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REVIEW MISE AU POINT

Pathological features of neonatal EEG in preterm babies born before 30 weeks of gestationnal age

Les aspects pathologiques de l'EEG du nouveau-né prématuré avant 30 semaines d'âge postmenstruel

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Outcome

Summary Pathological features on very premature EEG concern background abnormalities and abnormal ictal and nonictal patterns. Positive rolandic sharp waves keep an important place regarding diagnosis and prognosis of white-matter lesions. Background abnormalities, that may be classified as acute-stage or chronic-stage abnormalities, give essential complementary information. These abnormal patterns remain precocious markers of cerebral lesions and are complementary to cerebral imaging. Analysis of these abnormalities has always to take into account medication received by the baby during the recording and that could modify the EEG.

Abbreviations: GA, Gestational age; IBI, Interburst interval; NICU, Neonatal intensive care unit; PMA, Post menstrual age; PRS, Positive rolandic sharp waves; PTS, Positive temporal sharp waves.

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Résumé Les aspects pathologiques de l'EEG du grand prématuré portent sur les anomalies de l'organisation du tracé de fond et sur la présence de figures pathologiques. Parmi celles-ci, les pointes positives rolandiques (PPR) tiennent une place importante par leur valeur diagnostique et pronostique bien reconnue dans la leucomalacie périventriculaire du prématuré. Les anomalies du tracé de fond apportent des renseignements complémentaires essentiels. Les graphoéléments inhabituels par leur morphologie, leur amplitude ou leur localisation sont des marqueurs potentiels précoces de lésions cérébrales. L'analyse de ces aspects pathologiques doit tenir compte des médicaments administrés à l'enfant et qui peuvent modifier l'EEG. Plusieurs cas cliniques illustrent l'intérêt d'une surveillance systématique et régulière de l'EEG.

1. Introduction

Preterm birth is associated with neurodevelopmental impairment. The most severe adverse outcomes can be diagnosed before the age of two when motor impairments or severe cognitive delay may be detected. Premature birth is also related to learning disabilities that become apparent in later childhood (at school age) [37,40]. The origins of these sequelae are multifactorial; some are clearly linked to neonatal brain insults [21] but antenatal pathological conditions may play a role as well as events in early childhood. Social and educational environment is also a key factor.

Most brain injury occurring in the antenatal and neonatal period that leads to neurodevelopmental impairment tends to be clinically silent. Routine neurological assessment by cerebral imaging and neurophysiological recordings is required. Long-term follow-up until school age is mandatory in this population in order to assess the effects of specific EEG and cerebral imaging abnormalities on outcomes. Routine neonatal neurological assessment is unable to detect non-neurological injuries such as sensorial impairment and will not detect events that occur after the neonatal period. Therefore the relationship between adverse outcome and neonatal events is important to keep in mind when the prognostic value of EEG or cerebral imaging is considered.

Cerebral imaging allows diagnosis of brain injury as it becomes established. Bedside cranial ultrasound is useful for detecting severe white-matter lesions such as periventricular leucomalacia; diffuse or cystic (see clinical case report of Julien and Rose below), unilateral or bilateral intraventricular hemorrhage, hemorrhagic parenchymal infarction and ventricular dilation. MRI gives more precise information on diffuse and punctuate white-matter lesion, cerebellar hemorrhage, and basal ganglia and thalamic abnormalities [16,19,47,68].

Neonatal EEG allows a precise study of brain maturation during a phase of rapid evolution — equivalent to the third trimester of gestation ex-utero. This maturation process follows a precise schema, which can be assessed using successive EEGs that show progressive changes over short periods, closely linked to the postmenstrual age (PMA) [3]. EEG as a neurophysiological tool has an excellent temporal resolution but a low spatial resolution. This is more evident in the newborn as the smaller size of head allows fewer electrodes. Hence, precise information on location of potential brain lesions, which may be the cause of the abnormal waveforms, is not obtained. Conversely, EEG allows a comprehensive approach to the study of evolution of ongoing cerebral injury bringing additional information to cerebral imaging [23,30]. As a result, the accuracy of EEG data depends greatly on the timing of the record and serial recordings are recommended [33]. This early diagnosis of presymptomatic or subclinical ongoing brain insult may allow a window for neuroprotection before the constituted brain lesions become established.

Analysis of abnormal EEG is commenced with the description of significant changes of background activity and of pathological features such as sharp waves or ictal events. The combination of these abnormalities constitutes a selection of EEG patterns of various severities. Some of these patterns may herald the onset of severe brain lesion, such as PVL. Precise information regarding the medication the infant is receiving at the time of each EEG is required as most sedative drugs can affect EEG patterns. Several clinical cases are presented to illustrate the practical use of EEG in NICU.

2. Description of abnormal EEG patterns

2.1. Background abnormalities

Numerous parameters contribute to the constitution of a normal background EEG pattern; continuity, amplitude, spatial and temporal organization, spontaneous or provoked lability, synchrony and symmetry, sleep state cycle. Between 24 and 30 weeks, PMA the most important parameter is continuity, significantly correlated to the degree of global cortical folding [7], but the presence of sleep state changes remains an excellent index of normality.

Assessment of continuity should include the proportion of burst and interburst intervals (IBI) and the variations of this proportion in the whole record. Several approaches may be used to assess the discontinuity. The measurements of the longest burst and the longest IBI are frequently used as relatively rapid and simple to assess by visual analysis [7]. The 90th percentile, instead of the maximum value, has also been used [65]. A semi-quantitative method uses the classification of predetermined epochs (usually 20 s to 1 min) as either 'continuous' or 'discontinuous' depending on the proportion of time occupied by burst during this epoch. An epoch is usually considered as 'discontinuous' when the proportion of burst is below 50%. Discontinuity can also be approached by the proportion of discontinuous periods in the whole recording [48].

Discontinuity is considered as abnormal when the duration or the number of IBIs is increasing (Figs. 1—3). However the cut-off between normal and pathological values remains