The Sleep-Deprived Electroencephalogram

Evidence and Practice

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Background: Sleep deprivation for the initial electroencephalogram for suspected seizures is a widespread but inconsistent practice not informed by balanced evidence. Daily practice suggests that nonneurologists are confused by the meaning and value of, and indications for, “sleep” (tracing) vs “sleep deprivation” (and other alternatives). They need specific, informed guidance from general neurologists on best practices.

Objectives: To document illustratively the variability of neurologists’ practices, the level of relevant information among nonneurologists, and the current state of published evidence; and to stimulate formulation of consensus advisories.

Design and Setting: I surveyed knowledge and practices of (1) nonneurologists in a community teaching hospital; (2) local and national neurologists and epileptologists; (3) electroencephalogram laboratory protocols; and (4) textbook accounts and recommendations and the relevant journal literature. National professional organizations were contacted for advisories or guidelines.

Results: Most nonneurologists surveyed misunderstood “sleep” vs “sleep-deprived” electroencephalograms and their actual protocols. They are unaware of evidence on benefits vs burdens. Neurologists’ practices are inconsistent. Experts generally agree that sleep deprivation produces substantial activation of interictal epileptiform discharges beyond the activation of sleep per se. However, most published recommendations and interviewed epileptologists do not suggest sleep deprivation for the initial electroencephalogram because of “inconvenience” (burdens) for the patient. Evidence-based or reasoned guidance is minimal, and professional societies have not issued advisories.

Conclusion: Confusion over sleep deprivation, disparities between evidence and recommendations, and inconsistent practices create a need for expert consensus for guidance, as well as comparative research on alternative methods of increasing diagnostic yield.

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MENDATIONS OF PAST REVIEWERS AND WITH ALTERNATIVE METHODS.

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I contacted the relevant national professional organizations to ascertain the existence of advisory opinions or practices with respect to sleep-deprived EEGs. I searched the journal literature for guidance on this subject and did the same with more than 25 major textbooks and manuals of internal medicine, family practice, neurology, epilepsy, and EEG. The percentage of EEGs performed (in this hospital’s laboratory) for suspicion of seizure, and the distribution of ordering physicians by specialty, were ascertained.

Communication of pertinent information and leading opinion is inadequate, and practices are inconsistent. The challenge is to elucidate the “best practice” opinions in the absence of strict, evidence-based standards.

To highlight these disparities and clarify the current basis for diagnostic decision making, I surveyed the relevant knowledge of a group of nonneurologists and epileptologists. In this article, the status of evidence on sleep deprivation is summarized and contrasted with the recommendations of past reviewers and with alternative methods.

METHODS

With the use of a structured, written questionnaire, a group of 49 physicians at an urban, community-based teaching hospital were surveyed to determine their practical understanding of the issues regarding sleep-deprived EEGs. All 31 attending physicians who received the survey (three fourths of the total staff) responded, as did approximately two thirds of the entire medical house staff (all levels). The survey included definition of sleep EEG vs sleep-deprived EEG, indications for such methods, knowledge of relevant evidence, and awareness of the protocol of our EEG laboratory.

In a second survey by personal interview or e-mail, I discussed practices and knowledge of evidence with a nonrandomized sample of 15 adult neurologists situated locally and from around the country. Similarly, I queried 14 local and nationally prominent epileptologists on sleep deprivation and their practices, teachings, and recommendations for the initial EEG. These surveys were intended to be illustrative rather than regionally or nationally definitive.

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RESULTS

ATTENDING PHYSICIAN AND MEDICAL HOUSE STAFF SURVEY AND EEG ORDERING PATTERN

To 10 (20%) of the 49 respondents, a sleep EEG meant simply a sleep tracing; to 27 (55%) it meant sleep deprivation, and the remainder did not know the distinction. For 7 (14%) the rationale for sleep deprivation was to “encourage sleep during the tracing” and for 42 (86%) it was also to increase “seizure” discharges. According to 32 (65%), the indication for a sleep or sleep-deprived EEG was suspected seizure; the other 35% (mostly house staff) did not know. The protocol for a sleep EEG in our laboratory was unknown to 38 (78%) of 49, and 10 respondents (20%) indicated an allowance of 0 to 5 hours of sleep. (Our laboratory routinely offers “awake only” or “sleep,” for which patients sleep no more than 5 hours, to induce sleep during the EEG. A sleep-deprived EEG protocol can be arranged at the discretion of a neurologist.) A full 69% could not recall ever having been instructed on sleep deprivation. No one could cite relevant evidence.

