SYNOPSIS

KEY POINT SUMMARY

OBJECTIVES

The main objective of the study was to identify the profiles of acoustical disruptions in hospitals during sleep by studying and analyzing the cortical arousal responses to sound level, type, and sleep stage (REM and NREM).

Sleep Disruption due to Hospital Noises: A Prospective Evaluation

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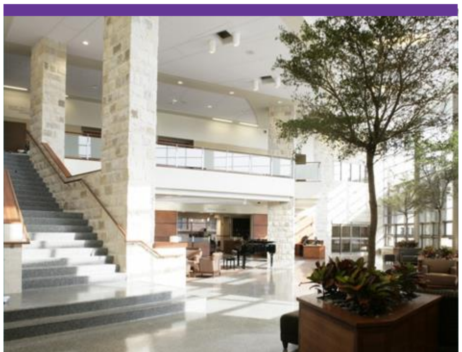
Key Concepts/Context

Hospital noises can have a negative effect on a patient's sleep pattern. Sleep disruption is associated with hypertension, cardiovascular disease, impaired immunity, and elevated stress. Limited information is available on the connection between specific sounds and sleep physiology. However, there is evidence that during sleep the brain responds differently to noises during rapid eye movement (REM) compared to non-rapid eye movement (NREM) stages. These are intervals that occur during sleep and have different physical characteristics. This study examined various responses to hospital noise during all sleep stages to explore the differences in sleep disruption.

Methods

The study was conducted over a three-day period in a sound-attenuated sleep lab using a sample of 12 healthy participants at a general hospital in Massachusetts. They were recruited through several means and were screened using a questionnaire, physical examination, and lab tests. The exclusion criteria included history of drug or alcohol abuse, depression, anxiety, post-traumatic stress and obsessive-compulsive disorders, neurologic and sleep disorders, infectious diseases, diseases of the cardiovascular system, and treatment with anti-depressants, neuroleptics, and major tranquilizers. Normal hearing was confirmed in the 12 participants through audiometric screening. They were asked to sleep at home on a regular schedule for a minimum of four days before the study and they were given 8.5 hours of sleep periods beginning at their normal bedtimes. The first night provided the baseline, so they slept undisturbed to adjust to the equipment and the lab environment. It was followed by two nights of exposure to 14 common hospital noises like voice, intravenous alarm, phone, ice machine, outside traffic, and helicopter flyover. Four studio monitor loudspeakers were placed above their



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heads. Sound levels were measured in one-second increments using an environmental sound monitor. The noises were presented in a random order generated by a computer during each sleep stage throughout the two nights. The sounds were introduced using an increasing decibel level adjusted for normal hearing. After a period of steady sleep was recorded, the stimuli were presented starting at 40 dBA and increasing by 5 dBA until sleep was disrupted, a change in sleep stage occurred, or the maximum noise level of 70 dBA was reached.

The measurements were made by encephalographic arousals using a criteria during REM and NREM sleep. The NREM stage had progressively deepening sleep levels, N1, N2, and N3. N2 was the longest deepening sleep stage while the N3 was the deepest sleep stage level. A protocol was designed to study the influence of graded noise through polysomnographic (PSG) sleep assessments. During the study electroencephalograms (EEGs) arousals and electrocardiogram heart rate increases were recorded. Heart rate increases were expected during sleep exposure to hospital noises. Standard PSG recordings were collected using skin surface electrodes during the three nights. Sleep stages and the arousals were identified based on the current criteria. An abrupt shift of EEG frequency for more than three seconds indicated a standard arousal. REM sleep arousals required a concurrent increase in submental electromyogram activity. A sleep technician assessed body position by watching infrared videos on the same screen as the EEG signals. Other tasks were coordinated by a sleep technician maintaining PSG signal quality classification of sleep stages, the identification of cortical arousals, and the documentation of body positions. Another technician maintained the acoustic equipment and presented the increasing noise stimuli. In addition, a sleep physician resolved any discrepancies with real-time scoring. A statistical analysis followed and graphs were used to examine the probability of arousal by stimulus, sound level, type, and sleep stage.

Findings

The arousal response curves varied because of the sound level, type, and sleep stage. There were wide differences in responses depending on the sound type with electronic sounds being more arousing than other sounds at the same level. Louder sounds caused more sleep disruptions and the effects varied by the type of stimulus. Arousal effects on sleep included heart rate elevations during short and brief disruptions. Ringing phones, IV alarms, and similar sounds were the most disruptive more than 50% of the time. Other disruptive sounds were staff conversations and voice paging, which were found to be very alerting. The least arousing noises were external such as airplanes flying over and street traffic. Continuous stimuli were found to be less arousing than intermittent stimuli and therefore less disruptive. It was discovered that the brain during REM sleep was less capable of differentiating between sounds in comparison to NREM stages. This was due to cerebral resources being dedicated to internal processes like dreaming instead of external sources.

Limitations

The study was limited to only 12 healthy younger participants and did not account for the impact of noises on hospitalized patients. Sounds were introduced for only 10 seconds and stopped after arousal to prevent waking the participants. In normal settings, sounds last for longer durations and occur simultaneously. This practice could have resulted in an underestimation of the effects of noise on sleep.

Design Implications

The study findings could improve the design of the acoustics in new hospital facilities to enhance the quality of care and maximize health outcomes. Providing essential information on the impact of noises on sleep disruption would guide future architectural design. The data presented could provide a framework for the implementation of adequate design strategies. This would include the elimination and the control of sound sources. Examples are using advanced building materials, sound- absorbing surfaces, door closers and frame gaskets, personal digital assistants instead of overhead paging, and telemetry from the nurses' stations. Other external noise-generating equipment like ice machines could be isolated for noise reduction.