

# Interdisciplinary Approach to Neurocritical Care in the Intensive Care Nursery

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Neurocritical care is a multidisciplinary subspecialty that combines expertise in critical care medicine, neurology, and neurosurgery, and has led to improved outcomes in adults who have critical illnesses. Advances in resuscitation and critical care have led to high rates of survival among neonates with life-threatening conditions such as perinatal asphyxia, extreme prematurity, and congenital malformations. The sequelae of neurologic conditions arising in the neonatal period include lifelong disabilities such as cerebral palsy and epilepsy, as well as intellectual and behavioral disabilities. Centers of excellence have adapted the principles of neurocritical care to reflect the needs of the developing newborn brain, including early involvement of a neurologist for recognition and treatment of neurologic conditions, attention to physiology to help prevent secondary brain injury, a protocol-driven approach for common conditions like seizures and hypoxic-ischemic encephalopathy, and education of specialized teams that use brain monitoring and imaging to evaluate the effect of critical illness on brain function and development.

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## Introduction

The advances in cardiopulmonary resuscitation and critical care during the 20th century have led to high rates of survival among neonates with life-threatening conditions such as perinatal asphyxia, extreme prematurity, and congenital malformations. However, in spite of these technological advances, neurologic complications of critical illness remain high, with up to 25% of patients at referral center intensive care nurseries having brain injury, seizures, or other neurologic conditions.<sup>1,2</sup> The sequelae of neurologic conditions arising in the neonatal period include lifelong disabilities such as cerebral palsy and epilepsy, as well as intellectual and behavioral disabilities. The recent advances in digital monitoring of brain function, including simplified

trends like amplitude-integrated electroencephalogram (aEEG), as well as safe brain imaging using magnetic resonance (MR), allow physicians to evaluate the effect of critical illness on brain function and development. Patients who have both acute and subacute or chronic neurologic conditions may benefit from specialized neurocritical care (Table 1).

Neurocritical care is a multidisciplinary subspecialty that uses these advances to combine expertise in critical care medicine, neurology, neuroradiology, and neurosurgery, and has led to improved outcomes in adults who have critical illnesses.<sup>3</sup> Centers of excellence in the United States and abroad have adapted the principles of neurocritical care (Table 2) to reflect the needs of the developing newborn brain.

At our center, the core neurocritical care team consists of a bedside nurse who is specially trained in neurology, a neonatologist, and a neurologist. This core comanagement team works together at the bedside to care for any neonate with suspected or confirmed neurologic signs or symptoms throughout the period of critical illness. The ancillary team members include pediatric neurosurgeons, neuroradiologists, and epileptologists. Before discharge, a neonatology specialist with expertise in developmental care and high-risk follow-up coordinates with the core team to help identify and care for children who are at risk for lifelong disability to implement services before hospital discharge.

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**Table 1 Neonatal Neurocritical Care Populations**

<b>Acute acquired brain injury</b>
Hypoxic-ischemic encephalopathy (HIE)
Arterial and venous ischemic stroke
Intracranial parenchymal hemorrhage
High-grade intraventricular hemorrhage
Meningoencephalitis
Inborn error of metabolism
<b>Seizures</b>
Acute symptomatic seizures
Neonatal onset epilepsies (benign and malignant)
<b>High risk for acquired brain injury</b>
Encephalopathy
Extremely low gestational age (<28-wk gestation at birth)
Hydrocephalus
Need for extracorporeal membrane oxygenation (ECMO)
Congenital heart malformations
Postnatal cardiopulmonary arrest
Vascular malformations of the central nervous system
Symptomatic hypoglycemia
<b>Developmental anomalies</b>
Brain malformation
Microcephaly
Dysmorphic neonate
Multiple congenital anomalies

## Establishing a Neonatal Neurocritical Care Program

The development of a neonatal neurocritical care program entails more than including a neurologist in the day-to-day care of the patient. Use of brain monitoring devices, the application of neuroprotective therapies such as therapeutic hypothermia, and increased awareness of neurologic complications of critical illnesses result in a change in unit culture to one where the brain is considered as an important organ system that is affected by everyday management. Training and education of all care providers, including physicians, nurses, nurse practitioners, and respiratory therapists, among others, as well as identification of leaders in each care domain to provide consistent application of guidelines and protocols, facilitates culture change. These care providers learn to consider the neurologic system to be as important as the cardiorespiratory systems, which results in the provision of brain-focused care.

Within a given unit, a neonatal leader should be identified to work with nursing and neurology leaders to develop a

neonatal neurocritical care program. Together, this group develops neurology-specific guidelines and protocols. These guidelines and protocols (Table 3) are meant to standardize the approach to the neurologic evaluation and treatment and reduce practice variation that can occur in large units with high turnover of medical and nursing staff. A thorough review of the literature, and concepts from team-training science and quality improvement can facilitate the development and application of these guidelines and protocols.<sup>4,5</sup>

## The Role of the Neonatologist

The neonatologist plays a critical role in identifying patients at risk of brain injury, as well as those neonates with an acute or subacute neurologic condition, and in providing optimized resuscitation and supportive care to prevent secondary injuries. Neonatologists are primarily responsible for and are experts in resuscitation and supportive management of critically ill neonates. In the setting of a neurocritical care service, the neonatologist triages patients with acute vs subacute neurologic problems and consults the pediatric or neonatal neurologist to participate in the day-to-day care of patients with acute neurologic compromise.

With an increased awareness of neurologic complications of prematurity and the effect of critical illness on the developing brain,<sup>6</sup> the neonatologist should be alert to neurologic compromise in these patients. When evaluating a neurologic sign or symptom, initial neonatal management includes the following: (1) close attention to the maintenance of physiological homeostasis with a focus on cardiorespiratory status, electrolytes, and glucose levels, and thermoregulation to help prevent secondary brain injury (Table 4); (2) early involvement of the pediatric or neonatal neurologist to help guide treatment and determine prognosis; and (3) initiation of brain monitoring to assess for seizures and degree of encephalopathy. As discussed later, the historical approach of neonatologists independently treating suspicious clinical events with anticonvulsants without the initiation of brain monitoring or EEG confirmation of seizures should no longer be the standard approach.

## Resuscitation and Supportive Care

Since the initial period of neurologic compromise is often around the time of delivery, the first consideration when optimizing support for the developing brain is during newborn resuscitation and with initiation of supportive

**Table 2 Principles of Neurocritical Care**

<b>Early recognition and treatment of neurologic conditions can lead to improved outcomes</b>
<b>Attention to basic physiology, including temperature regulation, glucose homeostasis, oxygenation, and blood pressure support can help prevent secondary brain injury</b>
<b>A protocol-driven approach can achieve lower mortality and higher rates of favorable outcomes</b>
<b>Specialized, multidisciplinary neurocritical care teams in dedicated referral units can reduce mortality and improve resource utilization</b>

Adapted from Rincon and Mayer.<sup>3</sup>

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