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Perspective

Importance of Artificial Intelligence in Neonatology

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DESCRIPTION

The term Artificial Intelligence (AI) refers to the general ability of computer algorithms to emulate human decision making. Machine learning (ML), on the other hand, is a subdivision of artificial intelligence and includes techniques that enable machines to learn from data without explicit programming. Both have had a major impact on personalized diagnosis and therapy, drug discovery, and medical imaging over the past decades. Potentially, these approaches could greatly improve our understanding of disease and treatment effects in both children and infants. ML uses algorithms to classify data and make predictions. ML includes three major subgroups such as supervised ML, unsupervised ML and neural networks. Supervised ML uses tagged datasets to train algorithms to perform data classification, especially in predictive applications. Unsupervised ML is commonly used as a data exploration tool, requiring less human input. Neural networks are inspired by biological neural networks, can learn from missed predictions, and are useful for processing image data. So far, supervised ML has been used primarily for designing predictive models in pediatrics and neonatology. For example, algorithms have been developed to identify patients at risk for pneumonia, urinary tract infections, bacterial meningitis, intra-abdominal injuries, or clinically relevant traumatic brain injuries in a straightforward manner. While AI tools may often appear superior to rule-based tools to support clinical decision-making, their use can lead to additional challenges. These include the need for large datasets, challenges of generalization, the presence of imbalanced data, lack of evidence-based care, variability in child maturity, and costs.

Neonatal Intensive Care Unit (NICUs) typically generates a certain amount of generally underutilized data that AI can compute and analyze.

The AI revolution, especially the ML subcategory, has impacted research on neuromonitoring of critically ill neonates over the past decades. With advances in computing power and data storage, AI has enabled computer systems to examine and analyze vast amounts of information to decipher disease patterns. Clinical neuromonitoring can generate a large amount of data, especially in relation to Electro Encephalo Gram (EEG) data. EEG is a non-invasive recording of electrical activity in the cerebral cortex, enabling real-time assessment of background cortical function useful for predicting prognosis in neonates. EEG is also a reference instrument for seizure diagnosis as it allows discrimination between epileptic seizures and non-epileptic events and can detect non-convulsive seizures. Continuous EEG (CEEG) recording maximizes the diagnostic utility of this tool. Not only is this likely to record electrographic events, but it is also of prognostic significance, allowing assessment of the evolution of background activity over time. Either way, interpreting the wealth of information generated requires expertise and is resource intensive, limiting the utility of CEEG monitoring.

Numerous ML algorithms based on EEG background activity have been proposed for various purposes. In the context of early staging of perinatal Hypoxic-Ischemic Encephalopathy (HIE), much research has been conducted in the field of automated EEG interpretation to provide diagnostic decision support. Recently, advanced signal processing and ML techniques such as convolutional neural network structures capable of self-extracting convolutional features from raw EEG have shown powerful performance metrics for HIE severity classification. ML models were developed separately for qualitative EEG function (assessed by a neurophysiologist) and quantitative EEG function (automatically generated by weighting the amount of discrete activity), and for clinical function. Developed in conjunction with interestingly, automated quantitative EEG analyzes performed, as well as analyzes performed by experienced neurophysiologists, enhance the predictive value of these models by adding clinical information. These reports highlight the possibility of using ML to process background EEG activity in her neonatal with HIE.

AI has also been extensively studied in term and preterm infant sleep research, using EEG data to automatically classify neonatal sleep stages. Sleep studies are particularly relevant to the treatment of sick infants because of their prognostic value. Alternating states of vigilance are a positive prognostic factor and

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a global marker of neurological health. Sleep state detection may also improve neuroprotective care, as reducing interruptions during deep sleep could be a therapeutic approach. In any case, research on AI-driven tools for assessing background neonatal cortical activity is still in the preclinical stage.

Detection of seizure-type events is another important goal of EEG monitoring. Newborns are at the highest risk of seizures of any age group, and seizures are the most common neurological emergency in this age group.

The incidence of seizures in neonates is estimated to be about 8% and becomes parabolic with gestational age, with seizures occurring more frequently in infants <30 weeks gestation and >36 weeks gestation. Seizures are often a sign of underlying medical conditions such as HIE, meningitis and stroke, and recent evidence suggests that early diagnosis and treatment of seizures improves response to medication. Therefore, early detection of seizures is very important. Moreover, it is well established that impaired long-term neurodevelopmental outcomes are associated with increased seizure load. Seizure recurrence itself appears to have additional neurodevelopmental effects, regardless of the underlying etiology. On the other hand, treating non-epileptic events exposes the neonate to unnecessary and harmful drugs.

Diagnosing seizures in newborns is particularly difficult. Because seizures are usually only an electrical recording, their symptoms can be masked by drugs and even if seizures are present, they can be difficult to distinguish from normal neonatal movements.