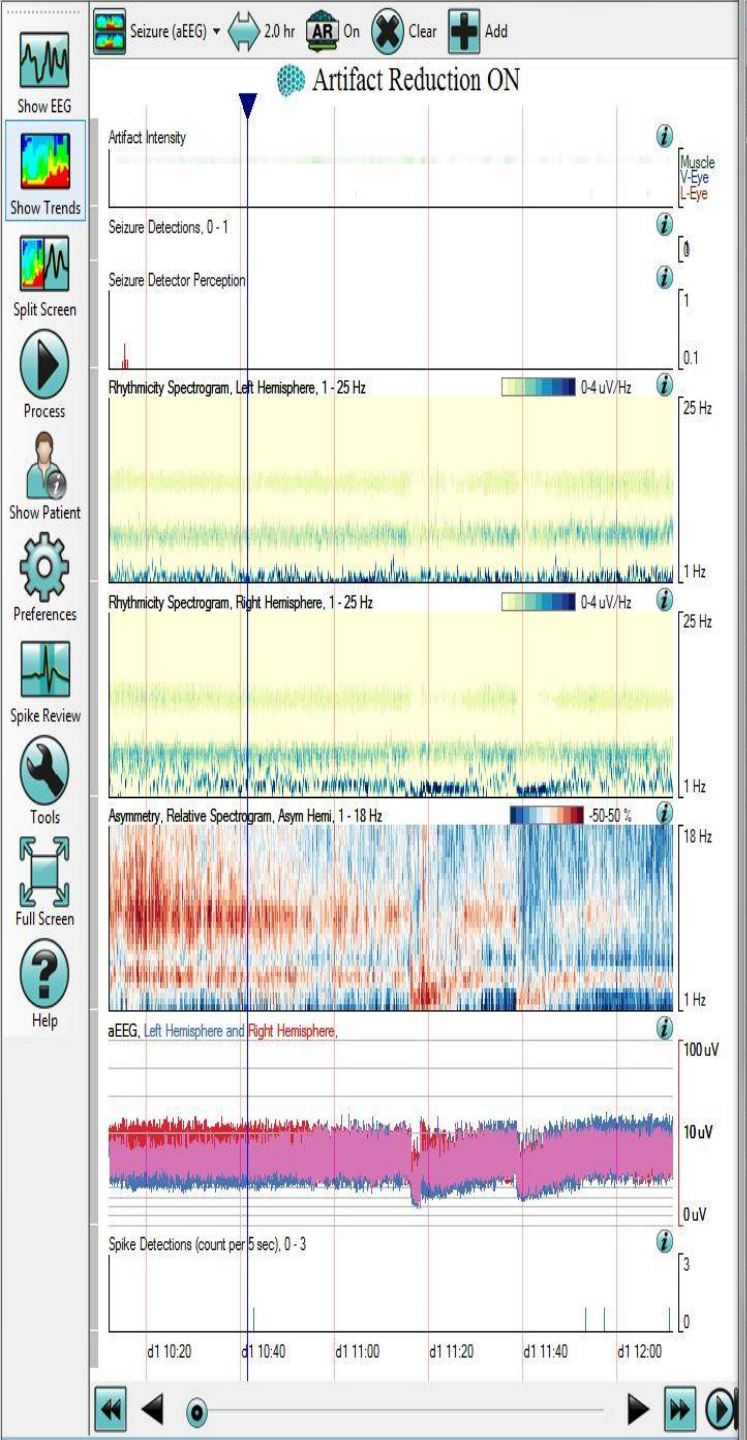


Cosa chiedo all'EEG

Pr Mauro Oddo

Department of Medical-Surgical Intensive Care Medicine

CHUV-Lausanne University Hospital

Faculty of Biology and Medicine,

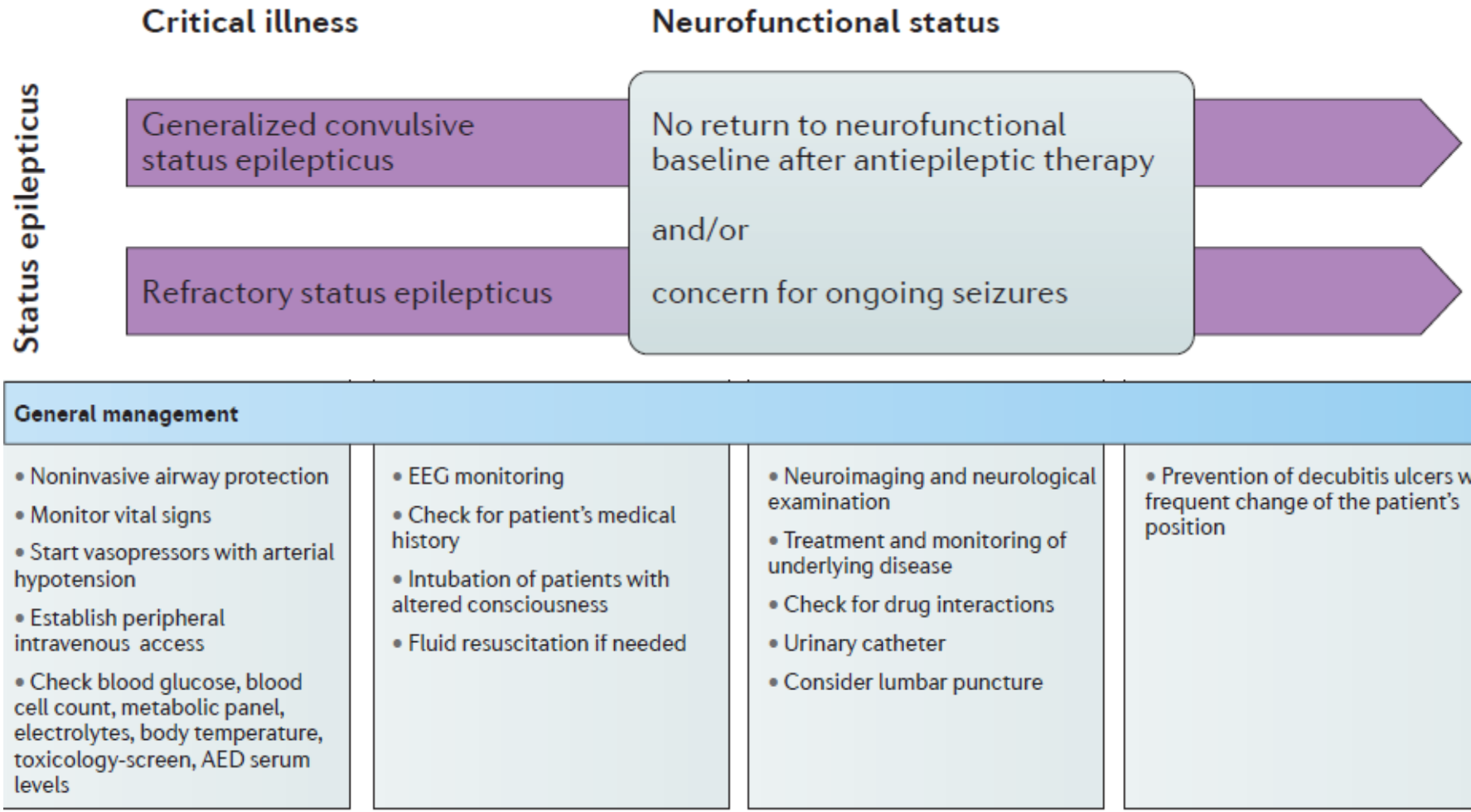
University of Lausanne, Switzerland

NEURO UPDATE TORINO

9-10 marzo 2017

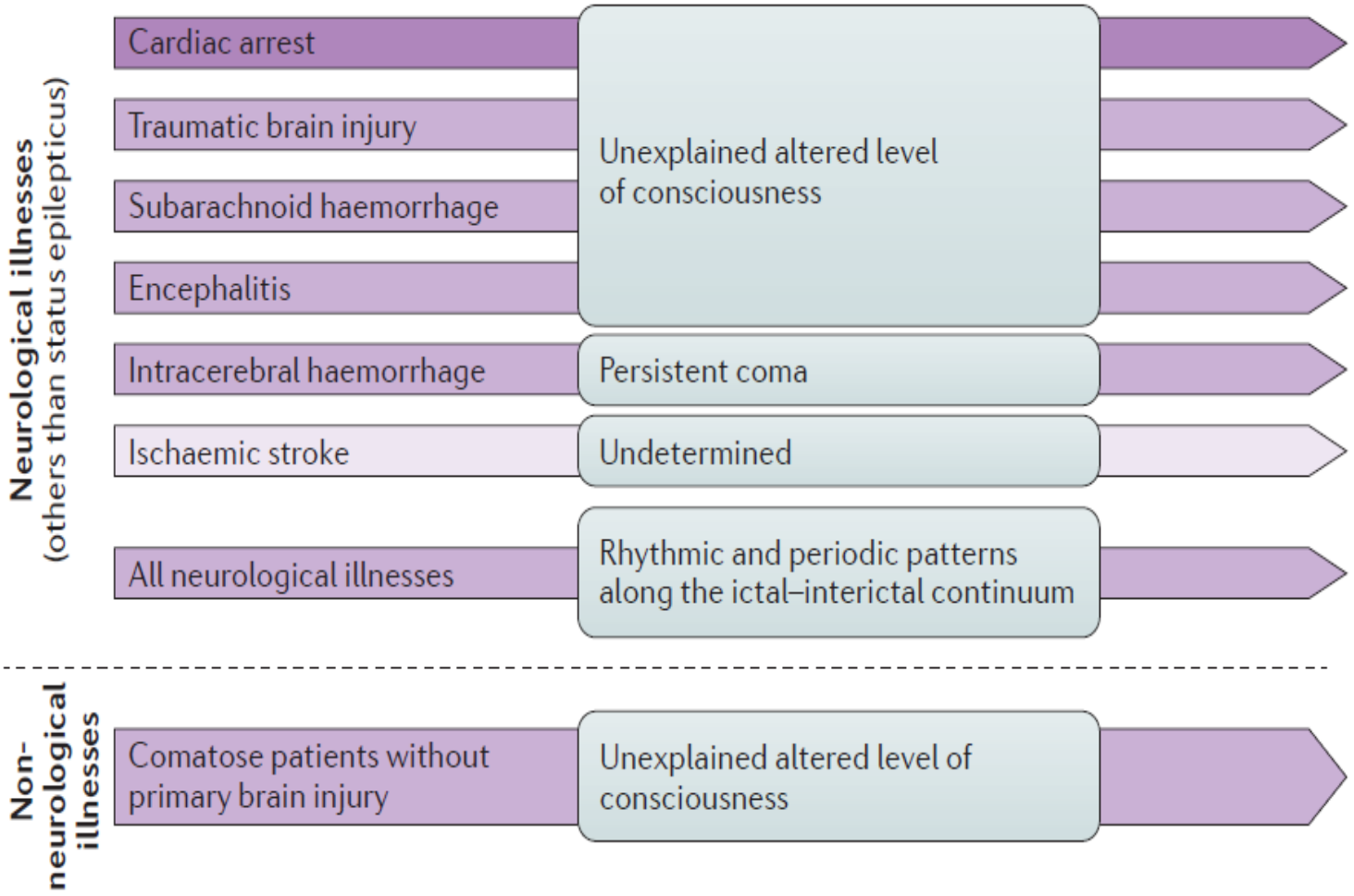
INDICATIONS TO EEG MONITORING IN THE ICU

GENERALIZED STATUS EPILEPTICUS



NATURE REVIEWS | NEUROLOGY
Raoul Sutter[1,2], Saskia Semmlack[1] and Peter W. Kaplan[3]
VOLUME 12 | MAY 2016 |

