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Diagnostic Accuracy of *micro*EEG: A Miniature, Wireless EEG Device

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Abstract

Measuring the diagnostic accuracy (DA) of an EEG device is unconventional and complicated by imperfect interrater reliability. We sought to compare the DA of a miniature, wireless, battery-powered EEG device ("*micro*EEG") to a reference EEG machine in emergency department (ED) patients with altered mental status (AMS). 225 ED patients with AMS underwent 3 EEGs. EEG1 (Nicolet Monitor, "reference") and EEG2 (*micro*EEG) were recorded simultaneously with EEG cup electrodes using a signal splitter. EEG3 was recorded with *micro*EEG using an electrode cap, immediately before or after EEG1/EEG2. The official EEG1 interpretation was considered the gold standard (EEG1-GS). EEG1, 2 and 3 were de-identified and blindly interpreted by two independent readers. A generalized mixed linear model was used to estimate the sensitivity & specificity of these interpretations relative to EEG1-GS, and to compute a diagnostic odds ratio (DOR). 79% of EEG1-GS were abnormal. Neither the DOR nor κ_f representing interrater reliabilities differed significantly between EEG1, EEG2, and EEG3. Mean setup time was 27

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Dr. Abdel Baki is an employee of BSG, owns stock options in BSG and is a co-inventor on US patents pending 61/554,743, 13/284,886.
Dr. Omurtag was previously an employee of BSG, and is a co-inventor on US patents pending 61/554,743, 13/284,886.
Dr. Fenton is a share-holding founder and president of BSG, is the inventor on US patent 7767195, and a co-inventor on US patents pending 13/61,554,743, 13/284,886, 11/694,855, 11/694,816, 10/314,890, 10/425,023, is an Associate Editor at the Journal of Neuroscience, and has had travel paid for by BSG.
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minutes for EEG1/EEG2 and 12 minutes for EEG3. Mean electrode impedance of EEG3 recordings was 12.6 kΩ (SD 31.9 kΩ). DA of *micro*EEG was comparable to that of the reference system and was not reduced when the EEG electrodes had high and unbalanced impedances. A common practice with many scientific instruments, measurement of EEG device DA provides an independent and quantitative assessment of device performance.

Keywords

sensitivity and specificity; EEG; altered mental status; diagnostic accuracy

1. Introduction

EEG can provide useful clinical data. In the emergency department (ED), EEG can narrow the differential diagnosis of patients with altered mental status (AMS), and potentially help avoid unnecessary tests, procedures, and admissions. An EEG is necessary to diagnose non-convulsive seizures and non-convulsive status epilepticus, diagnoses that typically trigger emergent and specific treatment protocols. We previously found that the EEG is abnormal in 78% of ED patients with AMS, including 5% with electrographic seizures [1].

Although EEG is a useful, non-invasive and relatively inexpensive diagnostic test, its routine use in the ED faces several obstacles. Hospital EEG labs are rarely open around the clock. Very few EDs are equipped with EEG machines, or staffed with a technologist who can properly apply EEG electrodes and record a technically adequate study in an environment that is often electrically hostile. The long electrode wires and EEG machine may impede patient movement and limit access of medical personnel to the patient.

*micro*EEG is a miniature, wireless and battery-powered EEG device that can potentially overcome these limitations to routine use of EEG in the ED. Beyond engineering and safety testing required by the FDA, the device has undergone extensive analyses that were driven, in part, by skepticism among experienced emergency medicine physicians and neurologists that such a device would perform as intended in the ED environment. For instance, we previously reported technical and clinical analyses of *micro*EEG recordings obtained from *normal volunteers*, and compared them to recordings made with a common commercially available system [2]. Those experiments demonstrated high concordance in the time and frequency domains between *micro*EEG and the standard system. In a parallel recording made simultaneously with *micro*EEG and the standard system, imperfect correlation between the signals was due primarily to relatively greater 60 Hz noise in the standard system [2].

This transvalue of *micro*EEG continues with the present clinical trial, designed to measure the diagnostic accuracy of *micro*EEG in identifying abnormal EEG activity in ED patients with AMS. Measuring and reporting the diagnostic accuracy of new scientific and medical instruments is common practice. However, it is rarely if ever performed for new EEG devices, possibly because the process is complicated by three apodictic facts. First, there is no gold standard for EEG interpretations. Second, inter-rater agreement on interpretation of complete EEG recordings is imperfect and poorly studied. Third, estimation of the new

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device's true accuracy must account for the accuracy of both the reference device and the EEG interpreters. These challenges led to two appurtenant studies, the results of which are utilized in the present analyses [3, 4].

