Physician concordance with EEG guidelines and prognostic factors for obtaining EEG in intracranial hemorrhage patients admitted to intensive care unit

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Background / Aim

- AHA and ACNS guidelines have been developed to inform physicians when to consider EEG-monitoring in patients with brain injury including ICH. However, relatively little is known about the clinical factors that are associated with whether EEG is obtained in this patient population in clinical practice.
- Aims:**
- To Gain insight into the clinical factors associated with whether EEG was obtained in a cohort of patients admitted to a neurocritical care unit with ICH.
 - To determine how frequently EEG informed clinical decision making; i.e., how many patients had an “informative EEG.” and
 - To determine clinical factors relating to an informative EEG.

Methods / Analysis

- Design:** Retrospective study on 330 patients with spontaneous ICH admitted to the UMass neurological intensive care unit (ICU).
 - Cohort Period:** 01/2013 - 12/2015.
 - Data Collection:** Chart/Imaging review during patients' hospitalization:
 - Demographic data, Hemorrhage location, EEG Results.
- Based on the AHA and ACNS guideline for the use of EEG in critically ill adults, we abstracted whether patients met criteria for routine EEG during hospitalization using the following criteria:
- Deficit out of proportion or prolonged AMS
 - Acute change or fluctuation of symptoms including clinical seizure
 - Prognostication (e.g., brain death assessment).
- Informative EEG definition:** EEG was considered to be informative when physician notes indicated that EEG informed on any of the following: initiation or withholding of AED; change, continuation, or discontinuation of AEDs; addition of another AED to the existing AED regimen; and brain death assessment or changes in the goals of patient care (e.g. CMO).
 - Continuous variables: Mean $\pm$ S.D. or Median (25th-75th quartile).
 - To determine variables associated with EEG prescription in ICH patients admitted to the neurointensive care unit we used multivariable logistic regression.
 - Variables associated with EEG prescription in the univariable analyses ($P < 0.2$) as well as age and gender were individually added and removed to the model to create a parsimonious model. Two-sided significance tests were used throughout and a two-sided $P < 0.05$ was considered

Results

- 83 patients (25.2%) underwent routine EEG.
- Among these, 13 patients (15.7%) also underwent continuous EEG monitoring.
- Overall, 190 (57.6%) of patients fulfilled criteria for obtaining EEG per existing guidelines. Of these, 78 underwent EEG (sensitivity [i.e., the probability that EEG criteria were fulfilled when an EEG was done] = 94.0% [95%-CI 86.5% to 98.0%]).
- Conversely, of the 140 patients not fulfilling criteria, 135 did not have an EEG (specificity = 54.7% [95%-CI 48.2% to 61.0%]). The accuracy (i.e., the overall probability that an EEG was obtained concordant with guideline criteria fulfillment) was 64.6% (95%-CI 59.1% - 69.7%).
- Clinicians used information on admission GCS, and the presence of a clinical seizure during hospitalization in addition to established criteria for obtaining routine EEG in patients with ICH.
- The probability that EEG was informative when the patient fulfilled the criteria for EEG was 61.5% (95% CI 58.6 – 64.4%). The probability that EEG was not informative when the patient did not fulfill the criteria for EEG was 60.0% (95% CI 20.9 – 89.5%). The accuracy was 61.5 %.

