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Point-of-Care EEG in the ICU: Towards a New Standard of Seizure Care

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Nonconvulsive status epilepticus (NCSE) is often invisible or impossible to distinguish from other sources of altered mental status. Without immediate and continuous access to EEG monitoring, physicians must treat without confirmation or delay their diagnosis. Point-of-Care EEG is helping to close both these gaps and make EEG accessible across health networks.

Key Points

- Electrographic seizures have major implications for patients' lives, ranging from neurological damage to the possibility of a permanent coma.
- While anti-seizure medication is effective and widely available, the limitations of conventional EEG undercut the timely treatment of this serious threat to patient health.
- The operation and interpretation of conventional EEG means most physicians must wait hours and sometimes days to reach a diagnosis of nonconvulsive status epilepticus (NCSE).
- A point-of-care EEG-enabled brain monitor from Ceribell meets the needs of the critical care unit by detecting suspected seizures without the presence of a neurologist or EEG technician.

When left untreated, electrographic seizures have major implications for patients' lives, ranging from neurological damage to the possibility of a permanent coma. As in the condition of nonconvulsive status epilepticus (NCSE), these seizures are often invisible or impossible to distinguish from other sources of altered mental status without the use of electroencephalography. Thus while anti-seizure medication is both effective and widely available, the limitations of conventional EEG have long undercut the timely treatment of this serious, prevalent threat to patient health (Sutter 2016).

The operation and interpretation of conventional EEG means most physicians must wait hours and sometimes days to reach a diagnosis of NCSE, even in the best of circumstances. Without immediate and continuous access to EEG monitoring—including the technicians to operate the equipment and interpret the results—physicians must either treat without confirmation or delay their diagnosis, leading to a need for more medication, increased monitoring, worse injury, and a longer length of stay.

These delays negatively impact patient outcomes even at large medical centres specialising in neurocritical care. The problem is even more pronounced at smaller community hospitals, where it is not just the delay in diagnosis but the lack of EEG access altogether that poses the greatest challenge. Without a way to rule out NCSE, physicians typically have to transfer any patient with suspected seizure activity.

To address the drawbacks of this default approach to seizure care would mean expanding access to neurological monitoring beyond hub medical centres—and eliminating the delays in diagnosis and monitoring gaps that remain even within those centres. Point-of-care is helping is helping to close both these gaps and make EEG accessible across health networks.

The Extent of the Problem

Epidemiologic evidence shows that electrographic seizures that can only be picked up by EEG, with minimal or no clinical manifestations, are detected in around 13% of patients with sepsis-associated encephalopathy and and around 30% of patients with haemorrhages into the brain, subdural haematomas, intercerebral haemorrhages, and the like (Strein et al. 2019). In fact, what we've learned from our vantage point in the ICU is that the vulnerability of the brain to injury extends far beyond the conventional neurocritical care population of patients with strokes, brain haemorrhages, and trauma. Being

critically ill for any prolonged amount of time can do damage to the brain by increasing vulnerability to encephalopathy, delirium, and disorders of consciousness.

To assess all of these cases requires more EEG capacity than we currently have. Many hospitals—particularly smaller hospitals or community hospitals—have fewer conventional EEG machines than they would need to appropriately diagnose nonconvulsive seizures. The cost of the equipment is often not the greatest barrier, though: it's the technicians who operate and maintain it, in addition to the neurologists needed to interpret its results. Both of those roles are ones smaller hospitals have difficulty filling.

In some ways, this lack of personnel has ended up clouding the question of how aware we are of this highly prevalent, highly damaging condition. Most neurocritical care units do see a large number of patient transfers specifically for EEG monitoring, however, which suggests that it's not limited awareness but limited resources that are slowing down the diagnosis and treatment of NCSE.

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Similarly, it's not the availability or even the complexity of the treatment which limits our ability to care for these patients: it's simply knowing with certainty who needs it and who doesn't. And then, for those who do need medication, when have we given enough? Whether to make a diagnosis after initial seizure activity or to assess the efficacy of anti-seizure treatment, more than a third of all critical patients will require continuous EEG—and those with refractory status may need a week or more of monitoring. Traditionally, the demand for such resource- and time-intensive monitoring could only be fully met at a few hub hospitals with the expertise and staff power to perform it. In nearly all contexts, then, the need for EEG has always outstripped the supply.

A Breakthrough Tool

Attempts have been made to address this gap. Prior to the advent and FDA approval of rapid-EEG technology, device manufacturers experimented with a limited montage that anybody, not just a trained technician or neurologist, could put on the patient. For a variety of reasons, however, these attempts have not worked out.