2. Methods

2.1 Subjects

The study was conducted at Kings County Hospital Center (KCHC) and Downstate Medical Center (DMC), which together have > 200,000 ED visits annually. All ED patients ≥ 13 years old with AMS were screened for study participation until the enrollment target was achieved. AMS was defined as any alteration in consciousness, responsiveness, or alertness. Exclusion criteria included an immediately correctable cause of AMS (finger stick or serum glucose less than 60 mg/dl, body temperature below 35.0 °C, hyperthermia, heat exhaustion or heat stroke, opioid overdose responding to naloxone), hemodynamic instability (SBP <90 mm Hg), and inability to undergo an EEG recording (e.g. severe scalp injury, combativeness). All data were collected prospectively. The study was approved by the joint KCHC and DMC institutional review board, which waived the requirement for informed consent. A surrogate consent was obtained from a legally authorized representative, when available. The study was registered on ClinicalTrials.gov (#NCT01355211).

2.2 EEG devices

*micro*EEG measures 9.4 × 4.4 × 3.8 cm and weighs 88 g (Figure 1). It digitizes the EEG signals close to the electrodes, transmits the digital data wirelessly to a personal computer located within 10 meters, and stores the data on an on-board memory card. Custom software running on the PC controls the device, measures electrode impedances, displays the signals, allows entry of annotations, and writes data to the hard disk. The manufacturers' specifications for *micro*EEG and the Nicolet Monitor (Natus Medical Inc., San Carlos, CA) which was used as the reference system, are shown in Table 1.

2.3 EEG studies

The EEG studies were obtained 24/7 by a pool of five technologists (each with at least 5 years experience) and one physician with research and clinical EEG experience (SAB). We intended to examine *micro*EEG performance with both standard EEG cup electrodes applied individually, and with an electrode cap that can be quickly applied by minimally trained assistants in the ED. This goal led to the recording of three EEGs from each subject. EEG1 was recorded with the reference system, and EEG2 was recorded simultaneously with *micro*EEG using a signal splitter [2]. EEG1/EEG2 were obtained with 9 mm gold-plated cup electrodes placed according to the international 10-20 system, with all electrode impedances below 5 kΩ. EEG3 was recorded immediately before or after EEG1/EEG2 with *micro*EEG, using an electrode cap composed of an elastic spandex-type fabric with recessed pure tin 10-20 system electrodes (ECI, Inc., Eaton, OH). A small amount of electro-gel was injected through a hole in the center of each electrode to minimize impedances, but there were no impedance restrictions for cap electrodes. The order of EEG1/EEG2 and EEG3 was randomized. All EEG recordings were 30 minutes in duration.

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2.4 EEG interpreters and interpretations

The absence of a true gold standard, and the presence of imperfect inter-rater agreement on EEG interpretations, led to the following design and designations for the EEG interpretation process. EEG1 was the official recording that became part of each patient's medical record. Its final interpretation was considered the gold standard for this study, and is designated EEG1-GS. EEG1-GS interpretations were “unblinded” in that the interpreter was aware of patient age, medications, presenting symptoms, clinical history, and technologist comments within the EEG recording. The fact that the accuracy of EEG1-GS may be less than perfect is taken into account in our assessment of *micro*EEG (see section 2.7).

EEG1, 2 and 3 were de-identified, including removal of technologist comments, and subject to blinded interpretation by a group of six epileptologists board-certified in clinical neurophysiology. The three de-identified EEGs from each subject were interpreted independently by two readers, unaware that they were interpreting all three studies from the same subject. Interpreters knew only that the EEGs were recorded from ED patients ≥ 13 years-old with AMS. Interpreters assigned each study to one of six diagnostic categories: status epilepticus (SE), seizure (Sz), interictal epileptiform discharges (Ep, with or without independent slowing), slowing only (Sl), normal (Nl), and uninterpretable. Burst-suppression and triphasic waves were categorized as “slowing.” EEG1-GS interpretations were converted to the six category format by one of the authors (ACG).

