Paediatric EEG provision in New Zealand: a survey of practice

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Abstract

**Aim** Epilepsy is a common neurological disorder in children. Electroencephalography (EEG) is integral to the diagnosis of an electroclinical epilepsy syndrome. Here we aim to describe provision of paediatric EEGs in New Zealand.

**Method** All neurophysiology departments in New Zealand performing paediatric EEGs were invited to participate. Personal interviews were conducted to ascertain the number and type of EEGs performed in children and the paediatric protocols used in each department.

**Results** 12 of the 13 eligible neurophysiology departments participated. These departments performed between 2–950 paediatric EEGs each year. Waiting times were variable: urgent (8 hours–14 days); semi urgent (1 day–8 weeks); routine (1 week–4 months); with two centres unable to perform urgent or semi urgent EEGs. Seven departments routinely sleep deprived children. The percentage of all outpatient paediatric EEGs that were sleep deprived ranged from 1–100%. Children's EEGs were reported by either paediatric (five departments) or adult neurologists (seven departments).

**Conclusions** There is marked variability between neurophysiology departments in the provision of EEGs for New Zealand children. As EEGs are important for epilepsy diagnosis, increased resources are required to ensure New Zealand children have equitable access to timely quality paediatric EEGs.

Epilepsy is a group of disorders classified into electro-clinical syndromes defined by age of onset, type of seizures, electroencephalographic (EEG) features and comorbidities. It is the most common serious neurological disorder of children affecting ~7300 New Zealand children under 14 years of age. Although individuals may live normal lives, 30% have seizures resistant to current therapy with major social, psychological, physical and cognitive sequelae. Mortality in children with severe epilepsy is 25% by 20 years of age. Epilepsy syndrome diagnosis is essential as it directs investigations for aetiology, guides therapy and allows accurate prognostic information to be given. Misdiagnosis leads to inappropriate unnecessary investigations and poor outcomes with significant impact on individuals, families and the New Zealand health system.

An electroencephalography (EEG) is an integral part of the diagnosis of an epilepsy syndrome and is also often important for monitoring the effectiveness of ongoing therapy. The ideal Paediatric EEG (PPEEG) would show epileptiform discharges in all children with epilepsy. Unfortunately this is not the case as only 29–50% of children with seizures have epileptiform discharges in their first routine EEG. To increase this diagnostic yield, guidelines recommend activating procedures such as hyperventilation, photic stimulation, sleep deprivation and sleep be performed.

Although guidelines for recording EEGs have been developed, gaps are evident and departmental protocols vary significantly. Departmental audits are an effective way of assessing common practice and provide a basis for future research questions and recommendations. In this audit, we surveyed the delivery of paediatric EEGs (PPEEGs) in New Zealand.
Methods

All neurophysiology departments in New Zealand were contacted and invited to participate if they performed any paediatric EEGs (PEEGs) in 2009. PEEGs were defined as EEGs performed on children 16 years and under. Due to reported poor response rates from postal questionnaires, interviews in person or via teleconference were conducted between December 2009 and February 2010 with senior clinical physiologists from each participating department. Following the pilot of an initial questionnaire with one department, a revised questionnaire was emailed to all departments for their perusal prior to the interview. Departments that were unable to undertake a personal interview were posted the questionnaire and contacted if further information was required.

The questionnaire collected information on: protocols for PEEGs (standard PEEGs, sleep-deprived PEEGs, early PEEGs defined as performed within 48 hours of a seizure, and sedated PEEGs); number of PEEGs; referral patterns; waiting times; protocols for intermittent photic stimulation (IPS), hyperventilation (HV) and response testing; number, training and experience of clinical physiologists; and who reported the PEEGs. Attempts were made to gather actual numbers of EEGs performed in 2009. In departments where these statistics were not available estimates from the senior physiologists were used.

Results

Twelve of the 13 neurophysiology departments in New Zealand who performed PEEGs elected to participate (92%, 11 public departments/1 private department). One small private neurophysiology department declined participation.

EEG departments—Both adult and paediatric EEGs were performed in all departments. The number of EEGs performed by each department varied from ~50 – ~1900 per year. The number of PEEGs varied from 2 – ~950. Four of the 12 departments performed >300 PEEGS per year with five departments performing <100 PEEGs per year.

