



Research paper

The additional diagnostic benefits of performing both video-polysomnography and prolonged video-EEG-monitoring: When and why



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ABSTRACT

Objective: Video-polysomnography (VPSG) and prolonged video-EEG-monitoring (pVEEG-M) are neurophysiological investigation modalities. Depending on indication either is performed, but occasionally patients undergo both (during the same or separate stays). We sought to assess the reasons and potential benefits of dual diagnostic assessments with both modalities.

Methods: A retrospective chart-review was performed to identify patients who underwent both VPSG and pVEEG-M during the 10 year period between 2007 and 2017. One-hundred-nine patients were identified who had undergone both studies. Patients were grouped according to indication and outcome.

Results: One-hundred-nine patients had both, a VPSG and pVEEG-M, in 62 (56.9%) the studies were performed because of separate diagnoses independent from each other. In 47 patients (43.1%) investigation with both modalities was needed to clarify the suspected diagnosis or to refute differential diagnoses. Out of these 47, 11 (10.1% of the whole group) arrived a new final diagnosis whereas in 36 (33%) the primary diagnosis was corroborated with the second modality.

Conclusions: In the majority of cases VPSG plus pVEEG-M were indicated to diagnose or monitor different comorbid diseases (e.g. sleep-related breathing disorder and epilepsy). In the other cases, performing both modalities was useful to achieve a higher diagnostic accuracy or to refute differential diagnoses.

Significance: VPSG and pVEEG-M are neurophysiological investigations which complement each other, especially in case of two different comorbid diseases in a single patient, to rule out differential diagnosis or when a higher diagnostic certainty is sought.

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1. Introduction

Both, sleep disorders and epilepsy are common. They may co-occur in the same patient (Manni and Terzaghi, 2010; Grigg-Damberger and Foldvary-Schaefer, 2021; Kataria and Vaughn, 2016; Malow, 2007; Nobili et al., 2020; Unterberger et al., 2015) and exert mutual influence on each other. For instance, obstructive sleep apnea (OSA) is common in patients with epilepsy (Bergmann et al., 2020; Manni et al., 2003; Liu and Wang, 2017) and may increase the risk of epileptic seizures during sleep, (Malow et al., 2000) although this is controversial (Vendrame et al., 2014). Additionally, sleep quality was worse in epilepsy compared to controls in a large meta-analysis (Bergmann et al., 2021).

Furthermore, it is often challenging to differentiate between parasomnias and epilepsy by medical history alone, as nocturnal movements are a hallmark of both parasomnias and sleep-

related hypermotor epilepsy (SHE) and share similar characteristics (Montini et al., 2021; Proserpio et al., 2019).

Video-polysomnography (VPSG) is the gold standard to diagnose different categories of sleep disorders according to the International Classification of Sleep Disorders (ICSD-3) (American Academy of Sleep Medicine, 2014), and prolonged video-EEG-monitoring (pVEEG-M) is required to differentiate epileptic seizures from non-epileptic events, classify epilepsy syndromes, quantify seizure frequency, detect ictal and interictal epileptiform discharges and to perform presurgical evaluations (Baumgartner and Pirker, 2019).

In this retrospective study, we aimed to identify patients who had undergone both VPSG and pVEEG-M and to analyze the reasons and potential benefits of such dual procedure.

2. Methods

The study was performed at a large tertiary academic center of Neurology. A retrospective chart review was conducted to identify patients who had undergone VPSG at the Sleep Laboratory of the

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Sleep Disorders Clinic, and pVEEG-M at the Epilepsy Monitoring Unit, Department of Neurology, Medical University of Innsbruck, Austria. VPSG and pVEEG-M results of each patient were analyzed.

