Monitoraggio della profondità dell'anestesia

Zaccaria Ricci
Azienda Ospedaliero-Universitaria Meyer, Firenze

Meyer
Azienda Ospedaliero Universitaria

UNIVERSITÀ DEGLI STUDI FIRENZE
SCUOLA DI SPECIALIZZAZIONE IN ANESTESIA, RIANIMAZIONE TERAPIA INTENSIVA E DEL DOLORE


COVIDIEN
BIS
34
EMG
EEG
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MENU
SENSOR
CHECK
31 May 2024
Beta
Alpha
Theta
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L1
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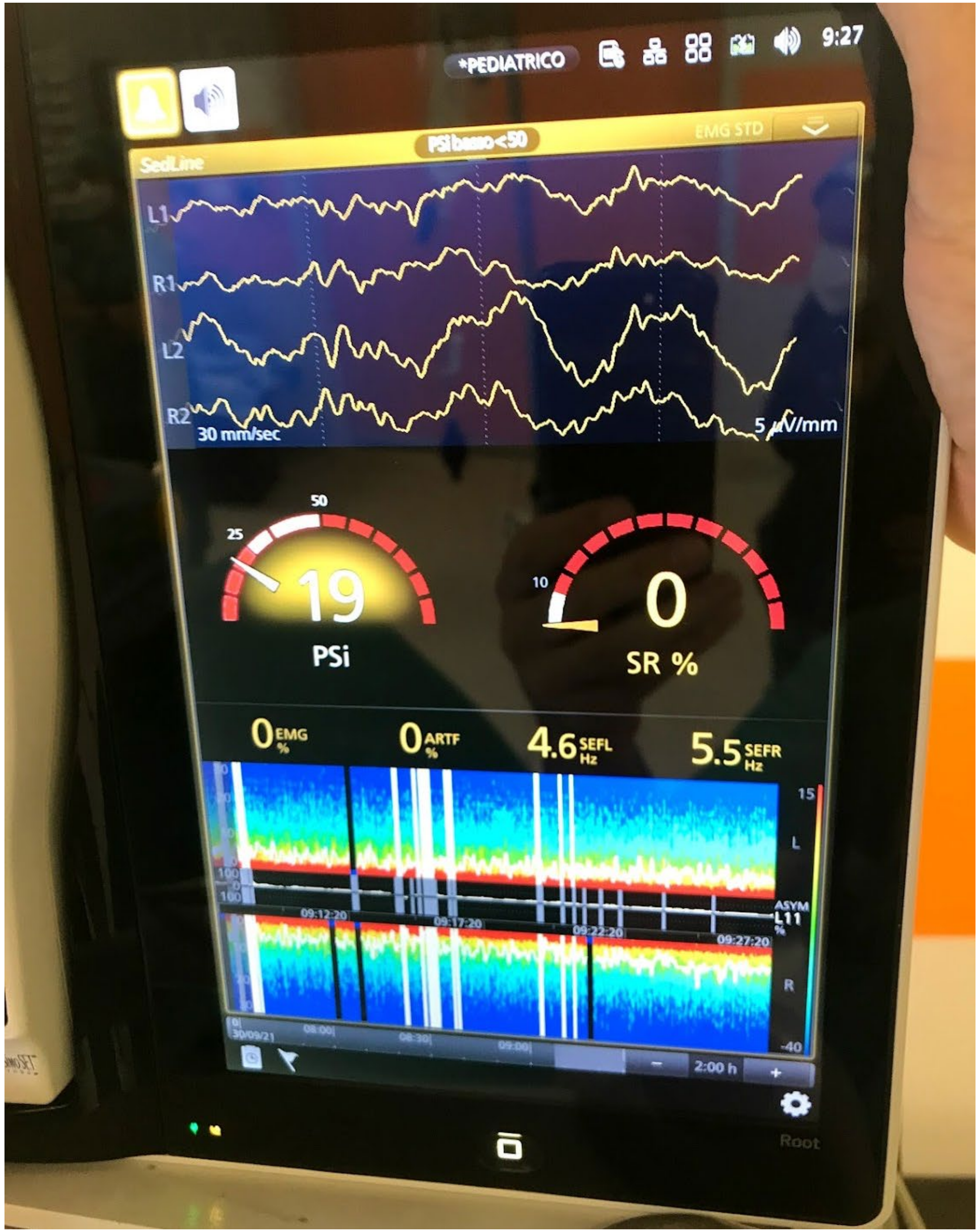
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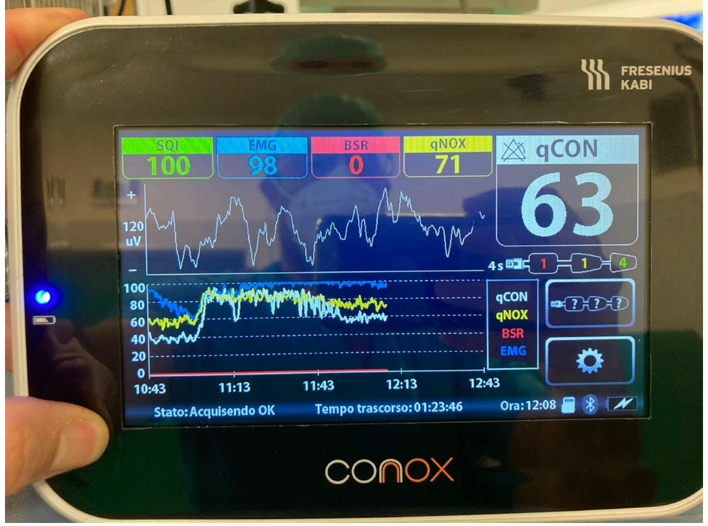
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10:43 11:13 11:43 12:13 12:43
Stato: Acquisendo OK
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Ora: 12:08
conox


FRESENIUS KABI
SQI 100
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475 uV
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conox


Narcotrend
D2
43
EMG
Narcotrend

PROCESSED EEG

Proprietary (secret) algorithm gets the necessary EEG information and digest them in order to provide a single resuming number

Anesthesiology 2022

NARRATIVE REVIEW ARTICLE

A Narrative Review Illustrating the Clinical Utility of Electroencephalogram-Guided Anesthesia Care in Children

Choon Looi Bong, FRCA,* Gustavo A. Balanza, MD,† Charis Ern-Hui Khoo, FANZCA,*
Josephine Swee-Kim Tan, MMed (Anaes),* Tenzin Desel, BA,† and Patrick Lee Purdon, PhD†

1) Avoiding oversedation
    - Children undergoing general anesthesia with (and without) NMBA
    - Children with Atypical Neurodevelopment or Neuropsychiatric Disorders
    - Children with Altered Levels of Consciousness Before Induction of Anesthesia
    - Neonates and Infants
2) Special circumstances
    - TIVA
    - Hemodynamic instability
    - CPB
    - Brain states (i.e., ketamine vs GABAergic vs alpha2)
    - [Children with locoregional anesthesia]

REVIEW

COA 2019

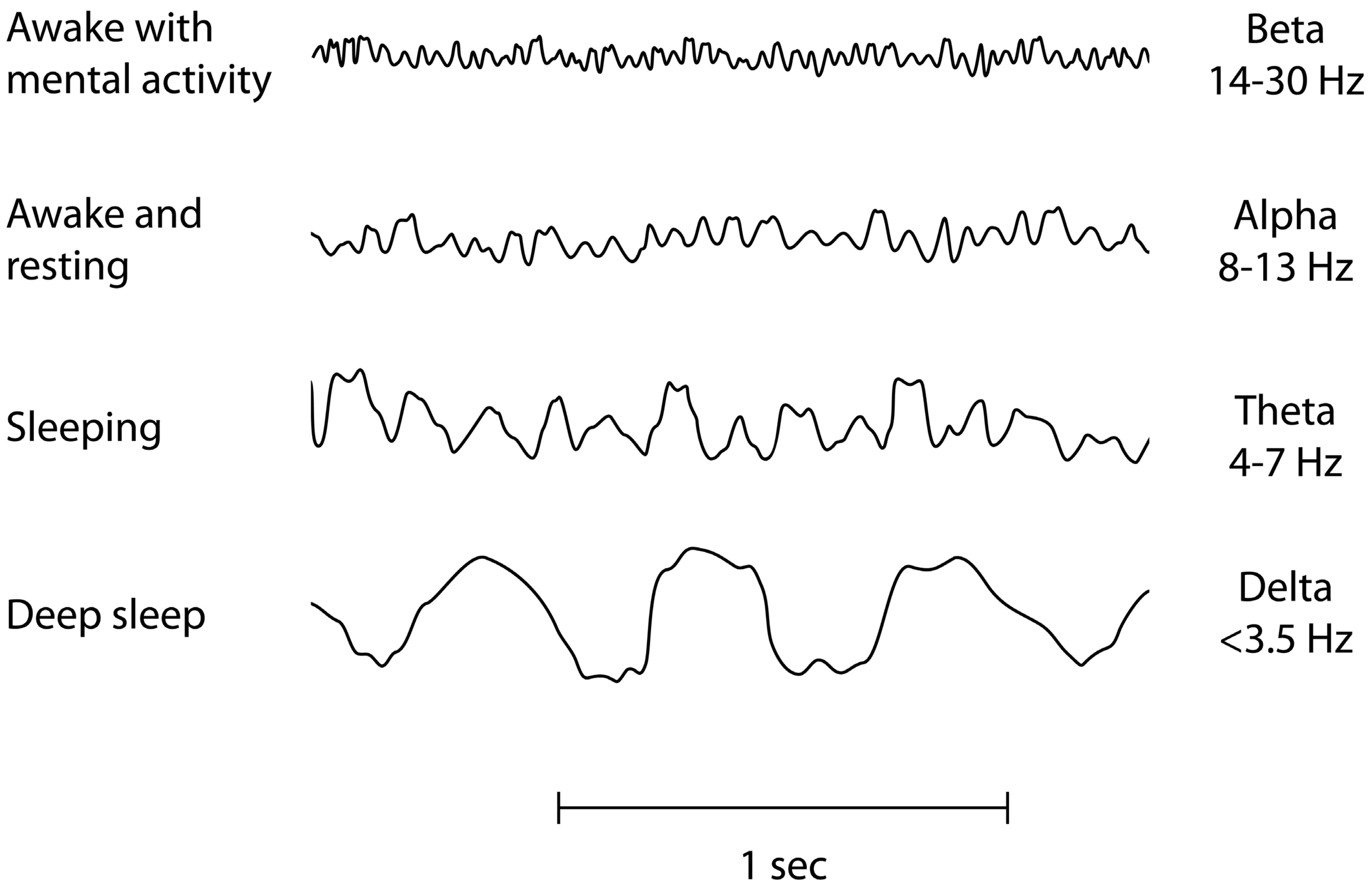
Neuromonitoring in paediatric anaesthesia

Andrew Davidson[a,b] and Justin Skowno[c,d]

- There are few studies, which demonstrate better outcomes in paediatric anaesthesia with EEG-derived depth monitors in children and there is no evidence that any particular EEG-derived depth monitor is superior in children.
- The EEG during anaesthesia is fundamentally different in infants and children.

Proprietary algorithms are made on adults' neurophysiology. Go back to basics

Normal Adult Brain Waves



Anesthesiology 2015; 123:937–60

Clinical Electroencephalography for Anesthesiologists

Part I: Background and Basic Signatures

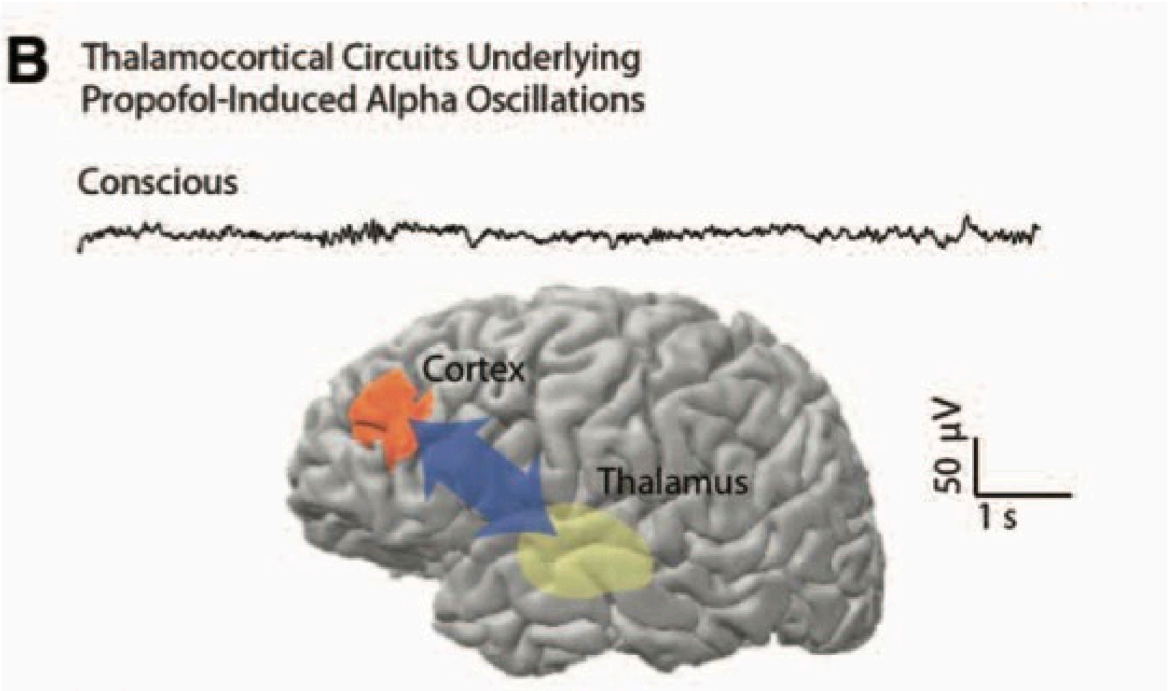
Patrick L. Purdon, Ph.D., Aaron Sampson, B.S., Kara J. Pavone, B.S., Emery N. Brown, M.D., Ph.D.

GABA agonist drugs

During consciousness, there is broadband communication between the thalamus and the frontal cortex with beta and gamma activity in the electroencephalogram.

