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GRAY MATTERS

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Letter

Postictal stereo-EEG changes following bilateral tonic-clonic seizures

To the Editors:

We read with interest the study of Bateman et al[1] on postictal electroclinical changes following bilateral tonic-clonic seizures using subdural grids, depth electrodes, or both. They observed postictal gamma band activity in the majority of 31 seizures, whereas other frequencies were suppressed. This calls into question whether postictal generalized electroencephalographic (EEG) suppression (PGES) is characterized by absence of activity, as suggested previously. Gamma activity was hypothesized by the authors as possibly representing persistent brainstem activity.

We recently studied postictal electrical activity in 100 bilateral tonic-clonic seizures using stereo-electroencephalography (SEEG).[2] Different patterns were described: PGES (all electrodes involved), regional suppression (RS; subset of electrodes), or no suppression. We used a 70 Hz high-frequency filter; therefore, observed absence of activity in PGES and RS was within the 0-70 Hz range. Our definitions used different EEG criteria, notably higher sensitivity, to increase detection of low-amplitude changes (<20 μV/mm in our study vs a fixed 50 μV/mm cut-off in Bateman et al). This may help explain the higher prevalence of "post-ictal attenuation" (24/31 seizures, 84%) in the series of Bateman et al, compared to the prevalence of PGES in our study (27/100 seizures, 27%). We acknowledge that the term "generalized" in PGES must be used with caution in the context of intracranial recording, since the whole brain is not sampled, as discussed previously.[2] We also highlight that in Marchi et al, we reported on 52 patients explored with SEEG, whereas Bateman et al report 16 patients of whom 3 had stereotactically implanted depth electrodes and the remainder subdural recording. To investigate whether high gamma band activity was present in our cases, we randomly selected three previously described SEEG cases with PGES,[2] all postictally unresponsive and immobile with no obvious muscle contraction. We studied unfiltered monopolar and bipolar recordings, sampled at 512 Hz, using time-frequency analysis. This detected marked increase in gamma activity (20-120 Hz) in both monopolar and bipolar recordings during PGES (Figure 1A) in all three. We noticed an anatomic gradient, whereby gamma activity was not seen in internal (deep) contacts, but predominantly occurred in the most external electrode contacts, that is, closest to the skull entry point. Indeed, some contacts displaying gamma activity were extracortical, within the cerebrospinal fluid (CSF) space (Figure 1B). This raises the question of a noncerebral cause. Previously, high gamma band power increases observed in SEEG electrodes close to periorbital regions were demonstrated to be contamination from ocular saccades.[3]

Association between tonic electromyographic (EMG) activity in frontalis muscles and presence of PGES was recently highlighted using surface EEG,[4] interpreted as possibly relating to seizure-induced hypoxemia as observed in rat models.[5] Authors excluded large EMG fluctuations associated with visible movements. Might it therefore be possible that some of the gamma activity observed by Bateman et al is related to facial/scalp muscular contraction? They observed "rigid immobility" postictally in around one-third of cases; it would be interesting to look at the association with gamma band activity and, most importantly, evaluate the anatomic distribution of gamma.

In light of these observations, we prospectively tested a single patient interictally, comparing SEEG signal with EMG of frontalis muscle. This showed gamma activity in external contacts of frontal SEEG electrode during voluntary facial contraction (Figure 1C and D), confirming muscle activity as a possible confounding factor.

Animal models of sudden unexpected death in epilepsy (SUDEP) show a large postictal DC shift in brainstem, likely reflecting a depolarization block, which can underlie spreading depression.[6] This could explain both cardiorespiratory shutdown and PGES, observed in clinical cases of SUDEP.[7] However, a widespread depolarization block would be expected to produce absence of broadband activity. Thus further investigation is crucial to confirm whether observed gamma activity is of cerebral origin or not.