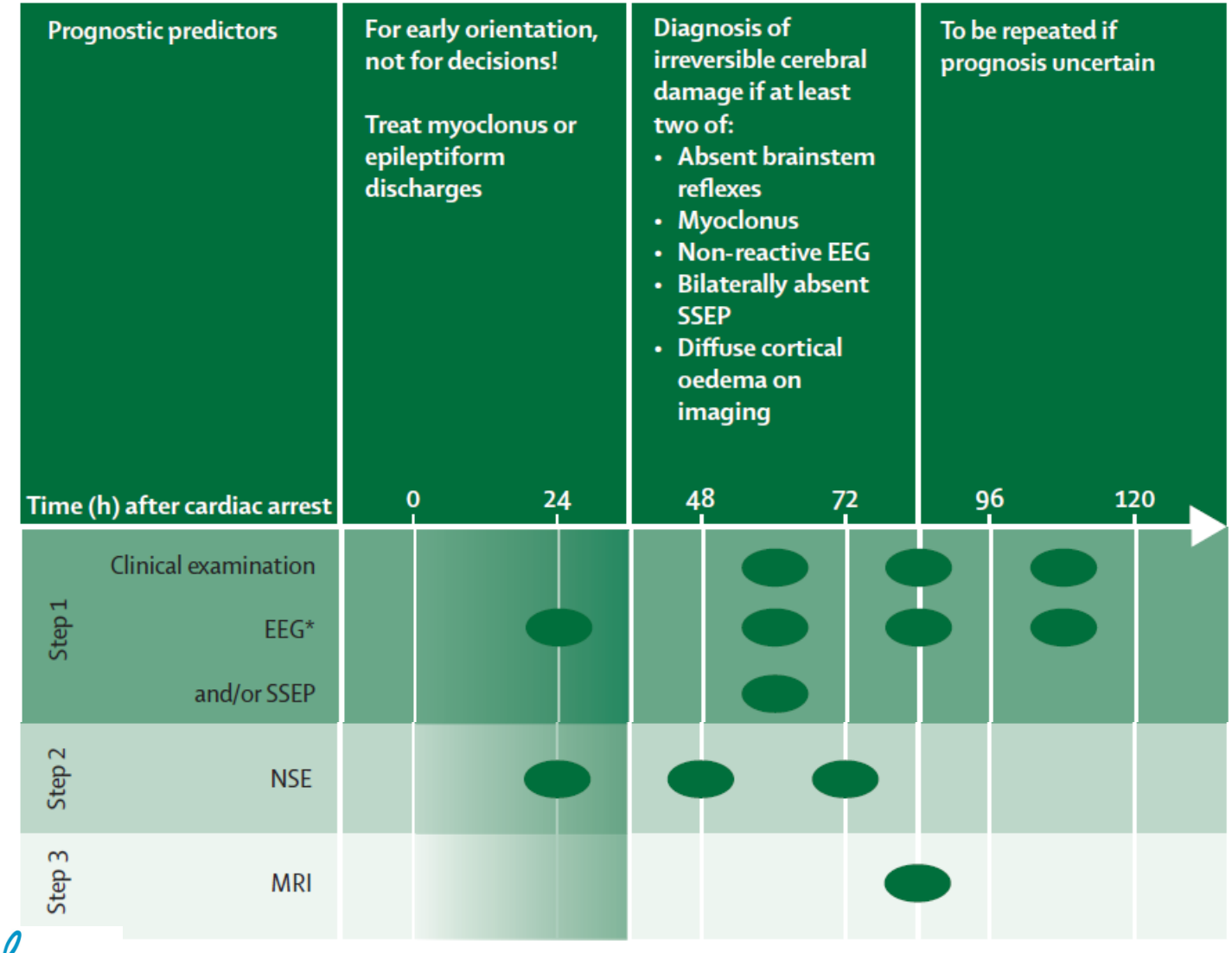
ALTERED MENTAL STATUS – NON-CONVULSIVE STATUS



Neurological prognostication of outcome in patients in coma after cardiac arrest

Lancet Neurol 2016; 15: 597–609

Andrea O Rossetti, Alejandro A Rabinstein, Mauro Oddo



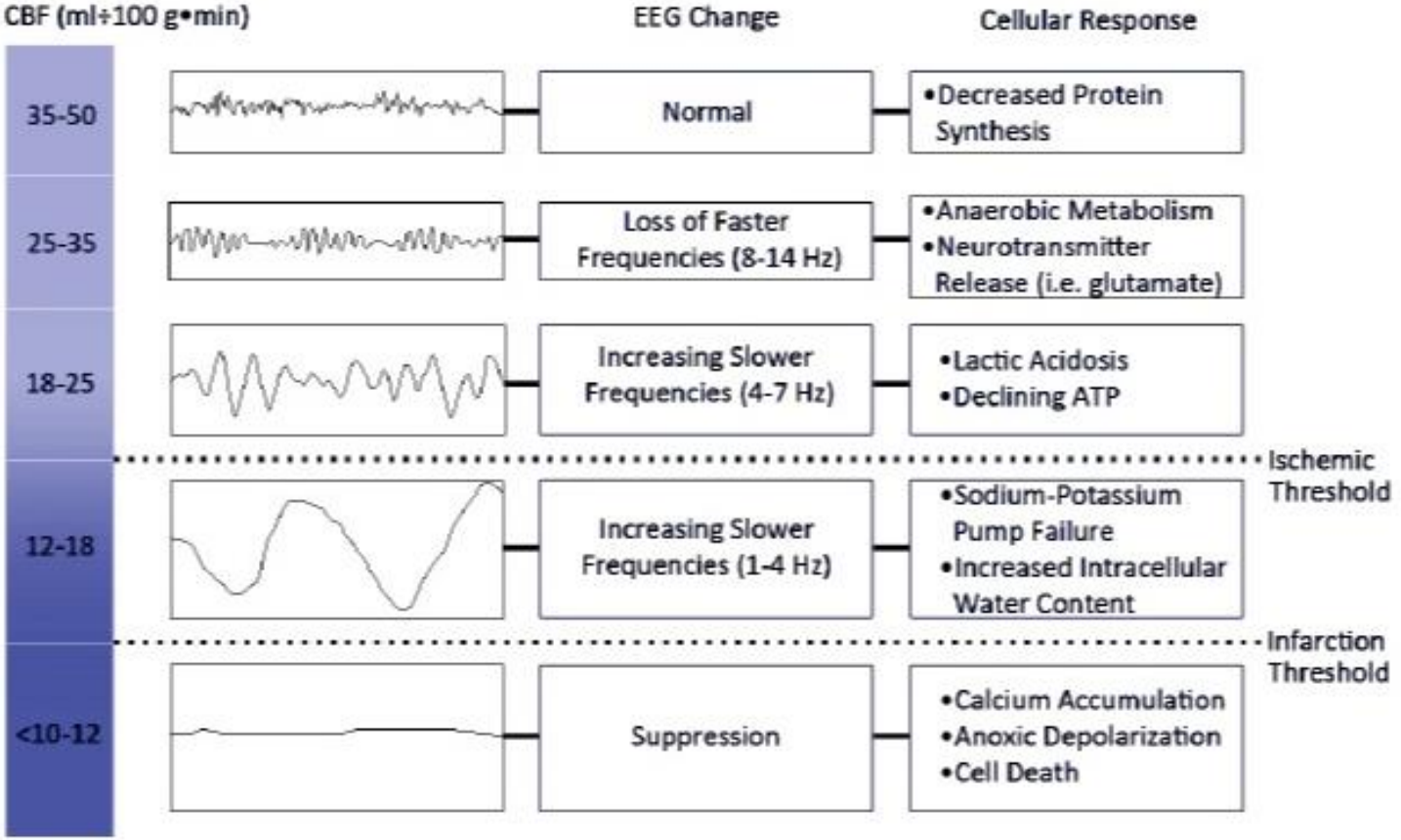
Foreman and Claassen *Critical Care* 2012, 16:216
http://ccforum.com/content/16/2/216

CRITICAL CARE

REVIEW

Quantitative EEG for the detection of brain ischemia

Brandon Foreman[1] and Jan Claassen[2]*



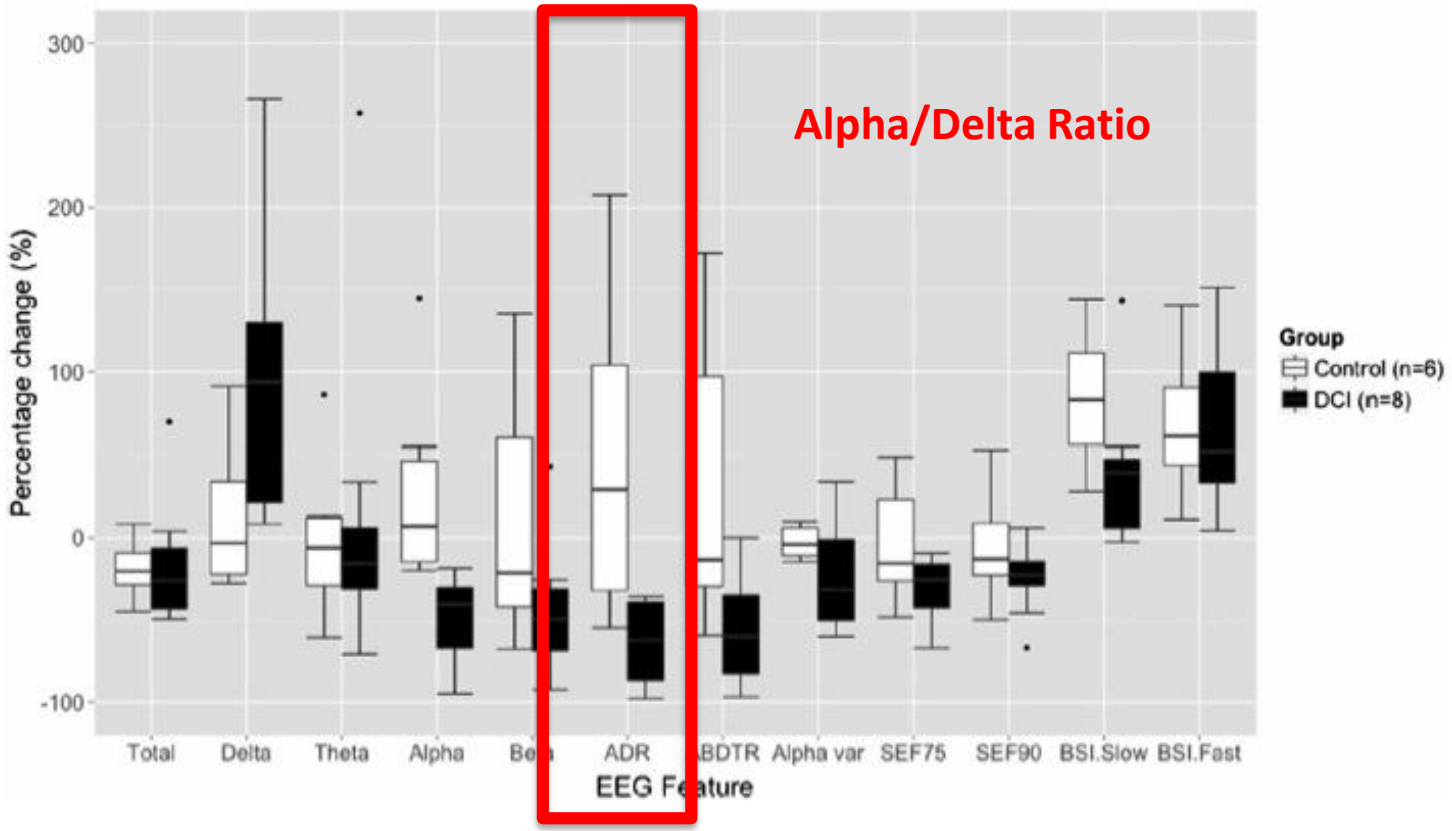
neurocritical care society Neurocrit Care
DOI 10.1007/s12028-015-0205-y

CrossMark

ORIGINAL ARTICLE

Continuous EEG Monitoring for Early Detection of Delayed Cerebral Ischemia in Subarachnoid Hemorrhage: A Pilot Study

M. L. Rots[1,2] · M. J. A. M. van Putten[2,3] · C. W. E. Hoedemaekers[4] · J. Horn[1]



WHAT THE RECOMMENDATIONS SAY

Intensive Care Med (2013) 39:1337–1351
DOI 10.1007/s00134-013-2938-4

SYSTEMATIC REVIEW

Jan Claassen
Fabio S. Taccone
Peter Horn
Martin Holtkamp
Nino Stocchetti
Mauro Oddo

