. Experienced health professionals in the community provided extensive advice, particularly, a community based epilepsy nurse. We also implemented an existing 'Lone Worker Policy' of our institution (King's College Hospital) which included also the acquisition of an electronic device which can trigger an alarm in emergencies. The technician working in the patient's home also carried a hospital mobile phone (cell phone). A telephone risk assessment was developed and introduced (see Appendix 1). Our departmental engineer designed and built a recording system and

Table 1
Outcome of initial feasibility study of 5 patients studied with both inpatient video-EEG telemetry (IVT) and home video-EEG telemetry (HVT).

	Inpatient video telemetry	Home video telemetry
Habitual seizures recorded (*n* cases (%))	4 (80)	4 (80)
Interictal discharges (*n* cases (%))	4 (80)	4 (80)
Ictal assessment (*n* cases (%))	3 (60)	3 (60)
Events in sleep (*n* cases (%))	4 (80)	5 (100)
Mean time to 1st event (days)	2	2.5
Total events observed	24	36
Electrode quality during events rated "good"	24/24 (100%)	34/36 (94%)
Video quality during events rated "acceptable"	19/24 (79%)	30/36 (83%)
Clinical outcome conclusive (*n* cases (%))	4/5 (80)	4/5 (80)

a lightweight cart which could be dismantled and transported in the back of any car. During transport the equipment was stored in travel bags. The overall weight of the equipment was 43 kg was divided up in 4 bags. The equipment was perceived heavy by some technicians. Training for technicians for setting up the system was provided and guidelines were introduced (see Appendix 1).

3.2. Pre-implementation Pilot Study

Eight patients were recruited over a 6 month period (Table 2). In 5/8, the patient's habitual seizures were recorded. We were able to include patients within a distance from the hospital ranging from 1.4 miles to 33 miles. The transport costs for technician and equipment ranged from £15 to £78 (we used public taxis). On average 3 recording days were carried out. The total technician time away from the base hospital ranged from 3.5 h to 9.5 h for the whole of the recording time (mean 6.3 h over 3 days).

All technicians (see Supplementary Online Table 3) found the telephone assessment helpful, the assembly of the HVT system easy but the system was felt to be somewhat bulky and heavy by some. Taxi transport was perceived prompt and reliable by all technicians. No technician felt that the recording would have been of a higher quality had it been carried out in the hospital. Only one technician experienced an urgent call-out to troubleshoot a recording problem. In some patients with Learning Difficulties, a second technician could have been helpful in putting on electrodes.

The 5 consultants involved in the study (see Supplementary Online Table 4) rated the HVT recording from "as good as" IVT recording to "slightly inferior". On 2 occasions the video quality was found inferior to typical hospital recording. The scheduled joint technician and consultant review of IVT data did not always happen as data was not always promptly available at the next review meeting. Consultants' opinions differed greatly in view of the general suitability of diagnostic HVT for paediatric and adult patients: two consultants were unsure; one felt 2/3 of cases would be suitable; one felt 100% would be suitable; and for one consultant only 10–20% would be suitable candidates for HVT.

8/8 patients or carers (see Supplementary Online Table 5) were 'very satisfied' with the HVT service and would have 'preferred' it over a hospital admission had they had the choice. 4/8 however would have seen the potential help from nurses and technicians during a hospital stay in managing the seizures.

The economic modelling (Supplementary Online Table 6) suggested that the direct costs of HVT are 66% of the direct costs of IVT (£1083 versus £1639 per case, assuming 3 days of data collection). In our setting, the surplus generated per case was doubled, from £561 per case for IVT to £1117 per case for HVT.

3.3. Implementation and evaluation of consecutive case series

Of the 34 patients, 12 were children without LD, 13 adults without LD, and 9 were adults or children with LD. One HVT was carried out in a brain injury rehabilitation unit and 1 in a nursing home for LD patients. Apart from 2 which were sleep studies (polysomnography) the vast majority of HVT evaluations were for seizure classification. On 8 occasions a consultant home visit was carried out, usually when the patient was severely disabled and an outpatient appointment for the clinical interview would have been impossible or very disruptive. On 4 occasions a multidisciplinary home visit was organised where a meeting with the community paediatric or psychiatric team was achieved. On one occasion the home visit and recording was abandoned as special sedation would have been required for electrode placement. In contrast to the previous pre-implementation study, a number of technicians encountered a suboptimal taxi service which caused delays.