Modeling studies suggest that during propofol-induced unconsciousness the spatially coherent alpha oscillations are highly structured rhythms in thalamocortical circuits

We postulate that the highly organized coherent alpha oscillations most likely prevent normal communications between the thalamus and cortex, whereas the incoherent slow oscillations represent an impediment to normal intracortical communication



Anesthesiology 2015; 123:937–60

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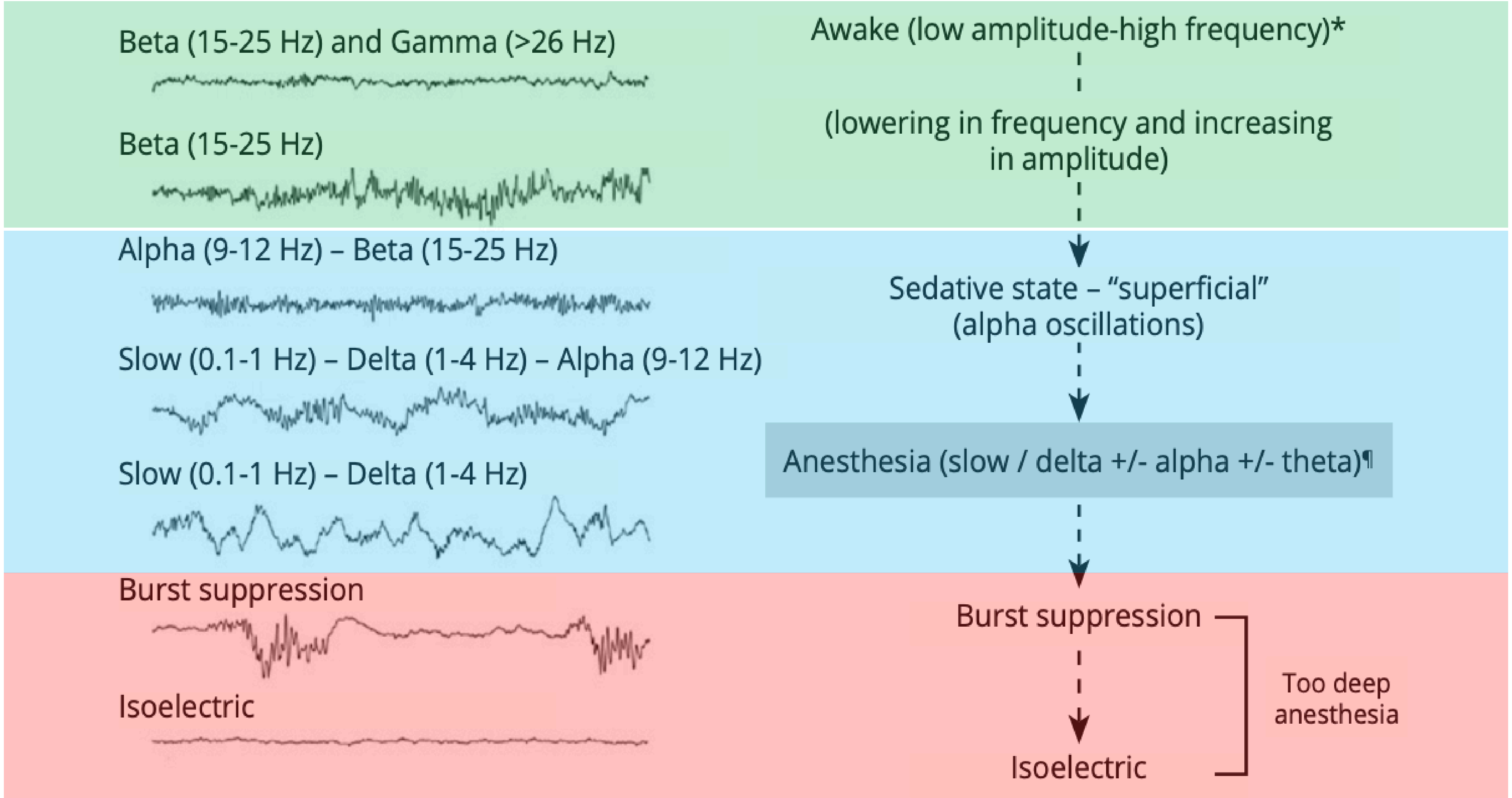


AVOIDING OVERSEDATION: CHILDREN UNDERGOING GA

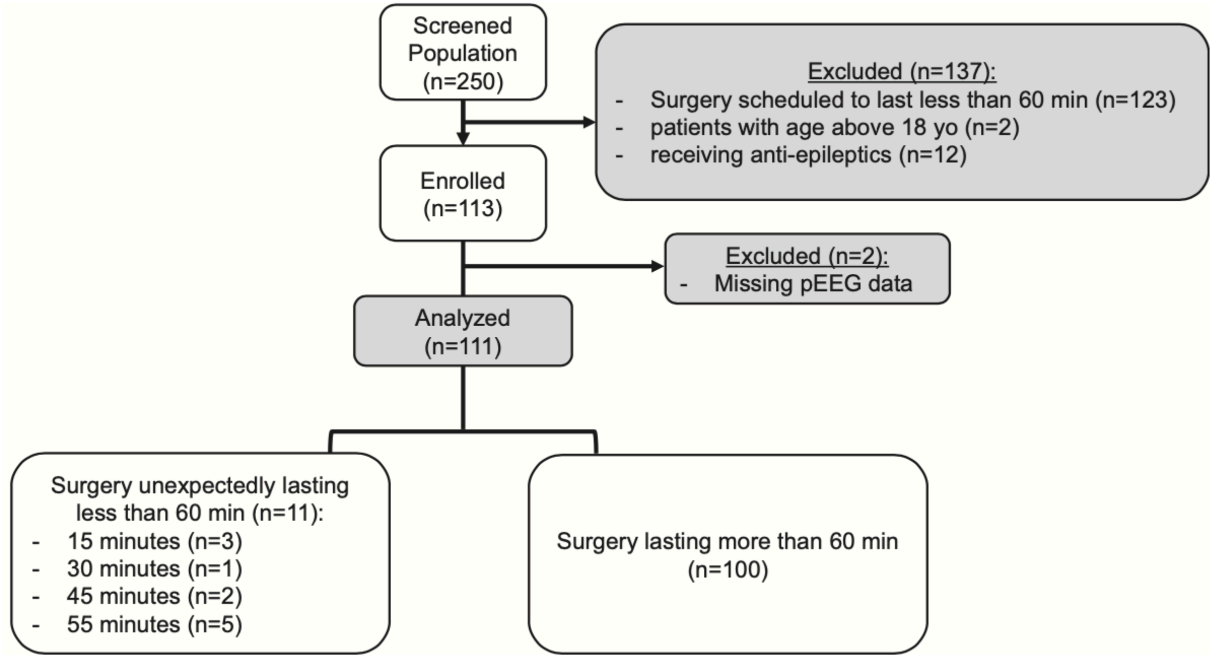
Received: 25 March 2023 | Revised: 5 June 2023 | Accepted: 6 June 2023
DOI: 10.1111/pan.14711

RESEARCH REPORT

Pediatric Anesthesia WILEY

Monitoring anesthesia depth with patient state index during pediatric surgery

Zaccaria Ricci[1,2] | Chiara Robino[2] | Paolo Rufini[2] | Silvia Cumbo[2] | Sara Cavallini[2] | Lorenzo Gobbi[1] | Agata Brocchi[1] | Paola Serio[2] | Stefano Romagnoli[1,3]



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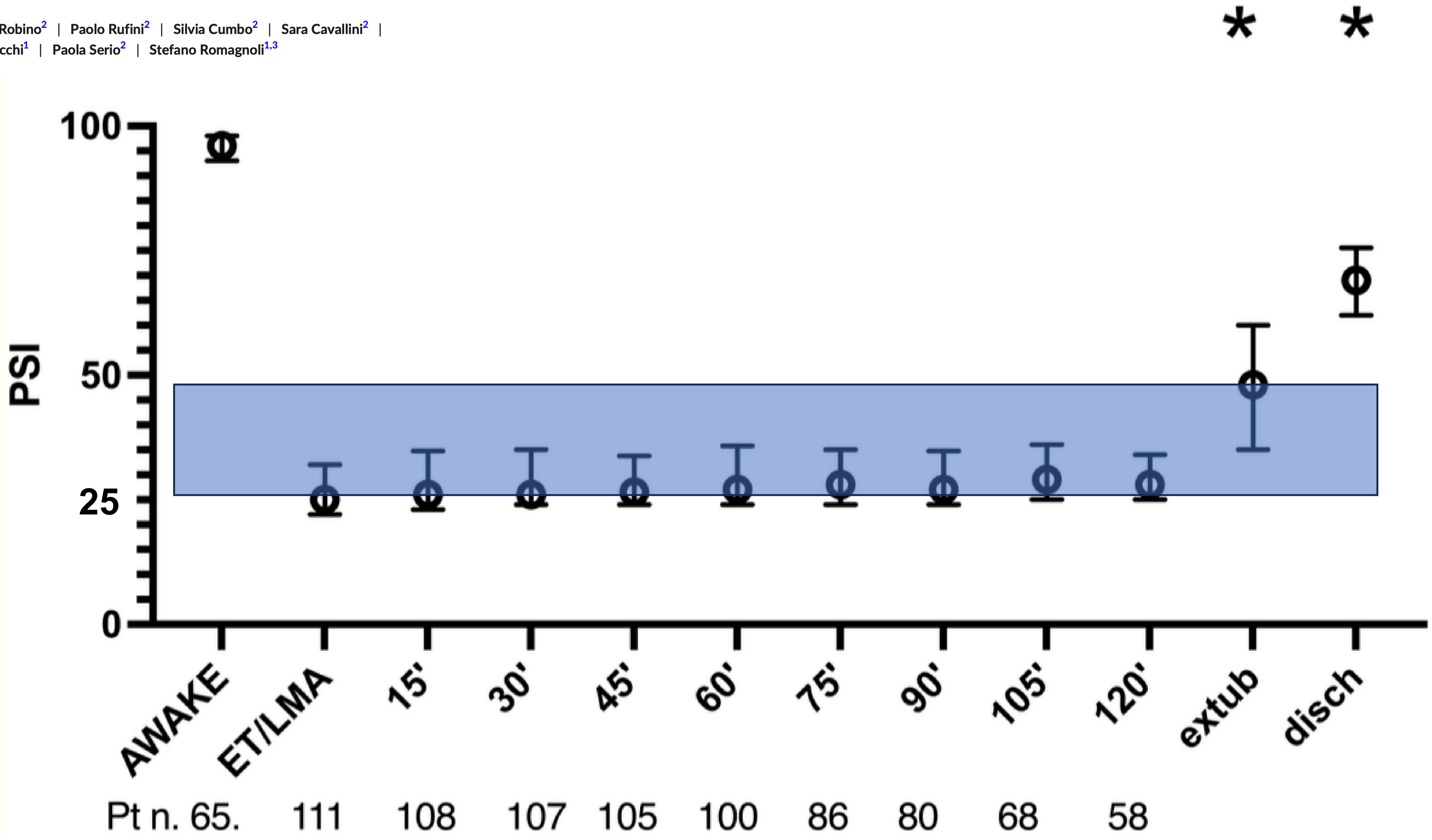

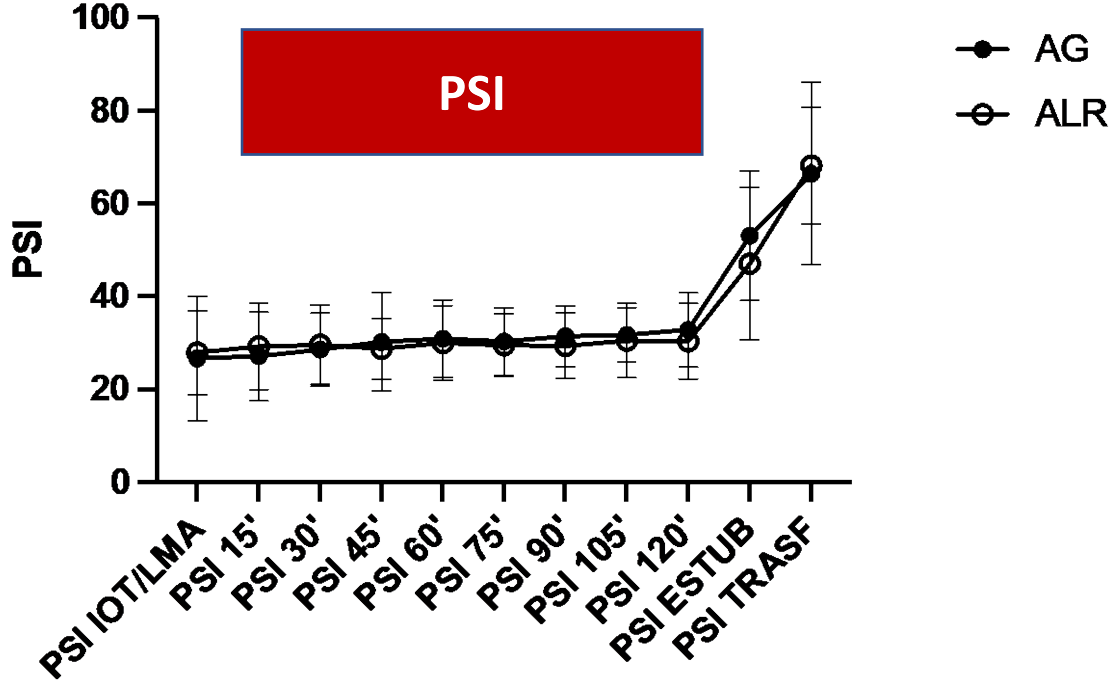

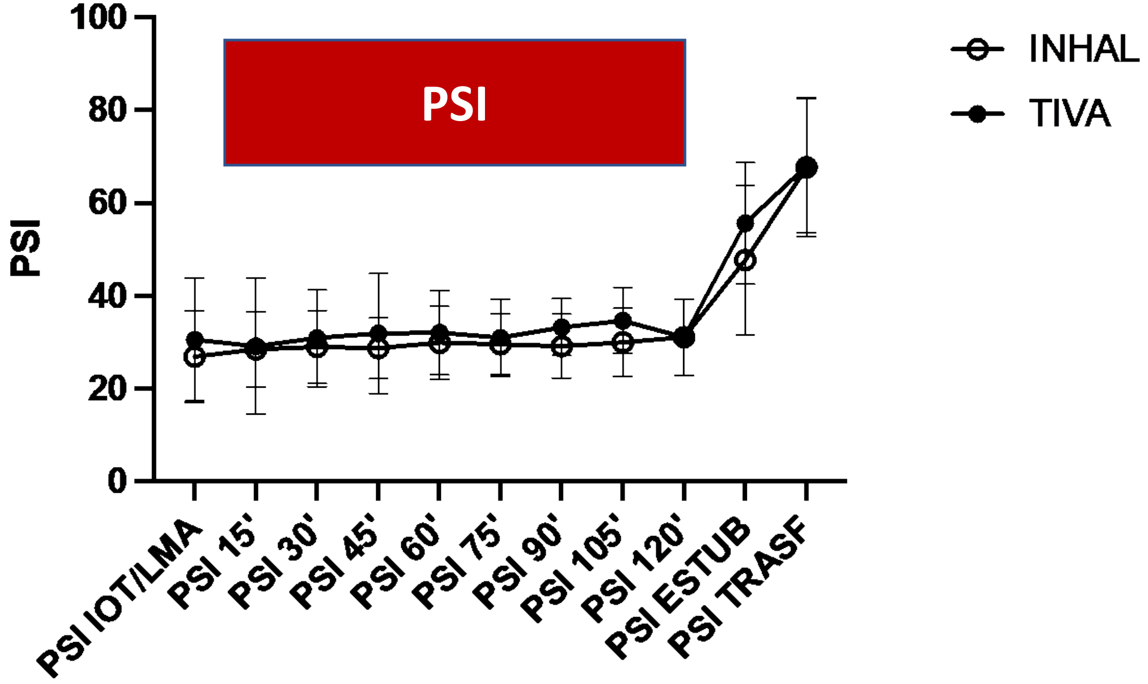

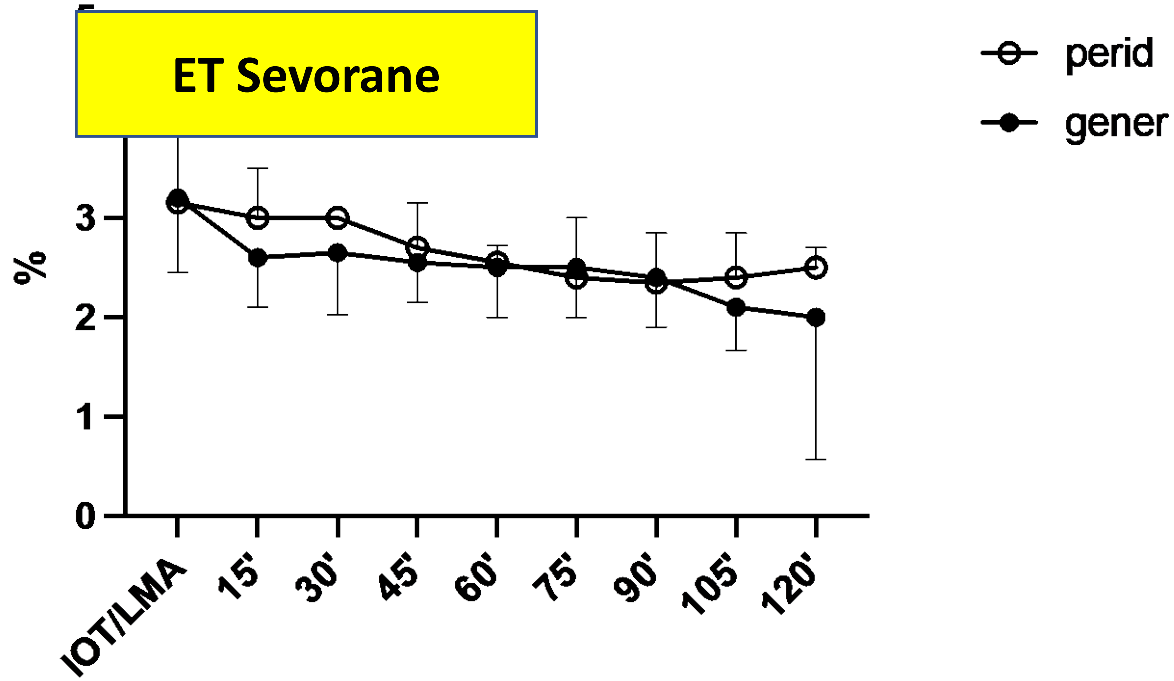

VLS?
OPEN?
ROBOT?