Recommendations on the use of EEG monitoring in critically ill patients: consensus statement from the neurointensive care section of the ESICM

GRADE recommendations			Patient description		Objective
Direction	Strength	Level of evidence	Underlying etiology	Scenario	
Pro	Strong (1)	Low quality (C)	Generalized convulsive status epilepticus	No return to functional baseline after initial antiepileptic therapy	Detect nonconvulsive seizures
Pro	Strong (1)	Low quality (C)	Refractory status epilepticus	Concern for ongoing seizure activity	Detect nonconvulsive seizures
Pro	Strong (1)	Low quality (C)	Traumatic brain injury	Unexplained alteration in consciousness[a]	Detect nonconvulsive seizures
Pro	Strong (1)	Low quality (C)	Subarachnoid hemorrhage	Unexplained alteration in consciousness[a]	Detect nonconvulsive seizures
Pro	Strong (1)	Low quality (C)	Intracerebral hemorrhage	Unexplained alteration in consciousness[a]	Detect nonconvulsive seizures
Pro	Strong (1)	Low quality (C)	Cardiac arrest	Persistent coma	Detect nonconvulsive seizures
Pro	Strong (1)	Low quality (C)	Encephalitis	Unexplained alteration in consciousness[a]	Detect nonconvulsive seizures
Pro	Strong (1)	Low quality (B)	Comatose patients without primary brain injury	Unexplained alteration in consciousness[a]	Detect nonconvulsive seizures
Pro	Weak (2)	Low quality (C)	Severe traumatic brain injury	Concern for ongoing seizure activity in high-risk patients (large cortical hemorrhagic contusion/hematoma)	Detect nonconvulsive seizures
Pro	Weak (2)	Very low quality (D)	Acute ischemic stroke	Unexplained alteration in consciousness[a]	Detect nonconvulsive seizures
Pro	Weak (2)	Low quality (C)	Subarachnoid hemorrhage	Patients in whom clinical examination is unreliable	Detect ischemia
Pro	Weak (2)	Low quality (C)	Cardiac arrest	Persistent coma	Prognostication
Pro	Weak (2)	Low quality (C)	All comatose ICU patients	Unexplained alteration in consciousness[a]	Prognostication
Pro	Weak (2)	Very low quality (D)	Encephalitis	Unexplained alteration in consciousness[a]	Prognostication

neurocritical care society Neurocrit Care (2014) 21:S129–S147
DOI 10.1007/s12028-014-0022-8

REVIEW ARTICLE

Electrophysiologic Monitoring in Acute Brain Injury

Jan Claassen · Paul Vespa · The Participants in the International Multi-disciplinary Consensus Conference on Multimodality Monitoring

Journal of Clinical Neurophysiology • Volume 32, Number 2, April 2015

Consensus Statement on Continuous EEG in Critically Ill Adults and Children, Part I: Indications

Susan T. Herman, Nicholas S. Abend,† Thomas P. Bleck,‡ Kevin E. Chapman,§ Frank W. Drislane,* Ronald G. Emerson,|| Elizabeth E. Gerard,¶ Cecil D. Hahn,# Aatif M. Husain,**†† Peter W. Kaplan,‡‡ Suzette M. LaRoche,§§ Marc R. Nuwer,|||| Mark Quigg,¶¶ James J. Riviello,## Sarah E. Schmitt,*** Liberty A. Simmons,††† Tammy N. Tsuchida,‡‡‡ and Lawrence J. Hirsch§§§*

WHAT ABOUT REAL ICU LIFE ?

Continuous EEG monitoring: A survey of neurophysiologists and neurointensivists

*Jay Gavvala, †Nicholas Abend, ‡Suzette LaRoche, §Cecil Hahn, ¶Susan T. Herman, #Jan Claassen, *Mícheál Macken, *Stephan Schuele, *Elizabeth Gerard, and On behalf of the Critical Care EEG Monitoring Research Consortium (CCEMRC)

Epilepsia, 55(11):1864–1871, 2014

Continuous EEG Monitoring Practice

Current vs. *Ideal* world

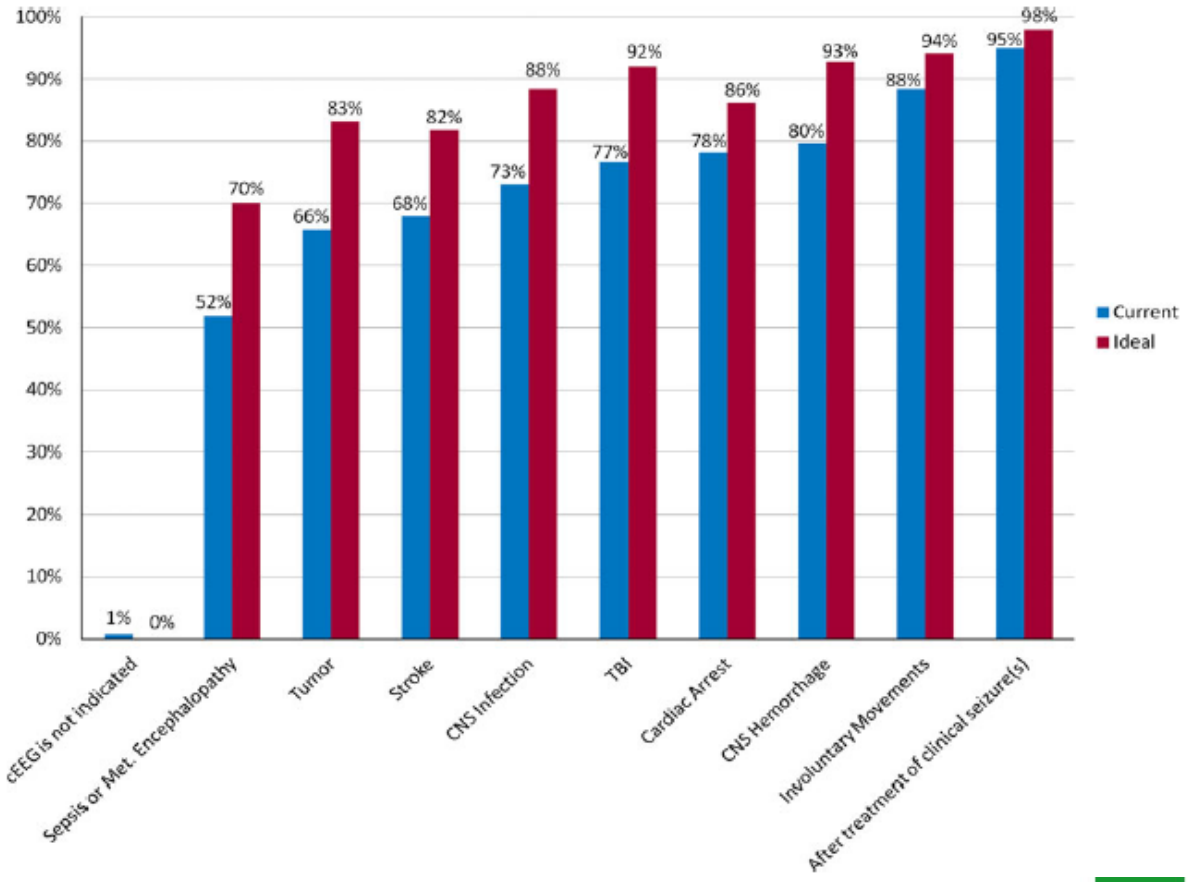


Figure 1.
Current and ideal practice of cEEG among critically ill patients with altered mental status or coma to identify nonconvulsive seizures (n = 137).
Epilepsia © ILAE

Andrea Park
J. Gordon Boyd

Intensive Care Med (2015) 41:1869–1870
DOI 10.1007/s00134-015-3990-z

EEG utilization in the medical/surgical ICU: a single centre prospective observational study

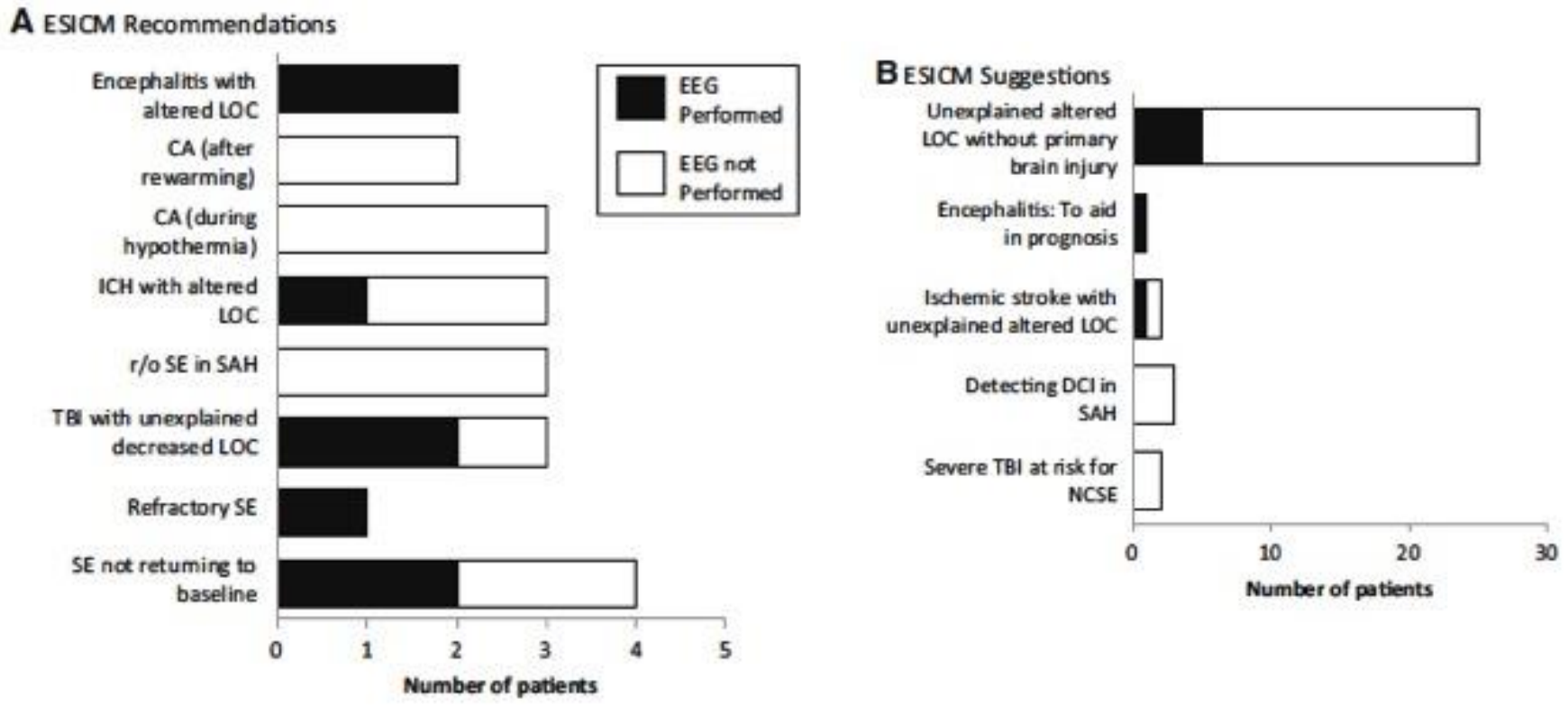
- Use of EEG in a 33-bed medical/surgical ICU and to compare local EEG usage to published Guidelines

- 12 non-consecutive weeks (1 June - 30 August 2014)
  - ✓ 220 patients screened 330 times
  - ✓ 44/220 patients (20 %) met at least 1 ESICM indication for EEG monitoring

Andrea Park
J. Gordon Boyd

tensive Care Med (2015) 41:1869–1870
OI 10.1007/s00134-015-3990-z

EEG utilization in the medical/surgical ICU: a single centre prospective observational study



- *EEG was performed for only 27 % of patients*

Andrea Park
J. Gordon Boyd

EEG utilization in the medical/surgical ICU: a single centre prospective observational study

- Additional 32 patients could have been considered eligible for EEG
- Additional 2–3 patients/week would be feasible if only routine (30 min) EEGs were performed
- Additional 2–3 continuous EEGs /week would over-burden EEG team

Intensive Care Med (2015) 41:1869–1870
DOI 10.1007/s00134-015-3990-z

HOW CAN WE IMPROVE EEG APPLICATION ?