We identified 109 patients who had undergone both VPSG and pVEEG-M in a 10-year time period between 2007 and 2017. We report problems, complaints, indications for the study, referral modalities and final diagnoses. Patients were grouped into two different categories:

- a) Patients in whom both modalities including VPSG and pVEEG-M were performed because of two separate diagnoses (e.g. sleep-related and epilepsy-related), mutually independent from each other.
- b) Patients in whom both modalities were performed in order to achieve higher diagnostic accuracy or to refute differential diagnoses. Here two subgroups were made. Patients who received the final diagnosis only after clarification with the second modality and patients in which the second investigation confirmed the diagnosis of the first investigation.

Ethical committee approval (1281/2019) was obtained from the Medical University of Innsbruck, Austria. Informed consent according to the Declaration of Helsinki was not necessary because of the retrospective study design.

Statistical analyses were performed with the Statistical Package IBM SPSS Statistics Version 26 (SPSS Inc., Chicago, Illinois, USA). Normal distribution was assessed with the Kolmogorov-Smirnov-normality Test. Patient characteristics are presented as median and interquartile range (IQR), when not normally distributed, and as means and standard deviation (SD) when normally distributed. Results are presented as numbers and percentages.

3. Results

3.1. Demographic data and pathways of patient referral

Between January 2007 and December 2017, 109 patients met inclusion criteria of having undergone both investigations, 64 men (58.7%) and 45 women (41.3%). Median age was 55 years (IQR 40–65).

Sixty-five (59.6%) patients were referred from VPSG to pVEEG-M or from pVEEG-M to VPSG dependently based on the result of the first investigation.

Forty-four (40.4%) patients were referred to the other investigation modality independently.

The order of investigation was VPSG first in 61 (56%) patients and pVEEG-M first in 48 (44%) patients.

Detailed problems and complaints leading to the first investigation are listed in [Table 1](#).

Further information about the order of the investigations is given in Appendix A, [Table A.1](#).

3.2. Final diagnoses after both investigations

Demographic data and final diagnoses (sleep-related, neurological, psychiatric and other diagnoses) of the study population (n = 109) are listed in [Table 2](#).

3.3. Analysis of outcomes

3.3.1. Patients with separate comorbid diagnoses

Sixty-two patients (62/109, 56.9%) received independent final diagnoses.

Of them, 43 (43/62) had a sleep disorder in addition to epilepsy. In the majority of these cases (39/43) this was a sleep-related

Table 1

Problems and complaints of the study population organized according to outcome groups.

Problems and complaints	Patients (n)	Patients (%)
Patients with separate comorbid diagnoses	62/109	56.9
<i>Sleep-related problems/complaints</i>		
Suspected sleep-related breathing disorder	16/62	25.8
Difficulty in initiating and/or maintaining sleep	2/62	3.2
Daytime sleepiness/tiredness	2/62	3.2
Nocturnal restlessness	2/62	3.2
Shifting of the day/night rhythm	1/62	1.6
Nocturnal behaviors	1/62	1.6
<i>Epilepsy-related problems/complaints</i>		
Clarification of epilepsy syndrome	18/62	29.0
Episodic reduced responsiveness	7/62	11.3
Evaluation of seizure frequency	5/62	8.1
Twitches during day and night	2/62	3.2
Change of anti-epileptic drugs	1/62	1.6
<i>Others</i>		
Episodic speech problems	3/62	4.8
Episodic feeling of cramps of the arms and legs	1/62	1.6
Episodes of amnesia	1/62	1.6
Need for confirmation or refutation	47/109	43.1
<i>Sleep-related problems/complaints</i>		
Nocturnal restlessness	15/47	31.9
Nocturnal behaviors	12/47	25.5
Suspected sleep-related breathing disorder	4/47	8.5
Involuntary falling asleep	3/47	6.4
Daytime sleepiness/tiredness	2/47	4.3
Episodic paralysis after awakening	1/47	2.1
Sleep-related eating	1/47	2.1
<i>Epilepsy-related problems/complaints</i>		
Twitches during day and night	3/47	6.4
Episodic reduced responsiveness	2/47	4.3
Clarification of epilepsy syndrome	1/47	2.1
<i>Others</i>		
Episodic paralysis during day and night	2/47	4.3
Trembling of the body	1/47	2.1

breathing disorder. Demographic data and detailed clinical information of the 43 patients with independent sleep-related disorders and epilepsy are shown in [Table 3](#).

