Original Research Article

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Sundowning and Rate of Decline in Mental Function in Alzheimer's Disease

Abstract

Nocturnal exacerbation of disruptive behaviors has long been recognized as a common occurrence in Alzheimer's disease (AD), however the basis for such sleep disruption is poorly understood. In this study, caregivers of 60 patients with probable/possible AD were asked to indicate the typical temporal pattern of occurrence of any of seven disruptive behaviors over the 24-hour day. Patterns of disruptive behavior were defined as sundowning (afternoon, evening, or nocturnal exacerbation), morning exacerbation, and as a nontemporally specific pattern of behavioral disruption. About 28% of the patients were reported to sundown whereas 20% showed a pattern of morning exacerbation. Sundowning was unrelated to total score on the Mini-Mental State Exam (MMSE), however, sundowning was related to a faster rate of decline over time in selected mental functions on the MMSE. Specifically, declines in ideokinetic praxis abilities were related to sundowning.

Nocturnal exacerbation of behavioral disturbance has long been recognized as common in, but not unique to, Alzheimer's disease (AD) [1, 2]. Despite recent interest in the behavioral, noncognitive aspects of AD [3–8] however, surprisingly few studies have examined such sleep disturbance. The clinical phenomenology of all types of dementia often has included passing reference to nocturnal behavioral disruption [9, 10] and some recent AD rating scales have included disturbed sleep [11, 12] but empirically based descriptions of such phenomena are scarce. More specifically, little is known about how such nocturnal behavioral disruption, often labeled 'sundowning' [13, 14], relates to the course and severity of AD. Although the mechanisms of sundowning are poorly understood, its disruptive effects on the lives of caregivers can be striking. Sanford [15] reported sleep disturbance

was the most powerful predictor of institutionalization in dementia. Similar results have been reported recently by Pollak et al. [16].

Many sleep laboratory studies have documented the electroencephalographic sleep patterns of AD patients [17–26]. These studies generally have shown that AD patients have lower sleep efficiencies, less slow wave sleep, and, possibly, less REM sleep than age-matched controls. Moreover, these findings are partially related to the severity of the dementia [20, 25, 26]. Findings regarding sleep apnea have been equivocal to date [27–30]. With the exception of occasional observations [29] most laboratory studies do not directly address the disruptive nocturnal behaviors experienced by the patients and their families, though Hoch et al. [28] noted that nocturnal awakenings requiring staff contact did not appear linked

to sleep apneic events. The laboratory studies have probably not clarified what happens in sundowning because of the inherent selection bias in studying such patients in the sleep lab. Patients who are severely agitated simply cannot tolerate the procedures associated with conventional polysomnography.

The few descriptive studies of AD which have mentioned the clinical phenomenology of sleep disturbance have viewed such nocturnal disruption from widely varying perspectives. Merriam et al. [31], for example, considered sleep disruption as a psychiatric symptom of depression in AD rather than as a function of CNS degeneration per se. Given known areas of degeneration in AD in the hypothalamic centers controlling circadian rhythms of rest/activity and sleep/wake [32], there may be more reason to view sundowning as a direct function of neuronal deterioration. In this framework Swearer et al. [6] reported no differences between AD patients and patients with multi-infarct dementia in the proportion of those experiencing sleep disturbance, unlike an early report by Hachinski et al. [33]. Yet another aspect of sleep disturbance in AD which remains unclear is when in the course of the illness these symptoms are seen. For example, it is often assumed that such exacerbation occurs late in dementia yet few data exist on this issue. In one retrospective study based on caregivers' recall of events in past years, Volicer et al. [34] reported that sleep disturbance occurred after loss of self-dressing ability but before loss of self-feeding ability and limb contractures.

In this study we present data from caregiver reports of AD patients which indicated *when* during the 24-hour day disruption behaviors were likely to occur. By relating such reports to measures of rate of decline of mental status in AD, we hoped to gain a better understanding of how sundowning related to the course of the illness.