- ❑ Technique
- ❑ Time
- ❑ Staff Education
- ❑ Multidisciplinary team
- ❑ Resource availability

Continuous EEG monitoring: A survey of neurophysiologists and neurointensivists

*Jay Gavvala, †Nicholas Abend, ‡Suzette LaRoche, §Cecil Hahn, ¶Susan T. Herman, #Jan Claassen, *Mícheál Macken, *Stephan Schuele, *Elizabeth Gerard, and On behalf of the Critical Care EEG Monitoring Research Consortium (CCEMRC)

Epilepsia, 55(11):1864–1871, 2014

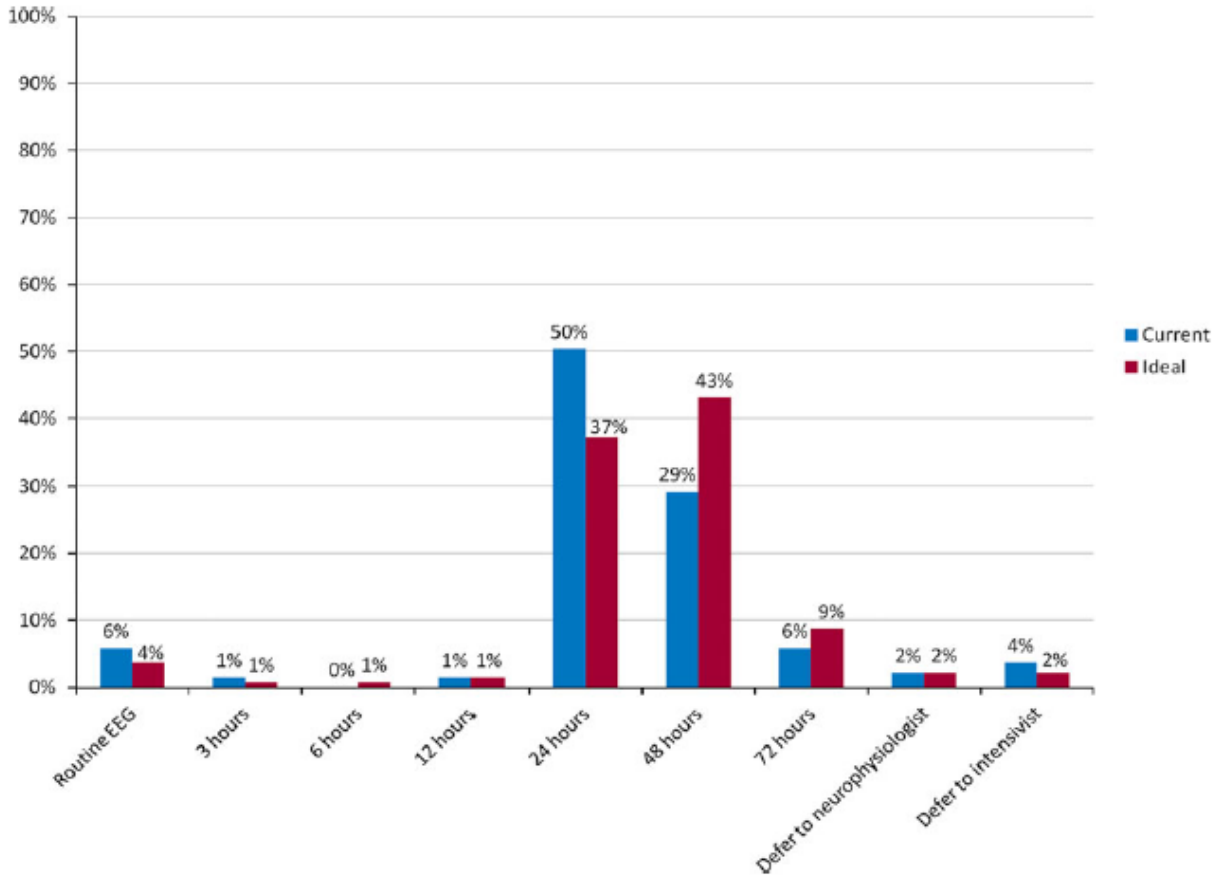
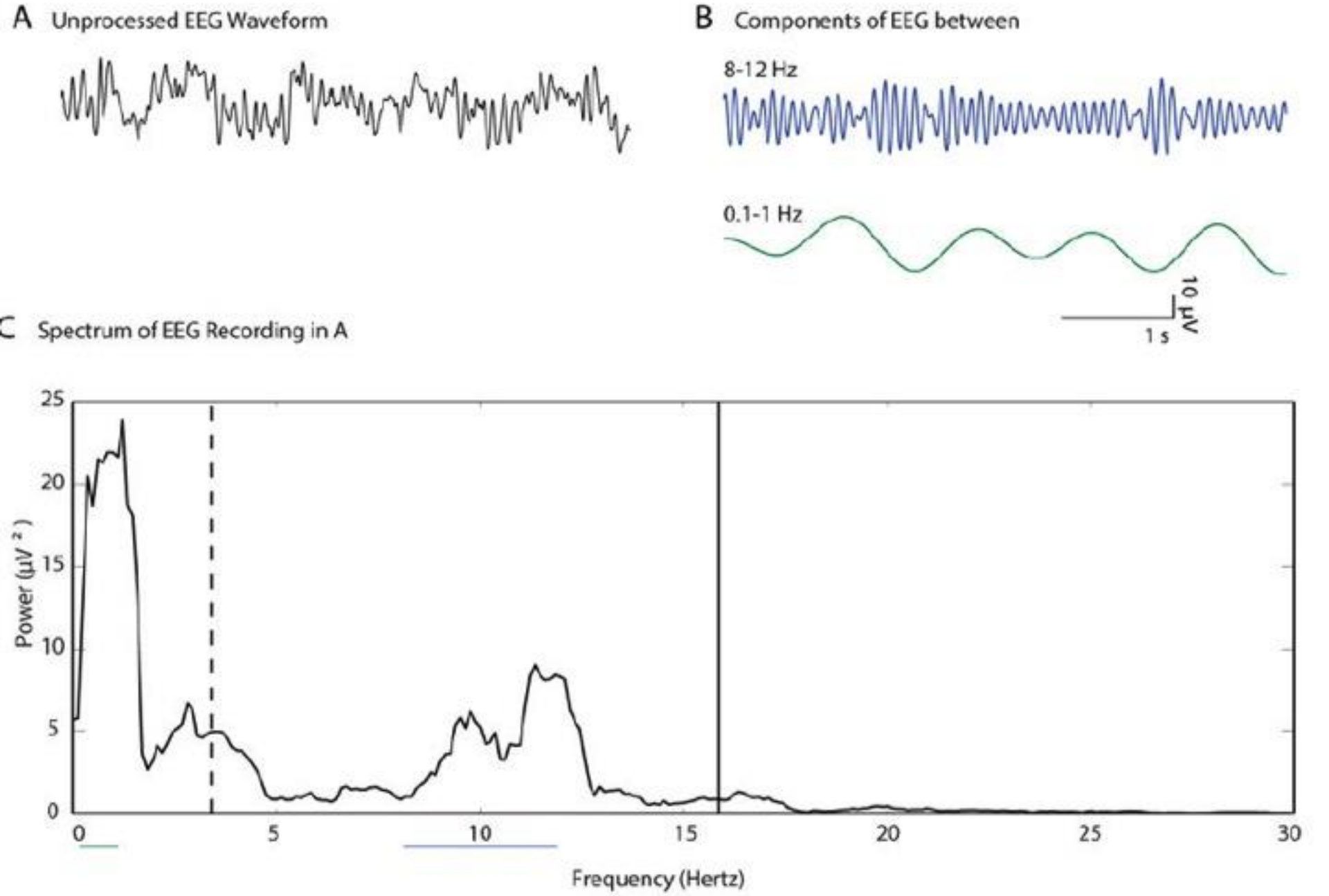
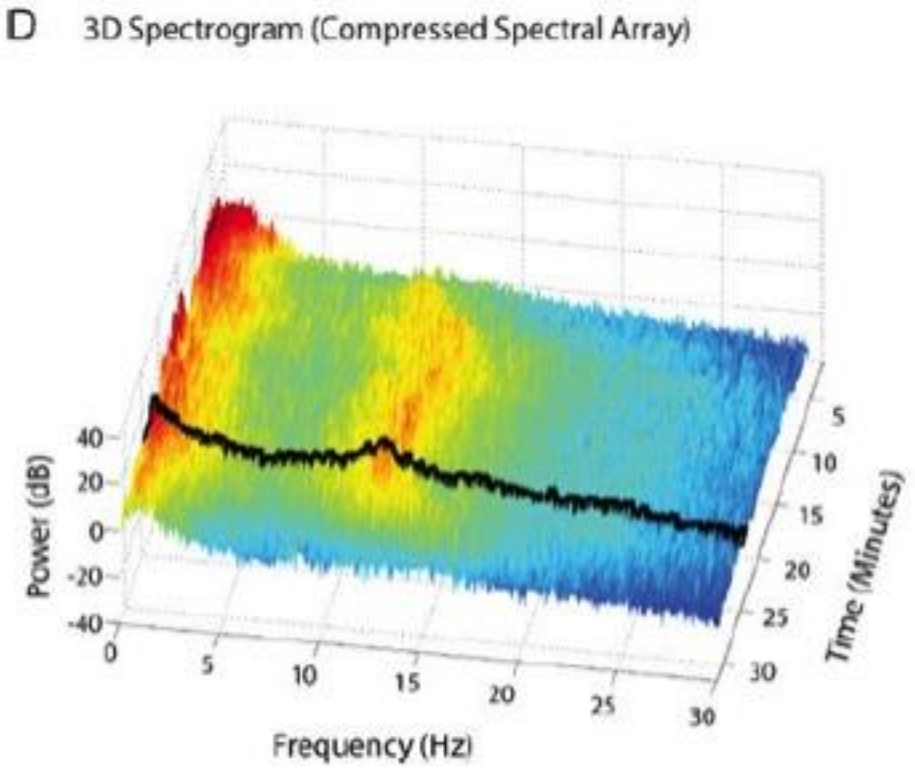
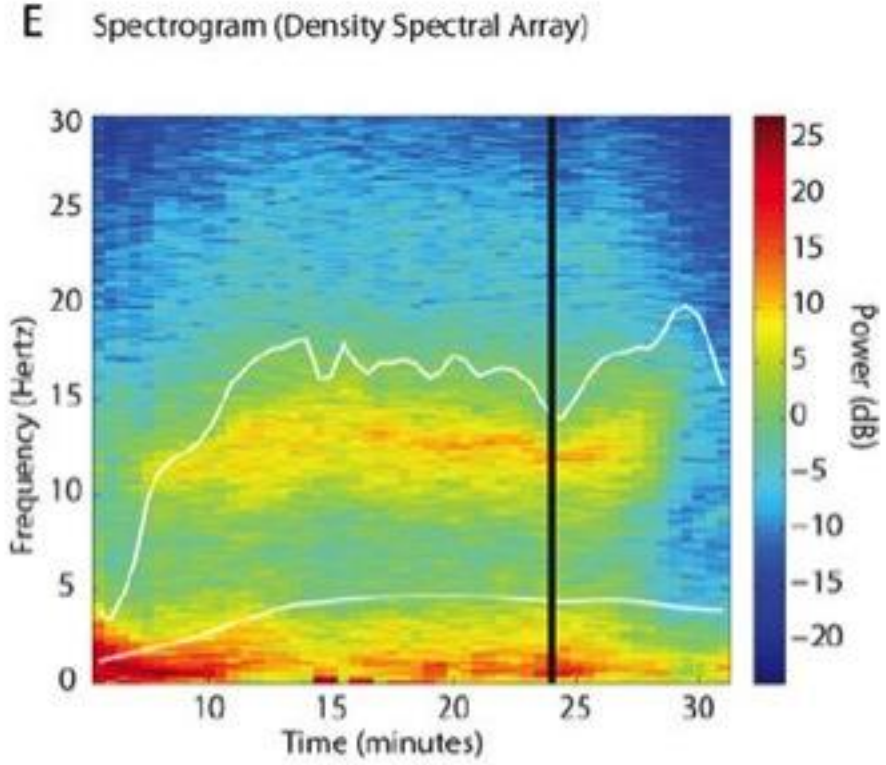