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Pediatric Anesthesia WILEY

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SPECIAL CIRCUMSTANCES: AVOIDING HEMODYNAMIC INSTABILITY

Pediatric Anesthesiology

Anesthesia and Analgesia 2019

ORIGINAL CLINICAL RESEARCH REPORT

Prevalence of Isoelectric Electroencephalography Events in Infants and Young Children Undergoing General Anesthesia

Ian Yuan, MD,* William P. Landis, BS,* Alexis A. Topjian, MD,* Nicholas S. Abend, MD,†
Shih-Shan Lang, MD,‡ Jimmy W. Huh, MD,* Matthew P. Kirschen, MD, PhD,*†
Janell L. Mensinger, PhD,§ Bingqing Zhang, MPH,* and Charles D. Kurth, MD*

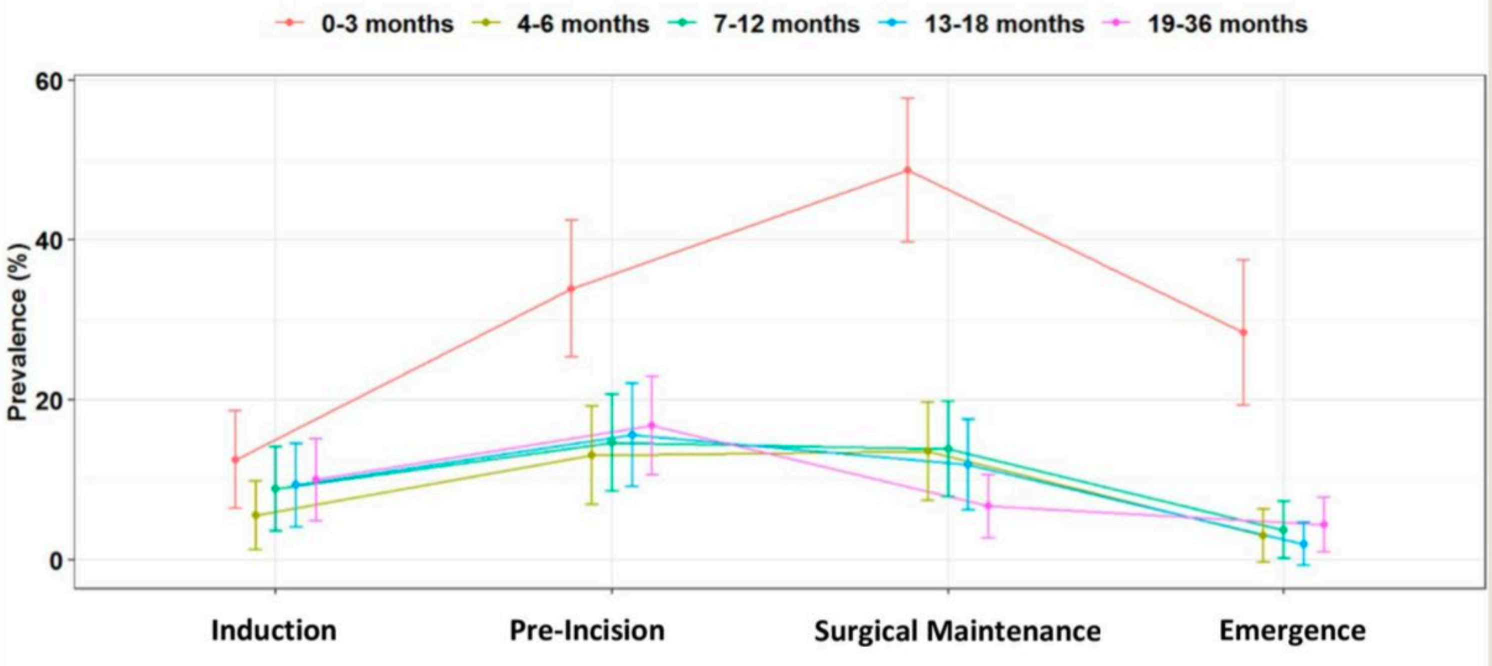


Fig. 3. Prevalence of isoelectric electroencephalography stratified by age groups. Median (*dot*) and 95% CI (*vertical lines*) displayed.

ANESTHESIOLOGY

Isoelectric Electroencephalography in Infants and Toddlers during Anesthesia for Surgery: An International Observational Study

Ian Yuan, M.D., Ting Xu, M.D., Justin Skowno, M.B.Ch.B., Ph.D., Bingqing Zhang, M.P.H., Andrew Davidson, M.B.B.S., M.D., Ph.D., Britta S. von Ungern-Sternberg, M.D., Ph.D., David Sommerfield, M.D., Jianmin Zhang, M.D., Xingrong Song, M.D., Ph.D., Mazhong Zhang, M.D., Ph.D., Ping Zhao, M.D., Ph.D., Huacheng Liu, M.D., Ph.D., Yifei Jiang, M.D., Ph.D., Yunxia Zuo, M.D., Ph.D., Jurgen C. de Graaff, M.D., Ph.D., Laszlo Vutskits, M.D., Ph.D., Vanessa A. Olbrecht, M.D., M.B.A., Peter Szmuk, M.D., Charles D. Kurth, M.D., for the BRAIN Collaborative Investigators*

ANESTHESIOLOGY 2022; 137:187–200

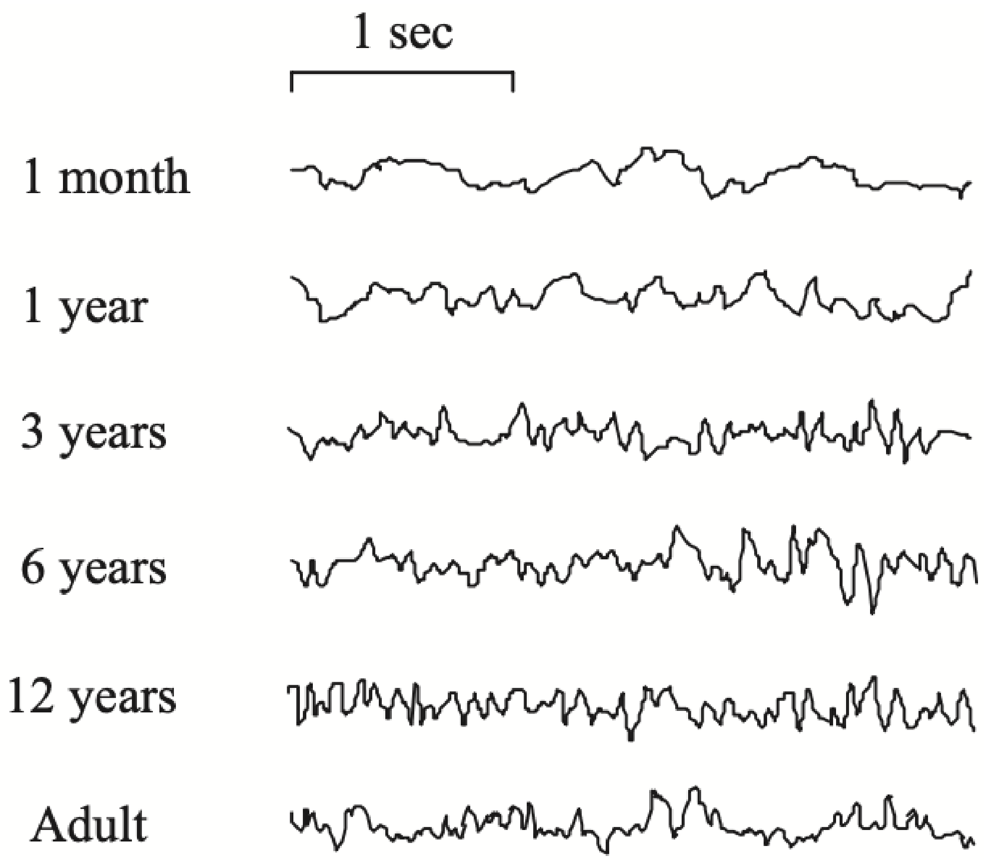
Pediatric Anesthesia 2013
Pediatric Anesthesia ISSN 1155-5645

REVIEW ARTICLE

The EEG signal: a window on the cortical brain activity

Isabelle Constant & Nada Sabourdin

Department of Anesthesiology, Armand Trousseau Hospital, AP-HP, UPMC, Paris, France



Developmental stages in detail:

- ✓ From birth to 2 months: Sleep spindles appear.
- ✓ From 3 to 5 months: Parieto-occipital sinusoidal activity appears, announcing alpha rhythm, with increasing frequency: from 4–6 Hz initially to 8– 9 Hz by the age of 3.
- ✓ In the normal child aged 3 years and older: The alpha parieto-occipital rhythm, initially discreet and slow (8 Hz), with high voltage and asymmetry. Theta rhythm is abundant, diffuse, and mixed with alpha in the posterior leads and predominates. Slow waves appear, grouped in bursts, and become rhythmic at 2–3 Hz.
- ✓ From 3 to 10 years: Alpha rhythm becomes more important and abundant

BJA

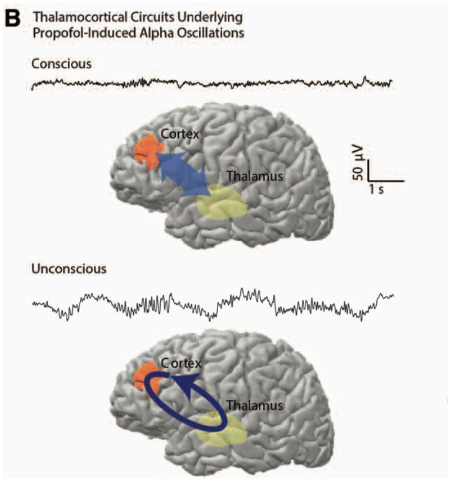
British Journal of Anaesthesia, 120 (6): 1274–1286 (2018)

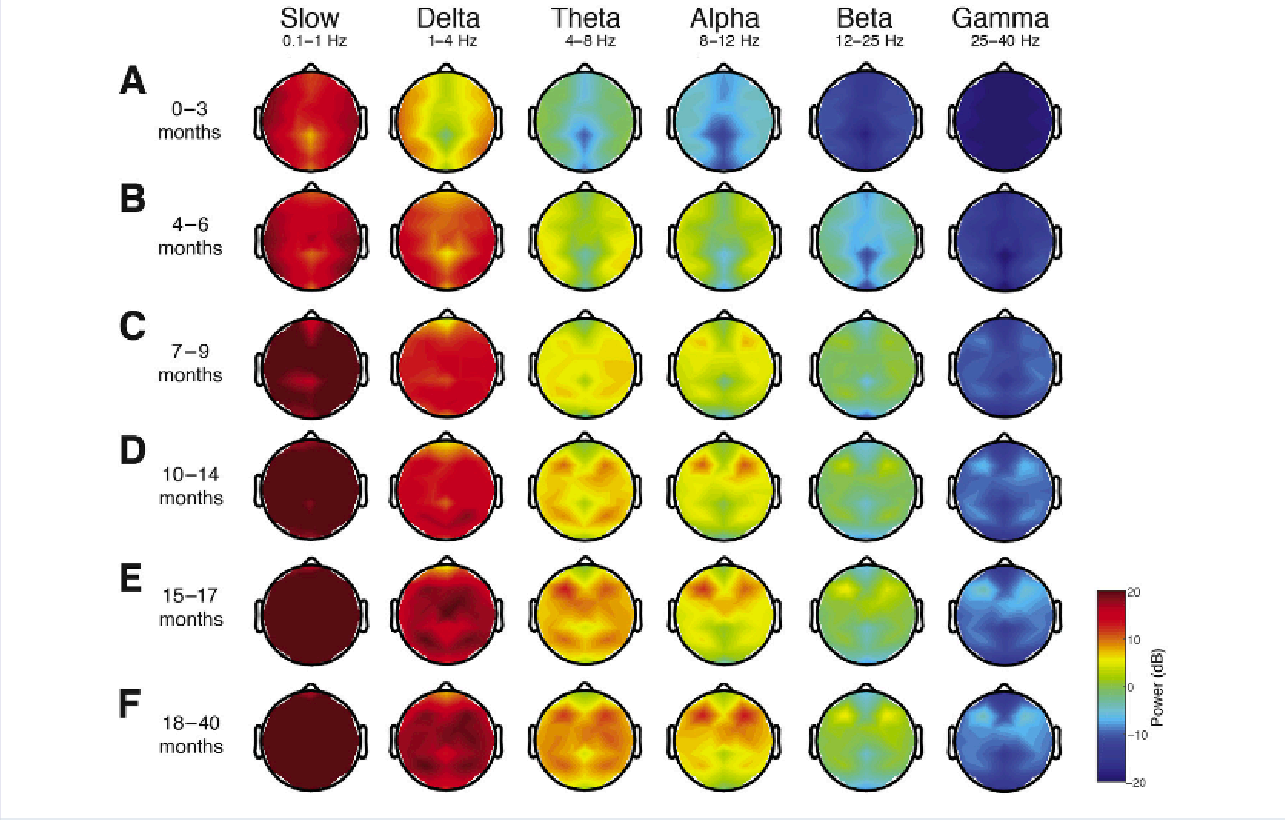
doi: 10.1016/j.bja.2018.01.037
Advance Access Publication Date: 5 April 2018
Neuroscience and Neuroanaesthesia

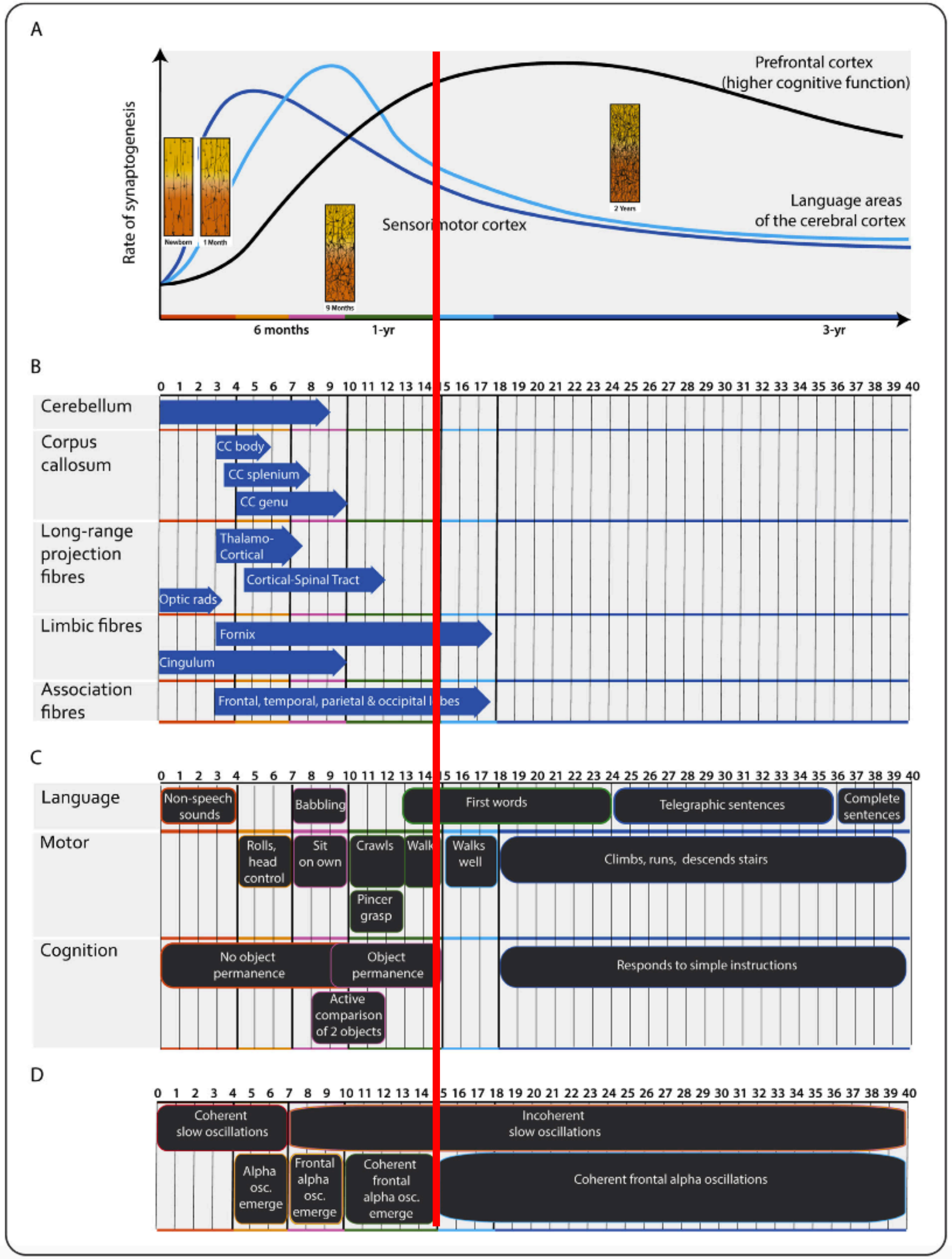
Electroencephalographic markers of brain development during sevoflurane anaesthesia in children up to 3 years old