Method

Subjects

Sixty AD patients and their caregivers enrolled in a Clinical Research Center for the study of AD completed a time-based behavioral disturbance questionnaire (TBDQ) (see Appendix) inquiring about the patient's temporal pattern of disruptive behavior. In 54 cases, the caregivers were spouses of patients who had resided with the patients. In the remaining cases, a child (n = 3) or other employed caregiver (n = 3) completed the form. All of the patients resided in private homes. Of the 60 patients, 46 carried a NINCDS-ADRDA classification [35] of probable AD and 14 carried a diagnosis of possible AD. Of these patients, 5 have now been confirmed neuropathologically. The mean age was 63.3 (SD = 7.2). There were 43 men and 17 women.

Procedures

The TBDQ was devised to examine the time of day caregivers most typically experienced seven common behavioral symptoms of AD within the last month. We defined sundowning as afternoon, evening, or nocturnal exacerbation of behavioral disturbance. In order to maintain caregiver cooperation, more precise temporal delineation was not specified inasmuch as pilot work suggested that requests for the caregiver to be more temporally specific produced more refusals and 'don't know' responses. Our assumption was that caregivers were probably at least somewhat sensitive to when behavioral symptoms typically occurred. A response was considered to indicate sundowning when the caregiver indicated that the behavior was likely in the afternoon, evening, and/or at night but not in the morning. If a given behavior occurred just in the morning, if it occurred at all times of day (as indicated by a positive response to all 4 possibilities) or if the time of day was unspecified (question answered affirmatively without further elaboration) the behavior was considered 'negative' for sundowning. The score for sundowning was the sum of behaviors for each patient meeting the aforementioned criteria. In addition, a score for morning exacerbation, defined by the number of behaviors for each patient with a morning-only response pattern, was derived. Finally, the number of disruptive behaviors exhibited by the patient, regardless of time of occurrence, was also derived. For these three variables (sundowning, morning exacerbation, or any disruptive behaviors), the score for each patient ranged from 0 to 7, corresponding to the number of behaviors fitting that temporal pattern. Frequency histograms for the 60 patients on these variables are shown in figure 1.

Some explanation of our use of night, evening *and* afternoon time periods (thus encompassing well over half the 24-hour period) to define sundowning behavior on the TBDQ is necessary. Our primary goal in using the TBDQ was to use caregivers' own experiences with the patient's behavior, however imprecise, to gather some time-based data on when disruptive behaviors occur. Because it is conceivable that at certain times of year 'sunset' could encompass 4 or 5 p.m., we wanted a definition of sundowning to be as broadly inclusive as possible. In addition, by examining a morning exacerbation pattern and a nontemporally specific pattern we hoped to provide some discriminative validity for caregivers' reports of when such behavior occurred. Thus, we viewed the generation of valid caregiver data on sundowning depending less upon a specific set of clock times of equal duration than upon a caregiver's accumulated experience about when he or she thought disruptive behavior was likely to have occurred.

Because a major goal of the Clinical Research Center is to describe the longitudinal course of dementia and examine its behavioral correlates [36], patients in the center are followed over time with the Mini-Mental State Exam (MMSE) [37] as well other measures [36]. Psychometrically derived 'dynamic' factor scores are used to describe the decline in mental function over the ensuing years of the illness [36] using a two-stage random effects model [38]. In our preliminary work using such a model for the MMSE, we obtained five factors accounting for 75% of the variance in declining mental function. These factors (I–V) can be roughly labeled and summarized as: (I) orientation; (II) ideo-kinetic praxis; (III) auditory-verbal praxis; (IV) expressive aphasia, and (V) memory. A slope is derived for each factor for each patient describing the relative rate of decline (per standardized unit of time, i.e. 12 months). Because all factors are transformed on a 0 to 1 scale, all slopes are comparable in terms of range, but not slope, of decline [36]. In brief, a steeper decline of a

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particular mental function is indicated by a more negative slope on a given function. Thus, a slope of 0.10 means a 10% decline of function per year whereas a slope of 0.20 means a 20% decline over the same period of time. Calculations are made on an individual only when at least 3 MMSEs are administered over a total interval of at least 2 years. Because each patient has a slope for each factor, it is possible to correlate a given static variable for that patient (i.e. a variable at a single time point) with each of 5 different slopes.

