



## Review of sleep-EEG in preterm and term neonates

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### ABSTRACT

Neonatal sleep is a crucial state that involves endogenous driven brain activity, important for neuronal survival and guidance of brain networks. Sequential EEG-sleep analysis in preterm infants provides insights into functional brain integrity and can document deviations of the biologically pre-programmed process of sleep ontogenesis during the neonatal period.

Visual assessment of neonatal sleep-EEG, with integration of both cerebral and non-cerebral measures to better define neonatal state, is still considered the gold standard. Electrographic patterns evolve over time and are gradually time locked with behavioural characteristics which allow classification of quiet sleep and active sleep periods during the last 10 weeks of gestation. Near term age, the neonate expresses a short ultradian sleep cycle, with two distinct active and quiet sleep, as well as brief periods of transitional or indeterminate sleep. Qualitative assessment of neonatal sleep is however challenged by biological and environmental variables that influence the expression of EEG-sleep patterns and sleep organization. Developing normative EEG-sleep data with the aid of automated analytic methods, can further improve our understanding of extra-uterine brain development and state organization under stressful or pathological conditions. Based on those developmental biomarkers of normal and abnormal brain function, research can be conducted to support and optimise sleep in the NICU, with the ultimate goal to improve therapeutic interventions and neurodevelopmental outcome.

### 1. Introduction

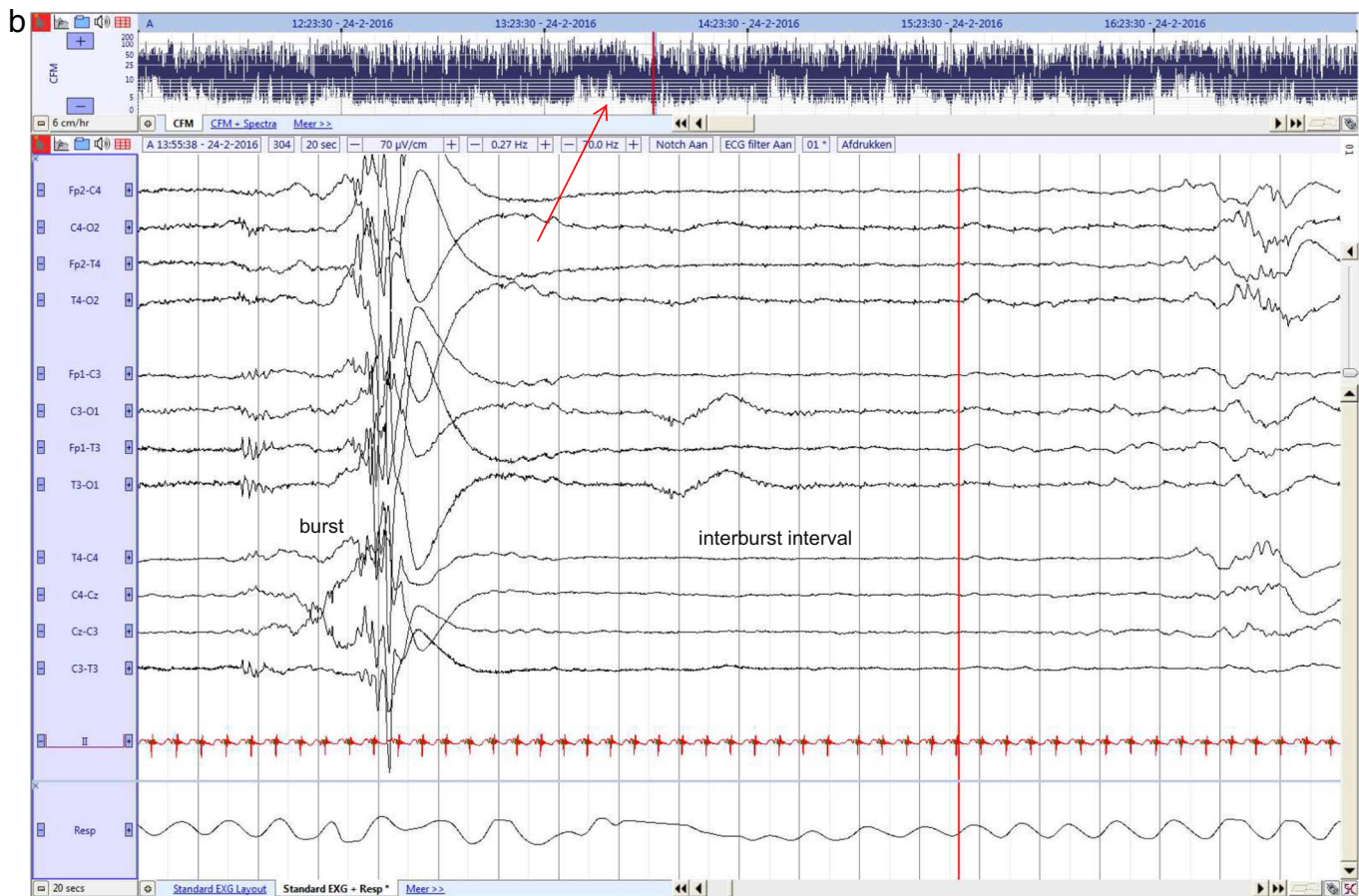
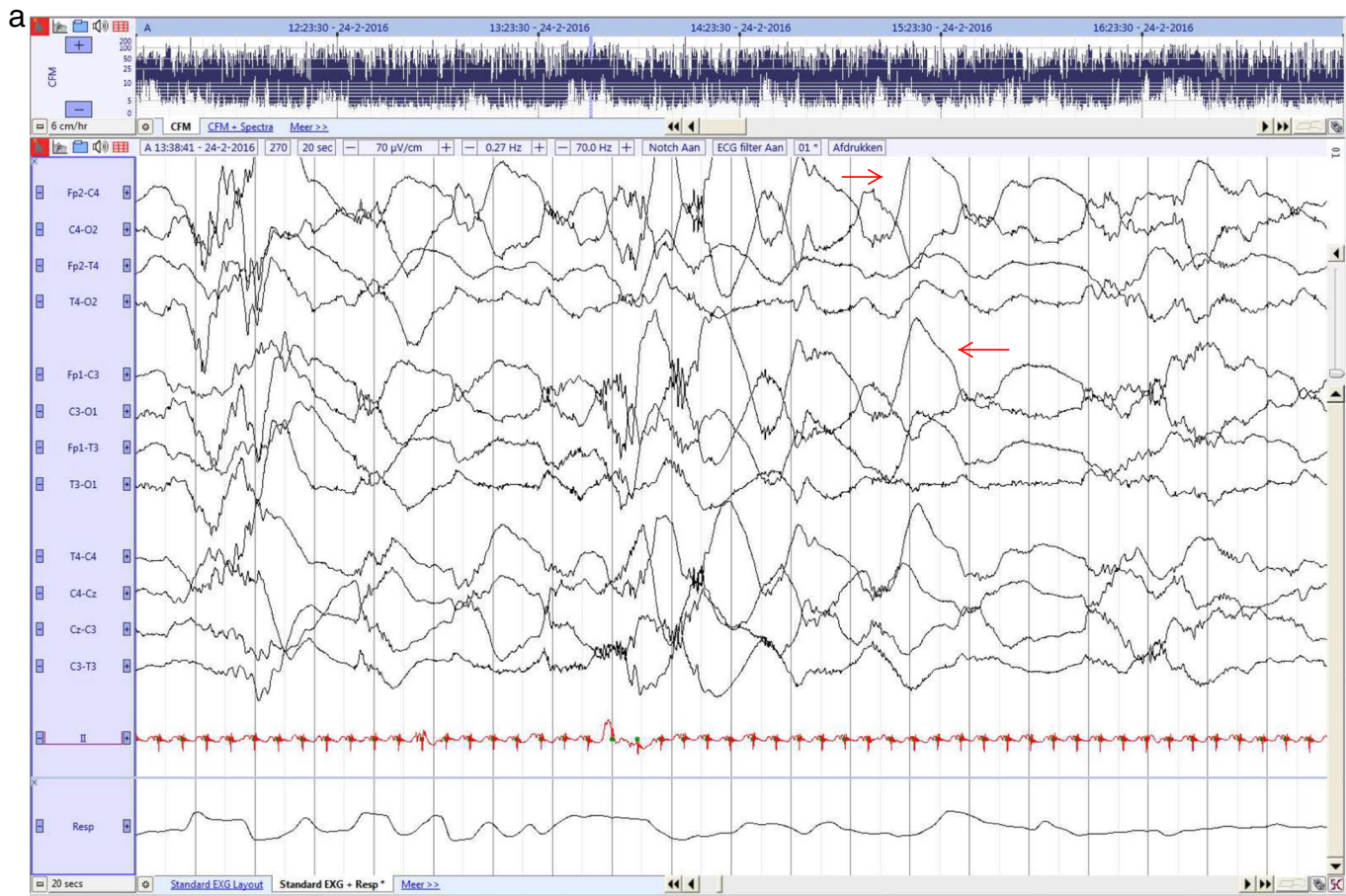
Intensive monitoring of the vulnerable preterm and critically ill term neonate, has been increasingly complemented with bed-side neuromonitoring to achieve optimal insight into neurological well-being [1–3]. Serial electro-encephalography (EEG) monitoring over time can document actual normal or altered brain function and provides insight into the progress of brain maturation during this period of intensive neonatal care [1,4,5], with the ultimate goal to improve therapeutic interventions and long-term neurodevelopmental outcome.

