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CASE REPORTS

Sleep-Related Rhythmic Sound From the Vocal Cords: A Possible Atypical Form of NREM Parasomnia

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Sleep-related noises may have different features and etiologies. Here we report an atypical case of an adolescent with episodes of "sleep-related vocalization" occurring every night, especially during the first part of the night. The patient had moderate mental retardation and a dysfunctional dysphonia; she had no recollection of the episodes and complained exclusively of mild excessive daytime sleepiness. A video polysomnography recording documented two typical manifestations during non-rapid eye movement (NREM) sleep, characterized by the persistence of slow waves and without any electroencephalographic or breathing abnormalities. The quantified analysis of the acoustic features while confirming the rhythmic and stable characteristic of the sound suggests the involvement of the vocal fold vibration on its production. We interpreted these episodes as an atypical form of NREM parasomnia. A possible influence of the otolaryngologic abnormality can be hypothesized.

Keywords: central pattern generator, NREM parasomnia, rhythmic sound, vocal cord

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INTRODUCTION

Different noises occur mostly or exclusively during sleep and have multiple etiologies, such as snoring, catathrenia, stridor and bruxism.[1] Video polysomnography (PSG) is the gold standard for the assessment and diagnosis of most sleep-related noise, especially in challenging cases. Here we report a case with sleep-related stereotyped episodes characterized by the emission of a rhythmic sound whose characteristics did not fit any current diagnostic entity.

REPORT OF CASE

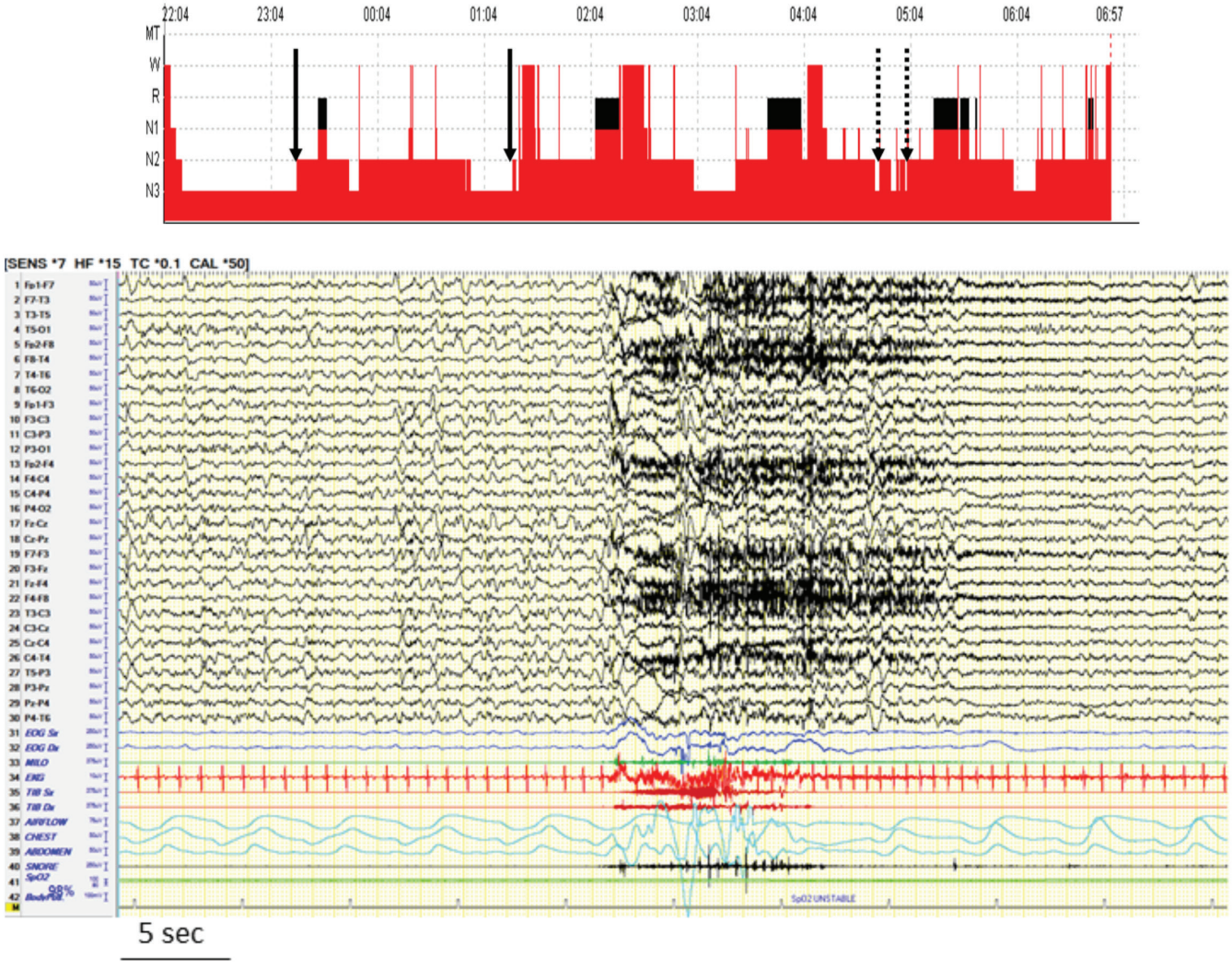
A 19 year-old female was referred to the Sleep Centre of Niguarda Hospital, Milan, Italy for recurrent nocturnal episodes characterized by the emission of a rhythmic noise. These manifestations, lasting between 30 seconds to 3 minutes, started at the age of 17 years and occurred every night, especially during the first part of the night. No clear triggering or predisposing factors were evident. Episodes were not followed by a clear-cut awakening and seemed not to be influenced by body position. The patient was completely unaware of the events, with no recall either immediately afterwards or the next morning. She did not complain significant daytime functional impairment, except for moderate excessive daytime sleepiness (Epworth Sleepiness Scale score 13).