L. Cornelissen[1,2,*], S. E. Kim[3,5], J. M. Lee[1,3], E. N. Brown[2,3,4], P. L. Purdon[2,4] and C. B. Berde[1,2]

[1]Department of Anesthesiology, Critical Care and Pain Medicine, Boston Children's Hospital, Boston, MA, USA, [2]Department of Anaesthesia, Harvard Medical School, Boston, MA, USA, [3]Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology, Cambridge, MA, USA and [4]Department of Anesthesia, Critical Care and Pain Medicine, Massachusetts General Hospital, Harvard Medical School, Boston, MA, USA



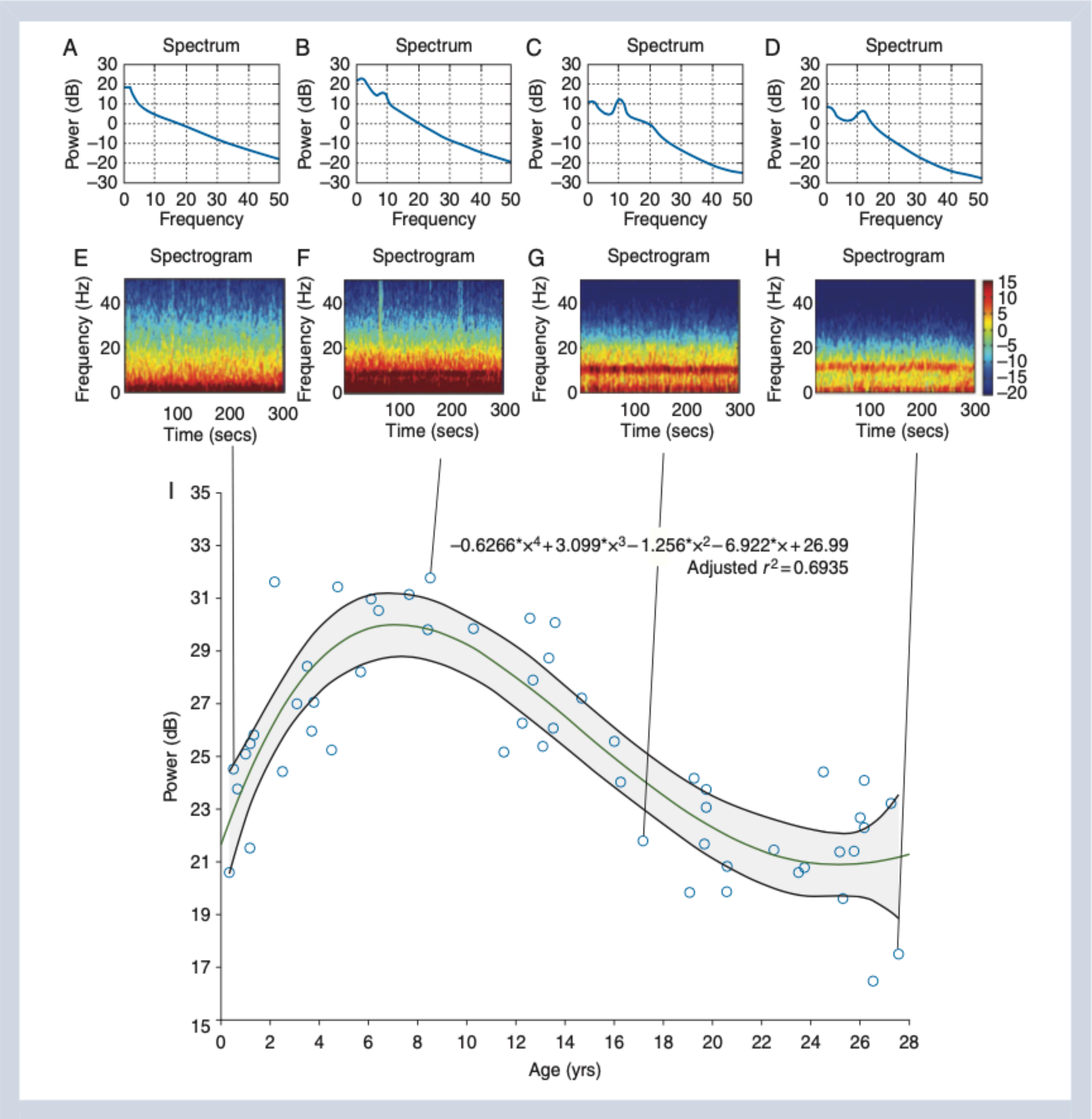




ARTICLE BJA 2015

Age-dependency of sevoflurane-induced electroencephalogram dynamics in children

O. Akeju[1,3,*], K. J. Pavone[1,†], J. A. Thum[3,5,†], P. G. Firth[1,2], M. B. Westover[2,3], M. Puglia[1,3], E. S. Shank[1,3], E. N. Brown[1,3,4,5,6], and P. L. Purdon[1,3,4,*]



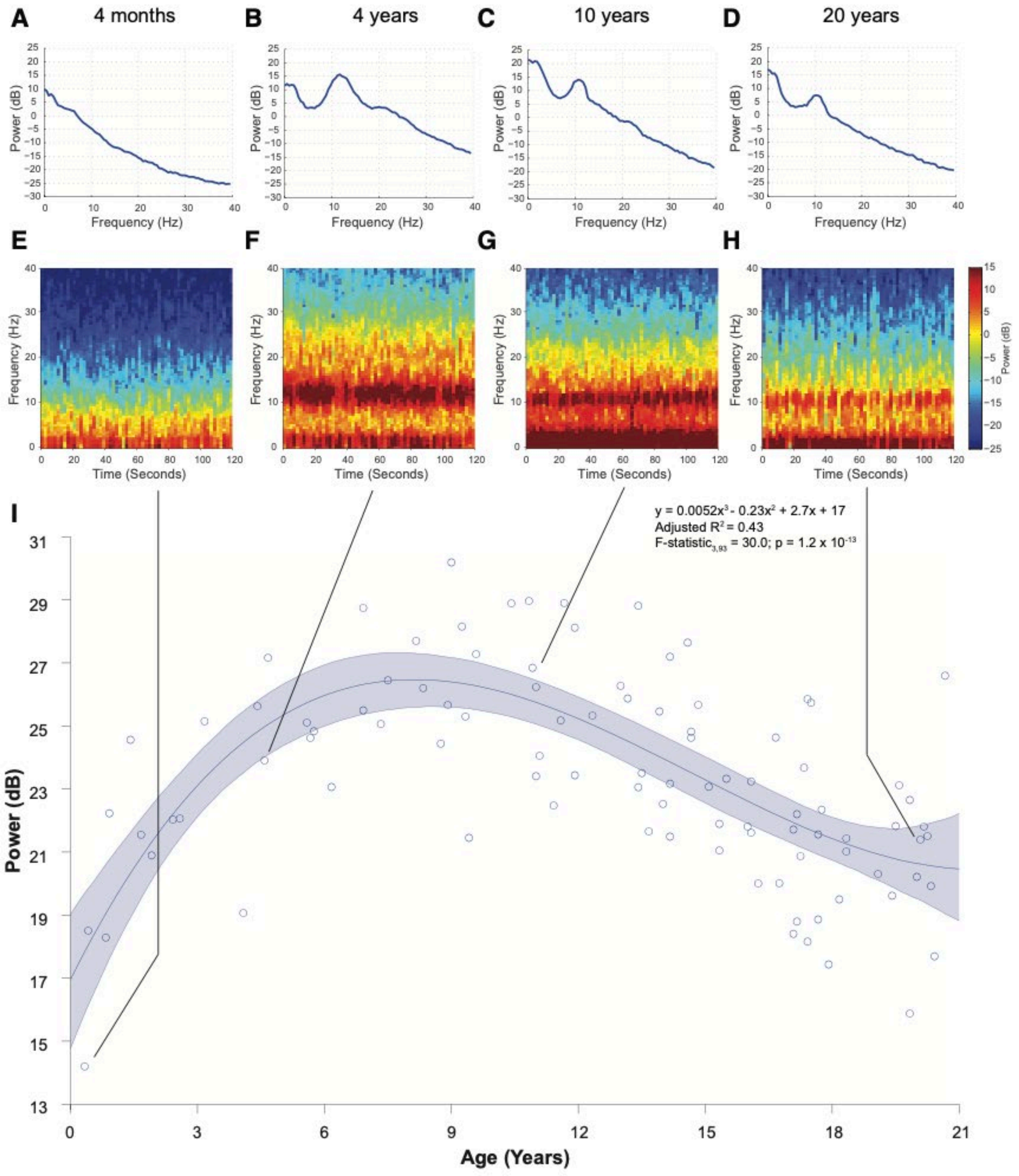
- EEG recorded during routine care of patients between 0 and 28 yr of age (n=54),using power spectrum and coherence methods.
- The power spectrum quantifies the energy in the EEG at each frequency, while the coherence measures the frequency-dependent correlation or synchronization between EEG signals at different scalp locations.
- 5 age groups: <1 yr old (n=4), 1–6 yr old (n=12), >6–14 yr old (n=14), >14–21 yr old (n=11), >21–28 yr old (n=13).
- **EEG power significantly increased from infancy through ∼6 yr, subsequently declining to a plateau at approximately 21 yr. Alpha (8–13 Hz) coherence, a prominent EEG feature associated with sevoflurane-induced unconsciousness in adults, is absent in patients <1 yr.**

A Prospective Study of Age-dependent Changes in Propofol-induced Electroencephalogram Oscillations in Children

Johanna M. Lee, A.B., Oluwaseun Akeju, M.D., M.M.Sc., Kristina Terzakis, Kara J. Pavone, B.S., Hao Deng, M.B.B.S., M.P.H., Timothy T. Houle, Ph.D., Paul G. Firth, M.B., Ch.B., Erik S. Shank, M.D., Emery N. Brown, M.D., Ph.D., Patrick L. Purdon, Ph.D.

Anesthesiology 2017

- Total electroencephalogram power (0.1 to 40 Hz) peaked at approximately 8 yr old and subsequently declined with increasing age.
- For patients greater than 1 yr old, the propofol-induced electroencephalogram structure was qualitatively similar regardless of age, featuring slow and coherent alpha oscillations.
- For patients under 1 yr of age, frontal alpha oscillations were not coherent.



ARTICLE

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O. Akeju[1,3,*], K. J. Pavone[1,†], J. A. Thum[3,5,†], P. G. Firth[1,2], M. B. Westover[2,3], M. Puglia[1,3], E. S. Shank[1,3], E. N. Brown[1,3,4,5,6], and P. L. Purdon[1,3,4,*]

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- ✓ These higher-frequency bands is elevated in children greater than 1 yr of age at surgical concentrations of anaesthesia when compared with adults.
- ✓ This important difference could cause index-based depth of anaesthesia monitors to compute a falsely elevated index value in children. In such instances, these falsely elevated index values, could lead to increased anaesthetic drug dosing beyond what is required.

Received: 25 March 2023 | Revised: 5 June 2023 | Accepted: 6 June 2023

DOI: 10.1111/pan.14711

RESEARCH REPORT

Pediatric Anesthesia WILEY

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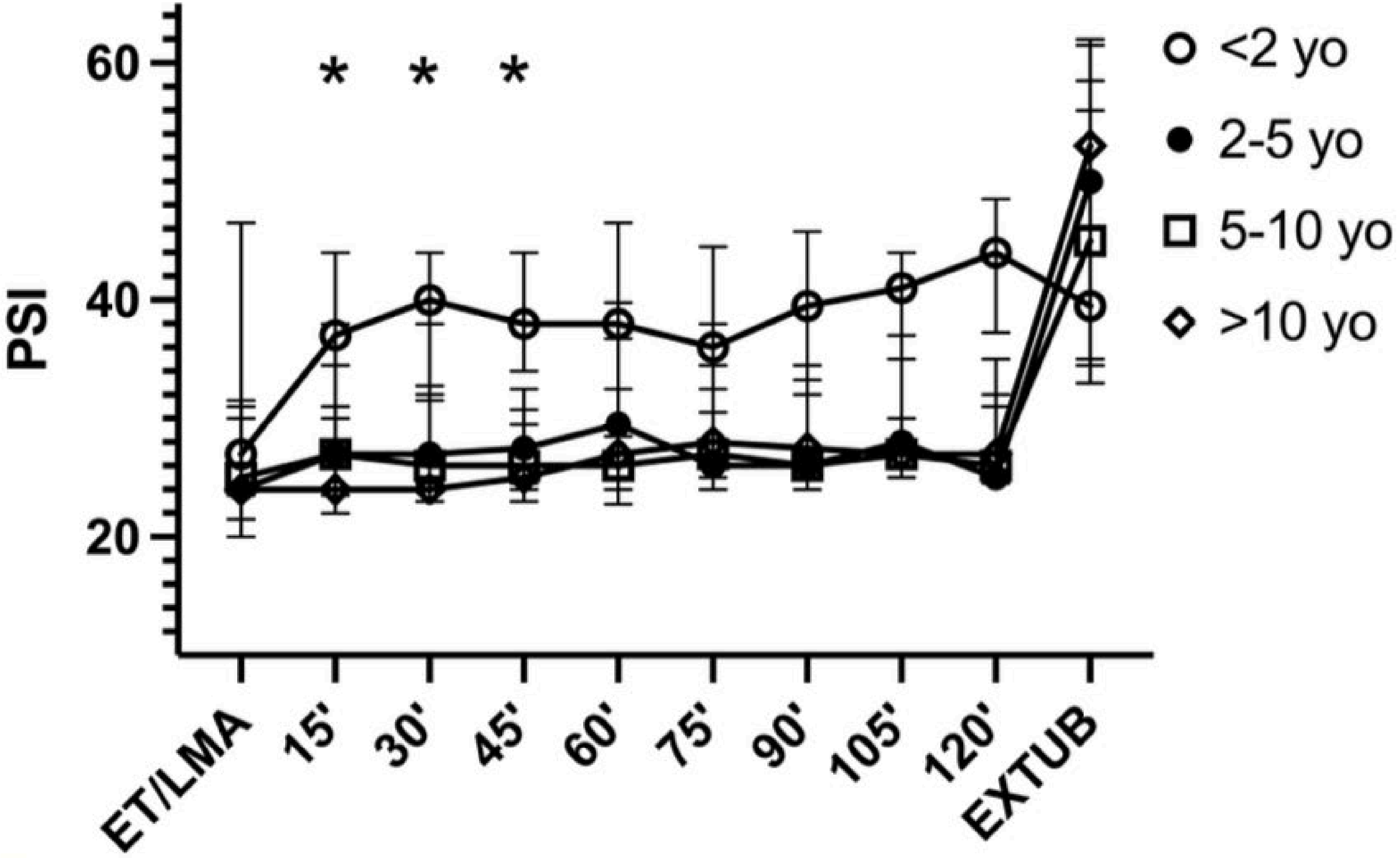