Figure 2.
Current and ideal duration of cEEG in comatose patients when screening for nonconvulsive seizures in (n = 137). *Epilepsia* ©ILAE



Purdon PL *Anesthesiology* 2015

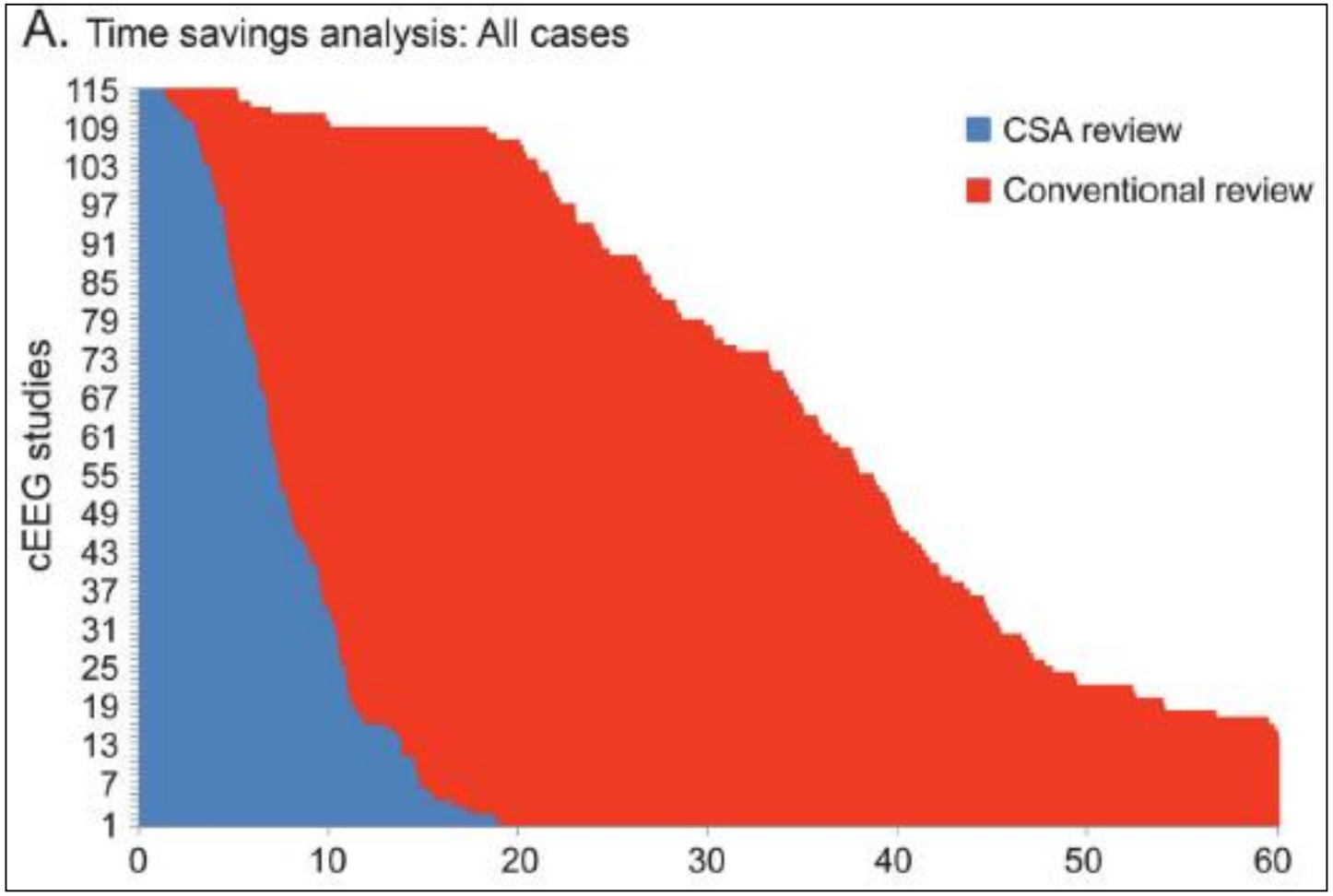




Purdon PL *Anesthesiology* 2015

Continuous EEG monitoring of NCS

compressed spectral array VS. conventional

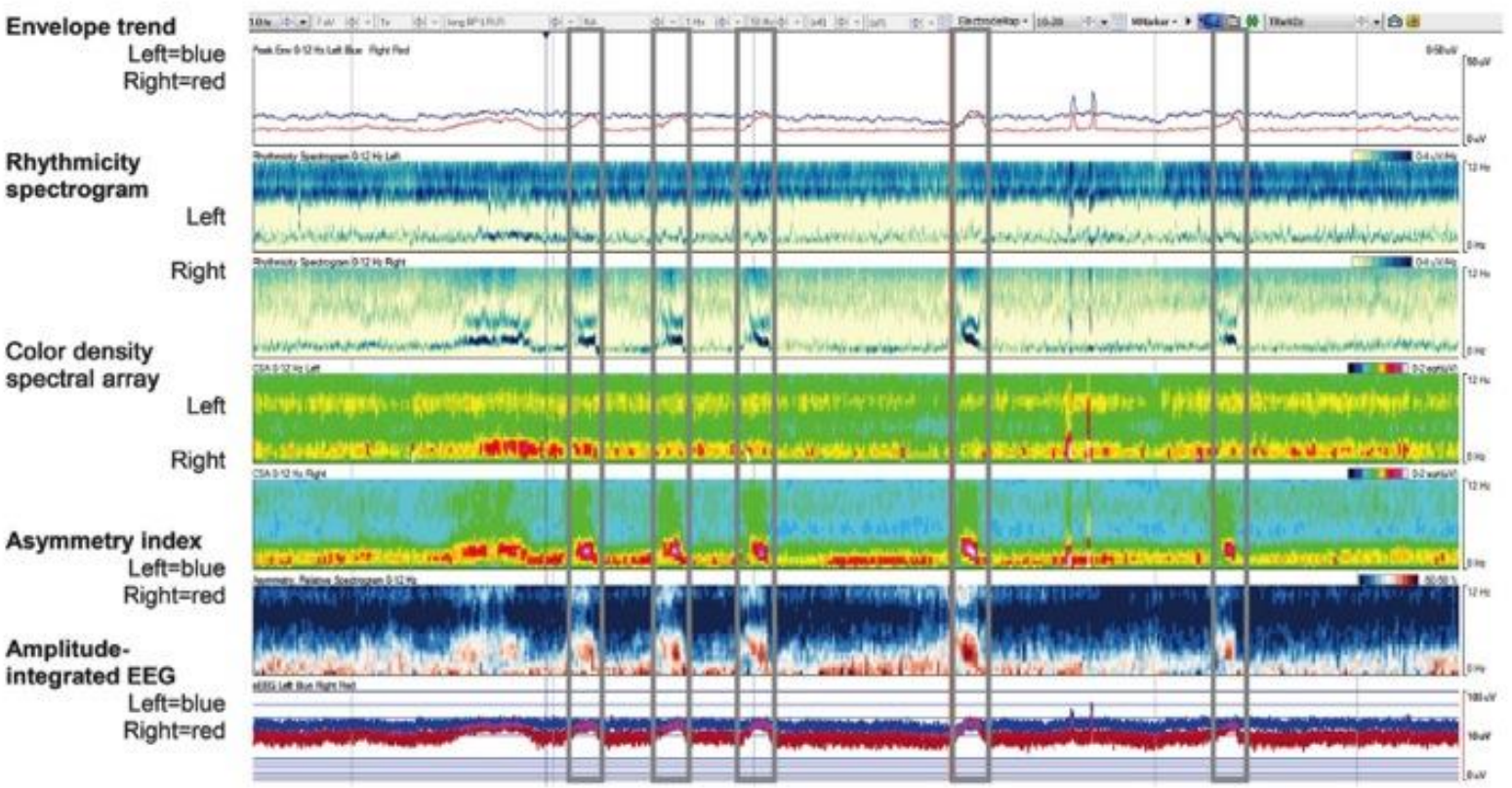


Moura *Neurology* 2014

Hiba A. Haider, MD
Rosana Esteller, PhD
Cecil D. Hahn, MD, MPH
M. Brandon Westover, MD, PhD
Jonathan J. Halford, MD
Jong W. Lee
Mouhsin M. Shafi, MD, PhD
Nicolas Gaspard, PhD
Susan T. Herman, MD
Elizabeth E. Gerard, MD
Lawrence J. Hirsch, MD
Joshua A. Ehrenberg, BSc, R EEG T CNIM
Suzette M. LaRoche, MD
For the Critical Care EEG Monitoring Research Consortium

Sensitivity of quantitative EEG for seizure identification in the intensive care unit

Figure 1 Example of a 1-hour quantitative EEG (QEEG) panel without automated seizure detection (SzD) as viewed by the QEEG and QEEG + raw reviewers



All QEEG analyses are displayed as hemispheric averages with blue representing the left hemisphere and red representing the right hemisphere. Frequency scale ranges from 0 to 12 Hz. This recording contained 5 electrographic seizures (see gray boxes).

Figure 3 Epoch 1: Periodic discharges mimicking electrographic seizures on quantitative EEG (QEEG)