Nine departments had child-friendly rooms with three having a dedicated PEEG room or a room which was predominantly used for PEEGs. PEEG referrals were accepted from paediatricians, neurologists (adult and paediatric), psychiatrists, and junior medical staff in all departments. Six departments accept referrals from general practitioners with two departments screening these referrals by the reporting neurologist prior to them being accepted. Information sheets explaining EEGs were sent to families by all departments.

Departments were asked how they prioritised PEEG referrals, specifically what their definition and indications were for urgent, semi-urgent and routine. Two hospital departments did not do urgent or semi-urgent PEEGs as the technician was not based in the area. One department did not prioritise EEGs. Indications and desired and actual waiting times for urgent, semi urgent and routine EEGs are seen in Table 1.
Table 1. Indications and timing of Paediatric EEGs

<table>
<thead>
<tr>
<th>Variable</th>
<th>Urgent</th>
<th>Semi urgent</th>
<th>Routine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of departments</td>
<td>Number of departments</td>
<td>Number of departments</td>
</tr>
<tr>
<td>Indications</td>
<td>Status, repeated frequent seizures,</td>
<td>Recurrent seizures prior to initiation</td>
<td>Single afebrile seizures, on AEDs, if</td>
</tr>
<tr>
<td></td>
<td>encephalopathy, brain death, and sub-</td>
<td>of AEDs, radical change in seizure</td>
<td>likelihood of the epilepsy is not high</td>
</tr>
<tr>
<td></td>
<td>clinical seizures</td>
<td>frequency, epileptic encephalopathy</td>
<td></td>
</tr>
<tr>
<td>Desired wait time</td>
<td>8 hrs–7 d</td>
<td>&lt;24 hrs to 3 w</td>
<td>&lt;3 w–3 m</td>
</tr>
<tr>
<td>Actual wait time</td>
<td>8 hrs–14 d</td>
<td>1 d–8 w</td>
<td>1 w–to 4 m</td>
</tr>
<tr>
<td>Reporting time</td>
<td>&lt;24 hrs in 7 dept</td>
<td>&lt;24 h–2 w</td>
<td>1 d–3 w</td>
</tr>
<tr>
<td></td>
<td>(24–48 hrs in 2 dept)</td>
<td>(&lt;1 w in 8 dept)</td>
<td>(&lt;2 w in 10 dept)</td>
</tr>
</tbody>
</table>

Hrs–hours, w–weeks, m–months, dept–department, AED–antiepileptic drug

**PEEG protocol**—Prior to recording PEEGs, equipment was calibrated either before (three departments) or before and after (nine departments) the recording. An impedance of <5 kΩ (10 departments) or <10 kΩ (two departments) was desired. Measuring the 10–20 system for electrode placement in older children was standard in each department. One department used an electrode cap in children under 4 years.

The recording time for routine PEEGs was usually between 20 to 30 minutes (10 departments). Two departments recorded routine PEEGs for greater than 30 minutes (up to 40 min or up to 45 minutes). Nine departments routinely recorded PEEGs with video monitoring. Eleven departments had the technology to copy EEGs onto disk which could be read off site. Four departments had remote access to EEGs. After hours and weekend services were available in three departments.

Intermittent photic stimulation (IPS) and hyperventilation (HV) were attempted in all capable children in each department. The photic frequency range of IPS varied. One department started at 0.5 Hz, eight from 1 Hz, two from 2 Hz and one from 3 Hz. One department used photic frequencies up to 20 Hz, 1 to 22 Hz, 8 to 30 Hz, 1 to 50 Hz and 1 to 60 Hz. The duration of each frequency was 6 seconds for one department, 10 seconds for 10 departments and 15 seconds for one department.

Three departments tested IPS for 20 seconds if a history of light sensitivity was present. IPS was commonly tested at the end of the recording (ten departments). The lamp was placed 30 cm from the face in eight departments (range 15–40 cm). All departments tested IPS with eyes both open and closed. In the event of a photoparoxysmal response, the photic stimulus was stopped by all centres. Ten of the 12 departments then tested the sensitivity range and five tested IPS occluding one eye.