The caregiver completed the TBDQ at some point in the patient's course in the CRC. Mean MMSE at time of entry in the CRC was 18.1 (SD = 8.2); mean MMSE at time of TBDQ administration was 15.0 (SD = 9.0). In 33 cases, TBDQ administration occurred within a year of entry, however in 10 cases, entry into the CRC preceded the TBDQ by 1–2 years and in 17 cases, by 2 years or more. In order to examine the relationship between *rate of decline* of mental function and sundowning we related sundowning score to each of the 5 factor slopes. In order to examine the relationship between *overall level of dementia* and sundowning, we correlated MMSE score at time of entry into the center and at the time of TBDQ administration.

Results

Figure 1a suggests that, using a definition of at least one sundowning behavior, the 1-month prevalence of sundowning would appear to be about 28% (17/60), though the prevalence of more marked behavioral disruption (3 or more behaviors) would be much lower (10%, 6/60). The most commonly endorsed sundowning behaviors on the TBDQ were: agitation (n = 7), disorientation, confusion, and combativeness (all n = 5), hallucinations (n = 4), and wandering and incoherence (both n = 3). Morning exacerbation (fig. 1b) was somewhat less common (20%, 12/60) and this pattern appeared to be more mild in that morning disruption was never indicated by the caregiver for more than 2 behaviors. In general, morning exacerbation and sundowning were only somewhat related within individuals (rho = –0.19, p < 0.08) with virtually no overlap. Only one individual was reported by his caregiver to show both morning exacerbation and sundowning (on different behaviors).

Figure 1c demonstrates that, for most of these patients, the caregivers noted that, regardless of temporal referent, the disruptive behaviors did occur over the past month. Only in 9 patients were disruptive behaviors completely absent. As would be expected, there were positive correlations between the total number of disruptive behaviors and the number of sundowning behaviors (rho = 0.37, p < 0.005) and the number of behaviors with morning exacerbation (rho = 0.21, p < 0.06). For the group of 60 patients there were no correlations between sundowning and morning exacerbation scores and MMSE at time of TBDQ administration. There was a significant negative
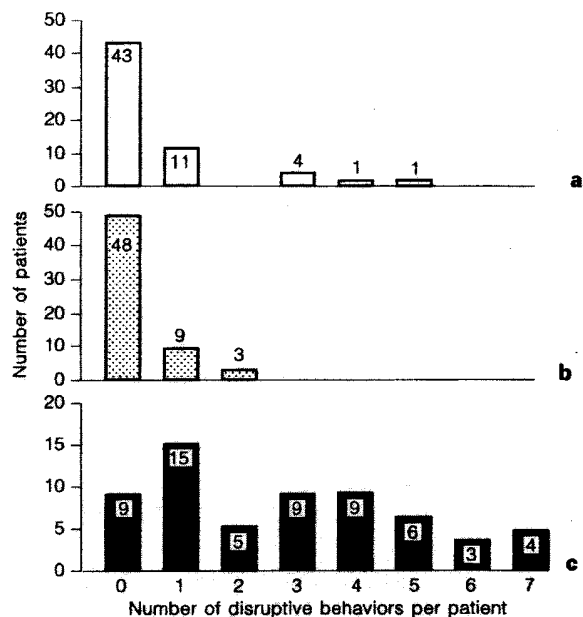

Fig. 1. Frequency distributions indicating number of disruptive behaviors (range 0–7) per patient for (**a**) sundowning (afternoon, evening and/or night pattern); (**b**) morning pattern; (**c**) any time of day.

correlation between this MMSE and number of non-temporally specified disruptive behaviors (fig. 1c) (rho = –0.36, p < 0.005), indicating lower MMSE scores were associated generally with a greater number of disruptive behaviors.

Because of our interest in relating slope of decline of mental function in dementia to sundowning, we examined those individuals for whom at least 3 MMSEs were available on which to generate slope measures (n = 47). Means (SDs) of the five slopes were as follows: I (mean = –0.069, SD = 0.070); II (mean = –0.127, SD = 0.149); III (mean = –0.098, SD = 0.170); IV (mean = –0.087, SD = 0.111); V (mean = –0.027, SD = 0.069). Intersubject variability (using coefficients of variation) indicated that factor V showed the greatest individual differences followed by (in descending order) factors III, IV, II, and I. Of these 47 individuals with slope data, a sundowning score of greater than 0 occurred in 15 cases. T-tests were then performed between these 15 cases and the remaining 32 cases on each individual's factor slopes (table 1). The results indicate that a steeper slope of decline for factor II (ideo-kinetic apraxia) was associated with sundowning. No other factors differentiated the groups. There were no sig-

