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Sleep EEG with or without Sleep Deprivation?

Does Sleep Deprivation Activate More Epileptic Activity in Patients Suffering from Different Types of Epilepsy?

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Abstract. A sleep EEG of 190 patients without sleep deprivation was recorded, followed by a sleep EEG after 24 h of sleep deprivation on the next day. The patients suffered from various types of epilepsy, in their routine EEGs no epileptic discharges were seen. Both sleep EEGs were recorded under the same antiepileptic drugs. A waking EEG was recorded immediately before each sleep EEG. The activation rates of epileptic activity in 52.6% (without sleep deprivation) and 53.2% (with sleep deprivation) of the patients showed no significant differences. Also on classifying the epileptic discharges no real difference was found between the 2 methods (generalized: 29.5 vs. 29.5%, generalized with lateral emphasis: 11.1 vs. 9.5%, focal: 12.1 vs. 14.2%). Only in the waking EEG, recorded immediately before the sleep EEG after sleep deprivation, a few more patients showed epileptic discharges (33.6 vs. 27.4%). Without there being any significant differences between the 2 methods there were some different results in comparing the EEG with the clinical findings: significantly more epileptic activity was shown in patients who had their first seizure before the age of 20 (55.6 and 55.6% vs. 26.3 and 31.6%), amongst females (59.8 and 61.9% vs. 45.2 and 44.1%), in awakening grand mal (= primary generalized tonic-clonic seizures, 76.5 and 70%) and in absences (69 and 72.4%). The higher activation rates in young subjects, in patients with a family history of seizures, with pathological neurological findings, mental retardation and delayed psychomotoric development in early childhood, were not statistically significant. As sleep deprivation is troublesome both for the patients and the staff, and as the same rate of patients show epileptic discharges in sleep without and with sleep deprivation, this method is dispensable for clinical practice.

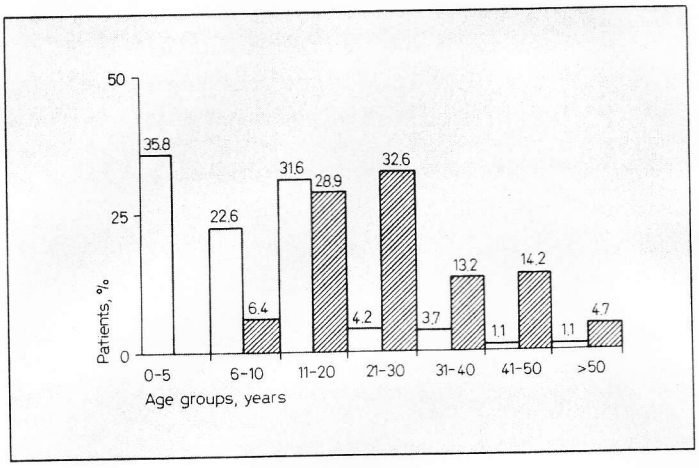

Fig. 1. Age at the time of 1st seizure (□) and examination (▨).

Introduction

That *sleep* has a marked activating effect on epileptic activity has been known ever since the studies of Gibbs and Gibbs [1947]. They were able to increase the rate of epileptic activity from 36% in the waking EEG to 82% in the sleep EEG. If other authors such as Merlis et al. [1951] and Gloor et al. [1958] found lower activation rates of 10 or 7%, respectively, then this was due to a different patient population, a greater number of routine recordings and the use of pharyngeal electrodes in the case of complex partial seizures. In previous studies, we recorded epileptic activity during sleep in 45 and 78.1%, respectively, in patients with complex partial seizures [Degen and Degen, 1981] and those with atypical absences [Degen and Degen, 1983a] whose routine EEGs showed no epileptic discharges.

A *sleep EEG after sleep deprivation* has been recommended for the last 15–20 years on the assumption that thereby still higher activation rates could be reached. These, as given in the literature, range between 34 [Geller et al., 1969] and 74% [Bechinger and Kornhuber, 1976]. We recorded epileptic activity amongst patients whose waking EEGs showed no specific discharges and who were under antiepileptic therapy, in sleep after sleep deprivation of 24 h in 58 and 51% [Degen, 1977, 1980a].

