Circadian rhythm of hospital death: difference between the intensive care unit and general room

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Abstract - *The purpose of the present study was to record the time at which biological phenomena stop in different hospital wards and determine regular patterns in times of death, as well as any factors involved. A comparative analysis was conducted for the morality distribution between the intensive care unit (ICU) and general rooms (GR), according to year, month, day of week, and hour of day, disease entity, as well as the age and sex of the patients. We collected the data on all deaths in ICU and GR during 7 years and analyzed by cross analysis process, which shows absolute numbers and proportions, for comparison of each wards. There are obvious differences in circadian rhythm between ICU and GR, it may be accounted for by the presence of preserved circadian rhythm.*

Keywords: Circadian rhythm, Chronobiology phenomena, Biological clocks

1 Introduction

Circadian rhythms are vital in adapting to changes in one's environment and sustaining life. Existing research illuminates the effects of changes in the circadian rhythms of animals. The suprachiasmatic nucleus (SCN) of the hypothalamus plays the most important role in the maintenance of the mammalian biological clock [1,2]. The SCN receives photosensitive information through the eyes, and its malfunction completely eliminates rhythms concerning regular sleeping and waking patterns. The retina includes not only regular photoreceptors, which participate in visual perception, but also light-sensitive photosensitive ganglion cells. These cells contain photopigments called melanopsin, through which they detect light. The detected light travels via the retinohypothalamic tract to the SCN, thus affecting biological rhythms. That is, the SCN receives information regarding the length of day and night via the retina and interprets it, after which it signals the pineal gland of the hypothalamus to secrete melatonin. The melatonin secretion level is at its highest during the night and lowest during the day. However, centuries of civilization and industrialization, and changes in living patterns and hobbies in humans are speculated to have brought about a change of behavior in daily, weekly, and even yearly activities of people, and thus caused human circadian rhythms to evolve. Death occurs when biological regulatory functions that maintain homeostasis stop working. Existing studies suggest that circadian rhythms and biological clocks may affect homeostasis, although results of previous research studies do not show consensus on the matter. The purpose of the present study was to record the time at which biological phenomena stop in different hospital wards and determine regular patterns in times of death, as well as any factors involved.

2 Materials and Methods

This study is a retrospective study which enrolled inpatients at the Keimyung University Dongsan Medical Center who died over 7 years, between January 2006 and December 2012. A comparative analysis was conducted for the morality distribution between the intensive care unit (ICU) and general rooms (GR), according to year, month, day of week, and hour of day, disease entity, as well as the age and sex of the patients. We collected the data on all deaths in ICU and GR during 7 years and analyzed by cross analysis process, which shows absolute numbers and proportions, for comparison of each wards. The Statistical significance level was set at 5% and all calculations were two-tailed. The flow of mortality case in ICU and GR was analyzed by annually, monthly, and weekly. The daily pattern of death was divided by 2-hour periods, proportion of death in age was divided by decade. The mortality case in two wards was compared by sex, surgical status and the format of mortality distribution was used by international classification of disease (ICD) categories.

3 Results and Discussion

A total of 6517 patients died, among whom 3198 (49%) were from the Intensive Care Unit (ICU) and 3319 (51%) were from the General Room (GR). Year-wise, of the 3198 (49%) who died in the ICU, 433 (13.7%) died in 2010, 468 (14.6%) died in 2011, and 489 (15.3%) died in 2012, thus

showing an increase over the most recent 3 years. Of the 3319 who died in the GR, 495 (14.9%) died in 2010, 470 (14.2%) died in 2011, and 447 (13.5%) died in 2012, thus showing a decrease over the most recent 3 years (P = 0.06). The number of deaths in the ICU notably increased on a yearly basis despite advances in medical techniques and information.

In terms of months, the ICU saw the highest number of mortalities in January (9.5%) and September (8.8%), whereas the GR saw the highest number of mortalities in January (9.1%) and August (9.0%) (P = 0.87). When analyzed by days of the week, the highest mortality rate occurred in the ICU on Wednesdays (14.9%), as opposed to Sundays (14.8%) in the GR. (P = 0.60).

When mortality rate was examined in 1-hour intervals, no statistical difference was found between the two wards (P = 0.09). When examined in 2-hour intervals, the ICU peaked in mortality between 14–16 (9.2%) and 20–22 hours (9.1%), whereas the GR peaked in mortality between 6–8 (9.6%) and 10–12 hours (9.4%), with a significant statistical difference between the two wards (P = 0.03; Table 1).

Table 1. Mortality rate by hour of day (P = 0.03).

Hour \ Ward	ICU	GR	Total
0–2	277 (8.7%)	245 (7.4%)	522
2–4	256 (8.0%)	270 (8.1%)	526
4–6	230 (7.2%)	303 (9.1%)	533
6–8	266 (8.3%)	318 (9.6%)	584
8–10	252 (7.9%)	279 (8.4%)	531
10–12	287 (9.0%)	312 (9.4%)	599
12–14	269 (8.4%)	286 (8.6%)	555
14–16	294 (9.2%)	260 (7.8%)	554
16–18	265 (8.3%)	270 (8.1%)	535
18–20	247 (7.7%)	254 (7.6%)	501
20–22	290 (9.1%)	263 (7.9%)	553
22–24	265 (8.3%)	259 (7.8%)	524
Total	3198 (100%)	3319 (100%)	6517

Differences in mortality rates, as according to time of day or day of the week, have been researched most commonly in terms of cardiovascular diseases [3-7]. In the present study, the high mortality rate in the early morning hours (4–6 AM) in the GR may be corroborated by such studies as shown in Table 1. The reason for the lack of such an effect in the ICU may be that endogenous circadian rhythms are changed as the excretion of melatonin from the pineal gland is affected by the use of various sympathomimetic and sedative drugs, as well as the environment such as a hospital ward, in which daytime and nighttime differences are unclear. Hourly melatonin secretion levels have not been measured in the present study, but future studies may be able to analyze the mortality rate differences between the ICU and GR by investigating the causal relationship between melatonin secretion and circadian rhythms.

When analyzed by age, mortality occurred most often in those aged in their 60s (ICU, 25.7%; GR, 26.2%) and 70s (ICU, 28.5%; GR, 24.2%) (P < 0.01). When analyzed by sex, mortality occurred more so in men in both groups (ICU, 59.8%; GR, 62.0%), but this effect was not statistically significant (P = 0.07). When analyzed by group, the patients whose diseases fell under group I (diseases of the circulatory system) of the ICD died most often in the ICU (28.3%), whereas those whose diseases fell under group C (neoplasms) had the highest mortality rate in the GR (77.7%). The difference was statistically significant (P < 0.01). When analyzed by surgical status, in both wards, the patients who did not receive any surgical treatment had significantly higher mortality than those who did (P < 0.01).

4 Conclusions

The difference between ICU and GR is notable in diurnal variation. The point of this difference is explained by presence of preserved circadian rhythm. Because ICU patients might have been influenced by more factors of environmental changes than GR patients such as differences in disease distribution, hospital room environments, use of various drugs, ICU patients represent changes in circadian rhythm compared with GR patients. However, the limitation of our study is that we have not investigated direct causation of circadian variation and such factors mentioned above.

5 References

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