Circadian Rhythm Abnormalities of Wrist Activity of Institutionalized Dependent Elderly Persons With Dementia

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Background. The study objective was to clarify the descriptive characteristics of circadian rhythm abnormalities of wrist activity of the institutionalized elderly with dementia.

Methods. We studied 82 elderly persons with dementia who were institutionalized in a long-term medical care facility. The ambulatory continuous monitoring of their wrist activity was conducted for 7 days at 1-minute intervals. The time series data were analyzed using the double-plotted chronogram, spectral analysis was performed using the fast Fourier transformation and periodogram analysis was performed as well.

Results. The frequency of circadian rhythm abnormalities of wrist activity rhythm in elderly persons with dementia was 57.3% (47 out of 82). The abnormalities were classified into four categories: severely impaired circadian rhythm type with no boundary between day and night, free-running rhythm type, decreased circadian amplitude type, and accentuation of ultradian rhythm type.

Conclusion. This four-category classification system provides a scientific approach for studying the mechanisms of circadian activity rhythm abnormalities of elderly persons with dementia.

It has been reported that circadian rhythms of the sleep-wake cycle and body temperature are frequently impaired in the elderly with dementia (1,2). The mechanism of the abnormalities of circadian rhythm is considered to be a disruption of circadian oscillation caused by pathological changes in the suprachiasmatic nucleus (3) and the reduction of external synchronizers associated with dementia (4).

Continuous monitoring of wrist activity rhythm has been considered useful for evaluating abnormalities of the sleep-wake rhythm in persons with dementia (5) because it is a noninvasive and acceptable way of measuring sleep-wake rhythm even in dependent elderly individuals. This methodology enables long-term monitoring of behavioral rhythms and provides a sufficient amount of data for quantitative chronobiological analysis.

Some researchers have reported that rest-activity rhythms of elderly persons with dementia were disturbed in institutionalized patients (5,6). Recently, Honma and colleagues (6) classified the circadian activity patterns of 13 demented patients with delirium into the following four patterns: nocturnal delirium type, wandering type, hypobulia type, and lying-down type. This classification system should be useful for both diagnosis and therapeutic decision making in clinical medicine, although more data are required for validation. In the present study, we studied the circadian rhythm of wrist activity of dependent elderly persons with dementia who were institutionalized in a long-term medical care facility because we hoped to develop a classification of circadian rhythm abnormalities of elderly persons with dementia.

METHODS

Subjects

The subjects were 82 elderly persons (10 men and 72 women; mean age 81.6 ± 5.9 years) with dementia who were institutionalized in a long-term medical care facility in the northern part of the Tohoku district of Japan. The clinical diagnosis of dementia was made by a physician at the facility based on (i) clinical course, suggesting senile dementia of the Alzheimer’s type (SDA) or multi-infarct dementia (MID); (ii) clinical history of hypertension or evidence of vascular brain disease on CT scan findings, indicating MID; and (iii) focal neurological deficit. A total of 55 elderly subjects were diagnosed as having MID, 11 were diagnosed as having SDA, and 16 were diagnosed as having dementia of the mixed type. Informed consent was obtained from the subjects or from their nearest relatives.

Continuous Monitoring of Wrist Activity

The ambulatory continuous monitoring of wrist activity was conducted with an Actiwatch (Mini-Mitter Co. Inc., Oxford, UK), a 27 × 26 × 9-mm device worn on the subject’s wrist, which measures spontaneous wrist activity. The device contains a piezoelectric linear accelerometer (sensitive to 0.003 g and above) that records both intensity and frequency of wrist movement. Over a period of 7 days, we took measurements at 1-minute intervals; measurements were made continuously except while bathing. We instructed the subjects to go about their daily lives as usual during the measurement period. The data were analyzed us-
Figure 1. Four types of circadian rhythm abnormalities. A, Severely impaired circadian rhythm with no boundary between day and night. The subject was a 79-year-old woman with multi-infarct dementia. B, Free-running rhythm type. The subject was a 74-year-old woman with dementia of the Alzheimer’s type. Both rising times and bed times seemed to phase-delay day by day. The periodogram analysis showed the dominant circadian period of 24.2 hours. C, Decreased circadian amplitude type. The subject was an 87-year-old man with multi-infarct dementia. D, Accentuation of ultradian rhythm type. The subject was a 92-year-old woman with multi-infarct dementia. She had an activity period of 3 to 4 hours, which almost coincided with toilet activity and short-term sleep.
ing the double-plotted chronogram, spectral analysis by the fast Fourier transformation, and periodogram analysis (7).