ACKNOWLEDGEMENTS

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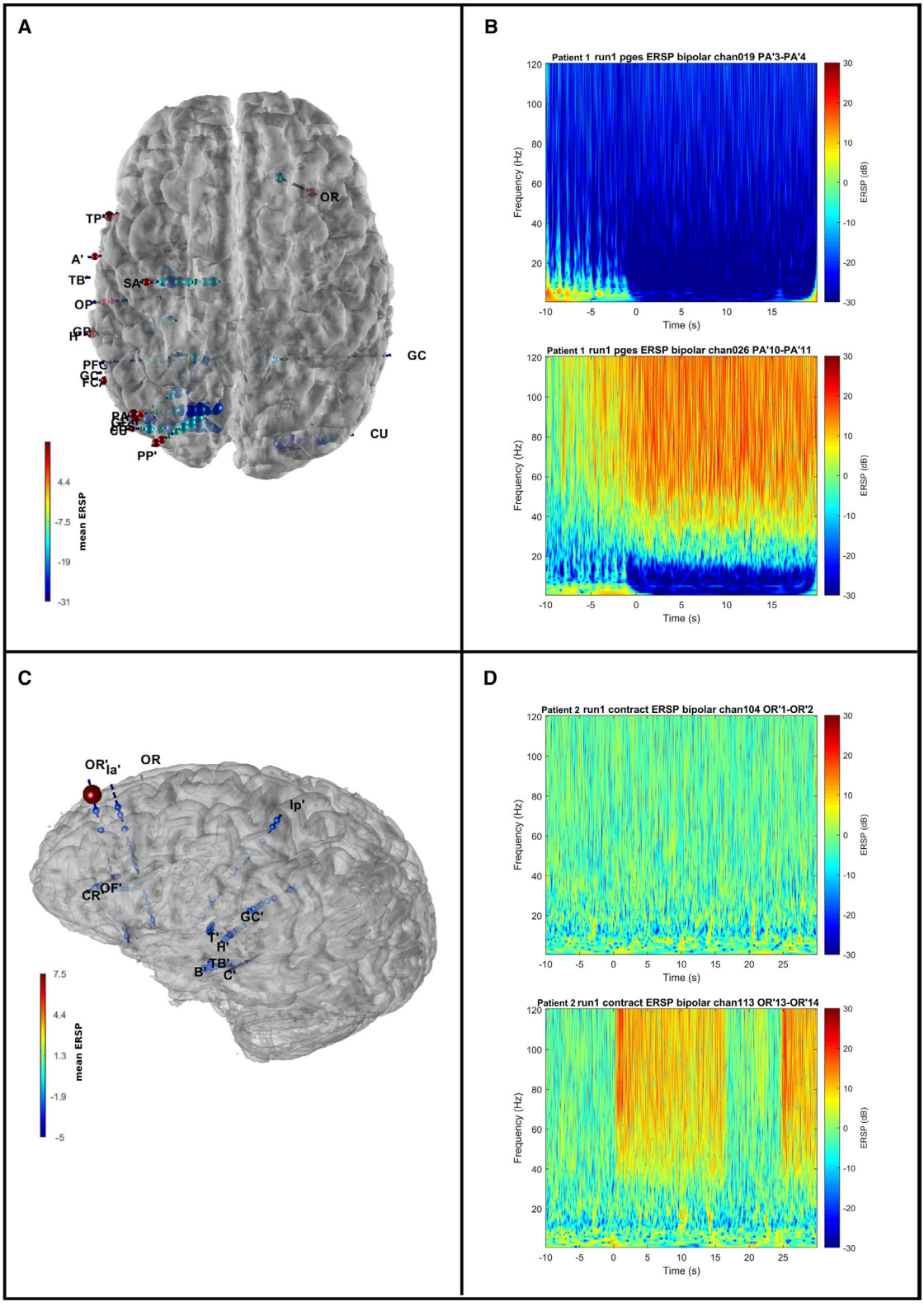
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FIGURE 1 A, Shows the three-dimensional (3D) cortical mesh with reconstructed electrodes of an adult male patient explored with stereoelectroencephalography (SEEG) for presurgical evaluation of left posterior cortex epilepsy, who presented with generalized tonic-clonic seizures during SEEG (included in the series of Marchi et al[2]). Each point of the time-frequency (TF) plane (square amplitude) was divided by the mean in the baseline and represented in dB ($10*\log_{10}$). The spheres' size and color represent the values of event-related spectral perturbation (ERSP) averaged across time and frequency, measured during a 15-s time window during postictal generalized electroencephalographic (EEG) suppression (PGES). The red spheres indicate the presence of gamma band activity (40-120 Hz) and the blue spheres indicate suppression in the same frequency band. It can be seen that gamma activity is present in a superficial cortical and sometimes extracortical distribution across multiple electrodes. B, Shows ERSP for a selected deep contact of the left parietal electrode PA' (top) of the same patient during the period of transition from seizure termination (at time = 0 s) to PGES, and a superficial contact of the same electrode (bottom) during the same time window. The deep contact shows broadband suppression of activity, whereas the superficial electrode shows marked increase in gamma activity from 40-120 Hz. C and D, Show the same processing as in (A) and (B), respectively, but for another patient during a facial contraction task. The adult female patient, who was being explored with SEEG for temporofrontal epilepsy, performed voluntary facial contractions during the interictal period, with simultaneous electromyography (EMG) of bilateral frontalis muscle. During periods of facial contraction, gamma band increase (40-120 Hz) was seen in the superficial contacts of the oblique electrode OR' exploring left dorsolateral prefrontal cortex, which corresponded with timing of EMG signal increase. These electrode contacts were anatomically closest to the muscle being contracted. Other deeper contacts of the same electrode and other electrodes did not show gamma activity during voluntary muscle contraction of frontalis

