EEG MONITORING

EEG MONITORING IN THE PICU

Electrographic seizures and electrographic status epilepticus are common in critically ill children and neonates with acute encephalopathy.[1] Most electrographic seizures are non-convulsive seizures and will not be identified without continuous EEG monitoring (cEEG). Yet the provision of continuous EEG monitoring is resource intensive and not readily available in many PICUs.[2]

The criteria used in different studies to instigate continuous EEG monitoring are variable but most often a GCS of ≤ 8 has been used. The cause of the encephalopathy leading to seizures in highly variable:

	n	Number affected by seizure (%)
Acute structural disorders		
CNS inflammation or autoimmune disorder	24	8 (33%)
Stroke	33	10 (30%)
Traumatic brain injury	61	18 (30%)
CNS infection	28	8 (29%)
Hypoxic-ischaemic encephalopathy	73	13 (18%)
Tumour/oncological	21	4 (19%)
Acute non-structural disorders		
Sepsis	19	11 (58%)
Metabolic	59	17 (29%)
Pharmacological sedation—no known neurological problem	15	2 (13%)
Toxin	8	1 (13%)
Paralytic drug administration	26	2 (8%)
Pre-existing diagnoses		
Epilepsy	159	76 (48%)
Brain malformation	24	9 (38%)
Unknown	14	3 (21%)
All patients*	550	162 (29%)

Table includes some data from reference 9. *Patients could have more than one diagnosis, so n for all patients does not match the sum of those for all diagnostic classifications.

Table: **Electrographic seizure diagnosis by cause among 550 children who underwent EEG monitoring in the paediatric intensive care unit**

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WHO SHOULD GET A CONTINUOUS EEG[3]

Patient Groups at Increased Risk for Non-convulsive Seizures

- Convulsive status epilepticus, with persistent encephalopathy after termination of clinical seizures
- Hypoxic–ischemic brain injury
- Acute ischemic or hemorrhagic stroke
- Traumatic brain injury
- Acute metabolic encephalopathy (sepsis, hepatic, renal, toxin)

Specific Conditions requiring cEEG

- Refractory status epilepticus, to guide titration of high-dose anticonvulsant therapy.
- Encephalopathy or coma, with suspicion of non-convulsive seizures (see higher-risk groups below).
- Neuromuscular blockade, with suspicion of non-convulsive seizures (see higher-risk groups above).
- To characterize clinical events suspected to be seizures.
- Any child on ECLS

Below are 2 tables, form Yang et al[4] and Payne[5] respectively, indicating children at risk of non-convulsive seizures:

Table 2
Risk factors in logistic regression model in model creation dataset.

Variable	Log OR (beta)	SE (beta)	z	p-Value	OR	OR 95% CI
Age (<24 months)	0.91	0.33	2.76	0.0058	2.48	1.30–4.72
Clinically evident seizures prior to CEEG (present)	0.81	0.32	2.49	0.0126	2.24	1.19–4.22
Typical EEG background category (ref=normal/sleep)						
Slow/disorganized	2.43	1.04	2.34	0.0192	11.40	1.49–87.39
Discontinuous	2.22	1.13	1.97	0.0488	9.24	1.01–84.4
Burst-suppression	3.08	1.15	2.69	0.0072	21.79	2.31–205.91
Attenuated/featureless	2.97	1.10	2.7	0.0069	19.42	2.25–167.33
Inter-ictal epileptiform discharges (present)	2.43	0.40	6.14	<0.0001	11.34	5.22–24.62

CEEG, continuous EEG monitoring; CI, confidence interval; OR, odds ratio.

Table 1. Patient characteristics associated with electrographic seizures

Clinical characteristics	EEG characteristics
Persistent encephalopathy	Abnormal background activity (e.g., burst suppression or suppression)
Younger age (<2 to 3 years)	Lack of background reactivity
Clinical seizures or status epilepticus before starting cEEG monitoring	Interictal epileptiform discharges, particularly periodic discharges
Diagnosis of an acute structural brain injury	
Prior diagnosis of epilepsy	

The table is based on data obtained from numerous observational clinical studies in neonates and children [4▪▪,5▪▪,7–11,14,16▪]. cEEG, continuous video-electroencephalography.