**RESULTS**

Of the elderly subjects with dementia, 57.3% (47 out of 82) showed circadian rhythm abnormalities of wrist activity rhythm, which were classified into four categories: (i) severely impaired circadian rhythm type with no boundary between day and night (30.5%), (ii) free-running rhythm type (12.2%), (iii) decreased circadian amplitude type (7.3%), and (iv) accentuation of ultradian rhythm type (7.3%).

In the severely impaired circadian rhythm type (Figure 1A), the boundary between day and night disappeared. The dominant circadian period of 24 hours was greatly decreased by the power spectral analysis, and the most frequently observed behavioral abnormality was wandering during the night.

In the free-running rhythm type (Figure 1B), both rising times and bed times seemed to phase-delay day by day by the visual inspection of the double-plotted chronogram. The power spectral density of 24 hours was less than that of 8 hours. This meant that a dominant circadian period of wrist activity differed from 24 hours. Periodogram analysis showed the dominant circadian period of 24.2 hours (data not shown). In this type, the dominant circadian period was greater than 24 hours in nine subjects, and less than 24 hours in one subject.

In the decreased circadian amplitude type (Figure 1C), the amount of wrist activity per day decreased. Activities of daily living were generally low, and based on our survey of daily pattern of activities, we found that these elderly persons exhibited a low level of physical activity, remaining, for the most part, in their bedrooms.

In the last category, the accentuation of ultradian rhythm type (Figure 1D), we observed an activity period of 3 to 4 hours, which almost coincided with toilet activity and short-term sleep.

**DISCUSSION**

The category, severely impaired circadian rhythm with no boundary between day and night, was considered to be a circadian rhythm abnormality related to internal desynchronization of circadian rhythms (8); that is, the dominant circadian period of wrist activity differed from 24 hours. This type of abnormality was relatively easily recognized by visual inspection by caregivers. However, in this study we found several cases in which nocturnal abnormalities were missed by caregivers because the abnormal activities were restricted to awakening and moving on the bed during the night and did not demand care services. Objective assessment of nocturnal activity by ambulatory monitoring of wrist activity proved to be an effective method of evaluating the nocturnal behavioral abnormalities of institutionalized, dependent dementia patients.

Free-running rhythm was classified as another type of desynchronized rhythm abnormality, although it was found to be less frequent than severely impaired circadian rhythm without boundary between day and night. Because the change in circadian rhythm activity of the free-running rhythm was not as great as that of severely impaired circadian rhythm, it seemed to be less recognized by caregivers. This type of patient may be more active during the night if the free running of activity rhythm is always present and the onset of the activity rhythm occurs during the night.

In the decreased circadian amplitude type, behavioral activity decreased in both daytime and nighttime. These elderly individuals stayed in bed almost the entire day. In spite of the decreased circadian amplitude, the circadian rhythm of wrist activity with a period of 24 hours was found in this type of subject.

The accentuation of ultradian rhythms in patients was the same as the decrease in circadian amplitude in patients with totally decreased activity rhythm. However, the transient increase in activity corresponded to toilet activity and short-term sleep with periods in the ultradian domain. The physical activity of daily living in this type of patient was higher than that of patients with decreased circadian amplitude.

Honma and colleagues (6) reported that the circadian activity patterns of demented patients with delirium could be classified into the following four types: nocturnal delirium type, wandering type, hypobulia type, and lying-down type. This classification and nomenclature were based on clinical observation of patients’ behaviors, whereas our classification and nomenclature are based on the characteristics of the chronobiological parameters of activity rhythm. The classification of abnormalities is nearly the same, but the free-running rhythm type is not described in the literature, and the frequencies of the types of abnormalities are never mentioned.

In the suprachiasmatic nuclei, pathological changes (such as a decrease in volume of the suprachiasmatic nucleus) have been suggested as the mechanism of behavioral abnormalities of the elderly with dementia (3). The other possibility is attenuation of the interaction between the external entrainment factors and the circadian clock mechanism (4,9). Procedures for reinforcing circadian rhythm by bright-light exposure and administration of methylcobalamin have been reported to be effective in resynchronizing circadian rhythm abnormalities in elderly persons with dementia (10).

In conclusion, the classification of circadian rhythm abnormalities of the elderly with dementia seems to provide a scientific approach for studying the mechanisms of circadian activity rhythm abnormalities and evaluating the temporal needs for providing care services in the elderly with dementia.

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