A 3-month sample of consecutive EEGs (inpatient and outpatient) showed that 41% were ordered by primary physicians, 18% by psychiatrists (adult and child), 5% by pediatricians, 25% by neurologists, and 11% by miscellaneous specialists. Of the EEGs ordered, 71% were for suspected seizures.

SURVEY OF GENERAL NEUROLOGISTS AND EPILEPTOLOGISTS

Of the 15 practicing neurologists interviewed, none could cite any specific evidence relevant to sleep-deprived EEGs, but most were aware of conflicting studies and variability of practices. While 13 of the 15 did not routinely use overnight sleep deprivation initially, 2 always did so, and one of these commented that the departmental standard is routine sleep deprivation for the first EEG. Two respondents estimated that their practice groups were equally divided on this issue. Five EEG laboratories in tertiary centers and those used by the neurologists in the survey have diverse protocols for sleep deprivation, ranging from only 4 hours of sleep to all night or 24-hour sleeplessness. None of the neurologists was aware of any national practice guidelines or of any consensus advice provided in the textbook or journal literature.

The 14 epileptologists all thought that the evidence favored a specific activating effect of sleep deprivation. However, they felt (in contrast to their past opinions and the practices of some colleagues) that this added value was not sufficient to justify its routine use for the first EEG for suspected seizures. The routine EEG would, if possible, include a tracing during drowsiness and sleep, but complete overnight sleep deprivation would be implemented subsequently for diagnostic dilemmas. They acknowledged a wide variation in the protocols for sleep deprivation and a high incidence of incomplete patient compliance, especially as more patients with suspected seizures are tested as outpatients.

NATIONAL PROFESSIONAL SOCIETIES AND TEXTBOOK REVIEW

Neither the American Academy of Neurology, the American Clinical Neurophysiology Society, nor the American Epilepsy Society has established practice advisories on sleep-deprived EEGs and the initial EEG evaluation for suspected seizures. I found virtually no detailed or reasoned guidance on sleep deprivation offered in the textbooks to which nonneurologists and neurologists typically turn. Journal reviews, to be cited subsequently, offer recommendations without balanced evidence (or no recommendations at all).
The flow of authoritative information on EEG practices comes down from the top. Epileptologists conduct research, modify their assessments of benefits vs burdens, and are expected to inform other neurologists as to best practices. Neurologists, in turn, should guide nonneurologists, who order most of the EEGs and, in particular, the first EEGs for suspected seizures. Data from this small but indicative survey of neurologists demonstrate that they, not surprisingly, are unaware of specific research data on sleep deprivation. As a group their practices are inconsistent. They are not prepared, therefore, to advise colleagues on best practices on the basis of the evidence, and they lack expert consensus opinions to implement and to teach.

Most primary care physicians and medical specialists surveyed at this general hospital do not understand exactly what they are ordering when they request a sleep or sleep-deprived EEG or what their patients will actually undergo. If we can generalize from these results (recognizing that they are illustrative rather than definitive), the information gap is large, as indeed, is the magnitude of the problem.

More than 500,000 EEGs were charged to Medicare in 1997, and it has been inferred that the total number of EEGs performed (for all causes) is probably 5 times the Medicare total (Marc Nuwer, MD, written communication, November 24, 1999). If, like at our institution, approximately 70% of all EEGs are requested because of suspected new seizure of any type were to receive an EEG, the Medicare total (Marc Nuwer, MD, written communication, August 2, 2000) would be considered for sleep deprivation annually in the United States. In addition, the many EEGs for questionable syncope and atypical spells would add substantially to the total.