Hyperventilation (HV) was induced in young children by instructing the child to blow on a tissue or windmill in all hospital departments. HV was performed for 3 minutes in 9 of the 12 departments. The three remaining departments performed HV for 2–3 minutes, 3–4 minutes or 4 minutes. If an absence seizure was suspected but not precipitated, HV was lengthened (three departments), repeated (four departments) or both (five departments).

Response testing during an epileptic event was routinely performed in 11 of the 12 departments. Testing techniques included: repeating a word (4 departments); performing a task such as counting (10 departments); calling out questions or the child’s name (8 departments); and applying a tactile stimulus (1 department). In 5 departments, testing was practiced interictally.
Sleep-deprived PEEG and sedated PEEGs were performed in all hospital departments. Figure 1 shows the proportion of these in each department (Figure 1). In seven departments, sleep-deprived PEEGs were routinely performed for all outpatients apart from those in whom a physician had specifically requested a sedated EEG.

Recommendations for the amount of sleep in young children (definition varied from <1 year to <5 years) for sleep-deprived PEEGs included staying up 1–2 hours later and woken 1–2 hours earlier than their regular routine (three departments), half their regular sleep (one department), 5–6 hours (one department), 2–3 hours less than their normal sleep (one department) or to remain awake for the morning of the test (five departments).

Older children were recommended to have 5–6 hours of sleep (six departments), to stay up 2 hours later and wake 2 hours earlier (four departments), half the child’s normal sleep (one department) or 2–3 hours less than their normal sleep (one department). All departments encouraged sleep and if the child slept they were left to sleep for 10–20 minutes (11 departments).

Figure 1. Histogram showing the percentage of PEEG types in each department

Sedated PEEGs were conducted after a failed first attempt at a sleep-deprived PEEG in nine departments, in children who were expected by their parents or doctor to not cooperate in five departments or in one department routinely in children 1–3 years old.

Ten departments used chloral hydrate as their first-line sedation medication. One department had no sedation protocol and one did not do sedated EEGs. Prior to sedation, the child was firstly seen by a consultant then chloral hydrate was administered by a doctor (three departments), nurse (five departments) or technician (one department). One department was unsure who administered the medication. No departments had a protocol for recording early PEEGs.

Staff—The number of full-time equivalent clinical physiologists in each department varied from 0.1–4.8 with 23 clinical physiologists in total. Six departments had a single part-time clinical physiologist,
although this was the same clinical physiologist in three departments. The remaining departments had two (two departments), three (three departments) or six (one department) clinical physiologists. Of the 23 clinical physiologists, 18 had formal neurophysiology qualifications and 3 had previously worked in a dedicated paediatric department overseas. PEEG reporting was predominantly performed by either paediatric neurologists (five departments) or adult neurologists (seven departments). Two departments posted PEEGs to a larger centre to be read by paediatric neurologists.

Discussion

There is international recognition based on class I and II evidence that an EEG helps determine seizure type, epilepsy syndrome, risk of recurrence and management in children with epilepsy.\(^2,7–9,11\) It is therefore international standard that all children with new onset seizures have an EEG. Recording of both awake and sleep states as well as hyperventilation (HV) and intermittent photic stimulation (IPS) are recommended to increase diagnostic yield.\(^5–12\) There is very little data available on aspects of epilepsy diagnosis or management in New Zealand. A survey of New Zealand paediatricians in 2006 found that only 89% of paediatricians requested an EEG after a child presents with new onset seizures. The authors suggested that paediatricians with poor EEG services were less likely to order EEGs.\(^14\)

Although it is well recognised that EEGs should be performed in children with epilepsy, there is variability in how PEEG services are provided. A 2006 survey of EEG departments in Great Britain performed with similar methodology to our study identified a range of practice and operational procedures that were felt to have implications on investigation and management of people with epilepsy. The UK study sent written questionnaires to all EEG departments in Great Britain and had responses from only 52 departments (42% response rate).\(^13\) Our audit is the first survey of PEEG provision in New Zealand. With a high response rate of 92% of all departments and 100% of all hospital-based departments, we are able to provide comprehensive data on how PEEGs are performed in New Zealand. Our New Zealand EEG audit found that HV and IPS protocols were similar between departments. The number and type of PEEG performed, the waiting times for PEEGs and the specialist reporting the PEEGs however varied considerably.