Nineteen further patients (19/62, 30.6%) had a combination of sleep disorders and other diagnoses. The main sleep diagnoses were: sleep-related breathing disorder (14/19, 73.7%), insomnia (2/19, 10.5%), REM sleep behavior disorder (2/19, 10.5%), and periodic leg movements during sleep (PLMS; 1/19, 5.3%). The other non sleep-related diagnoses included psychogenic/non-epileptic seizures, mild cognitive impairment, post-traumatic stress disorder, tic disorder, myoclonus of both upper extremities of unknown etiology, unclear episodes with reduced responsiveness and unremarkable EEG, episodic ataxia type 2, syllabic stutter, and postural tachycardia syndrome as final diagnoses.

3.3.2. Diagnostic confirmation and refutation of differential diagnoses

Final diagnosis achieved after both investigations

Eleven of the total 109 patients (10.1%) required both VPSG and pVEEG-M to achieve a final diagnosis:

Of them, 3/11 (27.3%) patients were diagnosed with a sleep disorder only [isolated REM sleep behavior disorder (n = 1), hypersomnia possibly associated with an astrocytoma of the thalamus (n = 1), restless legs syndrome plus obstructive sleep apnea syndrome (OSAS) (n = 1)].

63.4% (7/11) patients had, in addition to sleep disorders [OSAS (n = 5), hypnic jerks (n = 1), and isolated sleep paralysis (n = 1)], other non-sleep-related principal diagnoses [psychogenic/non-epileptic seizures (n = 3), delusional disorder (n = 1), intermittent

Table 2
Demographic data and final diagnoses of the study population.

Demographics and Clinical Data	Patients (n = 109)
Sex, n women (%)	45 (41.3)
Age, years, median (IQR)	55 (40–65)
Sleep disorders	
Sleep-related breathing disorder	
Obstructive sleep apnea syndrome, n (%)	58 (53.2)
Snoring, n (%)	18 (16.5)
Obesity hypoventilation syndrome, n (%)	2 (1.8)
Central sleep apnea syndrome, n (%)	2 (1.8)
Treatment-emergent central sleep apnea syndrome, n (%)	1 (0.9)
Parasomnia	
Non REM parasomnia, n (%)	24 (22)
REM sleep behavior disorder, n (%)	12 (11)
Isolated sleep paralysis, n (%)	2 (1.8)
Sleep-related movement disorders	
Periodic leg movements during sleep, n (%)	50 (45.9)
Restless legs syndrome, n (%)	15 (13.8)
Sleep-related bruxism, n (%)	15 (13.8)
Excessive fragmentary myoclonus, n (%)	6 (5.5)
Hypnic jerks, n (%)	2 (1.8)
Sleep-related rhythmic movement disorder (Head Banging), n (%)	1 (0.9)
Other sleep diagnoses	
Insomnia, n (%)	8 (7.3)
Delayed sleep phase syndrome, n (%)	1 (0.9)
Central disorders of hypersomnolence	
Hypersomnia possibly associated with an astrocytoma of the thalamus, n (%)	1 (0.9)
Idiopathic hypersomnia, n (%)	1 (0.9)
Narcolepsy type I, n (%)	1 (0.9)
Epilepsy	
Focal epilepsy with structural etiology, n (%)	20 (18.3)
Focal epilepsy with unknown etiology, n (%)	19 (17.4)
Genetic generalized epilepsy, n (%)	4 (3.7)
Focal epilepsy with immune etiology, n (%)	2 (1.8)
Neurological diagnoses	
Hippocampal sclerosis, n (%)	5 (4.6)
Meningioma, n (%)	4 (3.7)
Unclear episodes with reduced responsiveness and unremarkable EEG, n (%)	2 (1.8)
Spontaneous intracranial hemorrhage, n (%)	2 (1.8)
Autoimmune limbic encephalitis, n (%)	2 (1.8)
Severe traumatic brain injury, n (%)	2 (1.8)
Dementia, n (%)	2 (1.8)
Episodic ataxia type 2, n (%)	1 (0.9)
Myoclonus of unknown etiology, n (%)	1 (0.9)
Spinal segmental myoclonus, n (%)	1 (0.9)
Fibrillary astrocytoma, n (%)	1 (0.9)
Polymicrogyria, n (%)	1 (0.9)
Arnold Chiari malformation type II, n (%)	1 (0.9)
Arteriovenous malformation, n (%)	1 (0.9)
Middle cerebral artery stroke, n (%)	1 (0.9)
Migraine with brainstem aura, n (%)	1 (0.9)
Migraine without aura, n (%)	1 (0.9)
Multiple sclerosis, n (%)	1 (0.9)
Senile chorea, n (%)	1 (0.9)
Medication-induced oromandibular dyskinesia, n (%)	1 (0.9)
Mild cognitive impairment, n (%)	1 (0.9)
Postural tachycardia syndrome, n (%)	1 (0.9)
ADCY5-related nocturnal hyperkinetic movement disorder, n (%)	1 (0.9)
Psychiatric diagnoses	
Psychogenic/non-epileptic seizures, n (%)	16 (14.7)
Depressive disorder, n (%)	8 (7.3)
Alcoholism, n (%)	5 (4.6)
Post-traumatic stress disorder, n (%)	2 (1.8)
Delusional disorder, n (%)	1 (0.9)
Borderline personality disorder, n (%)	1 (0.9)