**EVIDENCE FROM THE LITERATURE ON SLEEP DEPRIVATION AND ALTERNATIVES**

The diagnostic importance of analyzing activation by sleep deprivation (or alternatives) derives from a range of observations that roughly 20% to 50% of patients who actually have epilepsy show IEDs on their first routine EEG. (However, the meaning of “routine” varies with respect to the incidence of sleep, which affects the yield, but is often not specified.) The problem of the 50% to 80% without IEDs creates a strong incentive to increase the yield of the first tracing. Comparison of activation by sleep deprivation with practical alternatives (Table), such as maximizing the incidence of sleep in routine tracings, partial sleep deprivation, simple repetition of the routine EEG, and prolonged ambulatory monitoring, is hampered by limited evidence.

An exhaustive review in 1984, a compendium in the same year, and a 2001 update addressed the activating effect of sleep deprivation, over and above the effect of sleep per se. None of the studies presents data from prospective, randomized, controlled trials (class I evidence), and study methods often defy comparison. Most trials would probably be considered class III in that patients serve as their own controls, comparing the yield of IEDs in a routine EEG with a waking and sleeping EEG after sleep deprivation. Methodologic suggestions have been proposed but would probably only add further credence to the evidence for activation already widely accepted.

On the basis of detailed assessment of the evidence to date, the landmark 1984 review affirmed a substantial activating effect of both sleep and sleep deprivation on the occurrence of IEDs (Table). An activating effect of sleep itself is regarded as beyond question. One frequently referenced, early study showed an incremental yield of 25% for sedated sleep (and an additional 30%...
for sleep deprivation), starting with a base incidence of only 25% IEDs in routine records.\(^3\)

For sleep deprivation, the preponderance of evidence in 1984 suggested an activation yield of approximately 10% to 30% beyond the effects of sleep and an estimated 20% “sampling effect”—the yield of simply another EEG or longer tracings. Subsequent research\(^5,14-16\) has not overthrown that conclusion, which was rearticulated in the 2001 review.\(^7\) A 1998 critical study, although small and retrospective, adduced evidence for a 52% activation (less any sampling effect) in patients whose previous sleep tracings yielded no IEDs.\(^8\) However, negative evidence has been reported in a small minority of studies (the basis for the contrary findings being unclear).\(^1,7,9,13\)

The activating effect of sleep deprivation applies to all age groups but tends to be as great or greater in children.\(^10,17\) Sleep-deprived activation occurs in patients who are taking as well as not taking antiepileptic medication.\(^7\) Most studies point to a greater yield in non–rapid eye movement sleep stages 1 and 2. The activating effect of sleep deprivation applies to both generalized and partial seizures. These and other particulars are discussed and referenced in the 2 major reviews cited.\(^1,7\)

The issue of ordering a sleep-deprived EEG after an initial negative study has been much less controversial. In the 1998 report\(^6\) of patients with an initial negative awake and asleep EEG, a sleep-deprived EEG identified IEDs in slightly more than 50%.\(^6\) Building on a 29% yield from a first, routine EEG, one group found incremental IED yields of successive sleep-deprived EEGs, with nonsopharyngeal leads, of 17% of subjects having a second tracing, 13% for the third, and 10% for the fourth.\(^18\)

By comparison with activation by sleep deprivation, how effective are simple repetitions of an initial awake and asleep tracing? Investigators found an unusually high incidence of IEDs (80%) from a single-session awake and asleep recording.\(^4\) A single repeat of the same protocol improved the overall yield to 92%, which approximates the maximum cumulative IED yield by any method. Although such results exceed the norm, they call attention to the value of an initial sleep (and waking) tracing and of repetition.

Would sleep reduction (partial sleep deprivation), rather than the dominant research criterion of 24-hour sleep deprivation, produce activation beyond the effect of helping to induce sleep? Evidence is meager, but one study found that an age-dependent sleep reduction to only 5 hours for older, and up to 8 hours for younger, children yielded IEDs in 54% overall, at least partly through higher incidence of sleep.\(^6\) Further data are needed to ascertain the degree of specific activation by partial sleep deprivation. In any case, the results are provocative, since limited compliance effectively produces a sleep-reduced, rather than a fully sleep-deprived, condition in many outpatients.

Another alternative is prolonged, “ambulatory” EEG monitoring. A 1998 report found roughly comparable increases in IEDs—33% for 24-hour, ambulatory EEG and 24% for partial sleep deprivation—over routine EEG baselines.\(^11\) Seizure (ictal) discharges were seen in 15% of the patients undergoing ambulatory EEG.