Table 1. Comparison of slope of decline in sundowning and non-sundowning patients[1]

Slope	Putative function	$\bar{X}$ (SD) Sundowning (n = 15)	$\bar{X}$ (SD) Non-sundowning (n = 32)	t	p
I	orientation	−0.068 (0.07)	−0.070 (0.07)	0.05	NS
II	ideo-kinetic praxis	−0.191 (0.17)	−0.098 (0.13)	2.07	<0.05
III	auditory-verbal praxis	−0.099 (0.11)	−0.098 (0.20)	0.03	NS
IV	expressive aphasia	−0.091 (0.13)	−0.085 (0.10)	0.16	NS
V	memory	−0.043 (0.05)	−0.020 (0.08)	1.22	NS

[1] Data presented for 47 patients with at least 3 times of measurement on MMSE to generate data on slopes for each case.

nificant differences between groups with (n = 11) or without (n = 36) morning exacerbation (score ≥ 1) on the slopes of factors I–V. Factor II consisted of the items on the MMSE involving the three-stage command to 'take a piece of paper in your right hand, fold it in half, and place it on the floor' (3 points) and the command to 'close your eyes' (1 point).

As a check on the relative strength of relationship between slope of decline of factor II and sundowning, we performed a stepwise multiple regression predicting the sundowning score from each individual's slope on factor II, initial MMSE score, and MMSE score at time of TBDQ administration. The resulting regression was highly significant (F = 7.84, p < 0.01) and accounted for 12.9% of the variance with only the slope of factor II entering in the regression ($\beta = -0.39$, t = 2.80, p < 0.01). A parallel regression predicting morning exacerbation score was nonsignificant, and a regression predicting the number of disruptive behaviors regardless of temporal pattern was significant (F = 8.55, p < 0.01) but included only MMSE at time of TBDQ administration.

Sundowning and morning exacerbation (defined as scores of greater than or equal to 1), respectively, were unrelated to sex or positive family history of dementia. Age of onset was also unrelated to these patterns.

Discussion

These results suggested that sundowing patients showed a steeper rate of decline in selected mental abilities relative to individuals who did not sundown. The decline was seen specifically in praxis functions involving ability to respond nonverbally to environmental cues. Whether decline in such functions may be related to inability to process environmental zeitgebers of day and

night or light and dark, as has been speculated to underlie sundowning [13], is unclear, but to the extent that the demented individual must respond behaviorally to his or her specific environment there would appear to be some gross parallels. Sundowning was *not* related to *overall level* of mental function on the MMSE, either at time of entry into the study or at time of TBDQ administration, thus suggesting that it is *rate* of decline of function rather than absolute level of function which is most critical. It is still possible, however, that because the MMSE is a relatively crude psychometric, a more thorough evaluation of mental function at a single point in time might reveal relationships between sundowning and absolute levels of function.

Certainly our method of assessing sundowning, caregiver report, is not infallible and could be influenced by many factors. Individual differences in the caregivers' depth of sleep may be one such factor. For example, a caregiver who is already predisposed to poor sleep might be more disturbed by a demented family member's wandering whereas one sleeping well might be unaware of the nocturnal behavior. Another factor may be caregiver biases. For example, a highly distressed caregiver may exaggerate the extent of nocturnal disruption. Alternate approaches such as 24-hour activity monitoring [39, 40], may provide useful validation for these caregiver observations. In one such study, Witting et al. [41] reported that AD patients were characterized by higher intra- and inter-daily variability in their rest activity rhythms than aged controls. Conceivably such widely varying activity levels might be consistent with sundowning. Yet another approach used successfully in an institutional setting is systematic behavioral observations [42]. This would not be feasible with the current patient group as none of these individuals were institutionalized at the time of the study. Although alternative approaches such as these could po-

tentially allow for more objective study of disruptive behaviors, the assessment of sundowning with the TBDQ is afforded at least some construct validation in that neither disruptive behaviors in general nor disruptive behaviors linked to the morning hours related to rate of mental decline.