program managed by the French National Research Agency (ANR).

CONFLICT OF INTERESTS

None of the authors has any conflict of interest to disclose. We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

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Epilepsia®

Letter

Postictal clinical and EEG activity following intracranially recorded bilateral tonic-clonic seizures

To the Editors,

We appreciate the opportunity to respond to the letter from McGonigal et al, which proposes alternative explanations for our observations of gamma activity during intracranially recorded postictal attenuation (IPA).[1] In our paper, we had avoided making the intuitive connection between IPA and postictal generalized electroencephalographic (EEG) suppression (PGES) due to the limited, often unilateral spatial coverage that is typical of intracranial implants. However, the authors of the letter had done so in their related study.[2]

We agree that further study of postictal EEG attenuation is warranted; however, the topic is sufficiently complex that it needs to be addressed in a comprehensive peer-reviewed publication. In our manuscript, we discussed several lines of evidence that led us to the conclusion that the IPA-associated gamma activity is of cerebral origin. We reiterate a few of these here. First, the pattern of postictal gamma activity is often inconsistent with electromyography (EMG) activity, which would diminish in power after a few seconds. This can be seen in the letter's Figure panel D. Second, there was no correlation with clinical semiology. It was as likely to appear with flaccid as with rigid immobility and did not appear to be modulated by body jerks or other transient movements. In fact, in Figure 2 of our paper,[1] gamma activity can be seen to emerge only after ictal bilateral clonic jerking ceases. Third, we observed cases in which IPA with superimposed gamma activity alternates with periods of EEG slowing with spikes, during which the gamma activity disappears and voluntary patient movements can be seen.

The data presented in the letter focus on extra-axial electrodes in stereo-EEG implants, which showed localized myogenic artifact correlating with forehead movement. As our center now routinely utilizes stereo-EEG implants with high-frequency recordings, we are quite familiar with the extensive high-frequency artifact in extra-axial contacts. It is our standard practice in any EEG analysis to exclude electrodes demonstrating persistent artifact, even if that artifact is not obvious on routine clinical review. It is also notable that McGonigal et al report that the forehead movement artifact was detected only in the nearby extraaxial electrode, and not in the contralateral/mirror electrode. Because during voluntary forehead contraction it is difficult to avoid contralateral movements, it was in fact a good demonstration that myogenic artifact is not typically prominent in single-trial intracerebral recordings. In any case, the extra-axial observations would not apply to subdural electrodes, which constituted the majority of the coverage in our study.