BJA

BRITISH JOURNAL OF ANAESTHESIA

British Journal of Anaesthesia, xxx (xxx): xxx (xxxx)

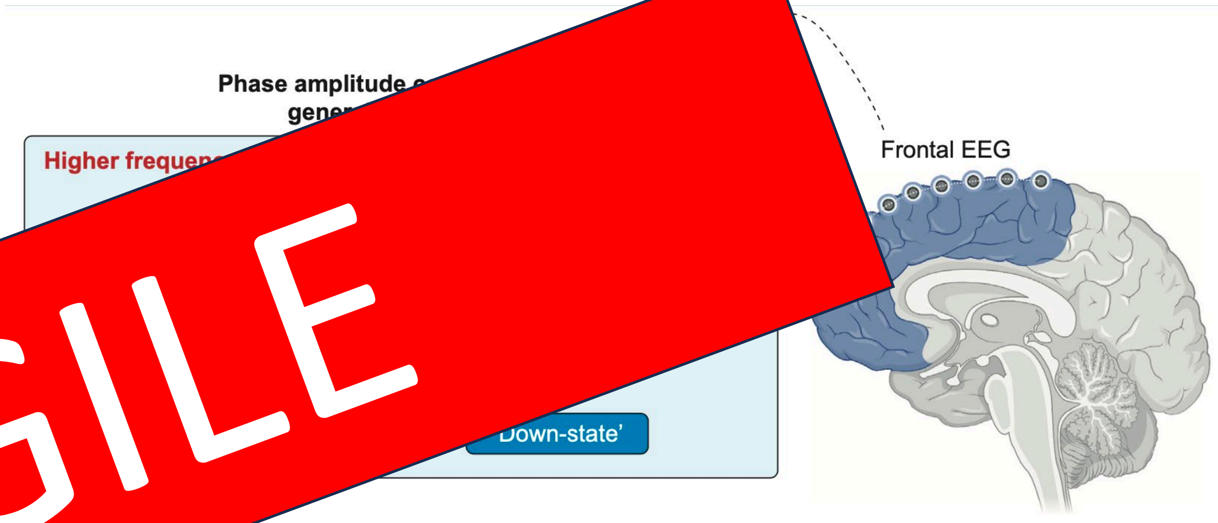
doi: 10.1016/j.bja.2023.01.025
Advance Access Publication Date: xxx
Clinical Investigation

CLINICAL INVESTIGATION

Electroencephalographic delta and alpha oscillations re… amplitude coupling in paediatric patients under… based general anaesthesia

Luai Zakaria[1,2,3,4], Adela Desowska[2,3], Charles…

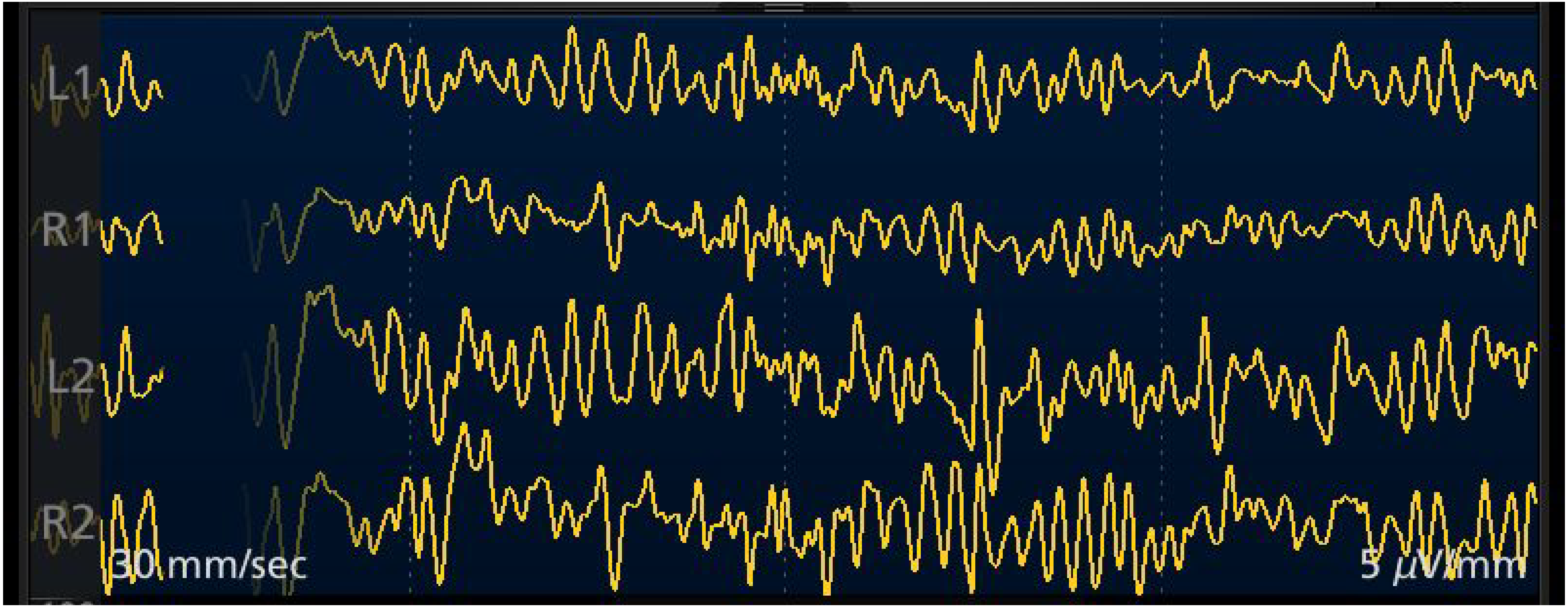
[1]Department of Anesthesiology, Perioperative…
Medical School, Boston, MA, USA and [3]…
Hospital, Boston, MA, USA



FRAGILE

The … amplitude coupling cannot exist in children under the age … clinical state of unconsciousness is still observed in these patie… ether with our findings, this emphasises the complex nature of how anaesthetics produce a state of unconsciousness.

Although a single unifying mechanism is unlikely, the underlying mechanisms could involve decreased integration of neuronal signals, decreased functional connectivity, a generalised neuronal disruption of rhythmic oscillations, or all three



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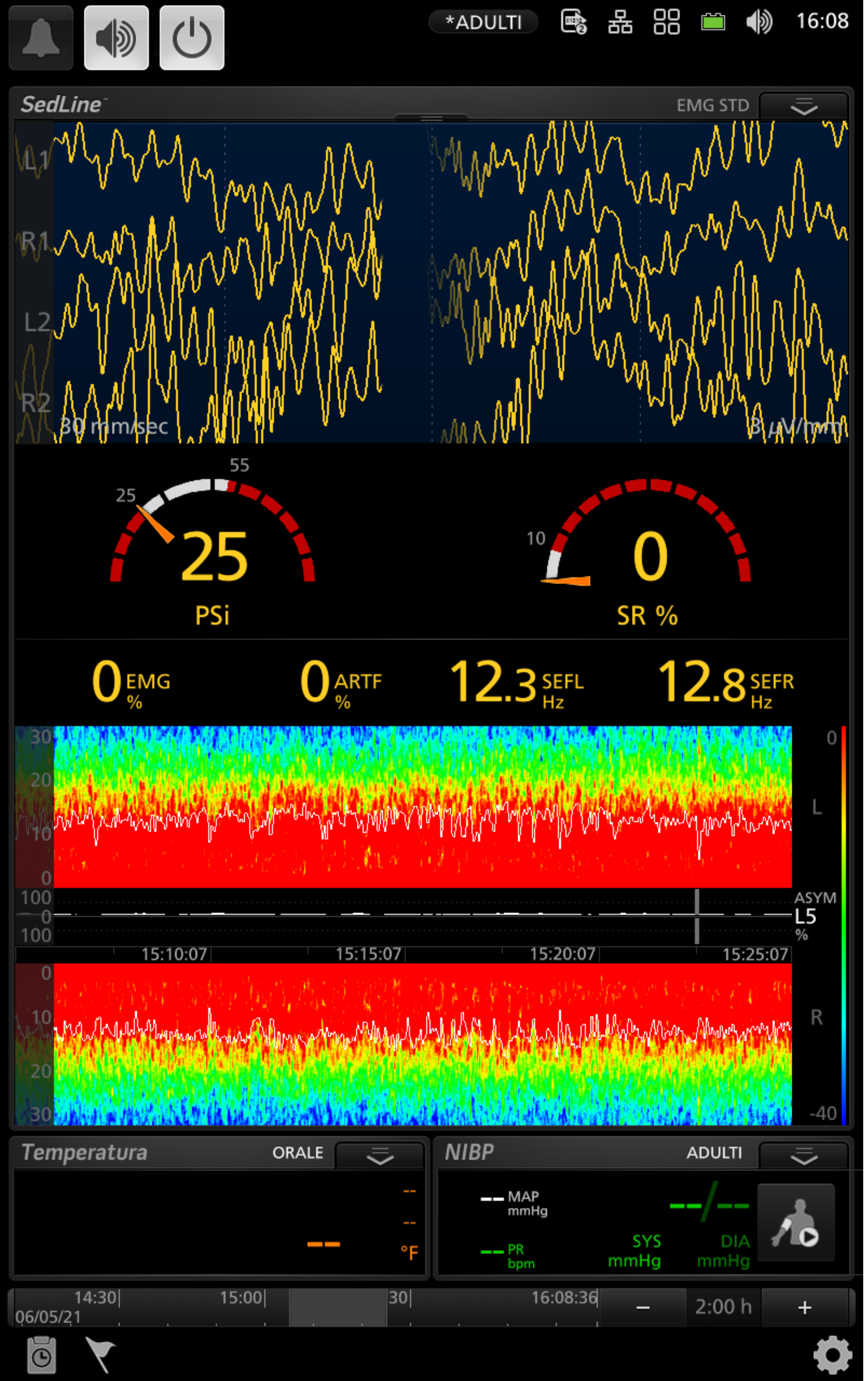
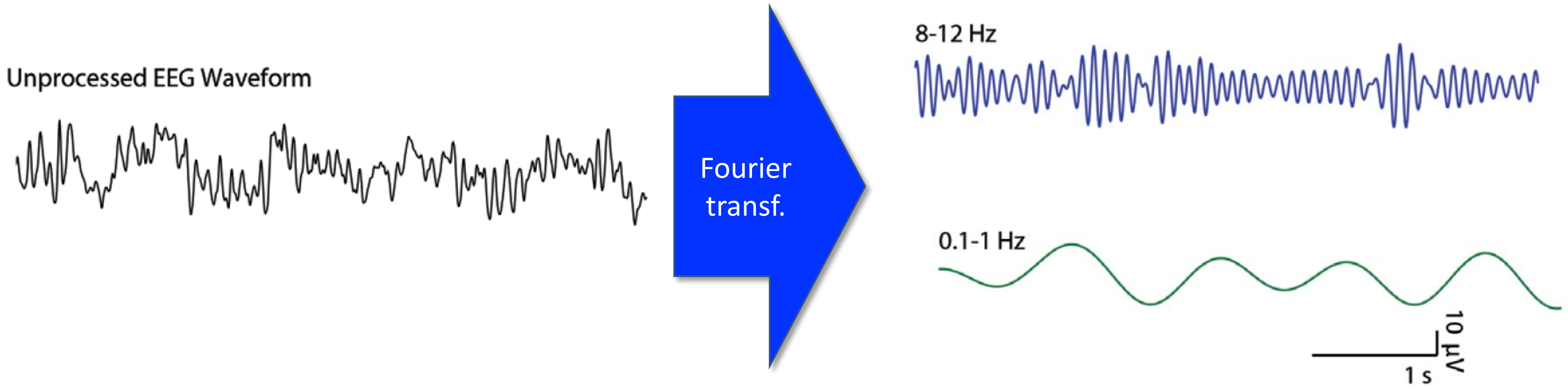


These anesthesia-induced oscillations are readily visible in the electroencephalogram

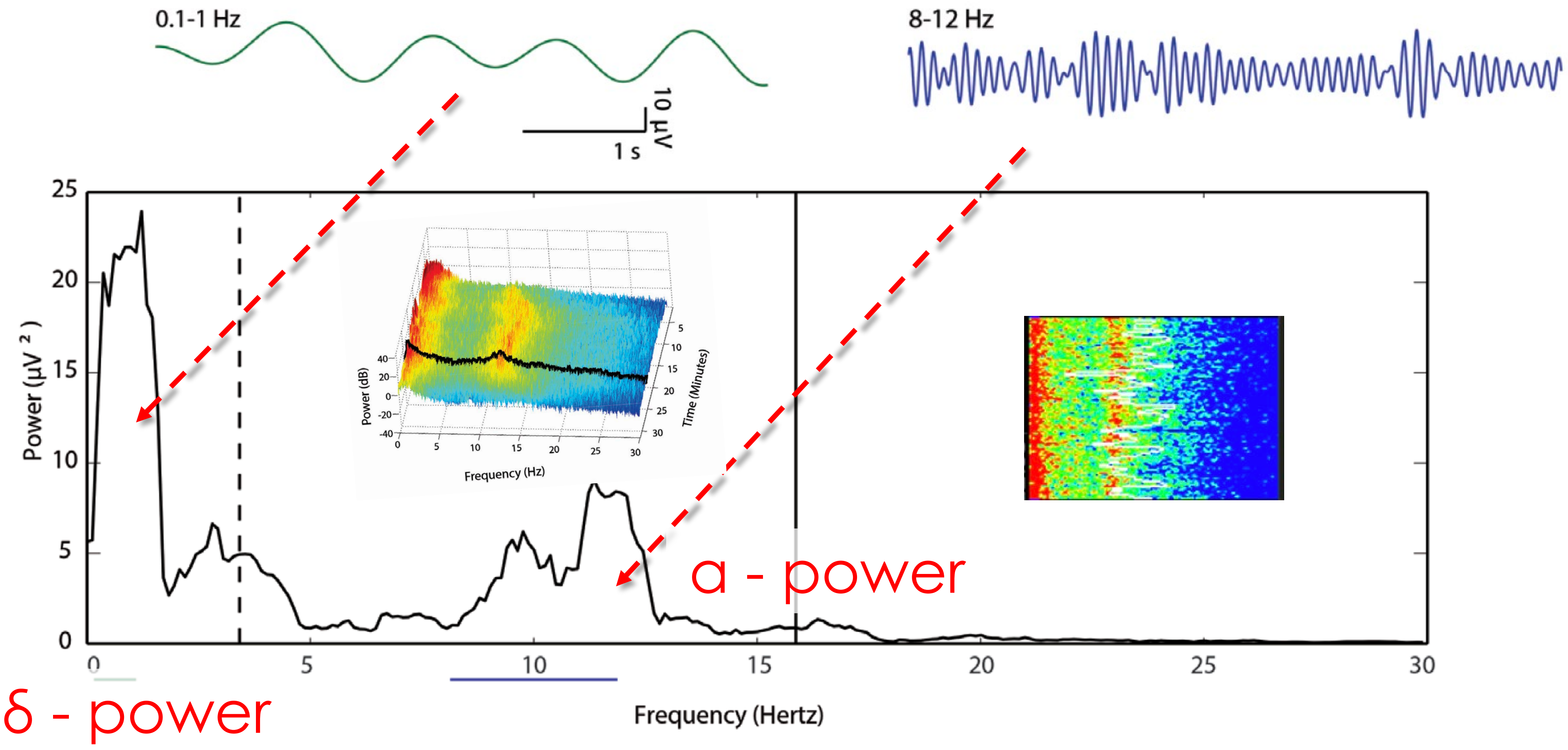
What about spectrogram?