2.5 Estimation of sensitivity & specificity of interpretation of de-identified EEG1, 2 & 3, relative to EEG1-GS

The diagnostic accuracy of *micro*EEG was estimated in two conditions. In the first condition, the six EEG categories were condensed to two: abnormal and normal. Data from patients whose EEG1-GS assessment was “uninterpretable” were excluded from this analysis. A generalized mixed linear model was constructed as follows: Let X_i be an indicator variable corresponding to the event that EEG1-GS of the *i*th patient is rated abnormal, and let Y_{ijk} indicate the event that the EEG of the *i*th patient in the *j*th "measurement mode" (*i.e.*, de-identified EEG1, 2 or 3) is rated abnormal by the *k*th rater ($k = 1 .. 6$). Y_{ijk} was modeled as a Bernoulli random variable with $E(Y_{ijk}) = \pi$, such that $\ln [\pi / (1 - \pi)] = \beta_0 + \beta_1 X_i + a_i + b_k$, where a_i and b_k are random patient and rater effects respectively, independently and normally distributed with mean $\mu_{a,b} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$ and covariance $\sum_{a,b} = \begin{bmatrix} \sigma_a^2 & 0 \\ 0 & \sigma_b^2 \end{bmatrix}$. This model allows for intercorrelation of outcomes among multiple observations of the same patient, and also among multiple observations supplied by the same blinded rater. Kenward-Roger adjustments of standard errors and denominator degrees of freedom were applied. Asymptotic confidence intervals (CIs) were constructed for the quantities $\beta_0 + \beta_1$ and $-\beta_0$; inverse-link transformations were applied to the limits of these CIs to generate measurement mode-specific CIs for estimates of sensitivity Prob ($Y_{ij}=1 \mid X_i=1$) and specificity Prob($Y_{ij}=0 \mid X_i=0$), *i.e.*, $\exp(\beta_0 + \beta_1) / [1 + \exp(\beta_0 + \beta_1)]$ and $\exp(-\beta_0) / [1 + \exp(-\beta_0)]$ respectively.

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A similar method was used to compute a CI for the diagnostic odds ratio (DOR), *i.e.*, $\exp(\beta_1)$. The DOR is an expression of the utility of a test in a single parameter rather than a (sensitivity, specificity) pairing. It is interpretable as the odds ratio for an abnormal blinded result associated with the gold standard result's being abnormal vs. normal. For instance, if DOR=2 for EEG1, then the odds of an abnormal EEG1 result from a randomly-selected blinded rater are twice as high if the unblinded gold standard rating is abnormal than if it is not.

In an initial analysis, β & Σ parameters were estimated separately for each measurement mode. In a subsequent pooled analysis, a measurement mode indicator Z_j was introduced as a second fixed factor; a significance test for this term was used to detect presence of differential bias (*i.e.*, variability among the measurement modes in their propensity to categorize patients as abnormal); also, the existence of an X_i Z_j interaction was tested to detect heterogeneity of EEG discriminability (*i.e.*, DOR) across measurement modes.

In the ED setting diagnosing status epilepticus and ongoing seizures is paramount, and ideally we would also determine the diagnostic accuracy of *micro*EEG with EEG1-GS interpretations condensed to 1) SE + Sz, and 2) all other. However, since the number of SE and Sz studies was very small the resulting diagnostic parameters would be meaningless due to extremely large confidence intervals. Therefore, the second condition in which the diagnostic accuracy of *micro*EEG was estimated was with the six EEG categories condensed to: 1) SE + Sz + Ep, and 2) Sl + Nl (again excluding “uninterpretable” studies from the analysis). This grouping separated the studies into those that are relatively more significant in the ED setting, and those that are relatively benign. The analyses were performed as described above, substituting SE + Sz + Ep for abnormal.

To estimate the probability of an uninterpretable EEG in each measurement mode, a single generalized mixed linear model was constructed similar to the ones used to estimate sensitivity and specificity. In this case the event of interest was an uninterpretable result rather than an abnormal result, and the only fixed effect was measurement mode.

Inter-rater reliability was assessed separately for each measurement mode using all six EEG diagnostic categories including uninterpretable. The Fleiss kappa statistic is reported. A χ^2 test was conducted of heterogeneity of kappa values across measurement modes. SAS (SAS Institute, Cary NC, USA) Release 9.2 statistical software was used for all analyses.

2.6 A priori sample size analysis

Using projections that 30% of EEG recordings would yield abnormal results, and that the sensitivity of EEG2 & EEG3 would both be 95%, 243 patients would be required to achieve 95% CIs around sensitivity estimates having width of 5% [5]. Allowing for a 5-10% rate of failure to collect adequate data yields approximately 260 subjects to be enrolled.

