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Improvements in a Machine-Learning Algorithm for Detecting Status Epilepticus

Baharan Kamousi (Ceribell, Inc.);Archit Gupta (Ceribell, Inc.);Suganya Karunakaran (Ceribell, Inc.);Ali Marjaninejad (Ceribell, Inc.);Raymond Woo (Ceribell, Inc);Josef Parvizi (Department of Neurology and Neurological Sciences, Stanford University)

Background & Purpose

Point-of-care EEG (POC EEG) systems enable rapid set-up and triage of patients at risk for seizures in acute care settings. Machine learning algorithms can enhance the benefit for bedside care teams by providing continuous monitoring of seizure activity. In this study, we evaluated the accuracy of an algorithm (Clarity, Ceribell Inc.) to detect status epilepticus in a large dataset of POC EEGs.

Methods

We retrospectively analyzed a dataset of 665 POC EEG recordings across 11 different hospitals. The output (maximum seizure burden, max. SzB) of two different versions of Clarity was recorded post-hoc for each file. The POC EEGs were also evaluated post-hoc by at least two epileptologists (three in case of disagreements) who were blinded to the Clarity output. We compared the accuracy of algorithm performance at ≥ 90% max. SzB (indicating suspected status epilepticus) to the majority consensus of the epileptologists in terms of sensitivity, specificity, negative and positive predictive value.

Results

The epileptologists labeled 20 cases as SE. For nineteen of these, the Clarity algorithm generated a status epilepticus alert (≥ 90% max. SzB). Clarity also alerted on 17 additional files, only 1 of which was labeled as slow/non-epileptiform by the epileptologists. Overall, Clarity demonstrated 95% sensitivity, 97% specificity, 53% PPV and 99% NPV for SE. This represents an increase in accuracy over a previous version of the algorithm, which showed 95% sensitivity, 94% specificity, 32% PPV and 98% NPV.

Conclusion

The accuracy of Clarity for detecting SE events in this large dataset – when compared against evaluations of the EEG by epileptologists – indicates the algorithm’s ability to assist clinicians in quickly identifying and treating, or ruling out, SE in critical care environments. Moreover, the increase in specificity and PPV achieved in the latest version of Clarity demonstrates continuing improvement of this machine learning algorithm.

Artificial Intelligence Algorithm Detecting Status Epilepticus and Measuring Seizure Burden

Baharan Kamousi PhD, Archit Gupta PhD, Suganya Karunakaran PhD, Ali Marjaninejad PhD, Ray Woo PhD, Josef Parvizi MD, PhD

INTRODUCTION

- Artificial intelligence (AI) algorithms are increasingly integrated into medical practice – improving efficiency, quality of life, and diagnostic decision making of clinical decision makers.
- The FDA-cleared **Ceribell Clarity Algorithm** automatically and continuously monitors the EEG, measuring the *seizure burden* every 10 seconds (i.e., burden of seizure activity in the last 5 minutes)
- When suspected status epilepticus is detected, it provides visual and auditory alerts at the bedside and remotely.
- With added data, AI algorithms have the potential to continuously improve.
- The current study was a comparative study to measure the accuracy of the latest version (v6.0) of the algorithm compared to the earlier version of the same algorithm (v2.0)

METHODS

1. We retrospectively selected 665 Ceribell EEGs from 11 centers.
2. Each EEG was categorized using the majority consensus of at least two expert epileptologists.

RESULTS

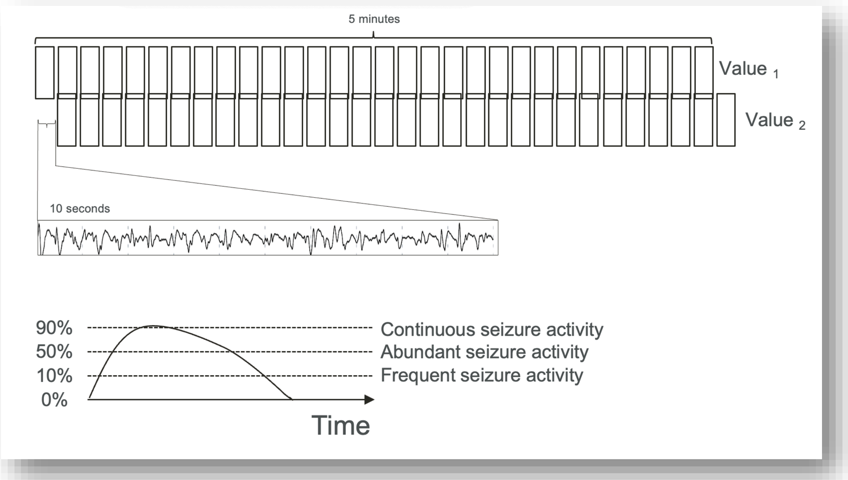
- The majority Epileptologist consensus labeled the EEGs as following:

Slow/Non-epileptiform	Highly Epileptiform	Seizure	Status Epilepticus
501	128	17	20

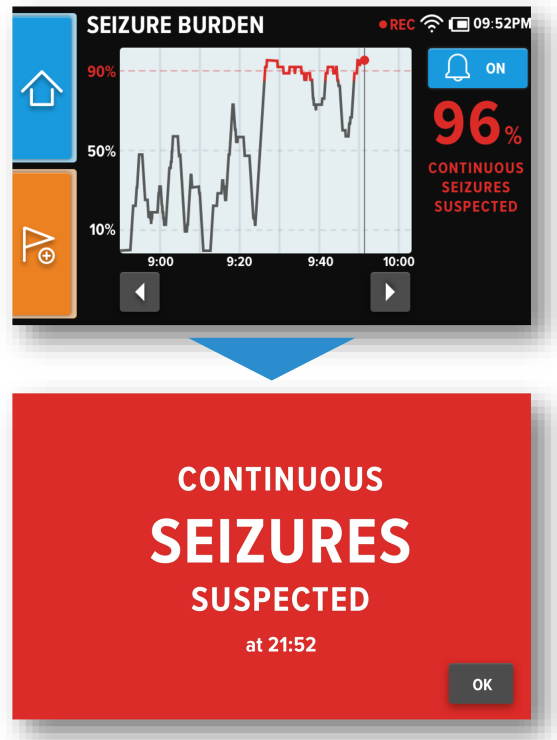
- The Clarity AI output was as follows:

Clarity v6.0 Seizure Burden	Human Epileptologist Rating			
	Slow/Non-epileptiform	Highly Epileptiform	Seizure	Status Epilepticus
0%	391	54	4	0
>0%, <90%	108	59	12	1
≥90%	1	15	1	19
Total	500	128	17	20

Clarity analyzes the EEG every 10 seconds to output seizure burden



Seizure burden display and alert on the Ceribell device.



Clarity v6.0 Algorithm Accuracy

95%	Sensitivity Accurately detecting status epilepticus
97%	Specificity Accurately identifying non-status cases as not status epilepticus
99%	Negative Predictive Value Accurately ruling out status epilepticus and seizures

- In the single missed case of status epilepticus, Clarity still indicated a high degree of seizure activity.
- Clarity had positive predictive value (PPV) of **53%** for status, due to overcalling 17 of 666 recordings. All but one of the 17 overcalled recordings had been labeled by majority consensus of epileptologists as highly epileptiform or seizure.
- There was a large improvement in the positive predictive value of the ≥90% seizure burden to alert to status epilepticus (32% to 53%) as the algorithm alerted to half as many non-SE cases compared to the earlier version.
- The negative predictive value (NPV) for 90% seizure burden ruling out only the presence of status epilepticus remained unchanged at 99.8% while the NPV for 0% seizure burden ruling out the presence of status epilepticus or any seizure improved from 98.4% to 99.1%

Comparative data for Seizure Burden ≥90%:

Clarity Algorithm	Sensitivity	Specificity	PPV	NPV
v2.0	95%	94%	32%	99.8%
v6.0	95%	97%*	53%	99.8%

*p<0.001

Conclusions

- This study demonstrates the ability of machine learning algorithms to improve with time and additional cases for training.
- The latest algorithm led to an improvement in specificity without sacrificing high sensitivity to SE.
- The high negative predictive value of the algorithm at 0% threshold suggests that cases of status epilepticus can be ruled out relatively accurately in a large proportion of cases within minutes of EEG recordings and thus can help prevent unnecessary or aggressive over-treatment in critical care settings – as shown in recent clinical studies.

Correspondence: eeg@ceribell.com