Table 2 (continued)

Demographics and Clinical Data	Patients (n = 109)
Schizoaffective disorder, n (%)	1 (0.9)
Tic disorder, n (%)	1 (0.9)
Others	
Fibromyalgia, n (%)	3 (2.8)
Syllabic stutter, n (%)	1 (0.9)
Spasmodic dysphonia, n (%)	1 (0.9)
Intermittent focal neurological deficits due to hypokalemia, n (%)	1 (0.9)
Noonan syndrome, n (%)	1 (0.9)

Legend: In case of more than one diagnosis, all are listed.

focal neurological deficits due to hypokalemia (n = 1), spinal segmental myoclonus (n = 1), and migraine with brainstem aura (n = 1)].

Finally, one (1/11, 9.1%) patient had psychogenic/non-epileptic seizures.

First diagnosis corroborated by the second investigation

In 36 patients (36/109, 33%), the main diagnosis made after the first examination was corroborated by the second examination i.e., either VPSG or pVEEG-M. Main diagnoses in these patients included sleep disorders (28/36, 77.8%; see below), epilepsy (focal epilepsy of unknown etiology; 2/36, 5.6%) and other diagnoses [ADCY5-related nocturnal hyperkinetic movement disorder (n = 1), senile chorea (n = 1), medication-induced oromandibular dyskinesia (n = 1), and three patients with psychogenic/non-epileptic seizures; 6/36, 16.7%].

In the 28 patients with sleep disorders the following main diagnoses were made: non REM parasomnia (20/28, 71.4%), REM sleep behavior disorder (3/28, 10.7%), OSAS (3/28, 10.7%), narcolepsy (1/28, 3.6%), and isolated sleep paralysis (1/28, 3.6%).