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DURATION OF CONTINUOUS EEG

Although the majority of seizures are captures within the first 24 hrs, with almost 50% captured within 1 hr of PICU admission, monitoring should be maintained for 24-48 hrs provided the encephalopathy persists.[6] Monitoring becomes less cost effective, especially after 24 hrs.[7]

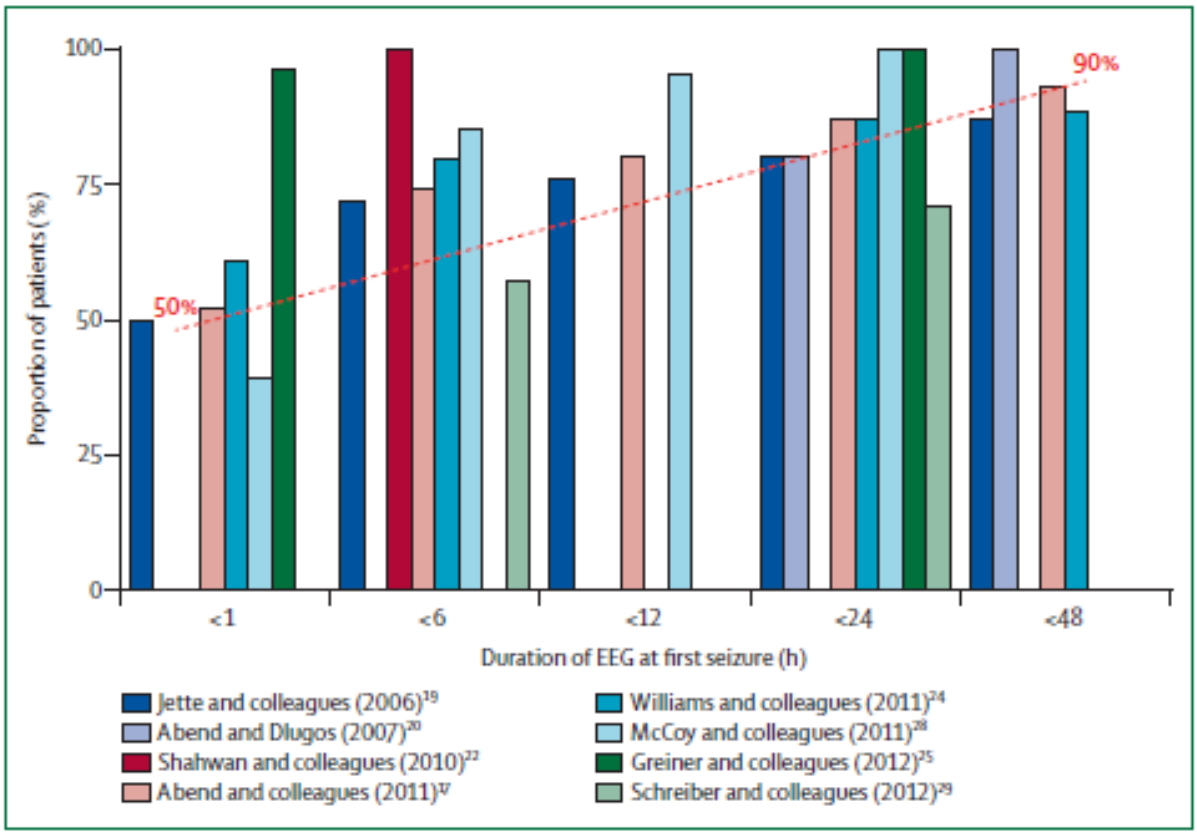

***Figure 2:* Duration of EEG monitoring at onset of the first electrographic seizure in critically ill children**
Across several observational studies, about 50% of patients with seizures were identified within 1 h, and about 90–100% were identified within 24–48 h.

The duration of cEEG monitoring will be determined by the Neurology attending and should be individualized according to patient circumstances. Once the decision to stop cEEG monitoring is made by the Neurology attending, cEEG interpretation will cease, regardless of when the patient is disconnected.

cEEG monitoring should stop when the following conditions are met:

- Clinical events suspected to be seizures are consistently demonstrated to be non-epileptic
- Mental status improves sufficiently to permit clinical assessment for seizures
- Neuromuscular blockade is lifted, permitting clinical assessment for seizures
- Patient remains seizure-free for 24 hours (after cessation of continuous anticonvulsant infusions, if any)
- Patient remains seizure-free for 24 hours after rewarming following therapeutic hypothermia