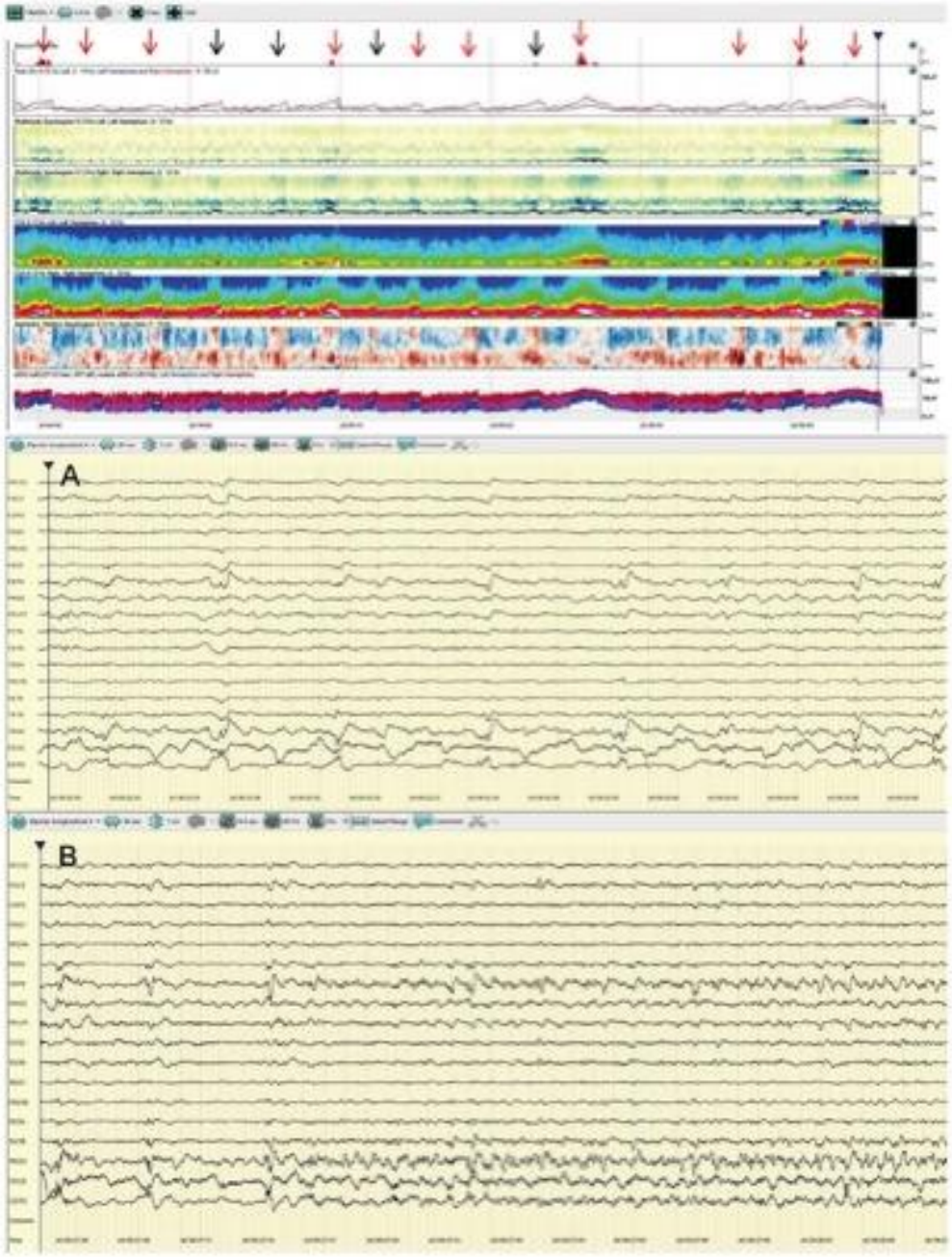
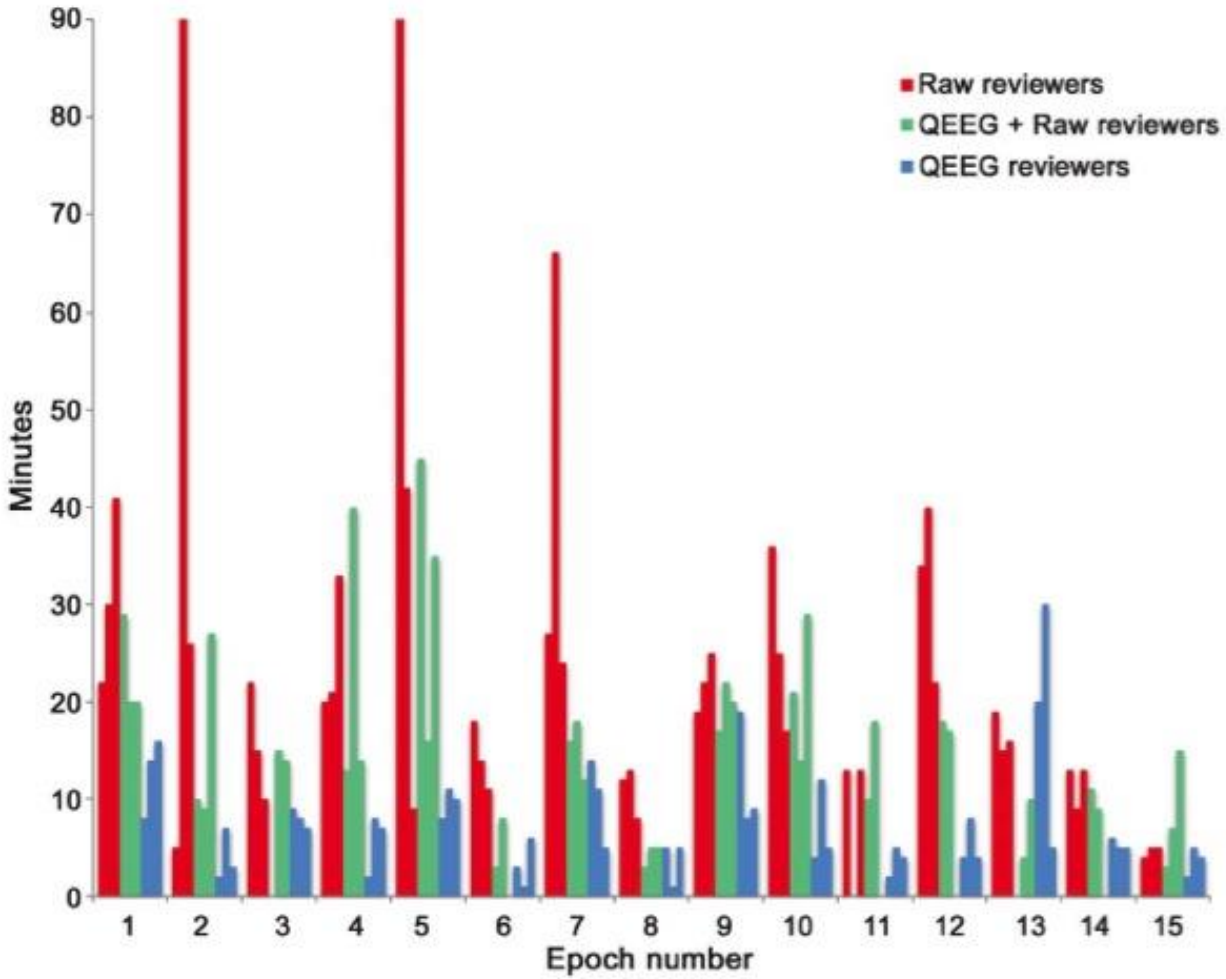
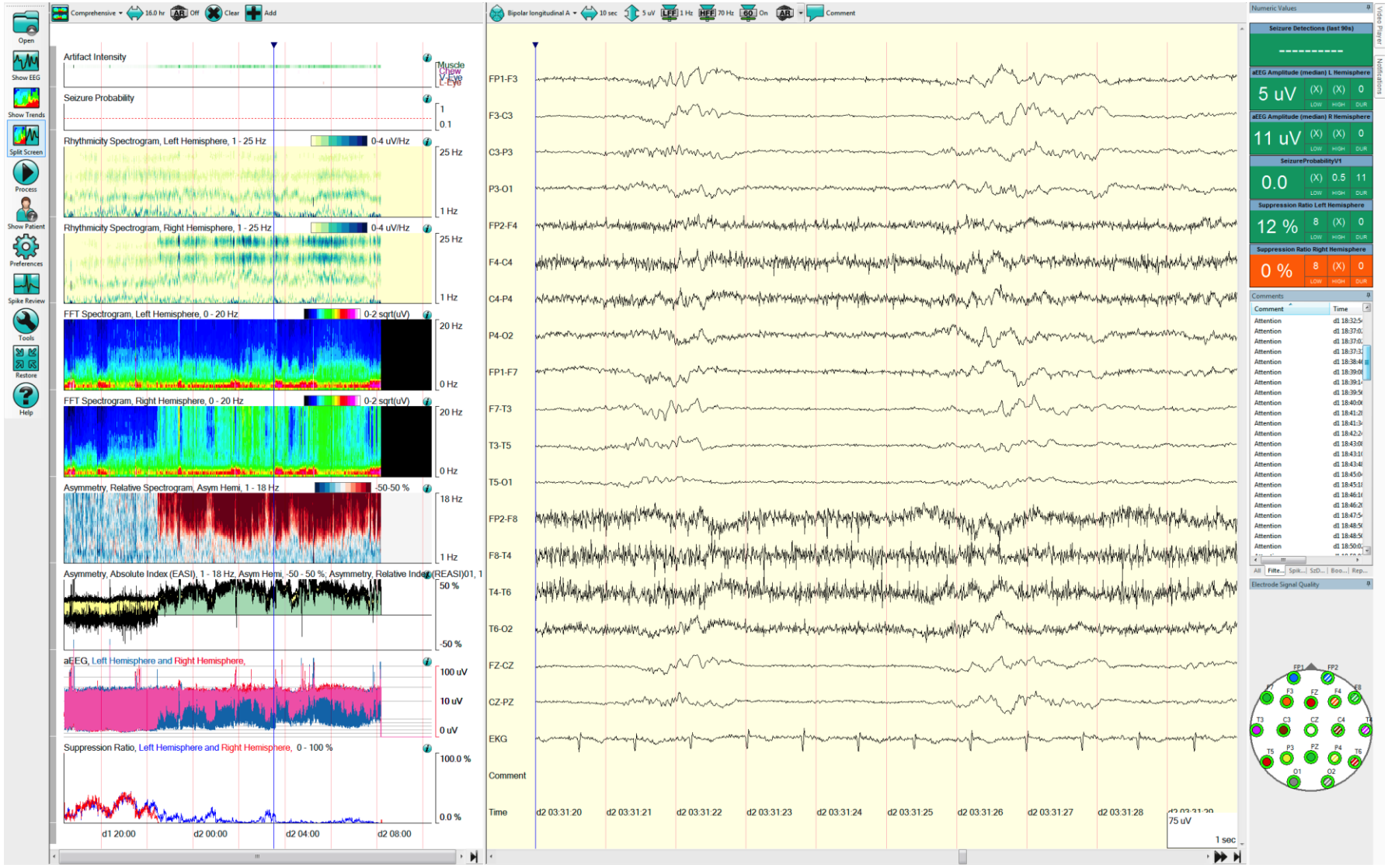


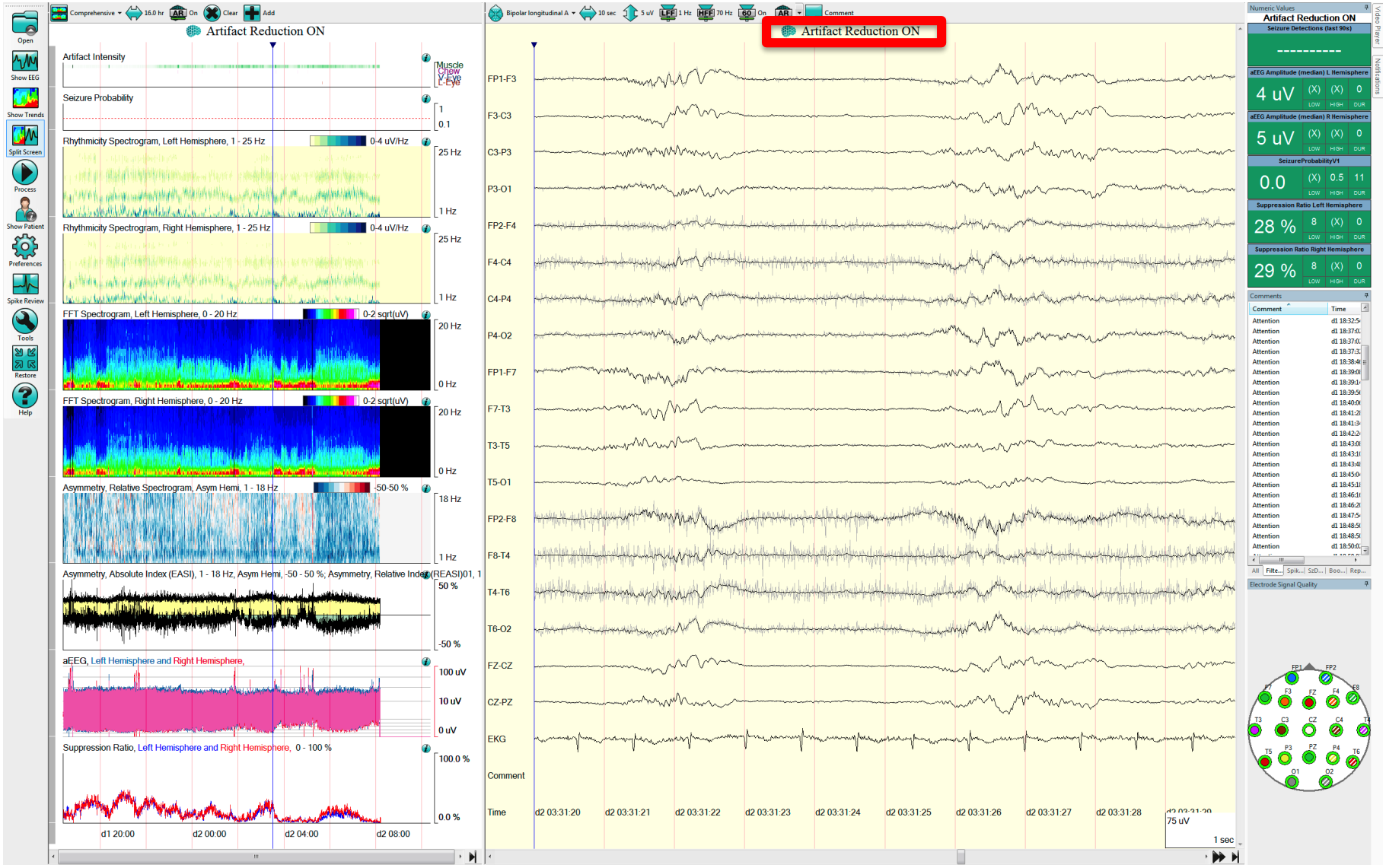
Figure 4 Comparison of reviewing time for reviewers when using raw EEG without quantitative EEG, quantitative EEG with raw EEG, and quantitative EEG alone