2.7 Procedure for correcting measured sensitivity and specificity

Ideally, the accuracy of *micro*EEG would be determined by directly comparing its outcome with the patient disease state. With a sufficiently large patient population this would have allowed its true sensitivity and specificity to be determined from a 2×2 frequency table. The

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typical and, under our circumstances best available, method is to compare the interpretation of *micro*EEG recordings with the interpretation of reference device recordings. This method yields the measured accuracy of *micro*EEG, and is confounded by two distinct effects. First, the standard system may not be perfectly accurate - meaning the degree to which it can generate a recording that would lead to a correct classification when interpreted by a perfectly accurate interpreter. Second, EEG interpretation accuracy is less than perfect. Omurtag and Fenton (2012) showed that imperfections in interpretation and in the reference system exert a downward bias on the measured sensitivity and specificity, and that the set of pairs of interpreter sensitivity and specificity which correspond to a single value of kappa generate a range of corrected sensitivity and specificity values [4]. They derive a formula for systematically correcting measured sensitivity and specificity as a function of standard system accuracy, the prevalence of abnormal gold standard interpretations, and inter-rater agreement [4]. This correction method is employed in the results section.

3. Results

3.1 Subjects

From May, 2011 through February, 2012 302 patients were screened and 261 were enrolled. Due to operator error, 36 EEG2 or EEG3 studies were not properly saved, leaving 225 subjects with all 3 EEGs available for review. Subject clinical data and their six category gold standard (EEG1-GS) findings are shown in Tables 2 and 3, respectively. There were no adverse events.

3.2 Diagnostic parameters for each measurement mode

Sensitivity, specificity and diagnostic odds ratio estimated separately for each measurement mode are shown in Table 4. Point estimates of sensitivity and specificity in Table 4A resemble closely those obtained from simple 2×2 frequency tables. There were no significant differences among the raters in their propensity to identify cases as abnormal (EEG1 p=0.061, EEG2 p=0.169, EEG3 p=1.000).

In the pooled analysis, the test of homogeneity of DOR across measurement modes yielded p=0.416; we conclude that the three DOR estimates do not differ significantly from one another. After removing the $X_i\ Z_j$ interaction term from the model, there was no evidence of differential bias (p=0.449); we conclude that the three modes do not differ significantly in their propensity to identify cases as abnormal. Model-based tests of differing sensitivity and specificity between EEG1 & EEG2 yielded p=0.305 & 0.487 respectively; we conclude that these 2 modes do not differ significantly in either sensitivity or specificity.

The analyses described above for the data in Table 4A were repeated for the data in Table 4B, i.e. for the diagnostic parameters derived with EEGs grouped into SE + Sz + Ep, and Sl + Nl, with identical qualitative results.

Fleiss kappas representing inter-rater reliabilities (with 95% CIs) for EEG1, 2 & 3 were 0.44 (0.35, 0.54), 0.47 (0.37, 0.56) and 0.47 (0.37, 0.56) respectively. A test of differences among these coefficients yielded p=0.842; we conclude that inter-rater agreement does not differ significantly across measurement modes.

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3.3 Corrected sensitivity and specificity

Corrected sensitivity and specificity for each measurement mode were also determined, for the standard condition with EEG1-GS interpretations condensed to abnormal and normal (Table 4A). Briefly, since the accuracy of the standard EEG device is unknown, we arbitrarily assumed that its sensitivity (s0) and specificity (p0) were equal (i.e. s0 = p0). We then derived the range of corrected sensitivities and specificities for two arbitrary but illustrative values of s0 and p0, namely 1.0 (i.e. the standard system was perfect or maximally accurate), and 0.9 (i.e. the standard system was "very good" but not perfect). These values are shown in Table 5.

3.4 EEG setup time, electrode impedances and uninterpretable studies

The mean EEG setup time, i.e. time to initialize the EEG equipment, apply electrodes or the electrocap, and begin the EEG recording, was 27 min (SD 2 min) for EEG1/EEG2 and 12 min (SD 2 min) for EEG3. The mean impedance of all EEG electrodes from a random sample of 25 EEG3 recordings was 12.6 kΩ (SD 31.9 kΩ) with a minimum of 1 kΩ and a maximum of 214 kΩ.

Since each de-identified EEG underwent two interpretations, there were 450 interpretations for each measurement mode. Of those 450 interpretations, 40 were "uninterpretable" for EEG1 studies (29 unique subjects), 30 were "uninterpretable" for EEG2 studies (22 unique subjects), and 51 were "uninterpretable" for EEG3 studies (32 unique subjects). There was a significant measurement mode effect (p=0.032). Post-hoc pair-wise comparisons with bootstrap-adjusted p-values showed that the estimated probability of an uninterpretable result differed significantly only between EEG2 & EEG3 (p=0.023).