4. Discussion

This retrospective study in a large academic Neurology Department investigated the causes and potential benefits of a combined assessment with VPSG and pVEEG-M. Within a period of 10 years, 109 patients were assessed with both investigation modalities. Such evaluation was needed in 56.9% of the patients to identify or monitor independent comorbidities, whereas in 43.1% it allowed achievement of the final diagnoses. Initial indications and reported complaints (see also [Table 1](#)) in the group of patients with separate comorbidities were mainly clarification of the epilepsy syndrome and suspected sleep-related breathing disorder. In the other patients, who received VPSG and pVEEG-M to achieve final diagnoses or to refute differential diagnoses, symptoms which were not always attributable to a specific diagnosis from the beginning were reported, e.g. episodic reduced responsiveness, trembling of the body, episodic paralysis or nocturnal restlessness/behaviors. In such cases, parasomnia and epilepsy are possible differential diagnoses and require further evaluation.

Both modalities including VPSG and pVEEG-M were judged to be necessary only in a few cases. Other authors have highlighted the usefulness of performing both investigations as well ([Phillips et al., 2013](#); [Sivathamboo et al., 2019](#); [Jain et al., 2019](#)). VPSG includes electroencephalography, electrooculography, electromyography and cardiorespiratory recordings and gives information about sleep stages, respiratory and motor events during sleep ([Berry et al., 2020](#)). Prolonged VEEG-M contains EEG recordings and electrocardiogram to quantify seizures as well as interictal and ictal epileptiform discharges ([Baumgartner and Pirker, 2019](#)). Both examinations could partly be mutually informative, e.g. generalized epileptic discharges can also be detected via VPSG. Pro-

Table 3
Demographic and clinical characteristics of patients with both sleep disorders and epilepsy (n = 43).

Demographics and clinical data	Patients (n = 43)
Sex, n women (%)	14 (35)
Age, years, median (IQR)	59 (49–70)
Sleep disorders*	
Sleep-related breathing disorder	
Obstructive sleep apnea syndrome, n (%)	34 (79.1)
Obesity hypoventilation syndrome, n (%)	2 (4.8)
Central sleep apnea syndrome, n (%)	2 (4.8)
Treatment-emergent central sleep apnea syndrome, n (%)	1 (2.4)
Parasomnia	
REM sleep behavior disorder, n (%)	4 (9.3)
Non REM parasomnia, n (%)	4 (9.3)
Sleep-related movement disorders	
Periodic Leg Movements during Sleep, n (%)	20 (46.5)
Restless Legs Syndrome, n (%)	4 (9.6)
Sleep-related rhythmic movement disorder (head banging), n (%)	1 (2.4)
Others	
Insomnia, n (%)	5 (11.9)
Delayed Sleep Phase Syndrome, n (%)	1 (2.4)
Idiopathic Hypersomnia, n (%)	1 (2.4)
Epilepsy	
Focal epilepsy with structural etiology, n (%)	20 (46.5)
Focal epilepsy with unknown etiology, n (%)	17 (39.5)
Genetic generalized epilepsy, n (%)	4 (9.3)
Focal epilepsy with immune etiology, n (%)	2 (4.7)

Legend: *16 patients showed a single sleep disorder, 27 had more than one sleep disorder. In case of more than one diagnosis, all are listed.

longed VEEG-M could also help to identify sleep stages, if electrooculography and mental EMG were added, but usually gives no information on respiratory events and periodic leg movements in sleep.

Our study further confirmed the frequent co-occurrence of a sleep-related breathing disorder and epilepsy. Nevertheless, it should be considered that sleep-related breathing disorders were already suspected in most patients and were the reason for admission to the VPSG. This co-occurrence was previously reported, namely OSA occurred in 22.9% of patients with drug-resistant epilepsy (Bergmann et al., 2020) and in 33% of candidates for epilepsy surgery (Malow et al., 2000), whereas a lower prevalence (9%, assessed by questionnaires) was found in patients with low seizure frequency (Al-Abri et al., 2015). The correct identification and diagnosis of both conditions has clinical relevance, because the treatment of OSA can improve epilepsy control in patients with epilepsy and OSA (Liu and Wang, 2017).