As sleep deprivation is troublesome for the patient as well as for the staff, we questioned whether in fact a higher rate of activation can be achieved by a sleep EEG after sleep deprivation than by a simple sleep EEG.

Patients and Methods

Patients

190 inpatients with different seizure types who were on anticonvulsant therapy were examined. Of these patients there were 97 females and 93 males; one third of them were 11–20 years of age at the time of examination (fig. 1). Over half of the patients (58.4%) had their first seizure within the first 10 years of life and over one third (35.8%) within the first 5 years (fig. 1). Only 85 patients suffered from one seizure type and 105 from more than one (table I). That on average more severe epilepsies were involved is also apparent from the fact that 58.4% suffered from men-

Table I. Seizure types

Gen. tonic-clonic seizures on awakening (= awakening grand mal = primary gen. ton.-clon. seizures)	4
+ Absences	11
+ Complex partial seizures	1
+ Absences + compl. part. seizures	1
Gen. tonic-clonic seizures in sleep (= sleep grand mal)	11
+ Absences	2
+ Compl. part. seizures	1
+ Absences + compl. part. seizures	1
Gen. tonic-clonic seizures occurring at no special time of day (= diffuse grand mal)	28
+ Absences	17
+ Compl. part. seizures	55
+ Absences + compl. part. seizures	9
+ Myoclonic-astatic seizures (Lennox-Gastaut-Syndrome)	2
+ Compl. part. seiz. + psychog. seiz.	1
+ Absences + compl. part. seizures + myocl.-astat. seizures	1
+ Psychogenic seizures	3
Complex partial seizures	37
Myoclonic-astatic seizures (= Lennox-Gastaut-Syndrome)	1
Simple partial seizures	1
Other epileptic seizures	3
Total	190

tal retardation and 74.3% from personality changes; there was a delayed psychomotoric development in infancy in 17.9% of the patients. The therapy also gives an indication of the severity of the epilepsies: Only 21 patients were treated with one drug, almost half with 2 and the remainder with more than 2 drugs. There was a family history of epilepsy in 40 patients (21.1%).

Methods

In the routine EEG of all patients no epileptic discharges were found. Two short-term sleep EEGs were therefore recorded, the first without sleep deprivation, the second on the following day after 24 h of sleep deprivation. The antiepileptic therapy remained the same.

A waking EEG was recorded immediately before each sleep EEG. As a rule, sleep without sleep deprivation was induced with 1.5 mg/kg body weight of Protactyl® (promazine hydrochloride). After sleep deprivation drug induction of sleep was not necessary. The waking EEGs were recorded, on an average, for 20 min and the sleep EEGs for 40 min.

The recordings were made in our sleep laboratory in which there are 3 sound-proof rooms which can be fully darkened. The 12-channel EEG recorders (Schwarzer and Alvar) were situated outside of the rooms, the patients could, however, be observed through a window. Bipolar montages were used, the electrodes being mostly fixed with paste. The time constant was 0.3 s, low-pass filters as a rule set at 70 Hz. The paper speed was 30 mm/s.

The tracings were visually evaluated, the sleep stages being classified according to Loomis et al. [1937]. The frequency of epileptic activity per minute was calculated by determining the total recording time and by counting the single epileptic discharges of each patient. The χ^2, Fisher and Wilcoxon tests were used for statistical evaluations. Statistical significance was accepted at a level of $p < 0.05$.

If, however, the *waking EEGs* recorded immediately before the sleep EEGs, with and without sleep deprivation, were considered, marked differences were seen: Epileptic discharges were found in only 27.4% of the patients in the waking EEG without sleep deprivation, and in 33.6% in the waking EEG after sleep deprivation. These differences, which were almost exclusively due to different activation rates of spike-wave complexes were, however, not statistically significant.

Considering the *frequencies of epileptic activity,* in the waking EEG recorded immediately before each sleep EEG significantly more epileptic activity was seen after sleep deprivation in all patients as well as those with generalized epileptic discharges without lateral emphasis (table II).

Significant differences were also seen in the sleep EEG; more epileptic discharges were recorded after sleep deprivation amongst all patients as well as those with generalized and focal epileptic activity (table III).