The patient was born in Brazil and adopted at age 13 years. Infant antecedents were unknown; her brother suffered from attention-deficit/hyperactivity disorder and presented rare nocturnal episodes resembling confusional arousals. The patient had moderate mental retardation (intelligent quotient 45) and a dysfunctional dysphonia. The results of general and neurological physical examinations, routine blood tests and brain magnetic resonance imaging were all normal. Laryngoscopic examination revealed an ovalar glottid and a reduction of mucous membrane of the left vocal cord.

A full video PSG recording did not reveal any electroencephalographic (EEG) abnormality or breathing and movement disorders (apnea-hypopnea index 0.8 events/h; periodic leg movements index 9.1 events/h) and documented 2 episodes during stage N3 sleep that lasted 20–50 seconds (**Figure 1**). They were characterized by a physiologic body movement (head or limbs) followed by the emission of a stereotyped and quasi-periodic sound. During the episodes the patient did not open the eyes and continued to sleep (**Video 1** in the supplemental material). PSG did not show any respiratory modification before or during the manifestation; the EEG preceding the episode was characterized by continuous slow waves in the first episode and by a periodical occurrence of delta bursts (cyclic alternating pattern sequences) in the second. During the episodes the EEG showed the appearance of muscular artifacts and a persistence of slow waves, in absence of any epileptic abnormalities, and during stage N2 sleep we recorded 2 analogous very brief episodes lasting 2–3 seconds (**Figure 1**).

Following the methodological approach previously applied on vocalizations produced by patients during "epileptic hypermotor frontal" seizures,[2] an analysis of the acoustic features of the audio extracted from the video was conducted.