### FROM EVIDENCE TO PRACTICE

The downside of full sleep deprivation involves substantial, unaccounted economic burdens, nonspecific disruption and stress, potential accidents, and occasional seizures. Patients kept awake through the night need to be accompanied to the test for safety. Thus, for tests done on an ambulatory basis, not only the patient but at least one other person typically loses time at work or school. Despite the clear preponderance of positive evidence noted herein, summarized in the 1984 and 2001 reviews\(^7\) and confirmed in key intervening studies,\(^8,9\) authors who have made recommendations have not suggested routine, full sleep deprivation for the first EEG for suspected seizure; its inconvenience\(^10\) outweighs the added value of the activation provided (Nathan B. Fountain, MD, written communication, August 2, 2000). Since those authors who offered advice did not specify the quantitative burden that inconvenience or what marginal yield would justify sleep deprivation, their recommendations (although they may represent the best current judgment) lack a balanced evidence basis. Thus, while the literature contains some conflicting results, a more striking disparity exists between the research evidence and the negative practice recommendations (for the initial EEG) by these experts and by those included in the survey.

The present state of guidance is perhaps best conveyed by 4 recent, authoritative articles. A review entitled “Uses and Abuses of the EEG in Epilepsy”\(^10\) does not mention sleep-deprived EEGs, although the authors state their own practice of an initial “routine and sleep EEG.” The 2001 review, despite finding strong evidence for sleep-deprived activation, offers no advice.\(^7\) In a prominent review of epilepsy for the generalist, the authors state their nonreferenced opinion that the initial EEG for suspected seizure should include sleep.\(^20\) If it is normal in the face of sufficient clinical suspicion, a repeated tracing should use not only sleep deprivation, but temporal and sphenoidal electrodes. If again normal, prolonged EEG and video monitoring should be performed. In contrast, the latest edition of Harrison’s textbook of internal medicine recommends that EEGs for suspected seizures should “ideally” be performed after sleep deprivation.\(^21\)

### TOWARD CLOSING THE GUIDANCE GAP

Little evidence, informed opinion, or guidance on sleep-deprived EEGs has penetrated to practitioners. Variable research results and uncertainty as to the added benefit vs burdens appear to have clouded the atmosphere of education and practice. Even lacking a sufficient evidence basis to issue a formal practice guideline, the expected cascade of reasoned information and advisories from professional societies, textbooks, and Web sites has not materialized.

Many epileptologists derive their personal recommendations for the first EEG in cases of suspected seizure from their overall judgment of good management, rather than simplistically from the evidence for the added yield of sleep deprivation. Those whom I contacted have modified their own practices, typically to omit full sleep deprivation for the initial EEG, but to reemphasize ob-
taining, if possible, a sleep tracing (acknowledging the difficulties of consistently inducing sleep). Full sleep deprivation is reserved for repeated testing when clinically indicated.

Improvement of diagnostic practice may best be served by comparative assessment of other approaches. Many of the experts whom I interviewed predicted that patients would increasingly be tested initially by prolonged "ambulatory" (outpatient, awake and asleep) EEG monitoring, with or without video, in place of sleep deprivation. Quite possibly the preferred diagnostic approach will become increasingly individualized, at least in the hands of neurologists, to capitalize on factors relevant to each case. Additional research is needed to demonstrate, for the initial EEG for suspected seizure, a net diagnostic benefit (and acceptable cost) of extended monitoring (and similarly for partial sleep deprivation).

In the meantime, epileptologists should seek consensus on what advice to offer regarding full sleep deprivation for the initial EEG. If sleep deprivation were to be ordinarily reserved for a follow-up EEG, should an attempted sleep tracing as part of the initial EEG (with or without previous sleep reduction) be established as a practice standard and "officially" publicized to nonneurologists? Instead, do technological advances, such as computer-assisted, ambulatory EEG and video monitoring, provide attractive alternatives that should be further researched and perhaps recommended for the first EEG? The neurologic profession, led by epileptologists, should accept the ongoing opportunity and responsibility to inform and guide its members and nonneurologists on current evidence and best practices for EEG diagnosis of suspected seizures.

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