❑ *Modern qEEG devices reduce EEG reading time*



❑ *Modern qEEG devices with artifact elimination*



❑ *Modern qEEG devices with artifact elimination*

Mouhsin M. Shafi, MD, PhD*
M. Brandon Westover, MD, PhD*
Andrew J. Cole, MD
Ronan D. Kilbride, MD
Daniel B. Hoch, MD
Sydney S. Cash, MD, PhD

Absence of early epileptiform abnormalities predicts lack of seizures on continuous EEG

Diagnosis	Initial EEG or cEEG seizures[a]
AMS	19/52 (37)
Brain tumor	1/6 (17)
CNS infection	2/8 (25)
CVA	6/17 (35)
HIE	16/30 (53)
ICH	6/29 (21)
Nsgy	2/11 (18)
Other	6/16 (38)
SAH	2/15 (13)
TBI	3/36 (8)
TME	7/22 (32)
Total	70 (29)

~ 30%

Neurology® 2012;79:1796-1801

Mouhsin M. Shafi, MD, PhD*
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Ronan D. Kilbride, MD
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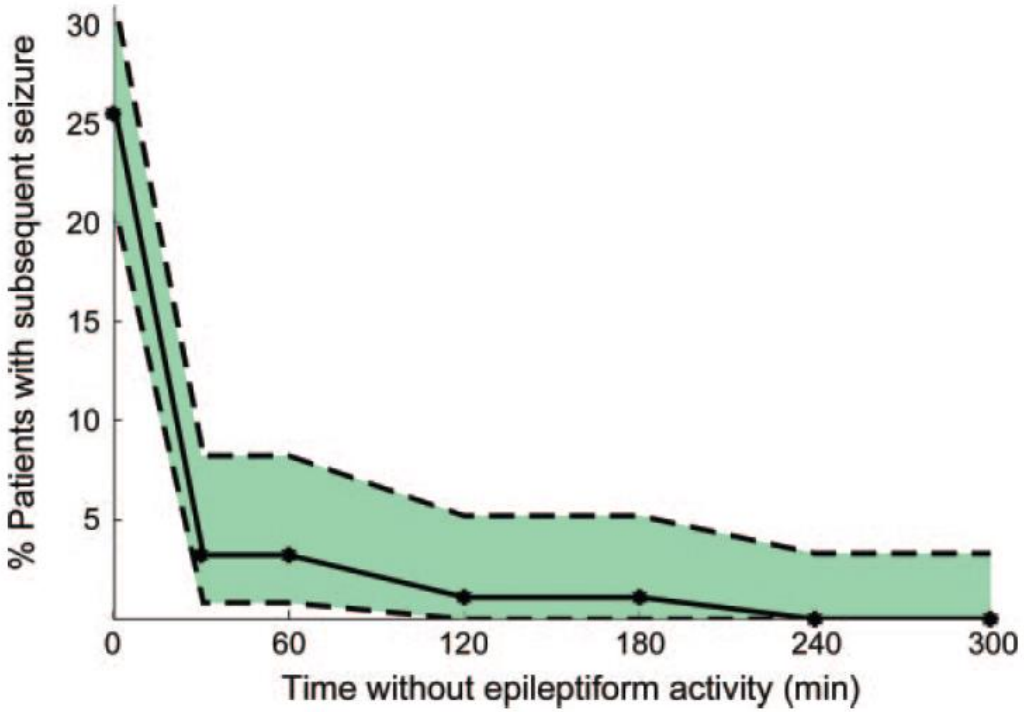
Absence of early epileptiform abnormalities predicts lack of seizures on continuous EEG



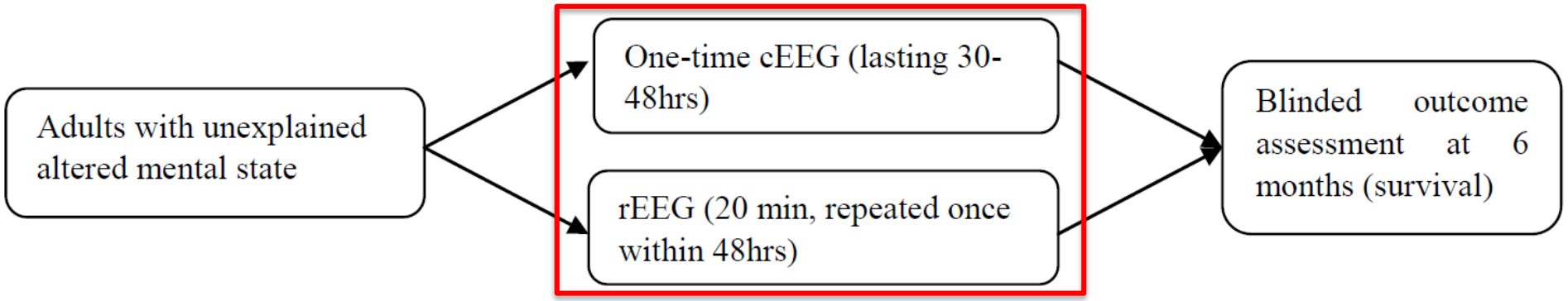
✓ Seizures were later detected in 22% of studies with epileptiform discharges vs. 3% without epileptiform abnormalities on initial EEG (*p0.001)*

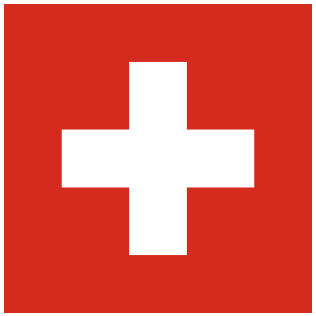
✓ In the 3 patients without epileptiform abnormalities on initial EEG but with subsequent seizures, the first epileptiform discharge or electrographic seizure occurred **within the first 4 hours of recording**

➢ *EEG features early in the recording help determine whether extended monitoring is needed*

Neurology® 2012;79:1796-1801

Impact on clinical outcome of continuous EEG monitoring in patients with disorders of consciousness: a randomized controlled trial.





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FONDS NATIONAL SUISSE
SCHWEIZERISCHER NATIONALFONDS
FONDO NAZIONALE SVIZZERO
SWISS NATIONAL SCIENCE FOUNDATION

A. Rossetti
R. Sutter
S. Ruegg
K. Schindler
V. Alvarez
M. Oddo
M. Haenggi
W. Z'Graggen
M. Seeck

canton de vaud
UNIL | Université de Lausanne
CHUV

Efficacy of a Reduced Electroencephalography Electrode Array for Detection of Seizures

Mark N. Rubin, MD[1], Oliver J. Jeffery, MBChB[2], Jennifer E. Fugate, DO[3], Jeffery W. Britton, MD[2], Gregory D. Cascino, MD[2], Gregory A. Worrell, MD, PhD[2], Sara E. Hocker, MD[3], Eelco F. Wijdicks, MD[3], and Alejandro A. Rabinstein, MD[3]

The Neurohospitalist
2014, Vol 4(1) 6-8

DOI: 10.1177/1941874413507930
nhos.sagepub.com
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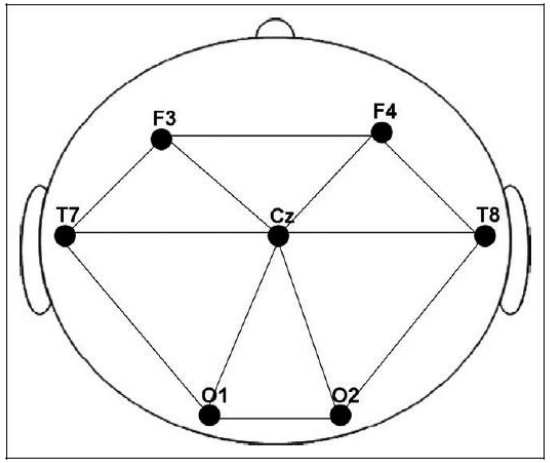


Table 3. Detection of Seizure With Reduced EEG Array by Seizure Type.

	Reviewer 1	Reviewer 2	Combined %
Focal (n = 25)	20/25	20/25	80
Generalized (n = 10)	6/10	5/10	55
NCSE (n = 11)	6/11	6/11	55
CSE (n = 4)	4/4	2/4	75

❑ *reduced montage is insufficient for seizure detection*

Impact of an ICU EEG monitoring pathway on timeliness of therapeutic intervention and electrographic seizure termination

*†Ryan P. Williams, *†Brenda Banwell, ‡Robert A. Berg, *†Dennis J. Dlugos, §Maureen Donnelly, *†Rebecca Ichord, *†Sudha Kilaru Kessler, *Jane Lavelle, *†Shavonne L. Massey, ¶Jennifer Hewlett, *Allison Parker, §Alexis A. Topjian, and *†§Nicholas S. Abend

Epilepsia, 57(5):786–795, 2016

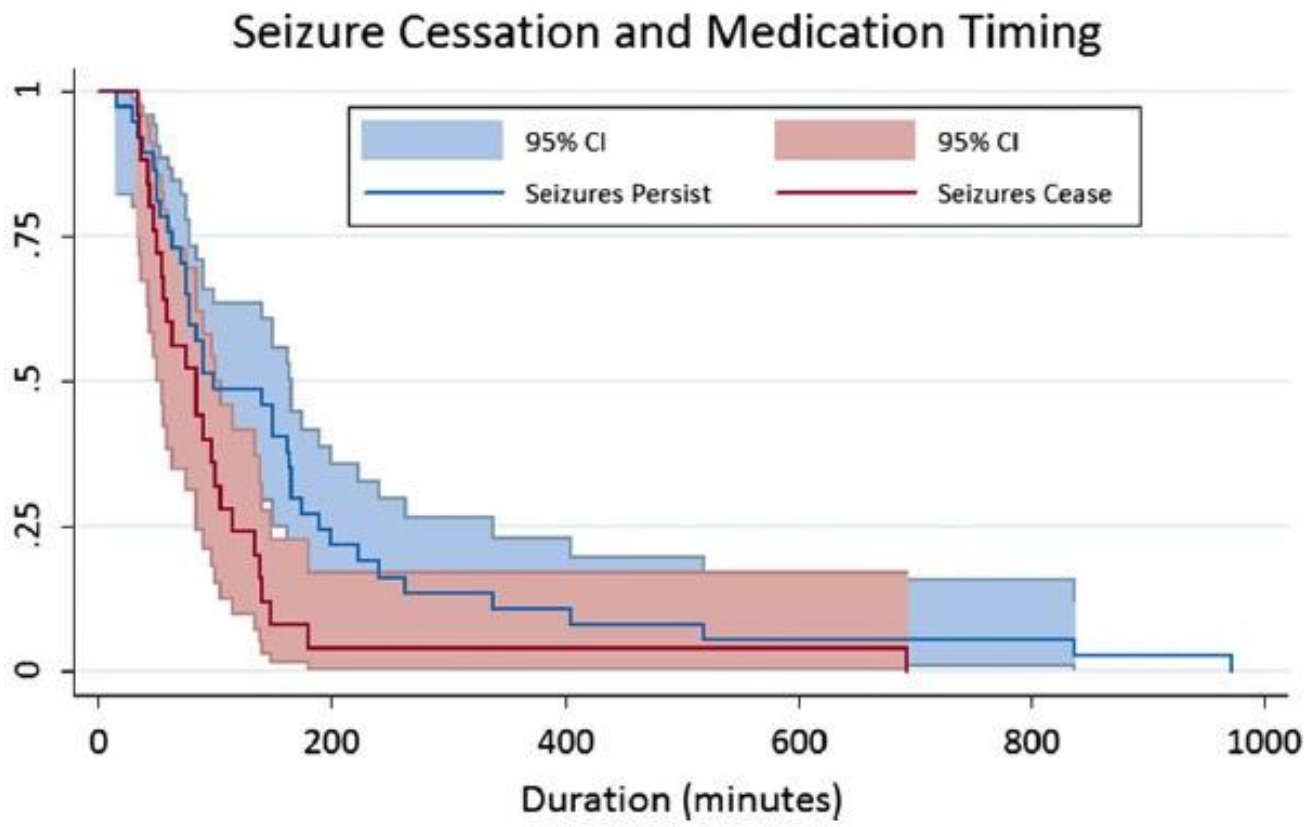
Table 2. Components of the intensive care unit continuous EEG monitoring pathway implementation