Figure 1

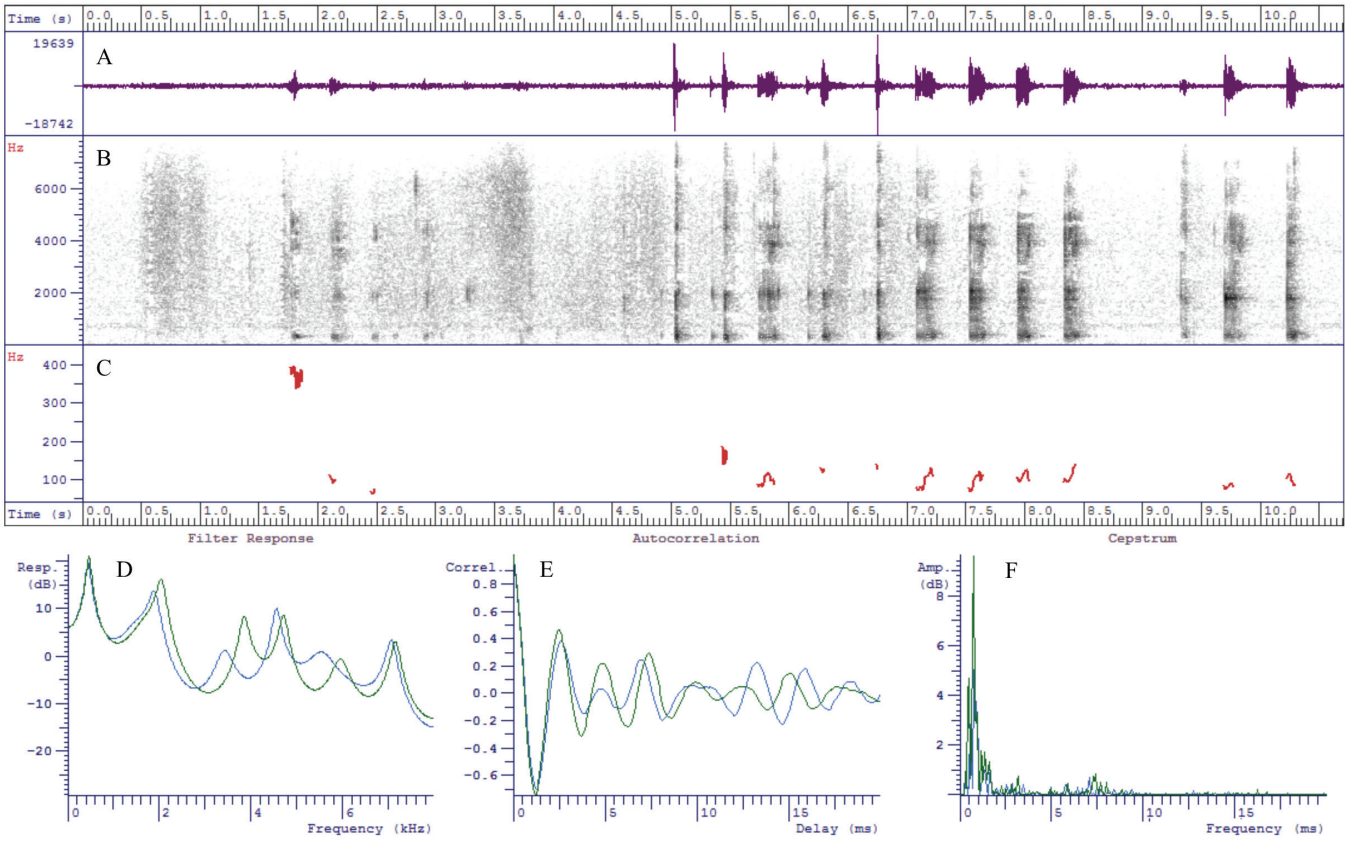


Upper part: Hypnogram. Solid arrows indicate major episodes and dotted arrows indicate minor episodes. W = wake; R = REM sleep. Lower part: Polysomnography traces of the first episode. EEG is filtered at 15 Hz to remove muscular artifacts. EEG = top 30 channels (international nomenclature); EOG = electro-oculogram; Sx = left; Dx = right; MILO = submental electromyogram; EKG = electrocardiogram; TIB = anterior tibialis electromyogram; AIRFLOW = oronasal airflow; CHEST = thoracic breathing effort; ABDOMEN = abdominal breathing effort; SaO_2 = oxygen saturation level.