A summary of the 34 cases is included in Supplementary Table 7.

4. Discussion

Video-EEG telemetry has conventionally been regarded as a highly specialised investigation requiring inpatient admission. It is costly, often availability is geographically limited, and several days admission to an inpatient monitoring unit is prohibitively difficult for some patient groups who may considerably benefit from the investigation. We saw an opportunity and a need to develop a new service of video-EEG telemetry in the patient's home, maintaining the highest clinical standards; our purpose here is to describe the process of feasibility testing and implementation, in particular emphasising the potential obstacles and cost savings. We acknowledge that our enthusiasm to develop this service may create a bias in the findings of the Pre-Implementation Pilot Study questionnaires, but believe that the data are sufficiently clear to justify our conclusions.

4.1. HVT development

Here we address the dynamics of one key element in the development-evaluation-implementation process. Development and consultation phases were repeatedly necessary to acknowledge and identify problems and achieve further acceptance and penetration within the hospital department. One of the biggest changes involved in implementing HVT was that staff and equipment from a previously entirely hospital-based department and service needed to go to the patients' homes. This community based work was novel and required an understanding of security and safety risks for our staff.

We encountered logistical obstacles. Based on the questionnaire we discovered that one patient lived on the 4th floor with no lift access and HVT was not suitable and on another occasion the family could not guarantee the safety of our equipment. As we progress with our HVT service, we are developing a second HVT system which will be laptop based, which may increase the risk of theft but will clearly decrease the weight and bulk required for transport. So far only senior technicians have taken part in setting up HVT, as experience is required and improvisation and troubleshooting often needed.

Table 2
Outcome of pre-implementation Pilot Study of HVT.

Patient #	Events captured	Duration of recording (days)	Technician time consumed (hours total)	Distance (miles)	History taken by telephone (T), in the hospital department (D), or in the patient's home (H)	Transport costs (British pounds)
1	Yes	2	4	9.5	T	37.17
2	Yes	3	4	1.4	D	13.42
3	Yes	3	9	24	T	0 (staff car)
4	Yes	4	3.5	2.7	D	49.06
5	Yes	3	9.5	33	D	64.02
6	No	3	8.5	31	T	74.34
7	No	3	4.5	9	D	78.47
8	No	2	8	14.3	H	0 (staff car)

We also encountered unfamiliar financial accounting and legal issues. In order to formally account for the admission and recoup income from purchasers, HVT was introduced on our EPR (electronic patient record) as a "virtual" hospital admission. Our hospital has other such virtual admissions already established, hence we did not end to develop a new policy or process for this purpose. Legal concerns and the range of clinical responsibilities were raised by medical staff. Our legal department assured us that the vicarious liability of the hospital for this diagnostic procedure and medical duties remained limited to the field of expertise of the consultants involved. The patients remained under the overall care of their family doctor.

A few limitations were encountered: Currently no sedation protocol has been developed and therefore on one occasion a home visit had to be abandoned. The telephone risk assessment triggered two incidents where domestic pets were perceived to be a risk for the recording system and as a consequence the procedure did not go ahead. The biggest limitation is distance between hospital and patient's home and consequent travel challenges and technician working time lost during travel.

There were unexpected benefits. With the advent of HVT new patient groups were identified (e.g. a patient with mental health problems who has not left his home for two decades). We also found that HVT is particularly suitable for patients with special needs where the residential home is better equipped and the routine carers were more experienced with these patients than hospital staff; we felt that the diagnostic procedure was less traumatic than a hospital admission. HVT provided an impetus for domiciliary home visits to be carried out by one of the consultants which proved to be a valuable source for understanding of the patient's condition in the home environment. It also gave the opportunity to consult with other professionals in the community who would not typically be available during a hospital admission. This was particularly helpful in patients with severe LD. On a few occasions multidisciplinary meetings were organised at the patients' home where the Consultant met with the community paediatric or psychiatric team. These MDT would not have happened during a conventional IVT.

4.2. HVT implementation

As acknowledged in the guidelines for complex interventions[8] the implementation of a complex procedure is not the direct endpoint of a linear process but more the result of circular or spiral movement of developing, piloting, evaluation and implementation. Although the process described here might seem simple, we began the feasibility phase in 2007, and the final implementation in 2011. From February 2011, HVT was implemented as a routine diagnostic procedure. It has become part of our video-EEG telemetry service, complementing a range of other services including day case recordings, outpatient activation procedures (using suggestion techniques to activate seizures, particularly psychogenic non-epileptic seizures), scalp and intracranial inpatient recordings (including functional stimulation) for adults and children.