Multidisciplinary team development
Team composed of electroencephalographers (2), neurology physicians providing care on the Critical Care Neurology Consultation service (2), critical care medicine physician (1), EEG technologists (2), ICU nurses (1), ICU pharmacist (1), quality improvement specialist physician (1), and quality improvement analyst (1).
Team bounded by specific and stable membership, scheduled meetings, unified goal, and time line.
Mandate provided since official institutional quality improvement project.
Staff education
Establishment of multidisciplinary standards for EEG monitoring indications, communication strategies, and management strategies.
Grand Rounds lectures for critical care medicine and neurology services.
Resident and Fellow educational lectures for neurology and critical care medicine trainees during the summer (as new trainees begin).
Discussion of related cases in Multidisciplinary Case Management Conferences.
Bedside teaching for ICU nurses by nurse education team.
Lectures and case discussions for EEG technologists in EEG Review Conference.
Daily work flow modifications
Single easily accessible pathway document guiding care for all involved staff.
EEG monitoring initiation based on critical care medicine recognition of EEG monitoring indication and subsequent order, rather than required neurologic consultation.
Revised EEG monitoring order in electronic medical record, which incorporated related nursing orders addressing button pushes to mark events and medication administration times and additional point-of-care educational materials.
Levetiracetam provided in ICU Pyxis allowing for more rapid administration, since it did not need to be delivered from pharmacy.
Just-in-time education for ICU nurses caring for patients undergoing EEG monitoring provided by EEG technologists using a jointly developed brief paper education book.
New EEG equipment button pads allowing easier bedside documentation of events and medication administrations by ICU nurses by a single button push.
Enhanced role for EEG technologists in screening for seizures and communicating data regarding seizures based on The American Society of Electroneurodiagnostic Technologist's "National Competency Skill Standards for ICU/cEEG Monitoring," which provides for roles in clinical staff education regarding EEG monitoring and communication of convulsive and electrographic seizure event data to encephalographers and other clinicians.[40] Prior to pathway initiation, these roles were not converted into standardized institutional standards and EEG technologists had varying understanding of their job expectations and appropriate bounds of practice. After pathway initiation, EEG technologists received extensive education to ensure they were capable of performing these roles and also understood that these roles were within appropriate practice bounds.
Involvement of EEG technologists in results communication to critical care medicine fellows.
Unified contact numbers for critical care medicine fellow teams provided at EEG monitoring initiation.
Removal of some trainee physicians (pediatrics residents rotating in the pediatric intensive care unit) from the communication work flow despite a recognized small reduction in educational experience.
Simplified Citrix-based remote EEG access for EEG attending physicians.

Impact of an ICU EEG monitoring pathway on timeliness of therapeutic intervention and electrographic seizure termination

*†Ryan P. Williams, *†Brenda Banwell, ‡Robert A. Berg, *†Dennis J. Dlugos, §Maureen Donnelly, *†Rebecca Ichord, *†Sudha Kilaru Kessler, *Jane Lavelle, *†Shavonne L. Massey, ¶Jennifer Hewlett, *Allison Parker, §Alexis A. Topjian, and *†§Nicholas S. Abend

Epilepsia, 57(5):786–795, 2016



J Clin Neurophysiol. 2013 April ; 30(2): 156–160. doi:10.1097/WNP.0b013e31827eda27.

Pediatric ICU EEG Monitoring: Current Resources and Practice in the United States and Canada

Sarah M. Sanchez[a], Jessica Carpenter[b], Kevin E. Chapman[c], Dennis J. Dlugos[a], William Gallentine[d], Christopher C. Giza[e], Joshua L. Goldstein[f], Cecil D. Hahn[g], Sudha Kilaru Kessler[a], Tobias Loddenkemper[h], James J. Riviello Jr.[i], and Nicholas S. Abend[a] On behalf of the Pediatric Critical Care EEG Consortium

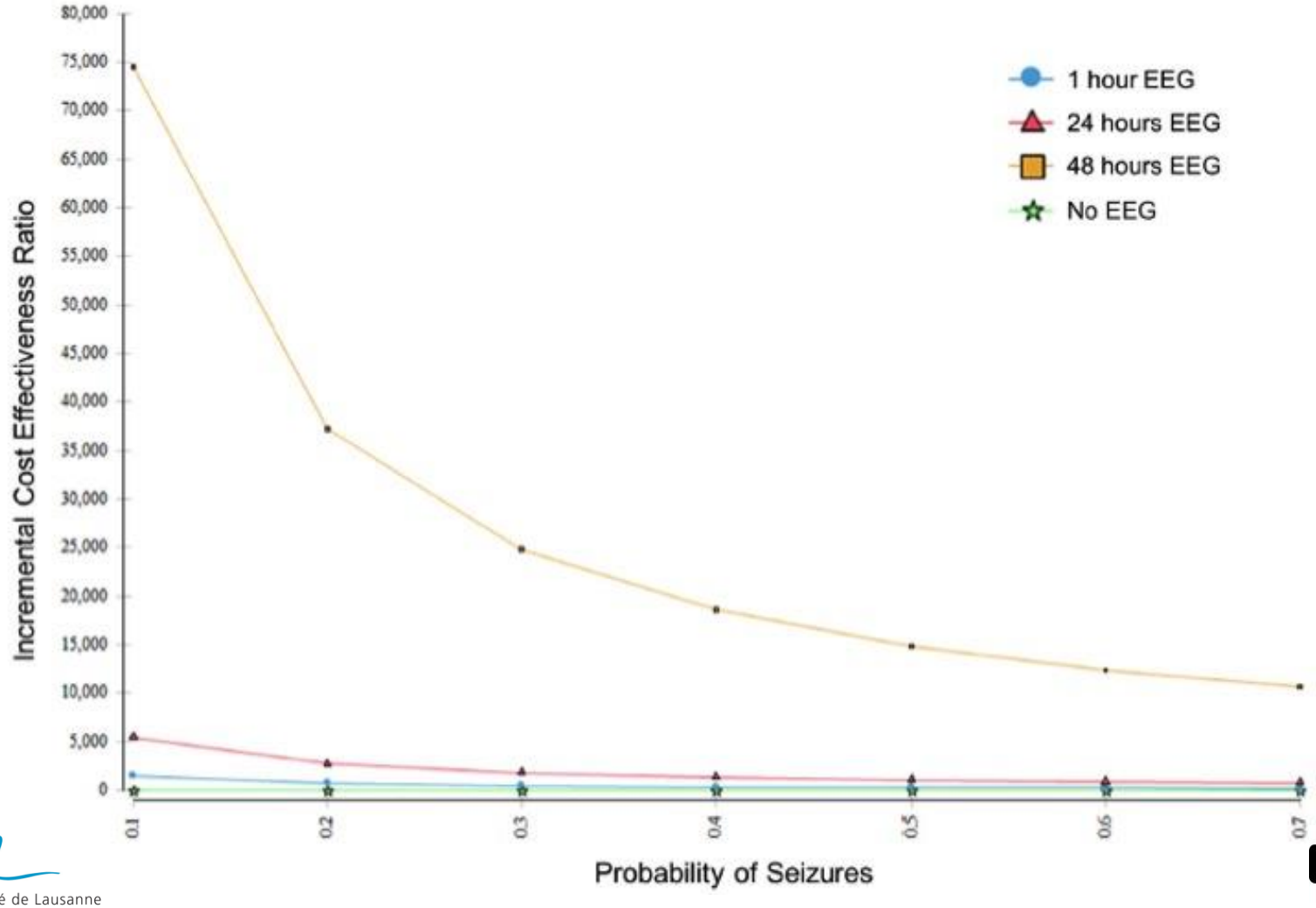
Technologist Availability and Work		All	U.S.	Canada
Availability	Always available in-hospital	28%	35%	0%
	Always available but sometimes by call-back	51%	52%	46%
	Not always available	21%	13%	54%
Technologist Work	Technical Only	51%	50%	55%
	Technical and EEG Screening	49%	50%	45%

COST-EFFECTIVENESS
&
IMPACT ON OUTCOME

J Clin Neurophysiol. 2015 June ; 32(3): 257–264. doi:10.1097/WNP.0000000000000170.

How much does it cost to identify a critically ill child experiencing electrographic seizures?

Nicholas S. Abend, M.D.[a], **Alexis A Topjian, M.D., MSCE**[b], and **Sankey Williams, M.D.**[c]



J Clin Neurophysiol. 2015 June ; 32(3): 257–264. doi:10.1097/WNP.0000000000000170.

How much does it cost to identify a critically ill child experiencing electrographic seizures?

Nicholas S. Abend, M.D.[a], **Alexis A Topjian, M.D., MSCE**[b], and **Sankey Williams, M.D.**[c]

Cost effectiveness analysis of base case values.

Strategy	Cost	Incremental Cost	Effect	Incremental Effect	Incremental Cost Effectiveness Ratio
No EEG	0	-	0	-	-
1 hour EEG	$84.69	$84.69	0.18	0.18	$465.67
24 hours EEG	$250.48	$165.79	0.28	0.1	$1,665.63
48 hours EEG	$500.96	$250.48	0.29	0.01	$22,648.36

John P. Ney, MD, MPH
David N. van der Goes, PhD
Marc R. Nuwer, MD, PhD
Lonnie Nelson, PhD
Matthew A. Eccher, MD, MSPH

Continuous and routine EEG in intensive care

Utilization and outcomes, United States 2005–2009

Table 2 Annual utilization of continuous and routine EEG in mechanically ventilated patients, at hospital level

	Continuous EEG monitoring			Routine EEG[a]		
	National totals	No. of hospitals performing	Mean studies per hospital (range)[b]	National totals	No. of hospitals performing	Mean studies per hospital (range)
2005	552	135	4.0 (1-20)	5,746	595	8.7 (1-100)
2006	800	167	4.7 (1-34)	6,427	602	9.9 (1-92)
2007	1,516	213	6.7 (1-58)	7,057	646	9.8 (1-97)
2008	1,070	189	5.7 (1-29)	8,545	671	11.4 (1-139)
2009	2,011	244	8.0 (1-69)	7,444	696	9.5 (1-112)
Annual Δ%	+33	+14	+17	+8	+4	+3

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Continuous and routine EEG in intensive care

Utilization and outcomes, United States 2005–2009

Table 3 Analysis of primary and secondary outcomes

	In-hospital mortality, proportion and logistic regression results	Total hospital charges, mean 2009 US dollars, and GLM results as %	Length of stay, mean days and OLS results
Sample-weighted proportions and means			
EEG only (95% CI)	0.39 (0.37, 0.41)	$167,300 ($147,000, $187,700)	18.2 d (17.0, 19.5)
cEEG (95% CI)	0.25 (0.23, 0.28)	$187,300 ($160,400, $214,400)	20.3 d (18.0, 20.3)
Univariate regressions			
β_{cEEG} (95% CI)	OR = 0.54 (0.45, 0.64)	12% (−4%, 31%)	2.1 d (−0.3, 4.5)
p Values	<0.001	0.16	0.09
Multivariate regressions			
β_{cEEG} (95% CI)	OR = 0.63 (0.52, 0.76)	5% (−11%, 23%)	0.5 d (−1.5, 2.7)
p Values	<0.001	0.58	0.66