To this aim, the audio of two main nocturnal sleep-related vocalization episodes was down-sampled at 16 kHz in order to remove frequencies higher than 8 kHz (since frequencies in conversational speech are always below this limit) and coded at 16 bit in order to apply on it algorithms for digital signal processing. In both episodes, the sounds had a quasi-periodical occurrence, with an approximate periodicity of 0.5 seconds in the first episode and 0.4 seconds in the second. This periodicity was broken in some time intervals. Moreover, to assess if the acoustic features of the sound remained unmodified over time, we compared the following parameters extracted from the acoustic measurements taken at different time instants: (1) the shape of the vocal tract resonances (ie, the main higher frequencies of the signal, displayed as peaks in **Figure 2D**), (2) the autocorrelation values (ie, the curve identifying repeating frequency patterns, **Figure 2E**) and (3) the cepstral spectra (ie, the periods or fundamental frequency of the harmonic components of a voice signal, **Figure 2F**). The features of these parameters overlapped extensively (**Figure 2**) suggesting similar acoustic properties of the consecutive sounds. Finally, to check for the involvement of the vocal cords, we estimated the values of the fundamental frequency and its contour (ie, the time intervals of the expected vocal folds vibrations, which are reported in red in **Figure 2C**). For sounds, where the algorithm was able to estimate fundamental frequency, the values ranged from 100 to 130 Hz, indicating the involvement of the vocal fold vibrations.[3,4]

For the management of this disorder, we proposed a treatment with clonazepam but the patient refused. A therapy with melatonin prolonged released (2 mg) did not induce any reduction of the frequency or duration of the episodes.

Figure 2



(A) Waveform, **(B)** narrowband spectrogram, and **(C)** fundamental frequency contour of the audio extracted from the first episode. For sounds where the algorithm was able to estimate fundamental frequency (red lines), the values range from 100 to 130 Hz. **(D)** The vocal tract resonance, **(E)** autocorrelation function, and **(F)** cepstral spectrum of two different sound emissions, measured at time 5.5 seconds and 6.25 seconds and superimposed in two colors (green and blue respectively). As it can be seen, the acoustic measurements taken at two different time instants overlap extensively, suggesting similar acoustic properties.

DISCUSSION

Our video PSG investigation did not allow making a definitive diagnosis. However, we interpreted these manifestations as an atypical form of non-rapid eye movement (NREM) parasomnia. Indeed, different clinical and electrophysiological features seemed to be in favor of such an interpretation, ie, positive family history, occurrence during the first part of the night, amnesia for the event and the video PSG finding of a persistence of slow waves during manifestations, without a clear-cut awakening.[5] Moreover, different recent studies support the notion that NREM parasomnia are associated with excessive daytime sleepiness[6] and can emerge during adolescence or adulthood, as in our patient.[7] Interestingly, it has been shown that the comorbidity of neurological disorders (ie, mental retardation) and NREM parasomnia is twice as frequent in adult-onset sleepwalking compared with childhood-onset sleepwalking.[8]

The quantified analysis of the acoustic features confirmed the rhythmic and stable characteristic of the sound and suggests the involvement of the vocal fold vibration on its production. Therefore, a possible relationship with the dysfunctional dysphonia and the laryngoscopic findings can be hypothesized. Moreover, these manifestations could be interpreted as an automatism whose occurrence could be favored by a release of inhibition of subcortical and brainstem "central pattern generators," that regulate stereotyped inborn fixed action patterns.[9] Interestingly, the events occurred exclusively during sleep, and the patient did not present any similar behavior during wakefulness. After playing the noises for the patient, she was asked to to reproduce them and was able to do so.

We could not assess the possible efficacy of any pharmacological treatment (such as benzodiazepine) on both nocturnal episodes and diurnal vigilance level. Moreover, we did not insist in proposing a drug therapy, also because the main request from the parents was to exclude the pathological nature of the nocturnal events and the patient was not complaining any significant daytime functional impairment.

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DISCLOSURE STATEMENT

All authors have seen and approved the manuscript. The authors report no conflicts of interest.