Parameters	Group N (% of total patients=330)	Patients without EEG (247)	Patient with EEG (83)	P Value
Gender N (%)				0.612
Female	163 (49.4)	124 (50.2)	39 (47.0)	
Male	167 (50.6)	123 (49.8)	44 (53.0)	
Age (Mean $\pm$ S.D.)	69 $\pm$ 15	70 $\pm$ 15	66 $\pm$ 16	0.827
Admission GCS (Mean $\pm$ S.D.)	11 $\pm$ 4	11 $\pm$ 4	11 $\pm$ 4	0.092
ICH location N (%)				0.046
Lobar	140 (42.4)	97 (39.3)	43 (51.8)	
Non-lobar	190 (57.6)	150 (60.7)	40 (48.2)	
ICH location N (%)				0.511
Supratentorial	277 (83.9)	204 (82.6)	73 (88.0)	
Infratentorial	47 (14.2)	38 (15.4)	9 (10.8)	
Both	6 (1.8)	5 (2.0)	1 (1.2)	
Neurosurgical intervention N (%)				0.021
No intervention	306 (92.7)	234 (94.7)	72 (86.7)	
Ventriculostomy placement	14 (4.2)	9 (3.6)	5 (6.0)	
Surgical evacuation	10 (3.0)	4 (1.6)	6 (7.2)	
Made CMO/in hospital death N (%)	102 (30.9)	79 (32.0)	23 (27.7)	0.466
Comorbidities N (%)				
Hypertension	261 (79.1)	197 (79.8)	64 (77.1)	0.608
Hyperlipidemia	132 (40.0)	93 (37.7)	39 (47.0)	0.133
Diabetes	75 (22.7)	53 (21.5)	22 (26.5)	0.342
Previous stroke/TIA	60 (18.2)	39 (15.8)	21 (25.3)	0.052
Atrial fibrillation	76 (23.0)	55 (22.3)	21 (25.3)	0.570
Coronary artery disease	62 (18.8)	40 (16.2)	22 (26.5)	0.037
Congestive heart failure	23 (8.2)	14 (5.7)	9 (10.8)	0.109
PAD or carotid artery disease	19 (5.8)	11 (4.5)	8 (9.6)	0.079
Seizure/Epilepsy history	27 (8.2)	14 (5.7)	13 (15.7)	0.004
Social History N (%)				
Tobacco	60 (18.2)	40 (16.2)	20 (24.1)	0.106
Alcohol	63 (19.1)	45 (18.2)	18 (21.7)	0.487
Illicit drugs	22 (6.7)	17 (6.9)	5 (6.0)	0.786
Medication Prior Admission N (%)				
Anti-Hypertensives	215 (65.2)	159 (64.4)	56 (67.5)	0.608
Anti-Hyperlipidemics	116 (35.2)	85 (34.4)	31 (37.3)	0.628
Anti-Diabetics	59 (17.9)	39 (15.8)	20 (24.1)	0.088
Antiplatelets	121 (36.7)	90 (36.4)	31 (37.3)	0.881
Anticoagulants	80 (24.2)	58 (23.5)	22 (26.5)	0.578
Anti-Epileptics	19 (5.8)	9 (3.6)	10 (12.0)	0.004
Meeting Any Criteria for EEG	190 (57.6)	112 (45.3)	78 (94.0)	<0.001
Criteria for EEG				
Deficit out of proportion/Prolonged AMS	4 (1.2)	1 (0.4)	3 (3.6)	0.021
Acute change or fluctuation of symptoms	181 (54.8)	107 (43.3)	74 (89.2)	<0.001
Prognostication	5 (1.5)	4 (1.6)	1 (1.2)	0.789
Seizure upon presentation/during hospitalization	37 (11.2)	9 (3.6)	28 (33.7)	<0.001

Table 1. Demographic data of all ICH patients (330) with EEG or without EEG.

Figure 1. Receiver operating characteristics curve analysis for EEG prescription in patients with intracranial hemorrhage admitted to a neurointensive care unit. Model 1: Admission GCS score, and presence of a clinical seizure during hospitalization. Model 2: EEG criteria fulfilled. Model 3: Fully adjusted model including routine EEG criteria fulfilled, admission GCS, and presence of a clinical seizure during hospitalization.

Independent variable	Adjusted OR (95%-CI)	P-value
Any EEG criteria fulfilled	24.1 (8.6-67.1)	<0.001
In-hospital seizure	5.3 (2.3-12.3)	<0.001
Admission GCS	1.1 (1.0-1.2)	0.002

Table 2. Multivariable logistic regression analysis for factors independently associated with routine EEG prescription in patients with intracranial hemorrhage.

Odds ratios indicate the increased or decreased odds of the clinical factor being present and for a 1 point increase in the admission Glasgow Coma Scale (GCS) score. The units for the GCS score are points on a scale from 1 to 15. Hosmer-Lemeshow goodness of fit χ^2 11.3, $P=0.125$.