We acknowledge that some cases may be unsuitable for HVT. These include obvious situations such as the requirement for drug reduction in some presurgical cases and video-EEG telemetry using intracranial electrodes. We did not attempt to provide HVT to patients more than 40 miles from our centre, and would expect travelling distance for the technician to be a limiting factor. Our experience has been that an individual technician can undertake HVT in up to four patients in a single week, and still be able to spend 50% of their working hours in the base hospital.

Certain aspects of the domestic situation were occasionally found to be unsuitable: in rare or single instances we have found uncontrolled animals felt to put equipment at risk, or that the patient is homeless, or entry to the home is refused. At the time of writing, 225 patients have been evaluated with HVT, with only 4 being found unsuitable for such reasons.

4.3. Recommendations for future development

Although the number of cases investigated here is not large, we have subsequently implemented HVT for approximately 80% of our diagnostic VT workload. Within our own practice, we believe that the vast majority of diagnostic referrals could be carried out in the patient's home, a nursing home or a local (non-specialist) hospital. We found in this study that patients prefer HVT to inpatient VT. We also believe that some patients could undergo the seizure monitoring component of presurgical evaluation using HVT, and indeed we have done this successfully, but acknowledge drug withdrawal at home would not be possible, and postictal cognitive assessment could not be carried out. HVT developed at a tertiary neuroscience centre has the potential to disseminate this level of expertise seamlessly into the community. Assessing the patient in his home environment is not only more convenient for the patient and more cost effective for the hospital and or the primary care provider but has the potential to add clinical information to the benefit of other aspects of medical management. For example, interactions between seizure occurrence and sleep phenomena, domestic stressors and other seizure-provoking issues may be clarified; and it might be possible to assess risks related to injury or SUDEP resulting from seizures occurring in the patient's natural environment. There is considerable research potential which could emerge from the study of the patient in their natural environment, which we can only speculate about here. In-hospital evaluation does not capture the interaction between the patient's epilepsy and their natural environment, and this "ecology of epilepsy" is a substantially underexplored area. Considerable thought needs to be put into ensuring the safety and security of patients, staff, equipment and confidential data; none of these is insurmountable, and we were able to make use in some instances of existing policies (e.g. on lone working).

We have begun to explore the benefits of community based Multidisciplinary Meetings, allowing patient management to be optimised in the patient's home. We have also begun to explore collaboration with local non-specialist hospitals, providing an outreach service in an identical manner to HVT, for example providing video-EEG telemetry in the ITU of non-specialist hospitals, thus avoiding expensive and potentially dangerous ambulance transfers to the specialist tertiary centre. By demonstrating feasibility and cost-effectiveness, we have been able to secure investment from our hospital to purchase a second HVT system.

Current collaborations between clinicians, engineers and communications technology experts are pointing the way to future monitoring systems with enhanced capabilities. A number of new approaches have been proposed, making use of current technologies to collect multiple parameters of data, track the patient's location and provide warning signals to carers and professionals, such as a system design which would collect EEG, automatically detect seizures, locate the patient using GSM systems, and send a seizure alert to carers or professionals using SMS messaging.[9] There are many challenges in implementing HVT especially over extended periods. The volume of data collected may be very considerable, and in the absence of professional staff constantly monitoring the data output as in hospital, these data need to be reviewed efficiently. Automated event detection is an important innovation in this context, such as automated detection of IEDs[10,11] and seizures.[12] A challenge in out-of-hospital data, which may be extreme, is the presence of many different artefacts related to movement and other sources of physiological and non-physiological noise. Methods to remove muscle artefact can considerably aid automated event detection.[13,14] The most important barrier to very long-term EEG monitoring outside the clinic is electrode technology. Electrodes in current use require skilled attachment and regular inspection to maximise signal quality, and without this the signal rapidly becomes degraded or lost. New technology such as gel-free ''skin-grabbing'' electrodes[15] may prove to be an important step forward.

It remains our hope that other centres profit from our experience and feel encouraged to adopt our results into their specific local circumstances. With a widespread network of collaborating centres providing HVT we hope to see even the most vulnerable and hard-to-reach patients benefiting from this expert diagnostic service in the future.

Conflicts of interest

None of the authors has any conflict of interest to disclose.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.seizure.2014.01.009.

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