Comparing the *waking* with the *sleep EEG,* both *without sleep* deprivation, it is seen that specific discharges are found more frequently during sleep in all patients and also after dividing the patients according to the various types of epileptic activity (table IV). The same results are also found on comparing the waking and sleep EEGs *after sleep deprivation* (table V).

Without there being a significant difference between both methods, most epileptic activity was activated in the sleep stage C (48.1 and 46%), followed by stages D (36.4 and 42.1%), B (34.4 and 31.4%) and A (31.3 and 30.9%).

A *comparison* of the EEG with the *clinical findings* showed that in patients with epileptic discharges a higher incidence of a family history with seizures is seen (in each method 23%) than in those without specific discharges (18.9 and 18%, NS). There was no real difference between sleep EEGs without and with sleep deprivation. In the case of generalized epileptic activity the occurrence of a family history was found, as expected, to be high (32.1 and 33.9%), in the case of generalized activity with lateral emphasis less so (19 and 16.7%) and in focal epileptic discharges very rare (4.3 and 7.4%, $p < 0.05$). There were no differences between either of the methods.

More epileptic activity (59.8 and 61.9%) was activated in females than in males (45.2 and 44.1%, $p < 0.05$), there being no significant difference between sleep EEGs without and with sleep deprivation.

Epileptic activity was seen most frequently in awakening grand mal (76.5 and 70.6%) and absences (69 and 71.4%) but more seldom in the remaining *epilepsy types* ($p < 0.05$) without a significant difference between sleep without and with sleep deprivation (sleep grand mal: 53.3 and 40%; diffuse grand mal: 49.1 and 50.9%, complex partial seizures: 48.6 and 54.1%). The classification of the grands maux is taken from Janz [1962].

A significantly higher activation rate was seen in patients whose first seizure occurred before the age of 20 (56.6 and 55.6% vs. 26.3 and 31.6%, $p < 0.05$). More epileptic activity was also activated amongst young patients (up to 20 years of age), patients with pathological neurological findings, mental retardation and delayed psychomotoric development in infancy. The results, however, were not significant. Again, there was no difference between the both methods.

To summarize, it is established, that there are *no significant differences between the activation rates in waking and sleep EEGs, without and with sleep deprivation.* This statement is important for clinical practice and applies to the question whether epileptic activity is seen or not. *If, however, the frequency* of epileptic discharges *is also taken into consideration* by counting the single epileptic discharges, *more specific activity is found* in the waking and sleep EEGs *after sleep deprivation.*

Discussion

High activation rates of epileptic activity in sleep without sleep deprivation [Degen and Degen, 1981, 1983a; Christian, 1961; Gänshirt and Vetter, 1961; Gibbs and Gibbs, 1947; Jovanović, 1967] as well as with sleep deprivation [Bechinger et al., 1973; Bechinger and Kornhuber, 1976; Degen, 1977, 1980a; Degen and Degen, 1981, 1983a; Gastaut et al., 1984; Kubicki et al., 1984; Mattson et al., 1965; Pratt et al., 1968; Ritter et al., 1977; Scollo-Lavizzari et al., 1975, 1977; Wittenberger and Kubicki, 1977] are reported in the literature. As sleep deprivation is very troublesome both for the patients and the staff, we questioned whether in fact sleep after sleep deprivation gives a higher activation rate than normal sleep.

In our study of 190 patients different results were found according to the questioning whether or not epileptic activity was found at all, or whether the frequency of epileptic discharges was also taken into consideration.

For clinical practice it is important, whether or not epileptic activity is found at all. In this respect, no significant difference in the activation rate during sleep without sleep deprivation (51.1%) and sleep with sleep deprivation (52.1%) was seen amongst our patients who had different seizure types. These results confirmed our earlier studies which we carried out using a smaller number of patients with specific seizure types (complex partial seizures: 45 and 52%; atypical absences: 78 and 71%) [Degen and Degen, 1981, 1983a].

However, results of studies using a small number of patients, which do not confirm our studies, are given in the literature by Rumpl et al. [1977]. These authors found epileptic activity in 4 cases during drug-induced sleep and in 12 patients in sleep after sleep deprivation in a total of 28 patients with different seizure types. From their report it is not absolutely clear, however, if in fact recordings were made during sleep in all patients. One also gains the impression that both examinations were possibly carried out at different times. It is thus conceivable that the patients in both examinations were not examined under the same therapeutic conditions.