It is an interesting proposition that muscle activity impacting EEG recordings should be so strongly linked to IPA/PGES, which would seem to counter the hypothesis of cerebral and/or brainstem suppression during this period. If myogenic activity is indeed routinely present during PGES, it must have a source, which we were not able to identify from our systematic exploration of postictal video recordings. We agree that a facial EMG recording may be helpful for future investigations, although we would caution that it should be recorded on a separate system to avoid reference contamination. This further emphasizes the need for scientifically rigorous human studies into postictal phenomena.

ACKNOWLEDGMENTS

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CONFLICT OF INTERESTS

None of the authors has any conflict of interest to disclose. We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

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2. Marchi A, Giusiano B, King M, Lagarde S, Trébuchon-Dafonseca A, Bernard C, et al. Postictal electroencephalographic (EEG) suppression: a stereo-EEG study of 100 focal to bilateral tonic–clonic seizures. Epilepsia. 2019;60:63–7.

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Announcements

Epilepsia – August 2019 – Announcements

13th Baltic Sea Summer School on Epilepsy (BSSSE 13)

18–24 August 2019
Rostock, Germany
Information:https://www.ilae.org/congresses/13th-baltic-sea-summer-school-on-epilepsy-bssse-13

4th African Epilepsy Congress

22–24 August 2019
Entebbe, Uganda
Website: https://www.epilepsycongress.org/aec/

5th SuSIE – Summer School on Imaging in Epilepsy, Epilepsy Surgery and Epilepsy Research

25–28 August 2019
Teaching, scientific exchange, and marketplace
Bochum, Germany
Website: http://www.imaging-in-epilepsy.org/

Epilepsia en Atención Primaraia para América Latina: Curso Virtual

26 August–20 October
Epilepsy for Primary Care Online Course
Information: https://www.ilae.org/congresses/epilepsia-en-atenci-n-primaraia-para-am-rica-latina-curso-virtual

2nd International Congress on Mobile Devices and Seizure Detection in Epilepsy

6–7 September 2019
Lausanne, Switzerland
http://www.mhsdepilepsy2019.com/

4th International Epilepsy Symposium: Epilepsy and Psychology Seizures, Cognition, and Behavior

6–7 September 2019
Bielefeld, Germany
Information: https://www.ilae.org/congresses/4th-international-epilepsy-symposium-epilepsy-and-psychology

4th International Symposium on Hypothalamic Hamartomas

12–14 September 2019
Washington, D.C., USA
Symposium website: http://www.hopeforhh.org/4th-international-symposium-on-hypothalamic-hamartomas/

Cleveland Clinic Neurological Institute Summit 2019: Epilepsy - Focal Cortical Displasia

12–15 September 2019
Cleveland, OH, USA
Website: http://www.clevelandclinicmeded.com/live/courses/ni-summit-epilepsy/default.asp

ILAE British Branch 17th SpR Epilepsy Teaching Weekend

14–15 September 2019
Oxford, UK.
http://www.epilepsyteachingweekend.com/

Introduction to Neuropsychological Methods in the Diagnosis and Treatment of People with Epilepsy

18–22 September 2019
Hanoi, Vietnam
Information: https://www.ilae.org/congresses/introduction-to-neuropsychological-methods-in-the-diagnosis-and-treatment-of-people-with-epilepsy

Congreso LACE

19–20 September 2019
Buenos Aires, Argentina
Website: http://www.lace.org.ar/constructor.php?categoria=1

9th Migrating Course on Epilepsy

19–22 September 2019
Vrdnik, Serbia
Information: https://www.ilae.org/congresses/9th-migrating-course-on-epilepsy

Canadian League Against Epilepsy 2019 Annual Scientific Meeting

20–22 September 2019
Winnipeg, Manitoba
https://claegroup.org/2019-meeting

Philippine League Against Epilepsy 10th Biennial Epilepsy Congress: Epilepsy Across the Ages: Advancing the Science, Improving the Care

26–28 September 2019
Manilla, Philippines
Congress Programme: https://www.ilae.org/index.cfm?objectxml:id=0A15EA80-35D7-11E9-B2E2204747814332