Purdon PL et al. Anesthesiology 2015; 123:937-60



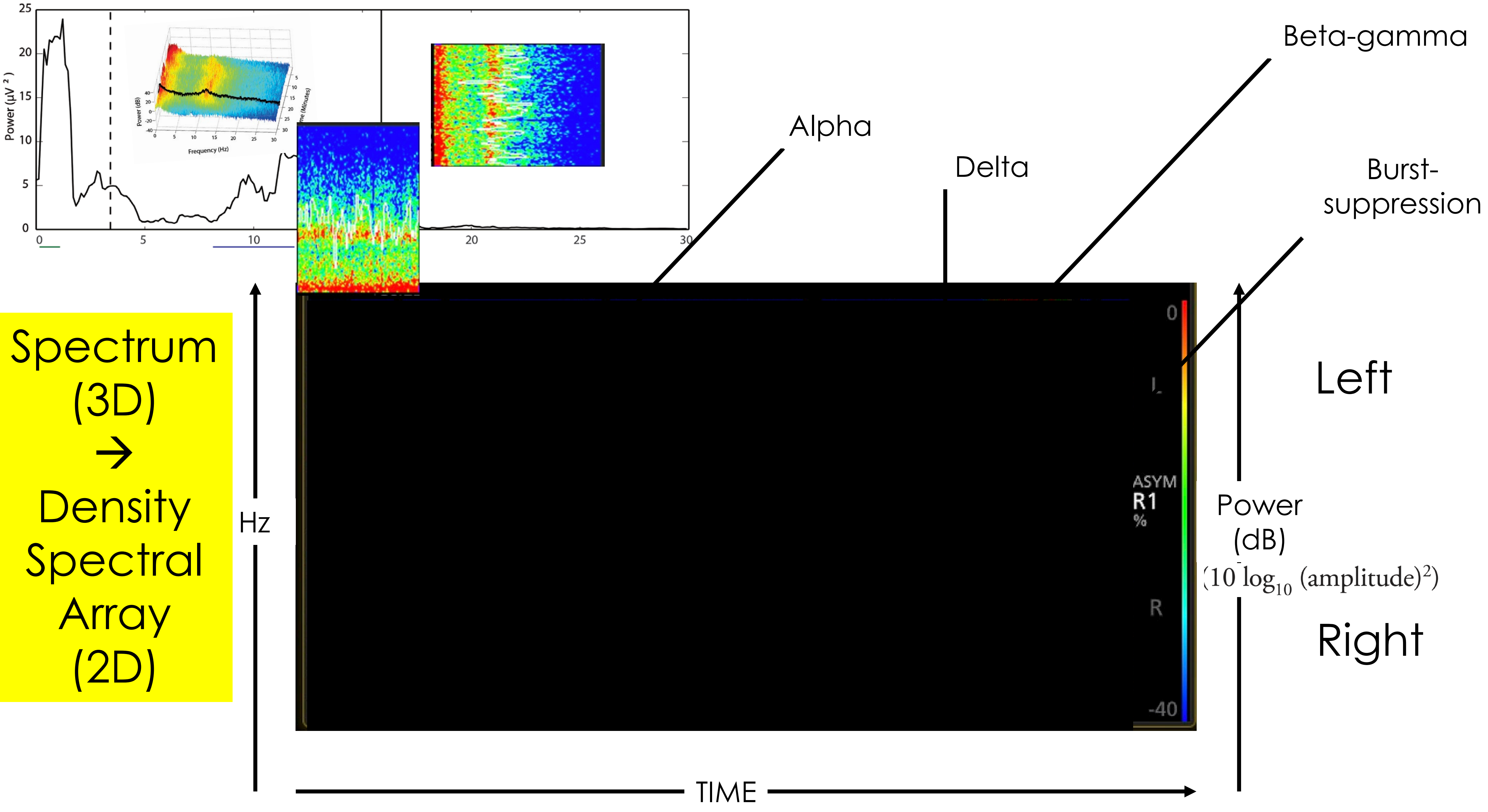
Purdon PL et al. Anesthesiology 2015; 123:937-60

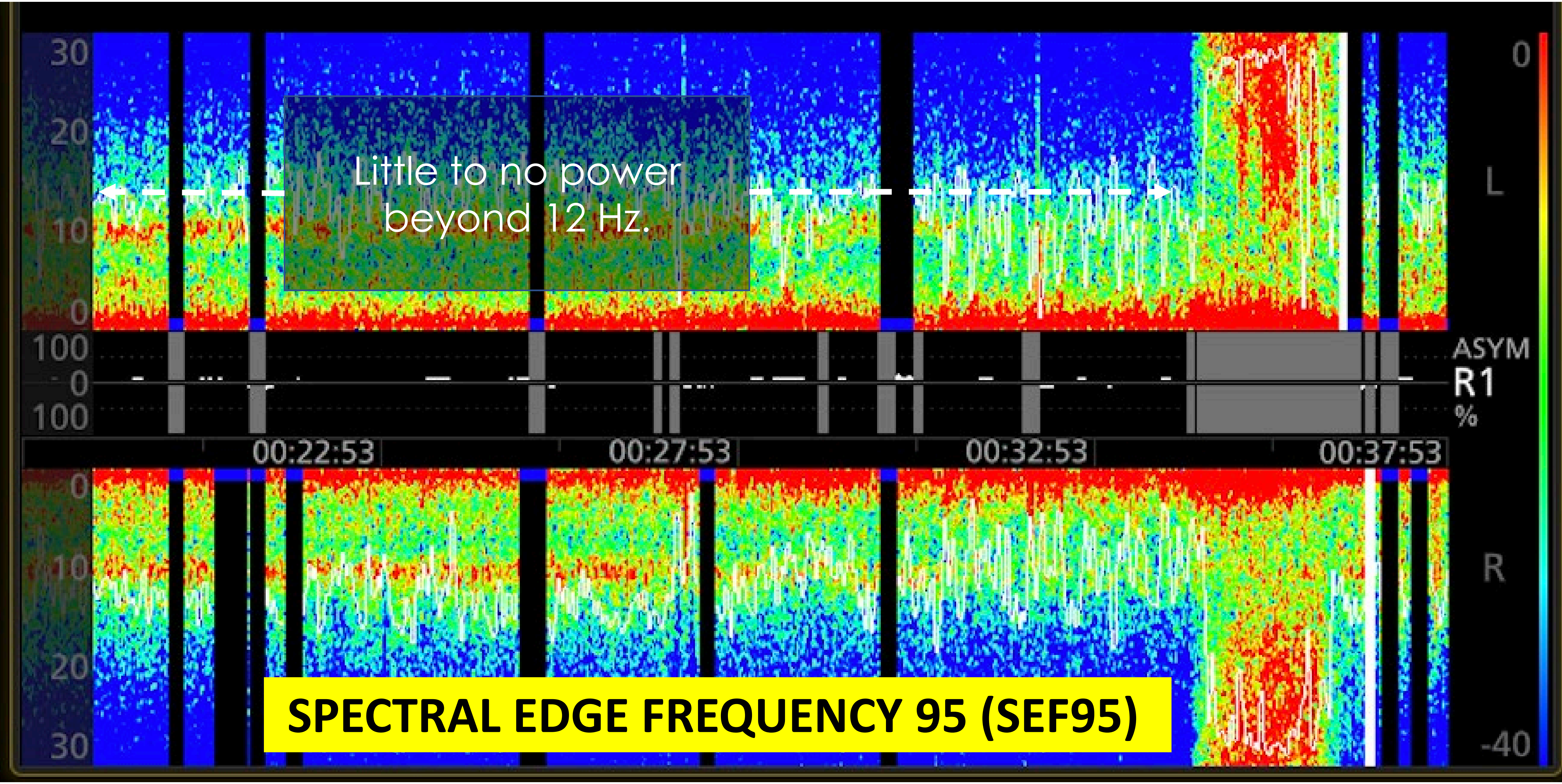
Spectral analysis → spectrum



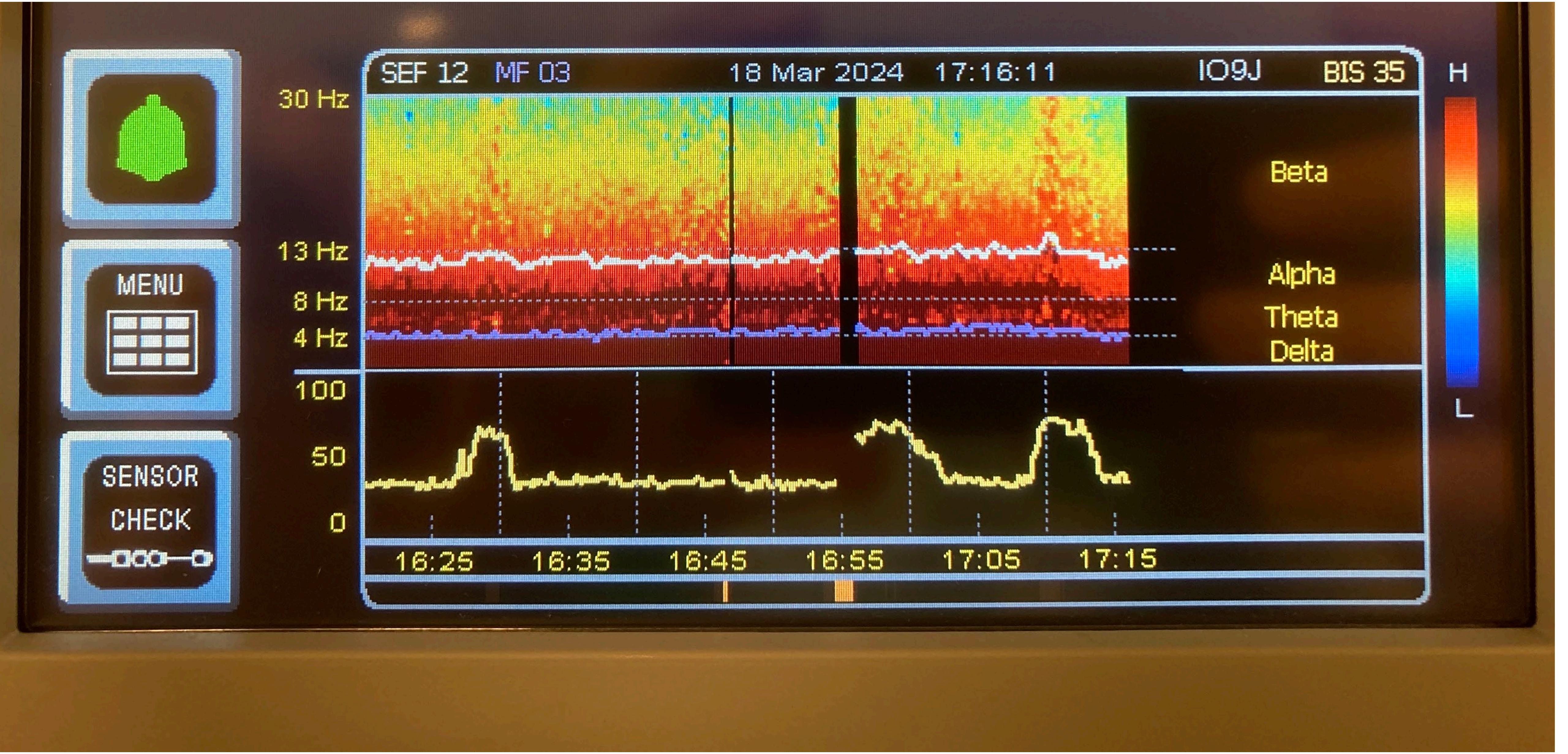
Purdon PL et al. Anesthesiology 2015; 123:937-60

Spectrum (3D) → Density Spectral Array (2D)





SPECTRAL EDGE FREQUENCY 95 (SEF95)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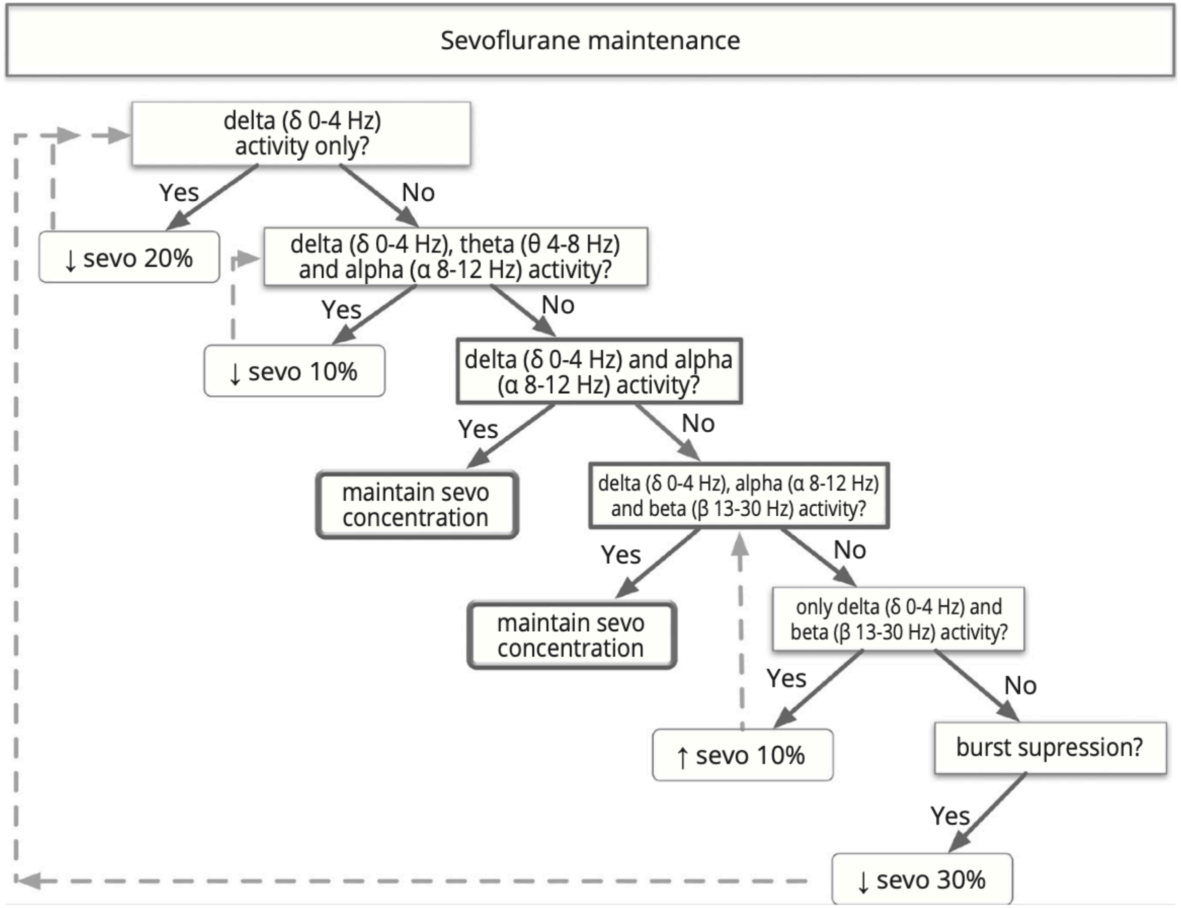
Online version at https://www.minervamedica.it

Minerva Anestesiologica 2023 Feb 17
DOI: 10.23736/S0375-9393.23.16999-9

Electroencephalographic Density Spectral Array monitoring in pediatric anesthesia: clinical background and practical applications