Neonates spend most of their time resting in the sleeping state. Previous research has highlighted the important role of neonatal sleep as a state that involves endogenous driven brain activity, crucial for neuronal survival and guidance of brain networks [6–9] and relate the impact of sleep on cognitive, psychomotor and behavioural development in both animal [10,11] as well as human studies [12–16]. Moreover, sleep ontogenesis is a specific, pre-programmed process of the maturing brain that manifests itself within a certain time window that begins in utero with rapid and major changes during the neonatal periods and infancy, and more subtle changes throughout childhood [11,17]. It's a complex and highly regulated neurologic function requiring the integration of different brain networks, influenced by the interplay between genetic endowment and environmental inputs, which allows for manifestations of neuroplasticity [6,8].

Qualitative assessment of neonatal sleep is therefore an essential and valuable measure of functional brain integrity [11,18], and recognition of sleep-wake states can be useful in the day-to-day monitoring, for assessing optimal periods for feeding and neonatal care, to support and optimise sleep in the NICU [19], as well as give insight in the sleep architecture of infants with sleep related problems (e.g. increased risk of sudden infant death syndrome, sleep apnoea).

*Abbreviations:* AS, active sleep; QS, quiet sleep; IS, indeterminate sleep; TS, transitional sleep; SWC, sleep-wake cycle; IBI, interburst interval; REM, rapid-eye movement; NREM, non rapid-eye movement; PMA, postmenstrual age; GA, gestational age; HVS, high voltage slow wave sleep; LVI, low voltage irregular pattern; M, mixed frequencies; W, wakefulness; NIDCAP, Newborn Individualized Developmental Care; SSC, skin-to-skin care; aEEG, amplitude EEG

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