Masterclass on Resistant Epilepsy – Part 2

2 October 2019
Bucharest, Romania
Information: https://www.ilae.org/congresses/masterclass-on-resistant-epilepsies-m2

2019 ILAE British Branch Annual Scientific Meeting

2–4 October 2019
Birmingham, UK
http://www.ilaebritishconference.org.uk/

Park City Epilepsy Meeting: Cutting Edge Approaches to Transform Epilepsy Therapy

6–8 October 2019
Park City, Utah, USA
Website: http://www.parkcityepilepsymeeting.com/

European Congress of NeuroRehabilitation 2019 (ECNR)

9–12 October 2019
Budapest, Hungary
https://www.ecnr-congress.org/

Jahrestagung des deutsch-österreichisch-schweizer Arbeitskreises Epilepsie German-Austrian-Swiss Workshop on Epileptology (DACH)

10–12 October 2019
Friedrichshafen, Germany
https://www.uniklinik-freiburg.de/jahrestagung-dach-ag-epilepsie.html

9th Caucasian Summer School on Clinical Epileptology

11–13 October 2019
Tbilisi, Georgia
Information: https://www.ilae.org/congresses/9th-caucasian-summer-school-on-clinical-epileptology-cssce-ix

EAN Autumn School 2019

17–20 October 2019
Loutraki, Greece
https://www.ean.org/Autumn-School.3752.0.html

ISPN 2019: 47th Annual Meeting of the International Society for Pediatric Neurology

20–24 October 2019
Birmingham, UK
https://www.ispnmeeting.org/2019/

Epilepsy and Psychiatric Disorders throughout Life Educational Symposium of the Psychiatry Commission

25–26 October 2019
São Paulo, Brazil
Information: https://www.ilae.org/congresses/epilepsy-and-psychiatric-disorders-throughout-life

WCN 2019: XXIV World Congress of Neurology

27–31 October 2019
United Arab Emirates
https://2019.wcn-neurology.com/

Congreso Argentino de Neurología

19–22 November 2019
Mar del Plata, Argentina
http://www.lace.org.ar/constructor.php?categoria=1

Le 3ème Congrès Marocain de Neurophysiologie & La 4ème Session des Ecoles EEG & EMG

29 November–1 December 2019
Marrakech, Morocco
Information: https://www.ilae.org/congresses/le-3-me-congr-s-marocain-de-neurophysiologie

American Epilepsy Society

6–10 December 2019
Baltimore, MD, USA
https://meeting.aesnet.org/abstracts

7th International Conference on Non-Invasive Brain Stimulation (NIBS)

24–26 March 2020
Baden-Baden, Germany.
https://www.nibs-conference.de/

64th annual meeting of the German Society of Clinical Neurophysiology

26–28. March 2020
Baden-Baden, Germany
https://www.dgkn-kongress.de/

14th World Congress on Controversies in Neurology (CONy)

26–29 March 2020
London, UK
http://cony.comtecmed.com/

3rd International Training Course on Neuropsychology in Epilepsy

29 March–3 April 2020
Bordeaux, France
Information: https://www.ilae.org/congresses/3rd-international-training-course-on-neuropsychology-in-epilepsy

55th Annual Meeting of the German Society of Epileptology

10–13 June 2020
Breisgau, Germany
https://www.epilepsie-tagung.de/

14th European Congress on Epileptology (ECE)

4–8 July 2020
Geneva Switzerland
Website: http://www.epilepsycongress.org/ece/

ESTM 2020: Epilepsy Surgery Techniques Meeting

9–10 July 2020
Geneva, Switzerland
https://www.estm2020.com/

First North American Epilepsy Congress (NAEC)

25–27 September 2020
Toronto, Canada
Call for session proposals: Session Proposal Form
https://www.surveymonkey.com/r/1stNAEC_Toronto2020

13th Asian and Oceanian Epilepsy Congress (AOEC)

8–11 October 2020
Fukuoka, Japan
Information: https://www.epilepsycongress.org/congresses/aoec2020/