Iris J. de HEER, Frank WEBER *



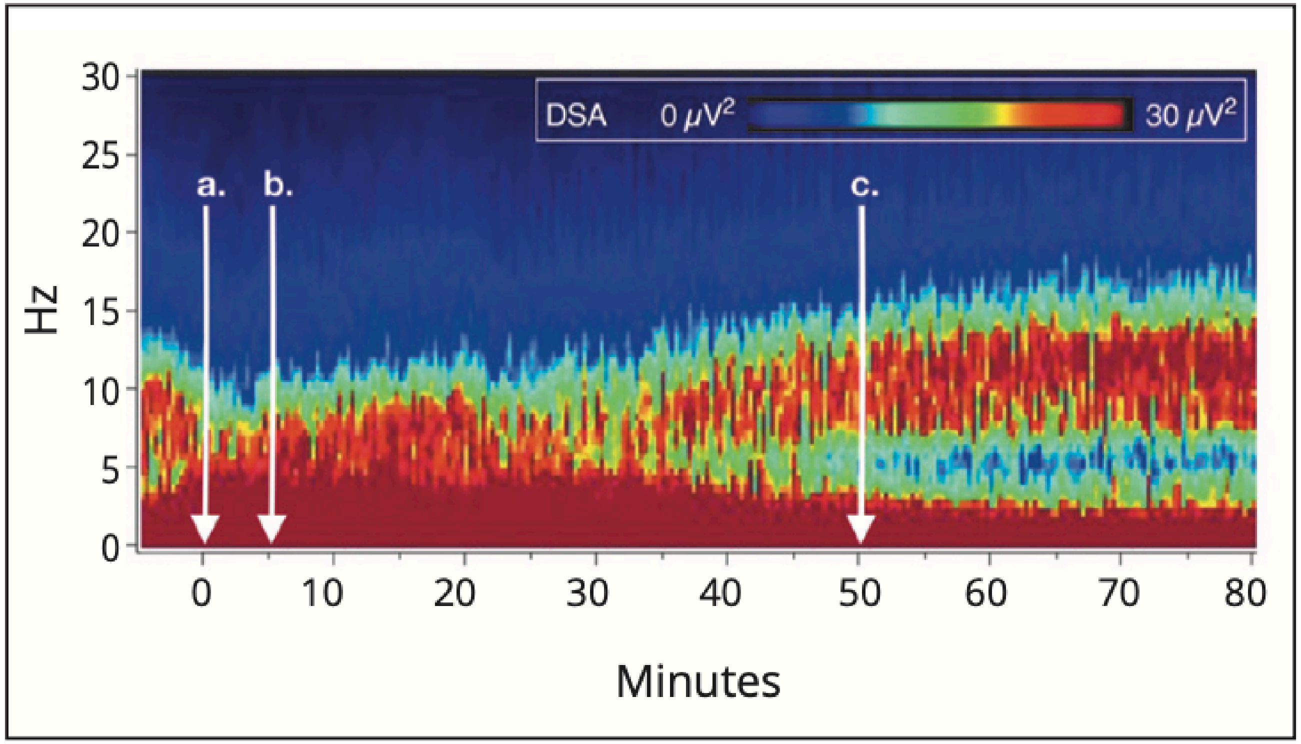


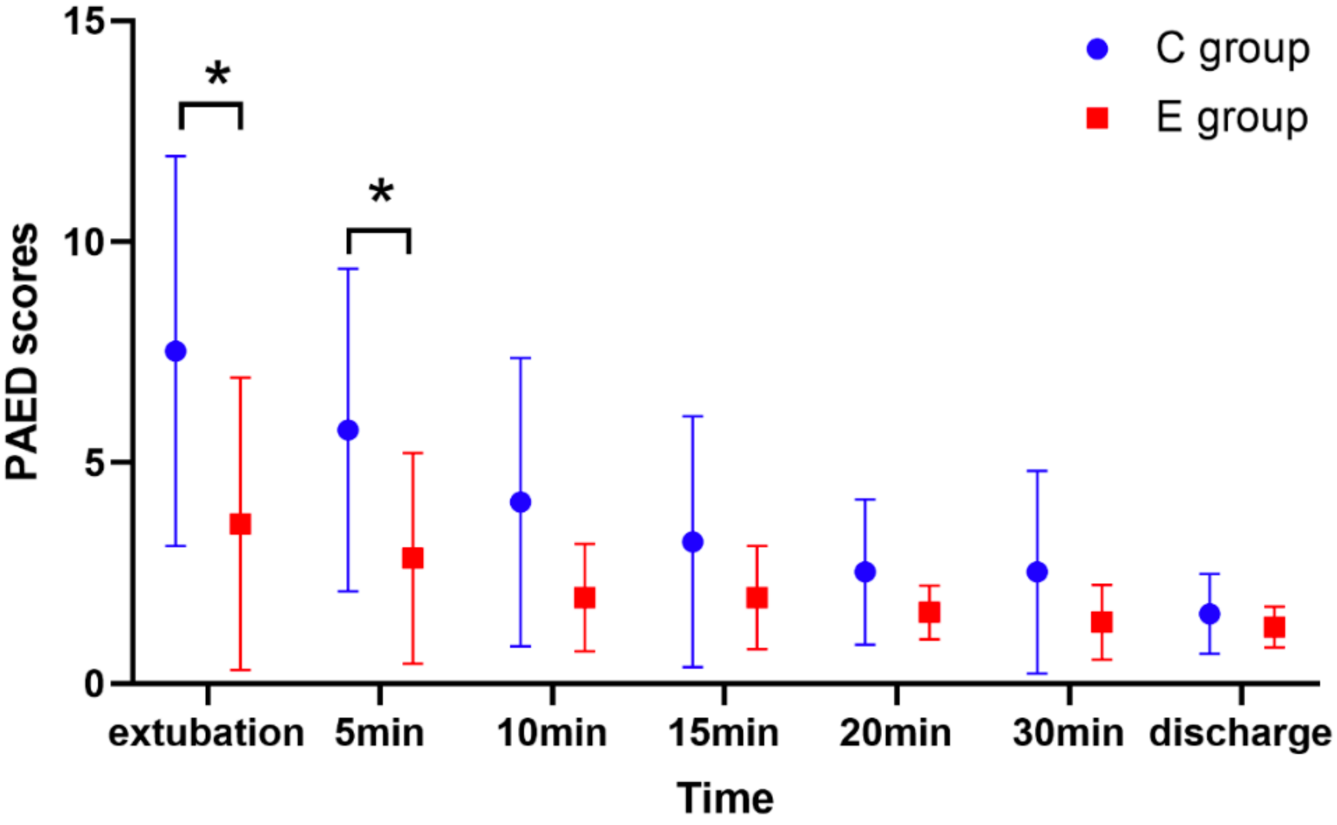
Figure 2.—Example of a DSA pattern during sevoflurane anesthesia in 9 months old infant.
a. IV induction with propofol followed by the onset of delta, theta and alpha oscillations; b. start sevoflurane maintenance, initial a Etsevo concentration of 3.0% was used followed by an increase in power of the theta oscillations and lower frequency alpha oscillations; c. EtSevo concentration of 2.0% was maintained followed by the presence of delta, alpha and beta oscillations.

brain sciences 2022

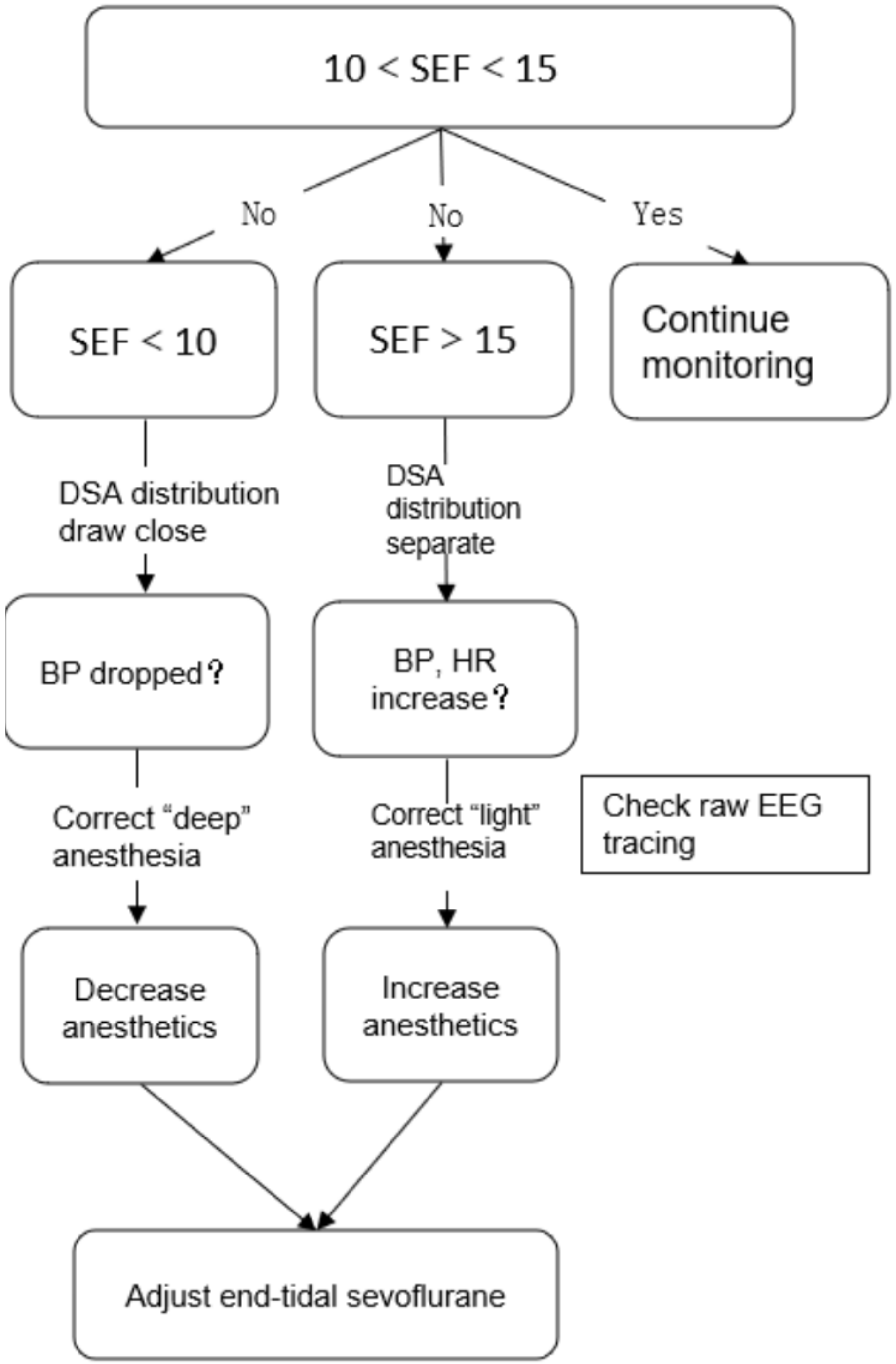
Article

EEG-Parameter-Guided Anesthesia for Prevention of Emergence Delirium in Children

Yaqian Han [1,2,†], Mengrong Miao [1,2,†], Pule Li [3], Yitian Yang [1,2], Hui Zhang [1,2], Beibei Zhang [1,2], Mingyang Sun [2,*] and Jiaqiang Zhang [1,*]



Data are expressed as means ± SDs, medians (inte
ASA, American Society of Anesthesiologists.



brain sciences 2022

MDPI

Article

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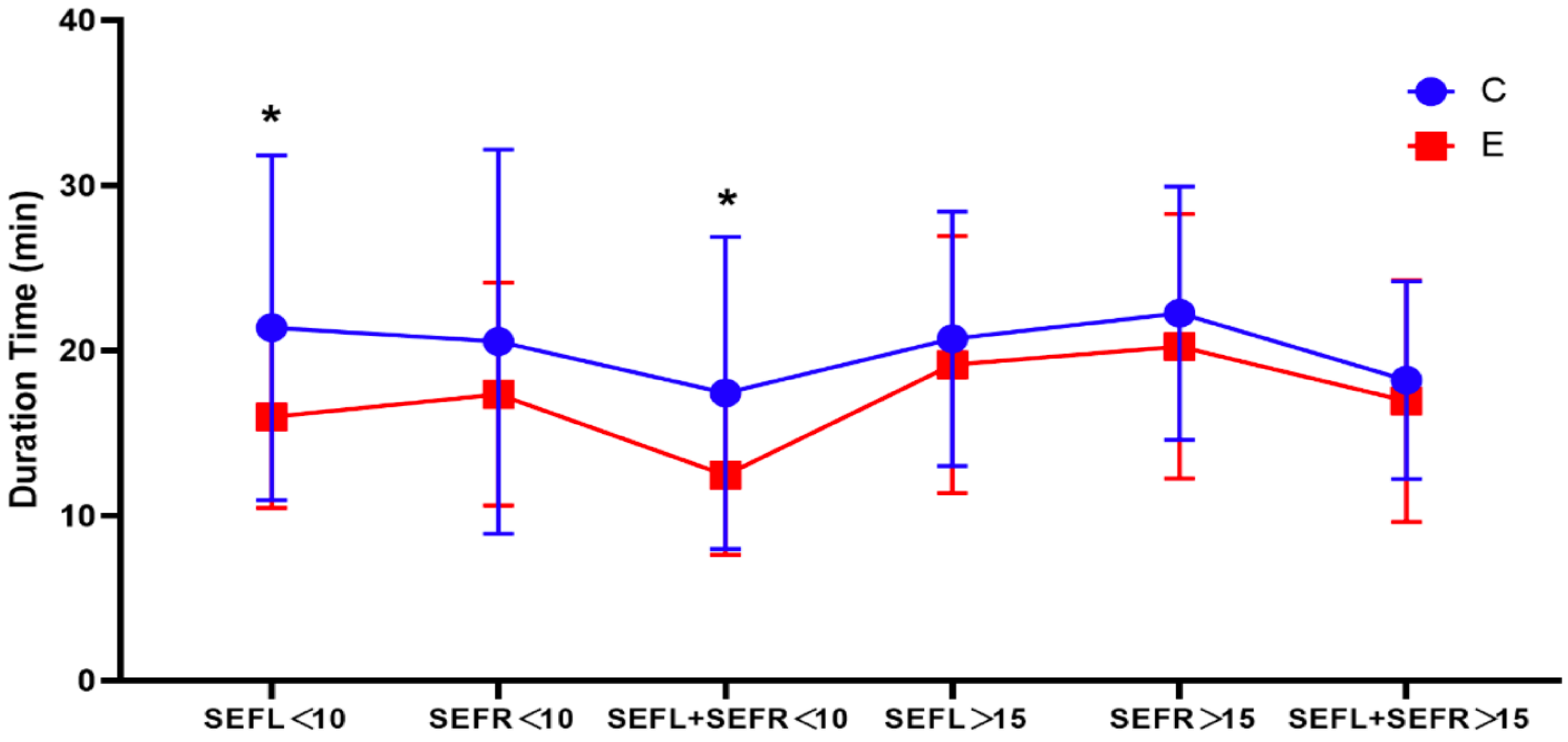

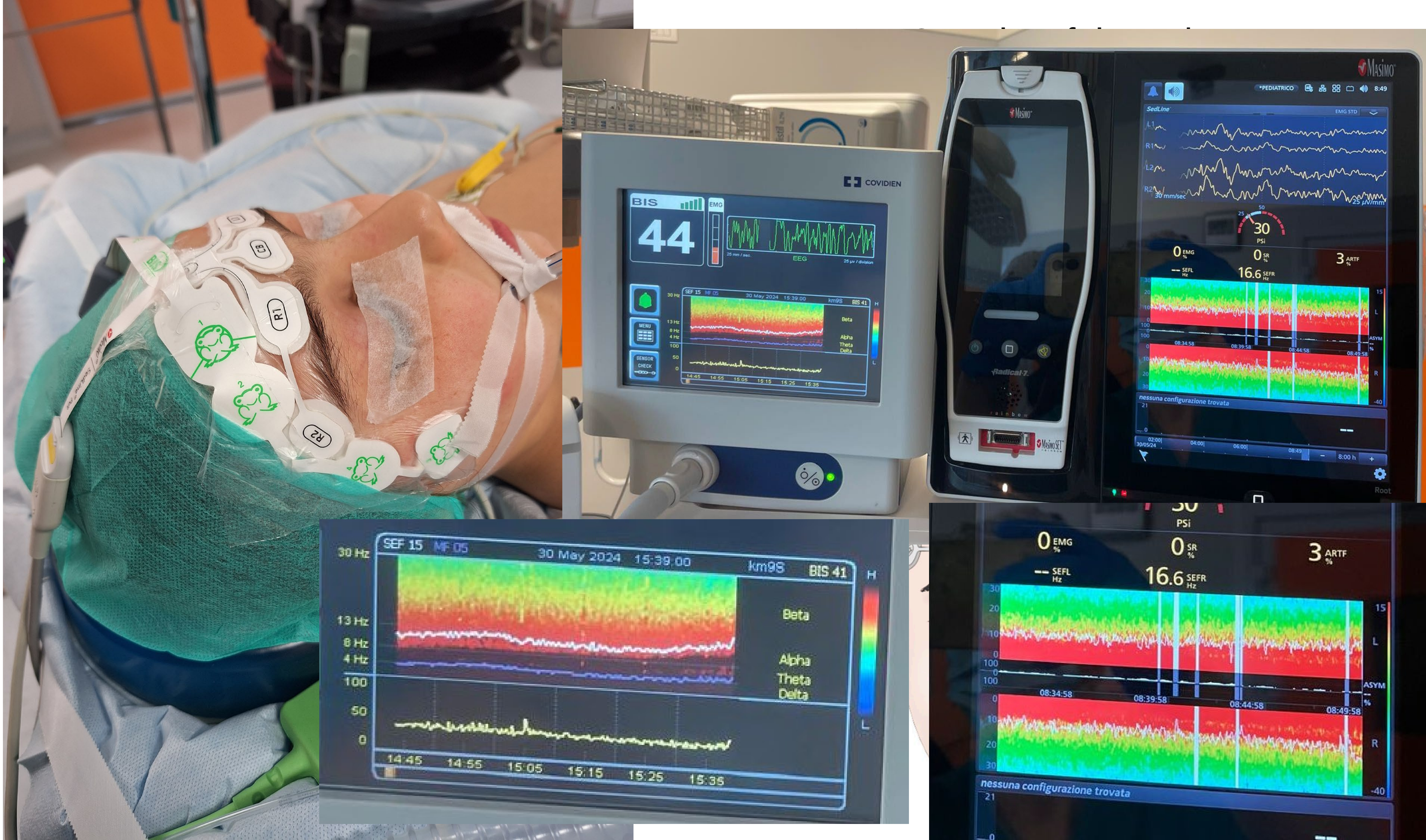
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Beta
Alpha
Theta
Delta
14:45
14:55
15:05
15:15
15:25
15:35
Masimo
Radical-7
SedLine
30
PSi
0 EMG
0 SR
3 ARTF
-- SEFL
16.6 SEFR
08:34:58
08:39:58
08:44:58
08:49:58
ASYM
nessuna configurazione trovata
Root

