Electroencephalography changes following fetal brain injury in intrauterine growth restriction: a literature review

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Introduction

Intrauterine growth restriction (IUGR) is a pathological condition in which a fetus fails to reach its genetically determined growth potential. Recent studies have demonstrated that IUGR leads to fetal brain injury and poor neurodevelopmental outcomes, but there is little research into how these neural pathologies manifest functionally, such as in electroencephalography (EEG) abnormalities.

Definition and characteristics of IUGR

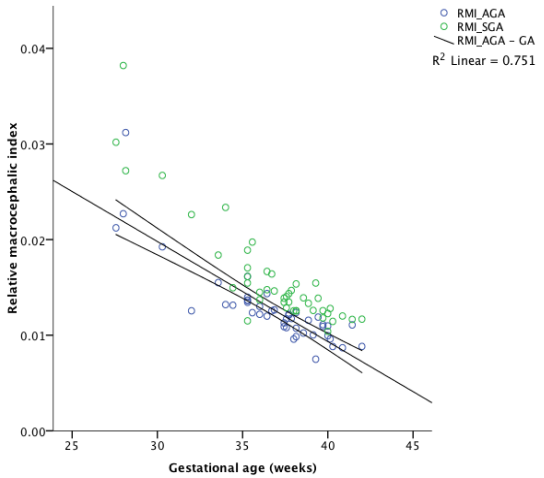
The 2016 Delphi consensus definition is well-supported by current evidence and recommended for future studies into IUGR.

Significant neonatal characteristics of IUGR include low birth weight and high relative macrocephalic index (ratio of head circumference to body weight). Significant antenatal characteristics of IUGR include small abdominal circumference, low estimated fetal weight, increased umbilical artery Doppler pulsatility index (PI) and reduced cerebroplacental ratio.

Methods

Published studies were accessed through the PubMed database. Relevant citations within the 61 selected papers were followed for a more comprehensive survey of the available literature.

Relative macrocephalic index of SGA and AGA neonates across gestational ages *(preliminary data)*



Neuropathological mechanisms in IUGR

Normal fetal development can become disrupted in IUGR, resulting in both microstructural and macrostructural abnormalities.

White matter disruption. There is evidence of reduced white matter volume and delayed myelination in preterm IUGR infants. Functional brain networks appear to be hyper-connected but sub-optimally organised. However, connectivity patterns may vary between different networks, which can manifest as differences in EEG patterns between different electrodes.

Neuronal grey matter and synaptic changes. There is evidence of reduced neuronal count in the cortex, cerebellum, and hippocampus, as well as impaired dendritic growth in the surviving neurons. Animal studies in the hippocampus and cerebellum have demonstrated reduced dendritic lengths and reduced branching densities, which may be the cause of the decreased number of synapses and widened synaptic clefts found in IUGR brains.

Heterogeneity in IUGR brain injury. While early- and late-onset IUGR both present with combined WM and GM injury, early-onset IUGR appears to be associated with neuroinflammation and more widespread white matter injury, and late-onset IUGR with increased levels of apoptosis within the cortex but limited neuronal loss overall.

EEG hypotheses

Changes in evoked EEG potentials could include reduced amplitudes due to neuronal loss, longer latencies due to myelination deficits in white matter tracts, and polymorphic waveforms due to differential damage to tracts. Heterogeneity in EEG abnormalities is also expected as patterns of brain injury differ between early- and late-onset IUGR.