When placed in the context of the growing literature on behavioral disruption in dementia [3–8], our results are neither surprising nor unexpected. A number of studies have shown that behavioral disturbances and agitated behavior are more likely to occur in more severe dementia [3–5, 7], and some of these studies have confirmed this over the longitudinal course of dementia as well. Using logistic models based on both the MMSE (for cognition) and the Blessed Dementia Rating Scale (for functional capacity), Stern et al. [5] noted that psychotic symptoms were strong predictors of rate of decline in both cognition and self-care activities. Drevets and Rubin [3] noted similar associations between psychotic symptoms (but not mortality) and rate of mental deterioration as assessed with the Clinical Dementia Rating Scale. More recently, Rosen and Zubenko [4] and Teri et al. [7] have reported similar results using the MMSE. What is missing in all of these studies is at least some description of when in the 24-hour day the psychosis and agitation are manifest. Our study complements this previous work and suggests that nocturnal behavior disruption may be related to rate of decline in specific aspects of mental function.

As mentioned previously, use of a single brief measure of mental status (MMSE) to describe decline of cognition in AD has limitations, though the issue is complex and may not be resolved by using a larger number of tests. Berg and colleagues [43, 44] have shown convincingly that with a large battery of neuropsychological tests and mental status exams, rates of change vary widely depending on which psychometric is considered. They strongly consider use of a diverse set of instruments to assess cognitive changes in AD. Salmon et al. [45], however, noted extremely high correlations among three mental status exams in AD and Katzman et al. [46] reported fairly consistent rates of change in the Blessed information-memory-concentration test regardless of population considered, so long as initial level of performance was taken into account. In another longitudinal study, Becker et al. [47] reported that although psychometric testing could clearly differentiate two subtypes of neuropsychological dysfunction in AD (lexical/semantic vs. visuospatial), the rate of decline was similar in the two groups. In our study, random effects regression lines for each of 11 MMSE components yielded 5 dynamic factors of decline. These 5 factors were, by definition, orthogonal and represented brief, but diverse samples of mental function. It is worthy of note that although sundowning related to the slope in one of these factors (II) this was not the slope of decline representing the largest differences across individuals (i.e. highest coefficients of variation).

The 1-month prevalence of sundowning (about 30%) in these noninstitutional AD patients is relatively consistent with the median prevalence figures for delusions, hallucinations and other psychotic symptoms in the review of Wragg and Jeste [8], which typically fell in the 30–40% range. Those few studies providing data on the prevalence of clinically important sleep disturbance in AD show nearly identical figures of 42 [12], 44 [31], and 45% [6]. These figures may be slightly higher than ours because our definition refers not simply to poor sleep but to a somewhat more specific pattern of behavioral disruption linked to the nocturnal hours. We encourage others interested in the noncognitive symptoms of AD to investigate the temporal pattern of occurrence of such behaviors to expand upon the small number of studies currently investigating this phenomenon.

Acknowledgements

Appendix

Behavioral Disturbance Questionnaire

Patient Name _____

Date _____

Respondent Name _____

Relation to Patient _____

1 How long have you known the patient?

_____ (Years)

2 Have you observed periods of combativeness in the patient?

    Y   N

When do these periods occur?

    Morn _____ Afternoon _____ Eve _____ Night _____

3 Have you observed periods of agitation and purposeless movement?

    Y   N

When do these periods occur?

    Morn _____ Afternoon _____ Eve _____ Night _____

4 Have you observed periods of wandering?

    Y   N

When do these periods occur?

    Morn _____ Afternoon _____ Eve _____ Night _____

5 Have you observed prolonged periods of incoherent speech (over 5 minutes)?

    Y   N

When do these periods occur?

    Morn _____ Afternoon _____ Eve _____ Night _____

6 Have you observed hallucinations or misinterpretations of the environment?

    Y   N

When do these periods occur?

    Morn _____ Afternoon _____ Eve _____ Night _____

7 Have you observed periods of confusion?

    Y   N

When do these periods occur?

    Morn _____ Afternoon _____ Eve _____ Night _____

8 Have you observed periods of disorientation?

    Y   N

When do these periods occur?

    Morn _____ Afternoon _____ Eve _____ Night _____

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