ANESTHESIOLOGY

Electroencephalographic Indices for Clinical Endpoints during Propofol Anesthesia in Infants: An Early-phase Propofol Biomarker-finding Study

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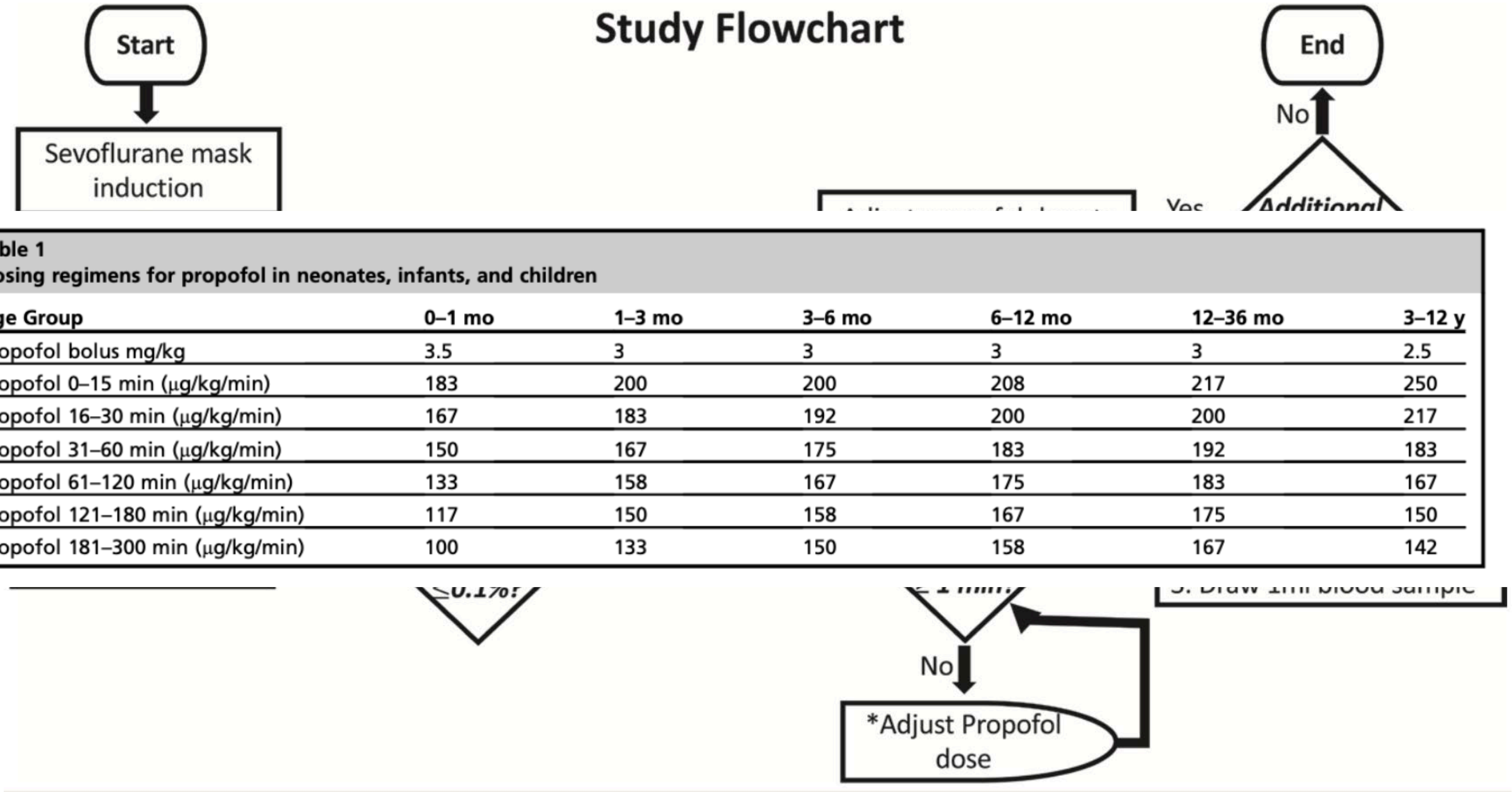

Table 1
Dosing regimens for propofol in neonates, infants, and children

Age Group	0–1 mo	1–3 mo	3–6 mo	6–12 mo	12–36 mo	3–12 y
Propofol bolus mg/kg	3.5	3	3	3	3	2.5
Propofol 0–15 min (μg/kg/min)	183	200	200	208	217	250
Propofol 16–30 min (μg/kg/min)	167	183	192	200	200	217
Propofol 31–60 min (μg/kg/min)	150	167	175	183	192	183
Propofol 61–120 min (μg/kg/min)	133	158	167	175	183	167
Propofol 121–180 min (μg/kg/min)	117	150	158	167	175	150
Propofol 181–300 min (μg/kg/min)	100	133	150	158	167	142

- The SEF95 for the first infant was targeted at 20, 14, and 10 Hz for oral pacifier, electrical stimulation, and laryngoscopy, respectively.
- If the first infant had a positive response the next infant will have SEF95 target decreased by 2 Hz for the same stimulus.
- The SEF95 target was achieved by adjusting propofol dose in each infant using a dosing table as a starting guide and confirmed by steady-state SEF95.

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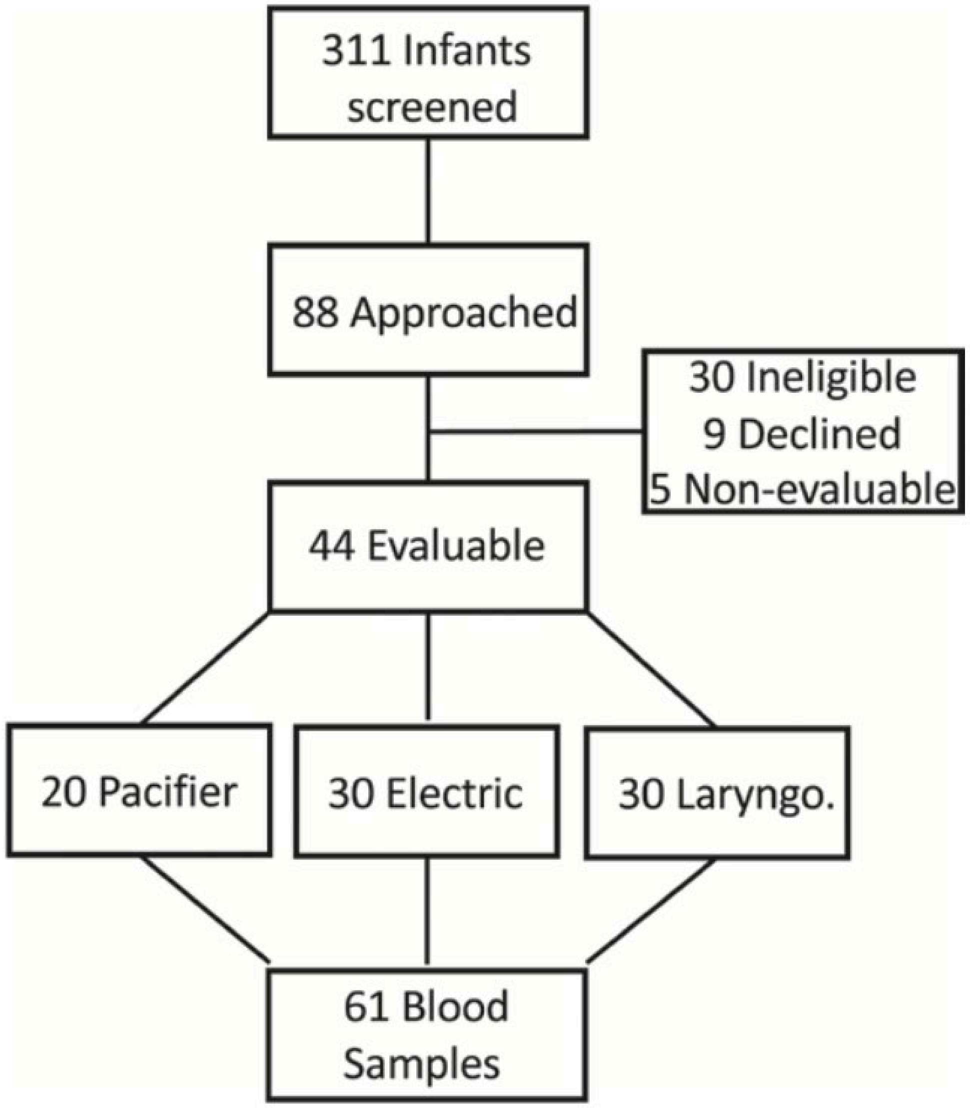
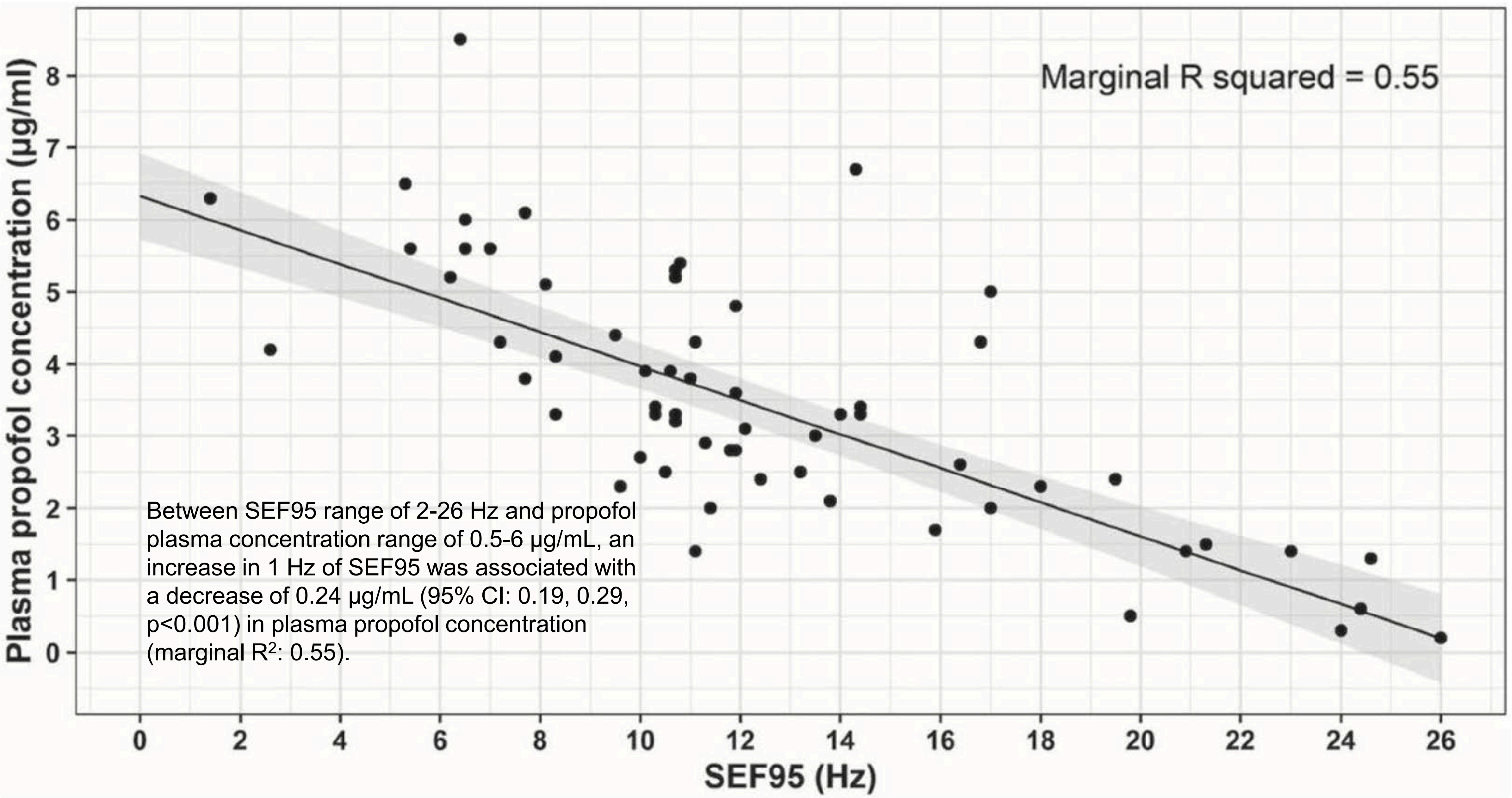
Inclusion criteria: ASA 1 or 2, muscle relaxant not planned for laryngoscopy/intubation, and anticipated surgery duration < 2h 40min. This time limit was required by the IRB, citing an FDA warning of anesthetic neurotoxicity in children under 3 years for longer than 3h of anesthesia exposure.



Exclusion criteria: infants undergoing emergency surgery, seizure disorder treated with anticonvulsant, congenital or acquired brain malformation, deformities of forehead, known or potential difficult airway, and allergy to propofol


Marginal R squared = 0.55
Plasma propofol concentration (µg/ml)
SEF95 (Hz)
0
1
2
3
4
5
6
7
8
0
2
4
6
8
10
12
14
16
18
20
22
24
26
Between SEF95 range of 2-26 Hz and propofol plasma concentration range of 0.5-6 µg/mL, an increase in 1 Hz of SEF95 was associated with a decrease of 0.24 µg/mL (95% CI: 0.19, 0.29, p<0.001) in plasma propofol concentration (marginal R^2: 0.55).

QUESTIONS

- No fentanyl?
- No roc?
- 3->12 months?
- Burst suppression?
- Sevorane?
- Locoregional?
- Electrical stimuli?
- LMA?

«The original dose-finding studies to determine median alveolar concentration used volatile anesthetic as the sole agent, as this was necessary to provide foundational knowledge.

Similarly, our study provides foundational knowledge of propofol for key clinical anesthesia endpoints, paving the way for future studies to determine responses to a combination of propofol with remifentanil or other drugs often during clinical care»

CONCLUSIONS

1. Neuromonitoring should become standard of care in pediatric anesthesia, at least in patients >2 yo
2. Developing ages still have many unanswered questions
3. pEEG guided anesthesia should target the lowest anesthetic dosages for the optimal anesthesia depth (threshold?)
4. Avoidance of BS is associated with lower hemodynamic instability and potentailly less postoperative neurologic impairment
5. Raw traces, spectrograms and SEF are useful for objective pEEG interpretation in different ages and with different technology
6. **A lot of research is due in this field and innovation is warranted (monitoring of power, relative power, nociception, delirium)**