3.5 Sample size reconsidered

Although the study is slightly underpowered relative to initial projections, the prevalence of abnormality was considerably higher than projected. Thus, confidence intervals for sensitivity estimates are at least as narrow as originally desired.

4. Discussion

We performed a prospective clinical trial of *micro*EEG to measure its sensitivity and specificity compared to a "reference" EEG machine, the Nicolet Monitor. EEG data were acquired from ED patients with AMS, a population where the advantages of a miniature, wireless and battery-powered EEG device are particularly valuable. Using the unblinded interpretation (abnormal or normal) of EEGs recorded from the reference system as a gold standard, the measured sensitivity and specificity of EEG1 and EEG2 did not differ significantly in either measurement condition, i.e. with EEGs divided into abnormal and normal, and with EEGs divided into SE + Sz + Ep and Sl + Nl. Thus, the diagnostic accuracy of microEEG is comparable to that of the reference system in this clinical setting.

Assuming a perfect reference system and accounting for the Fleiss kappa values for interrater agreement, the corrected specificities of each measurement mode were substantially higher than the measured values, but remained significantly lower than the

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corrected sensitivities (Table 5). These differences in sensitivity and specificity are expected, for at least two reasons. First, the prevalence of abnormal EEG1-GS studies was much higher than the prevalence of normal studies. Second, equivocal EEG findings such as mild diffuse slowing are more likely to be interpreted as abnormal when the interpreter is blind to patient age, state, history, and medications.

The EEG3 mean set up time of 12 minutes was considerably lower than the 27 minutes for EEG1/ EEG2. This time savings may be especially valuable in the ED, where there is high demand for access to the patient and the expectation that studies will be completed expeditiously. As anticipated, electrode cap impedances and inter-electrode impedance differences were substantially higher than longstanding professional society recommendations [6, 7]. Both of these variables contribute independently to increased common mode noise, which can result in an uninterpretable study [7]. Nonetheless, the probability that a randomly selected interpretation would be “uninterpretable” (i.e. due to artifact) did not differ significantly between EEG3 and EEG1. The most likely reason that more EEG3 studies were not obscured by 60Hz noise is the relatively short electrode wires when *micro*EEG is used with an electrode cap [2]. In that configuration, the maximum electrode wire length was 45 cm, compared to the 140 cm length of standard electrode wires.

Because EEG3 was recorded immediately before or after EEG1/EEG2, it was *a priori* a different study. Most EEG3 findings should be identical to those of the corresponding EEG1/EEG2, but different findings could occur if the patient were undergoing simultaneous treatment for seizures or status epilepticus, seizing intermittently, or had other intermittent findings such as interictal epileptiform discharges. The fact that EEG3 was a different study could account for its lower DOR compared to EEG1 and EEG2 (Table 4), although the differences were not statistically significant.

An inevitable limitation of comparing devices whose output is subject to human interpretation is the imperfect nature of the interpretive process. Aware of this limitation, we performed a separate study of EEG intra- and inter-rater reliability [3]. Briefly, a pool of six epileptologists interpreted 300 EEGs in such a way as to generate both intra- and inter-rater reliability data, as well other variables of interest. The Cohen kappas for 15 reader pairs ranged from 0.29 to 0.62, with an aggregated Fleiss kappa of 0.44. This value is very similar to the kappas obtained in this study, and to results from other studies [8-11].

That the diagnostic accuracy of *micro*EEG is not compromised by use of an electrode cap suggests that EEGs adequate for the ED setting can be recorded by personnel other than trained EEG technologists. That hypothesis was tested in a separate study in which ED patients with AMS were randomized to receive standard care or standard care plus a *micro*EEG recorded with an electrode cap by personnel without formal EEG technologist training. Outcome variables included the impact of *micro*EEG data on the differential diagnosis, patient management, and patient outcome [12].

5. Conclusions

The diagnostic accuracy of a new EEG device compared to a standard or reference system can be measured in a clinical setting. For this measurement to be meaningful the

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methodology must account for the absence of definitive "gold-standard" EEG interpretations, imperfect inter-rater agreement on EEG interpretations, and the theoretical possibility that the reference device is imperfect. Using such methodology, we showed that the diagnostic accuracy of *micro*EEG is comparable to that of a Nicolet Monitor in ED patients ≥ 13 years old with AMS, a population with a very high prevalence of EEG abnormalities. EEG setup time was shortened by 56% when recordings were obtained with an electrode cap rather than individual electrodes, without compromising diagnostic accuracy.