The results of Veldhuizen et al. [1983] are comparable with ours although some methodical differences have to be considered. While we carried out waking and sleep EEGs without and with sleep deprivation in each of our 190 patients within 2 days, Veldhuizen et al. [1983] performed these recordings in a 'random order'. Apart from this they recorded the sleep EEGs without sleep deprivation after inducing sleep with 'quinalbarbiton 200 mg', whereas we used promazine hydrochloride. Finally, a few patients with 'suspected epilepsy' were included in their cases. This also implies that some were not under therapy. They examined all patients whereas we took only those whose routine EEGs showed no epileptic discharges.

On considering the question whether or not epileptic discharges were found in the individual patient at all, we saw no significant differences in the activation rates of the recordings without and with sleep deprivation. These results correspond with the findings of Veldhuizen et al. [1983]. These authors found a higher rate of patients with epileptic activity in sleep after sleep deprivation, but the difference was not significant.

Determining the *frequency of epileptic activity* by counting the single epileptic discharges, in agreement with our studies more specific activity was seen in sleep after sleep deprivation by Veldhuizen et al. [1983]. Contrary to our own investigations such differences were not found in the waking EEG after sleep deprivation.

Amongst our patients significantly *more focal* epileptic discharges were recorded *in the sleep EEGs with sleep deprivation* than in those without sleep deprivation. This difference was not significant in the patients of Veldhuizen et al. [1983].

Regarding generalized epileptic discharges, Veldhuizen et al. [1983] found significantly more potentials in the waking EEG after sleep deprivation; such differences were not seen in the sleep EEG. In our patients significant differences were present both in the waking and in the sleep EEG after sleep deprivation.

Differing from Veldhuizen et al. [1983], who found most epileptic activity in sleep stage I [classification according to Rechtschaffen and Kales, 1968], we saw the greatest incidence of specific discharges in stage C (48.1 and 46%). In our previous studies we likewise recorded most epileptic discharges in stage C of those patients with various seizure types [Degen, 1977, 1980a] as well as in those with specific types [Degen, 1980b; Degen and Degen, 1981, 1983a, b, in prep.]. Other authors also found most specific activity in the light to medium sleep stages [Bechinger et al., 1973; Delange et al., 1962; White et al., 1962]. That generalized spike-wave complexes as, moreover, also temporal discharges are most frequently found in the sleep stages B and C might result from the appearance of K complexes in these stages, which often act as a vehicle for epileptic activity. It is known that K complexes are caused by internal and external stimuli which for their part cause changes of vigilance, which in turn lead to a provocation of spike wave complexes [Halász, 1984; Niedermeyer, 1966, 1984; Wieser, 1984].

A *comparison of the EEG with the clinical parameters showed no significant differences* in the activation rates of sleep without and with sleep deprivation.

The higher activation rate in female patients (59.8 vs. 45.2% in sleep without, 61.9 vs. 44.1% in sleep with sleep deprivation) corresponds to our sleep recordings of siblings of patients with primary generalized tonic-clonic seizures [Degen and Degen, 1985]. Likewise, Gerken and Doose [1973] and Matthes and Weber [1978] were able to find increased epileptic activity in the routine EEGs of the sisters of patients with absences.

We had already established in earlier studies [Degen 1977, 1980; Degen and Degen, 1983] that in awakening grand mal (= primary generalized tonic-clonic seizures) and in absences, in contrast with the other types of epilepsy, significantly more epileptic activity can be seen.

The sleep without sleep deprivation was, as a rule, induced by promazine hydrochlo-

ride. It is known that phenothiazines can activate electroencephalographic epileptic activity as well as clinical seizures, when administered intramuscularly, intravenously or on long-term oral administration. We showed, however, in an earlier study that the drug given in the dose used be us (1.5 mg/kg body weight as syrup) did not have an activating effect [Degen and Degen, 1984].

In summary it is established that for clinical practice a *sleep EEG with sleep deprivation is not necessary;* the drug-induced sleep EEG gives the same results.

On counting, however, the single epileptic discharges in the waking and sleep EEG, more epileptic activity is provoked with than without sleep deprivation.

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