A new, point-of-care EEG-enabled brain monitor from Ceribell meets the NCSE needs of the critical care unit by delivering automated seizure detection without the presence of a neurologist or EEG technician. The device consists of a headband with an array of ten EEG contacts that anyone can apply—doctors, trainees, nurses, techs, respiratory therapists—as well as an AI-powered algorithm tthat NCSE takes about five minutes to produce a yes/no notification for seizure activity. A 2020 multi-centre observational study showed that this technology improved the sensitivity of physicians' seizure diagnosis from 78% to 100% and increased the specificity of diagnosis from 64% to 89%; the time it took to reach these diagnoses was about five minutes, opposed to the hours of delay with conventional EEG (Vespa et al. 2020). Like other vital sign monitors, this device can be applied immediately and then left on the patient.

The ease of use and clarity of this new brain monitor has two related benefits for hub-and-spoke health systems like the Westchester Health Network. Our system consists of smaller feeder hospitals and a hub, the Westchester Medical Center, a large quaternary care stroke and trauma centre north of New York City. Our feeder hospitals, which have the ability to transfer complex patients to the hub, can shift from zero access to EEG to having access with Ceribell. For the hub hospital, it means we can start EEG monitoring for patients immediately, regardless of EEG technician availability. Because the headband monitor can be left on the patient to provide EEG monitoring in the off hours, we can deliver a consistent standard of care even when EEG technicians are off duty or otherwise occupied. Spoke hospitals can determine with accuracy whether or not a patient must be transferred, and our hub can perform what we call "far forward monitoring," which includes catching NCSE before it has the time to develop into refractory status, which responds less well to treatment.

The gold standard for EEG monitoring and assessment is always going to be a human, an expert encephalographer. Point-of-care EEG is not a one-to-one replacement for conventional EEG. For one, it doesn't have the same spatial resolution: it measures brain electrical activity on the lateral aspects of the hemisphere in a straight line along each side of the temple. With its additional electrodes, conventional EEG includes additional electrodes towards the vertex or top of the head. point-of-care monitor is not replacing conventional EEG; it's replacing no EEG, or EEG that is inaccessible at the time when it is most needed.

Case Examples

On a recent night, a patient came into the ICU with convulsive seizures. The patient was intubated and started on midazolam. For whatever reason, the EEG tech wasn't there that night, so we hooked up Ceribell's brain monitor and started it between 10:30 and 11:00 PM. Without point-of-care, we would have had to wait eight or nine hours—until the tech came back to work in the morning—to assess the patient for

seizure activity. We had given medication to treat her seizures, but without EEG, we had literally no way of knowing if we were successfully eliminating the seizures or not. The monitor let us know definitively that the patient had received enough medication to suppress the seizures. If we had seen any additional activity, this case could be considered an example of "far forward monitoring," where we find out early if we have to escalate our intervention.

The other use case is at our feeder hospitals, which may have a neurologist see a patient for a change in the level of consciousness when the CT is unrevealing. Whereas in the past, the patient would have had to wait hours or a day simply to get a 30-minute spot EEG—which again is not as sensitive as prolonged monitoring—these hospitals can now perform this monitoring themselves with Ceribell. What that earns those feeder hospital physicians is situational awareness: they can be confident that they have ruled out NCSE have ruled out seizures after several hours of automated monitoring (where a clear alarm notifies them if there is suspected seizure activity). If seizures are detected, and they realise they'll be hard to treat, the patient can be transferred to the neurocritical care unit at our hub hospital. If not, they can avoid transferring the patient simply to get a conventional EEG. And the more those hospitals become practiced in using Ceribell, the more we are able to establish and refine our tele-ICU service, extending our neurocritical expertise and enabling our hub intensivists and neurologists to help assess potential transfers.

Towards a New Standard of Care

Stroke is acknowledged to be a massive public health problem and, as such, has been positioned squarely in regulators' crosshairs. Standards of care have been established and disseminated—sometimes to the public as well as to healthcare provider organisations—and these standards are now used to measure and incentivise healthcare organisation performance. Similar measures are in place for evaluating and certifying comprehensive epilepsy centres offering outpatient treatment and epilepsy surgery programmes.

The emergency treatment of status epilepticus has not evolved to that level yet. As early as a 2001 clinical trial (Alldredge et al. 2001) and certainly since the Rapid Anticonvulsant Medication Prior to ARrival Trial (RAMPART) (Silbergleit et al. 2011), it has been well established that seizures are more responsive to treatment the earlier they are treated. Yet even with that knowledge, there are still no guidelines to help hospitals meet the challenge of treating status epilepticus as a. time-sensitive neurological emergency. Part of the reason may be the historical lack of tools to allow hospitals to meet those guidelines—i.e., the lack of a quick, accurate, accessible way to assess for seizures.

Now that we actually have the tools, it's time to rigorously study different treatment approaches in-depth and work towards establishing a new standard of care. ■

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