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Highlights

- *micro*EEG is a miniature, wireless, battery-powered EEG device
- Diagnostic accuracy of microEEG was comparable to that of a standard EEG system
- Diagnostic accuracy was not affected by EEG electrodes with high impedances.
- Measuring diagnostic accuracy is complicated by imperfect interrater reliability

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Figure 1.
*micro*EEG attached to a headband.

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Table 1

Technical specifications for *micro*EEG and Nicolet Monitor

Product	***micro*EEG**	**Nicolet Monitor**
Company	Bio-Signal Group Corp.	CareFusion Corp.
A/D Converter resolution	16	16
Voltage resolution (μV)	0.15	0.15
Maximum input range	10 mV p. to p.	10 mV p. to p.
Sampling rate	1,000 Hz	Up to 2,000 Hz
Bandwidth	0.15 – 500 Hz	0.16 – 1,000 Hz
Input Impedance (MΩ)	>100	>100
Separately test GND/REF impedance	Yes	No
Number of Channels	32	64
Channel crosstalk	< -126dB	< -40 dB
Noise	< 2.4 μV p. to p. (0.1 -100 Hz)	< 1.5 μV p. to p. (0.1 -70 Hz)

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Table 2

Subject characteristics

Variable	n	%
Age	225	60[a]
Female	119	53
Presenting Symptom		
Confusion	90	40
Lethargy	55	24
Coma/unresponsive	56	25
Agitation	29	13
Delirium	7	3
Unexpected psychosis	6	3
Seizure in the field	73	32
Seizure in the ED	53	24
AC medication in the field	17	8
AC medication in the ED	146	65

[a]Median

Abbreviations: AC= anti-convulsive

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Table 3

Gold standard EEG findings

Category	Frequency	Percent
Slowing	136	61
Normal	43	19
Epileptiform discharges	31	14
Status epilepticus	7	3
Uninterpretable	5	2
Seizure	3	1

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Table 4

Diagnostic parameters estimated separately for each measurement mode.

A. EEGs grouped into abnormal and normal.			
Measurement Mode	**Sensitivity (95% CI)**	**Specificity (95% CI)**	**DOR (95% CI)**
EEG1	0.93 (0.86, 0.96)	0.46 (0.29, 0.64)	10.7 (5.1, 22.2)
EEG2	0.90 (0.84, 0.94)	0.51 (0.35, 0.67)	9.8 (5.0, 19.2)
EEG3	0.91 (0.87, 0.94)	0.41 (0.28, 0.56)	6.7 (3.3, 13.8)

B. EEGs grouped into SE + Sz + Ep and Sl + Nl.			
Measurement Mode	**Sensitivity (95% CI)**	**Specificity (95% CI)**	**DOR (95% CI)**
EEG1	0.65 (0.49, 0.79)	0.84 (0.74, 0.90)	9.7 (5.2, 18.0)
EEG2	0.62 (0.45, 0.77)	0.89 (0.81, 0.94)	9.8 (5.0, 19.2)
EEG3	0.55 (0.36, 0.72)	0.84 (0.73, 0.91)	6.5 (3.3, 12.5)

Abbreviations: DOR=diagnostic odds ratio, CI=confidence interval

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Table 5

Corrected measured sensitivity and specificity.

A. Assuming a perfect reference system with S0 = p0 = 1.0

Measurement	Sensitivity			Specificity		
Mode	**value**	**min**	**max**	**value**	**min**	**max**
EEG1	0.94	0.93	1	0.64	0.63	1
EEG2	0.91	0.90	0.96	0.69	0.52	0.69
EEG3	0.92	0.91	0.98	0.55	0.41	0.55

B. Assuming an imperfect reference system with s0 and p0 arbitrarily set to 0.9.

Measurement	Sensitivity			Specificity		
Mode	**value**	**min**	**max**	**value**	**min**	**max**
EEG1	0.97	0.95	1	0.85	0.84	1
EEG2	0.94	0.92	1	0.91	0.76	0.91
EEG3	0.94	0.93	1	0.72	0.61	0.73

Legend: s0 sensitivity of reference system, p0 specificity of reference system Min and Max refer to the minimum and maximum values obtained by varying interpreter sensitivity and specificity among all possible values for the measured Fleiss kappas of 0.44, 0.47, 0.47 for EEG1, 2 and 3, respectively.