We found considerable variation between the type of EEG that was performed on children in New Zealand. Sleep-deprivation or an early EEG within 24 hours of a seizure are generally recommended to increase the yield of an EEG.\(^6,8,9,11,12\) No departments had specific early EEG protocols although PEEGs were likely to have been performed early in some centres due to their short waiting times. The percentage of sleep-deprived EEGs in each department varied from 1–100%. Certain types of epileptic activity are provoked by drowsiness, sleep, or on awakening.\(^7,8\) It is therefore recommended that a period of relaxation, and if possible, sleep is captured in an EEG.\(^7,9,15\) This is supported by reports of increased yield in sleep-deprived EEGs compared to routine and sedated EEGs.\(^15\) Many departments in New Zealand do not routinely perform sleep-deprived EEGs instead opting for an initial routine EEG and a subsequent sleep-deprived EEG if that is not informative. This may be partly due to concern over the burden of sleep-deprivation for a family.\(^16,17\) Given children and families would prefer to be sleep-deprived than have venepuncture it seems that the burden/distress of sleep deprivation for the family is no greater than other routine hospital investigations\(^18\) and so may not be sufficient reason to defer sleep deprivation.

Waiting times differed by up to 4 months between departments in New Zealand. Only 8 of the 12 departments were able to perform and report PEEGs on new onset seizures within the internationally recommended 4 weeks.\(^2,11\) This finding is consistent with what was reported in the UK EEG audit.
where over two-thirds of departments were unable to meet this waiting-time recommendation. As expected, departments with more staff had shorter waiting times than those with one part-time technician.

PEEGs differ significantly from adult EEGs due to developmental variation in normal features and increased artefact making their interpretation more difficult than adult EEGs. The interpretation of PEEG abnormalities and specific correlation with clinical presentation is also unique to paediatrics as there is a wide range of paediatric epilepsy syndromes not found in adults. The majority of departments had clinical physiologists with formal training although only three had previous specific paediatric experience or training in a dedicated Paediatric EEG department. PEEGs were commonly read by adult neurologists. This is consistent with the UK survey that found only 50% of physiologists and 60% of EEG reporters had formal paediatric training.

It is concerning that the number of PEEGs reported in some departments is so small that the reporters may struggle to remain competent in paediatric EEG reporting. This lack of specific PEEG training of clinical physiologists, predominance of reporting by adult neurologists and lack of significant ongoing experience in some centres creates a risk that PEEGs may be misinterpreted. It has been suggested that in the UK all paediatric EEGs should be read by either paediatric neurologists or adult neurologists with considerable and ongoing paediatric EEG experience. This is perhaps even more relevant to New Zealand where there is a shortage of paediatric neurologists. Consequently in New Zealand the majority of the PEEG reports go to general paediatricians who may lack the necessary specific paediatric epilepsy syndrome knowledge to be able to effectively interpret reports from adult neurologists who also do not have this knowledge.

EEGs do not need to be reported onsite as they can be copied and posted, or read online by a paediatric neurologist remotely. It would therefore be possible to have all PEEGs in New Zealand reported by paediatric neurologists which would improve the standard of care for New Zealand children with epilepsy.

A weakness of this survey is that statistical data on total number and number of different types of PEEG were not recorded in all departments. We took a pragmatic approach and used estimates from the senior technicians in departments where this was the case. Although not ideal, senior EEG technicians are best placed to give accurate estimates.

**Conclusion**

There is marked neurophysiological department variability in the provision of EEG for New Zealand children. As an EEG is integral to the diagnosis of an electro-clinical epilepsy syndrome, all New Zealand children should have access to PEEGs performed to an international standard in an internationally recommended time frame.

The misdiagnosis of epilepsy or the specific epilepsy syndrome due to over or under interpretation of the EEG has significant impact on management and subsequent outcome for children with epilepsy. Guidelines should be developed to direct PEEG provision and resources made available to enable these to be followed. Specifically children should have access to sleep-deprived or early EEGs within 4 weeks of the onset of their seizures.

To allow for appropriate interpretation of EEG abnormalities and correlation with paediatric epilepsy syndrome diagnosis, PEEGs should be reported by paediatric neurologists. This could be achieved by increased use of offsite reporting.
Competing interests: Nil.

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References


