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Effects of neonatal intensive care unit nursing conditions in neonatal NREM sleep

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Abstract NREM sleep is the distinct stage of sleep during which essential brain functions related to neonates' neurodevelopmental outcome, take place. The multisensory environment of Neonatal Intensive Care Unit (NICU) often interrupts or inhibits neonatal NREM affecting its quality and duration. The purpose of this study was to investigate the relation between noise and light levels in the NICU environment and NREM sleep duration. Neonatal sleep was recorded through aEEG in three consecutive days. Recordings on the first day were under baseline conditions, the second day under sound intensity reduction, and the third day under light intensity reduction. Thirty-two neonates finished all the different parts of the study and were finally included in the analysis. By reducing sound or light intensity the duration of NREM sleep increased significantly ($p < 0.001$, and $p < 0.001$, respectively). No significant statistical differences were found in REM and total sleep duration among the 3 different days. Intense noise and light affect NREM sleep and may have detrimental effects on neurodevelopmental outcome of hospitalized neonates. Medical and nursing staff should be aware of the neonates' needs for

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adequate and good-quality sleep and implement interventions to optimize the NICU surroundings.
Precis: Effects of sound and light intensity in neonatal NREM sleep as can be identified from the changes in aEEG recordings.

Introduction

Sleep is the physiologic state of periodic relative suspension of consciousness and is of great importance for neonatal brain development (Graven and Browne, 2008). In adults, it is divided in two qualitatively different stages which show cyclicity: the active stage called Rapid Eye Movement (REM) sleep and the non active stage called non-REM (NREM) sleep. In newborns and infants less than 6 months old, sleep is also divided in two easily discernible stages: active sleep (AS) which corresponds to the adult REM sleep and is the main sleep state characterized by the presence of REM, body and facial movements, irregular respiration, and a continuous EEG pattern, and quiet sleep (QS), which corresponds to the non-REM sleep of adults, and is characterized by the absence of REM and body movements, regular respiration, and a discontinuous EEG pattern. There is also a third stage of shorter duration called Indeterminate sleep (IS) in which the sleep characteristics are not clearly classifiable as QS or AS (Bertelle et al., 2007). The corresponding terms REM sleep and AS, and NREM sleep and QS, will be used interchangeably in the rest of this paper.

REM sleep is generally considered of particular importance for the growth of neurosensory system. However, NREM sleep does contribute substantially to the development of neonatal central nervous system (CNS), since it is during this particular stage that synapses are formed and organized for specific functions (Peirano et al., 2003). NREM sleep constitutes an integral part of the memory and learning processes; it is during this stage that the strong and significant sensory stimuli are processed in the hippocampus and limbic system to create the long-term memory (Peigneux et al., 2004). With the advance of chronological age, the importance of NREM sleep becomes even more significant, since the brain matures and must assimilate a plethora of external stimuli (Mirmiran and Corner, 1982).

The organization of neonatal sleep into distinct stages is associated with normal neurodevelopmental outcomes (Thoman et al., 1981). There is much evidence showing that sleep cyclicity contributes to maintenance of brain plasticity, namely the ability of brain to reorganize its neural pathways in response to environmental stimuli (Constantinou et al., 2007). In contrast, experiments conducted on animals showed that sleep disorganization leads to permanent neurological damage or has a negative impact on growth and development (Penn and Shatz, 1999).

Premature and sick term neonates receive multisensory stimulation in Neonatal Intensive Care Unit (NICU) which leads to sleep disorganization (Sudha, 2011). Neonates are exposed to repeated stimuli causing frequent disruptions of sleep—wake transition. It has been estimated that their sleep is interrupted about 234 times over 24 h (Altimier and Lutes, 2001). Sound and light intensity are among the main NICU environmental factors which disturb neonatal sleep (Gray and Philbin, 2004; Lasky and Williams, 2009; Ludington-Hoe et al., 2006).

In the NICU, sound is produced chiefly by the medical and nursing staff and the equipment which is necessary for the survival of premature neonates, such as double-walled incubators, respirators and humidifiers. Studies have shown that the cumulative sound intensity received by preterm neonates, is inversely related with gestational age (GA) (Lasky and Williams, 2009). Sound intensity is associated with disruption of the autonomic nervous system, increased heart rate and vasoconstriction, delayed attainment of full enteral feeding, and deregulation of sleep and its cyclicity (Gray and Philbin, 2004).

Light intensity affects neonatal sleep too. In most of the NICUs, it is mainly the continuous intense light coming from artificial sources, such as examination lights, phototherapy lamps and ambient space light. Intensity of light varies according to the needs of NICU during the 24-h day. Light intensity may result in visual organ damage (Fielder and Moseley, 2000), and disruption of neonatal sleep and brain processes that take place during sleep (Bertelle et al., 2005). Moreover, neonatal synchronization of circadian rhythm is inhibited by intense continuous light, resulting in disruption of cyclicity of sleep (Rivkees, 2003).