Due to the frequent comorbidity of OSA and epilepsy, and the treatment implications of both disorders, it might be hypothesized if a combination of pVEEG-M and cardiorespiratory polygraphy could help to avoid performing VPSG and pVEEG-M separately in some cases. Cardiorespiratory polygraphy can measure nasal/oronasal airflow, thoraco-abdominal movements, oxygen saturation, ECG and body position (Pinna et al., 2014; Nerfeldt et al., 2014). Nevertheless, it must be kept in mind, that cardiorespiratory polygraphy alone may miss a significant proportion of patients with at least mild OSA (Nerfeldt et al., 2014). In addition, cardiores-

piratory polygraphy may be useful in patients with vagus nerve stimulation (VNS) because of the reported impact of VNS on sleep-related breathing disorder (Salvade et al., 2018; Gschliesser et al., 2009).

VPSG with abbreviated EEG montages (8-channel EEG montages) was reported to be inferior to standard EEG differentiating between epileptic seizures and psychogenic/non-epileptic seizures arising from sleep (Foldvary-Schaefer et al., 2006). This was further supported by a study including 237 combined VPSG and 18-channel EEG studies. Most reported EEG abnormalities were focal, so they would likely have been missed or misinterpreted with a limited EEG montage (Bubrick et al., 2014).

5. Conclusions

Our study showed that VPSG and pVEEG-M are both useful in the evaluation of patients suffering from two or more concomitant diseases and more importantly, in patients with etiologically unclear complaints during daytime and night, which are suspected to be seizures or sleep-related disorders. The rather low number of patients undergoing both investigations in a time-period of 10 years shows that a combined clarification was not often needed. In a tertiary center with both, a Sleep Laboratory and an Epilepsy-Monitoring-Unit, clinical expertise should ensure correct patient referral and diagnosis achievement with one modality, VPSG or pVEEG-M. In few cases, however, the possibility of performing both examinations is an important added value leading to a certain diagnosis or identification of multiple underlying conditions in a single patient.

Author contributions

Melanie Bergmann has participated in the conceptualisation, methodology, formal analysis, data curation, writing- original draft preparation, writing- review and editing and project administration.

Elisabeth Brandauer has participated in the project administration and in writing- review and editing the manuscript.

Ambra Stefani has participated in the conceptualisation, formal analysis, project administration and writing- review and editing.

Anna Heidbreder has participated in the conceptualisation, formal analysis and writing- review and editing.

Iris Unterberger has participated in conceptualisation, methodology, project administration and writing- review and editing.

Birgit Högl has participated in the supervision, conceptualisation, methodology, formal analysis, project administration and writing- review and editing.

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Conflict of interest

None of the authors have potential conflicts of interest to be disclosed. All authors have approved the final version of the manuscript.

Appendix A

Table A1

Problems and complaints in patients undergoing VPSG first or pVEEG-M first.

Problems/Complaints	Patients (n)	Patients (%)
VPSG first	61/109	56
Suspected sleep-related breathing disorder	20/61	32.8
Nocturnal behaviors	13/61	21.3
Nocturnal restlessness	12/61	19.7
Daytime sleepiness/tiredness	4/61	6.6
Twitches during day and night	3/61	4.9
Involuntary falling asleep	3/61	4.9
Difficulty in initiating/maintaining sleep	2/61	3.3
Shifting of the day/night rhythm	1/61	1.6
Episodic paralysis after awakening	1/61	1.6
Episodic paralysis during day and night	1/61	1.6
Sleep-related eating	1/61	1.6
pVEEG-M first	48/109	44
Clarification of epilepsy syndrome	19/48	39.6
Episodic reduced responsiveness	9/48	16.7
Evaluation of seizure frequency	5/48	10.4
Nocturnal restlessness	5/48	10.4
Episodic speech problems	3/48	6.25
Twitches during day and night	2/48	4.2
Episodes of amnesia	1/48	2.1
Change of anti-epileptic medication	1/48	2.1
Episodic feeling of cramps of the arms and legs	1/48	2.1
Episodic paralysis during day and night	1/48	2.1
Trembling of the body	1/48	2.1

Legend: VPSG: video-polysomnography; pVEEG-M: prolonged video-EEG-monitoring.