Parameters	Group N (% of total patients=83)	Informative EEG (n=59)	Non-informative EEG (n=33)	P Value
Gender N (%)				0.820
Female	39 (47.0)	24 (48.0)	15 (45.5)	
Male	44 (53.0)	26 (52.0)	18 (54.5)	
Age (Mean $\pm$ S.D.)	66 $\pm$ 16	66 $\pm$ 13	66 $\pm$ 19	0.875
Admission GCS (Mean $\pm$ S.D.)	11 $\pm$ 4	10 $\pm$ 4	12 $\pm$ 4	0.010
ICH location N (%)				0.080
Lobar	43 (51.8)	22 (44.0)	21 (63.6)	
Non-lobar	40 (48.2)	28 (56.0)	12 (36.4)	
ICH location N (%)				0.434
Supratentorial	73 (88.0)	44 (88.0)	29 (87.9)	
Infratentorial	9 (10.8)	6 (12.0)	3 (9.1)	
Both	1 (1.2)	0 (0.0)	1 (3.0)	
Neurosurgical intervention N (%)				0.077
No intervention	72 (86.7)	43 (86.0)	29 (87.9)	
EVD placement	5 (6.0)	5 (10.0)	0 (0.0)	
Craniectomy/hematoma evacuation	6 (7.2)	2 (4.0)	4 (12.1)	
Subsequent CMO/Death N (%)	23 (27.7)	15 (30.0)	8 (24.2)	0.566
Comorbidities N (%)				
Hypertension	64 (77.1)	37 (74.0)	27 (81.8)	0.407
Hyperlipidemia	39 (47.0)	25 (50.0)	14 (42.4)	0.499
Diabetes	22 (26.5)	11 (22.0)	11 (33.3)	0.252
Previous stroke/TIA	21 (25.3)	13 (26.0)	8 (24.2)	0.857
Atrial fibrillation	21 (25.3)	14 (28.0)	7 (21.2)	0.486
Coronary artery disease	22 (26.5)	15 (30.0)	7 (21.2)	0.375
Congestive heart failure	9 (10.8)	7 (14.0)	2 (6.1)	0.255
PAD or Carotid artery disease	8 (9.6)	6 (12.0)	2 (6.1)	0.370
Seizure disorder/Epilepsy	13 (15.7)	7 (14.0)	6 (18.2)	0.608
Social History N (%)				
Tobacco	20 (24.1)	12 (24.0)	8 (24.2)	0.980
Alcohol	18 (21.7)	11 (22.0)	7 (21.2)	0.932
Illicit drugs	5 (6.0)	1 (2.0)	4 (12.1)	0.058
Medication Prior Admission N (%)				
Anti-Hypertensives	56 (67.5)	31 (62.0)	25 (75.8)	0.190
Anti-Hyperlipidemics	31 (37.3)	18 (36.0)	13 (39.4)	0.754
Anti-Diabetics	20 (24.1)	9 (18.0)	11 (33.3)	0.110
Antiplatelets	31 (37.3)	15 (30.0)	16 (48.5)	0.088
Anticoagulants	22 (26.5)	13 (26.0)	9 (27.3)	0.898
Anti-Epileptics	10 (12.0)	6 (12.0)	4 (12.1)	0.987
Seizure upon admission or in hospital	28 (33.7)	16 (32.0)	12 (36.4)	0.681
Meeting Any Criteria for EEG	78 (94.0)	48 (96.0)	30 (90.9)	0.340
Criteria for EEG				0.665
Deficit out of proportion/Prolonged AMS	3 (3.6)	2 (4.0)	1 (3.0)	
Acute change or fluctuation of symptoms	74 (89.2)	45 (90.0)	29 (87.9)	
Prognostication	1 (1.2)	1 (2.0)	0 (0.0)	

Table 3. Informed making decision based on EEG in those ICH patients who underwent EEG during the hospitalization (total 83 out of 330 patients).

Conclusion

- Our study showed that approximately 60% of ICH patients admitted to ICU fulfilled criteria for obtaining an EEG per existing guidelines. However, among these, EEG was obtained in less than 50% relating to high sensitivity (94%) but poor specificity (54%) for guideline fulfillment to predict whether EEG was obtained.
- In addition to guideline criteria patient admission GCS and seizure history likely informed physicians' decision to obtain an EEG.
- EEG was overall informative in clinical decision making in 60% of cases.