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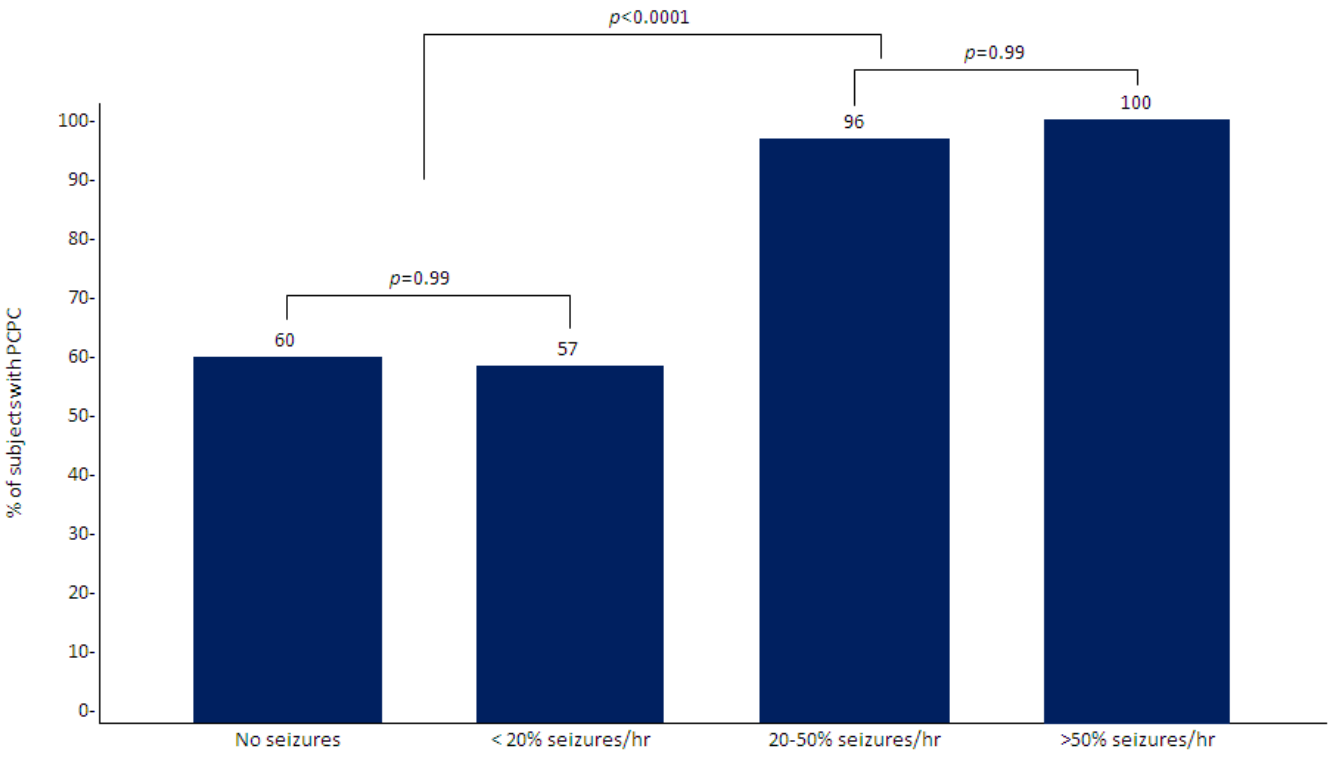
WHEN TO TREAT EEG SEIZURES

Although seizures are a marker of more severe brain injury, electrical status epilepticus probably independently contributes to that injury and a subsequent poorer outcome.[8 9 10] But there is no consensus as to how best manage seizure activity in critically ill children[11 12]. Nor is there any evidence that such management improves the outcome.

The seizure burden is associated with outcome and if seizure activity persists for more than 12 min/hr more aggressive therapy is probably required[13] (see PICU Status Epilepticus Guideline), irrespective of the etiology of the seizures.

Probability of neurological impairment increases significantly above a maximum hourly seizure burden of 12 minutes



Payne et al., 2013

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Factors associated with neurological impairment on multivariable analysis		
Subject Characteristic	**OR (95% CI)**	***p*-value**
Increasing seizure burden (max % sz/hr)	1.13 (1.05-1.21)	0.0016
Discharge diagnosis = Acute brain injury	14.1 (4.8-42)	< 0.0001
Clinical seizures in the acute presentation	3.79 (1.15-12.5)	0.029
Unreactive EEG background	6.70 (1.9-23.9)	0.0034
Prior history of epilepsy	0.060 (0.018-0.198)	< 0.0001
Minimum GCS during ICU admission	0.756 (0.640-0.983)	0.001

Disease severity markers, PRISM & PELOD fell out of the model

Payne et al., 2013

Intensive care mortality is associated with the presence of electrical status epilepticus, defined as continuous seizures for > 30 min or a seizure burden of > 30 min/hr[14], but again there is no evidence to indicate the time to termination of status epilepticus alters mortality.

ACCESS TO EEG IN PICU

EEG Technologist[15] Availability

Mon-Fri:

EEG tech onsite: 0800-1800*

On call: 1800*-21:00

**At times, due to staffing resource challenges, onsite service may occasionally end at 16:00. In this instance, on call will run 16:00- 21:00. This should not affect the availability of the on call tech or the ability to complete tests within usual time frame.*

Sat/Sun:

EEG tech onsite: 8:30-16:45

On call: None for weekends. Support will be given during hours of onsite operations.

Requests for continuous EEG monitoring must be placed through the NCC staff or the Attending Neurologist.

cEEG Interpretation

cEEG interpretation is performed by the Epileptologist on LTM (long term monitoring) service and will be done:

- Weekdays - report twice daily by 1000 and 2200 (closer to 1900 if possible) via SCM & upon request from Neuro or ICU staff
- No LTM MD reads 2200 – 0800
- No LTM MD reads on weekends

Neurologist on hospital service can review at any time at the request of PICU staff. This request can come direct from the bedside nurse.

Long term followup is required.[16] Consult Brain Injury/NCC team.

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