References

- American Academy of Sleep Medicine, 2014. *The International Classification of Sleep Disorders: Diagnostic & Coding Manual (ICSD-3)*. 3rd ed. rev. Darien, IL: American Academy of Sleep Medicine.
- Al-Abri, M., Al-Asmi, A., Al-Shukairi, A., Al-Qanoobi, A., Ramachandiran, N., Jacob, P., Gujjar, A., 2015. Frequency of obstructive sleep apnea syndrome among patients with epilepsy attending a tertiary neurology clinic. *Oman Med. J.* 30, 31–35.
- Baumgartner, C., Pirker, S., 2019. Video-EEG. *Handb. Clin. Neurol.* 160, 171–183.
- Bergmann, M., Prieschl, M., Stefani, A., Heidbreder, A., Walser, G., Frauscher, B., Unterberger, I., Hög, B., 2020. A prospective controlled study about sleep disorders in drug resistant epilepsy. *Sleep Med.* 75, 434–440.
- Bergmann, M., Tschiderer, L., Stefani, A., Heidbreder, A., Willeit, P., Hög, B., 2021. Sleep quality and daytime sleepiness in epilepsy: Systematic review and meta-analysis of 25 studies including 8,196 individuals. *Sleep Med. Rev.* 57, 101466. <https://doi.org/10.1016/j.smrv.2021.101466>.
- Berry, R.B., Quan, S.F., Abreu, A.R., Bibbs, M.L., DelRosso, L., Harding, S.M., et al., 2020. *The AASM Manual for the Scoring of Sleep and Associated Events: Rules, Terminology and Technical Specifications*. Version 2.6. Darien, Illinois: American Academy of Sleep Medicine.
- Bubrick, E.J., Yazdani, S., Pavlova, M.K., 2014. Beyond standard polysomnography: advantages and indications for use of extended 10–20 EEG montage during laboratory sleep study evaluations. *Seizure* 23 (9), 699–702.

- Foldvary-Schaefer, N., de Ocampo, J., Mascha, E., Burgess, R., Dinner, D., Morris, H., 2006. Accuracy of seizure detection using abbreviated EEG during polysomnography. *J. Clin. Neurophysiol.* 23, 68–71.
- Grigg-Damberger, M., Foldvary-Schaefer, N., 2021. Bidirectional relationships of sleep and epilepsy in adults with epilepsy. *Epilepsy Behav.* 116, 107735.
- Gschliesser, V., Hög, B., Frauscher, B., Brandauer, E., Poewe, W., Luef, G., 2009. Mode of vagus nerve stimulation differentially affects sleep related breathing in patients with epilepsy. *Seizure* 18, 339–342.
- Jain, S.V., Dye, T., Kedia, P., 2019. Value of combined video EEG and polysomnography in clinical management of children with epilepsy and daytime or nocturnal spells. *Seizure* 65, 1–5.
- Kataria, L., Vaughn, B.V., 2016. Sleep and epilepsy. *Sleep Med. Clin.* 11, 25–38.
- Liu, F., Wang, X., 2017. Diagnosis and treatment of epilepsy and sleep apnea comorbidity. *Expert Rev. Neurother.* 17, 475–485.
- Malow, B.A., 2007. The interaction between sleep and epilepsy. *Epilepsia* 48 (Suppl 9), 36–38.
- Malow, B.A., Levy, K., Maturen, K., Bowes, R., 2000. Obstructive sleep apnea is common in medically refractory epilepsy patients. *Neurology* 55, 1002–1007.
- Manni, R., Terzaghi, M., 2010. Comorbidity between epilepsy and sleep disorders. *Epilepsy Res.* 90, 171–177.
- Manni, R., Terzaghi, M., Arbasino, C., Sartori, I., Galimberti, C.A., Tartara, A., 2003. Obstructive sleep apnea in a clinical series of adult epilepsy patients: frequency and features of the comorbidity. *Epilepsia* 44, 836–840.
- Montini, A., Loddo, G., Baldelli, L., Cilea, R., Provini, F., 2021. Sleep-Related Hypermotor Epilepsy vs Disorders of Arousal in Adults: A Step-Wise Approach to Diagnosis. *Chest* 160 (1), 319–329.
- Nerfeldt, P., Aoki, F., Friberg, D., 2014. Polygraphy vs. polysomnography: missing osas in symptomatic snorers—a reminder for clinicians. *Sleep Breath* 18, 297–303.
- Nobili, L., de Weerd, A.I., Rubboli, G., Beniczky, S., Derry, C., Eriksson, S., Halasz, P., Högl, B., Santamaria, J., Khatami, R., Ryvlin, P., Rémi, J., Tinuper, P., Bassetti, C., Manni, R., Koutroumanidis, M., Vignatelli, L., 2020. Standard procedures for the diagnostic pathway of sleep-related epilepsies and comorbid sleep disorders: A European Academy of Neurology, European Sleep Research Society and International League against Epilepsy-Europe consensus review. *J. Sleep Res.* 29 (6). <https://doi.org/10.1111/jsr.v29.610.1111/jsr.13184>.
- Phillips, M.C., Costello, C.A., White, E.J., Smit, M., Carino, J., Strawhorn, A., Jackson, B., Kwan, P., French, C.R., Yerra, S.R., Tan, K.M., O'Brien, T.J., Goldin, J., 2013. Routine polysomnography in an epilepsy monitoring unit. *Epilepsy Res.* 105, 401–404.
- Pinna, G.D., Robbi, E., Pizza, F., Taurino, A.E., Pronzato, C., la Rovere, M.T., Maestri, R., 2014. Can cardiorespiratory polygraphy replace portable polysomnography in the assessment of sleep-disordered breathing in heart failure patients? *Sleep Breath* 18, 475–482.
- Proserpio, P., Loddo, G., Zubler, F., Ferini-Strambi, L., Licchetta, L., Bisulli, F., Tinuper, P., Agostoni, E.C., Bassetti, C., Tassi, L., Menghi, V., Provini, F., Nobili, L., 2019. Polysomnographic features differentiating disorder of arousals from sleep-related hypermotor epilepsy. *Sleep* 42 (12). <https://doi.org/10.1093/sleep/zsz166>.
- Salvade, A., Ryvlin, P., Rossetti, A.O., 2018. Impact of vagus nerve stimulation on sleep-related breathing disorders in adults with epilepsy. *Epilepsy Behav.* 79, 126–129.
- Sivathamboo, S., Farrand, S., Chen, Z., White, E.J., Pattichis, A.A., Hollis, C., Carino, J., Roberts, C.J., Minogue, T., Jones, N.C., Yerra, R., French, C., Perucca, P., Kwan, P., Velakoulis, D., O'Brien, T.J., Goldin, J., 2019. Sleep-disordered breathing among patients admitted for inpatient video-EEG monitoring. *Neurology* 92, e194–e204.
- Unterberger, I., Gabelia, D., Prieschl, M., Chea, K., Hofer, M., Hög, B., Luef, G., Frauscher, B., 2015. Sleep disorders and circadian rhythm in epilepsy revisited: a prospective controlled study. *Sleep Med.* 16, 237–242.
- Vendrame, M., Jackson, S., Syed, S., Kothare, S.V., Auerbach, S.H., 2014. Central sleep apnea and complex sleep apnea in patients with epilepsy. *Sleep Breath* 18, 119–124.