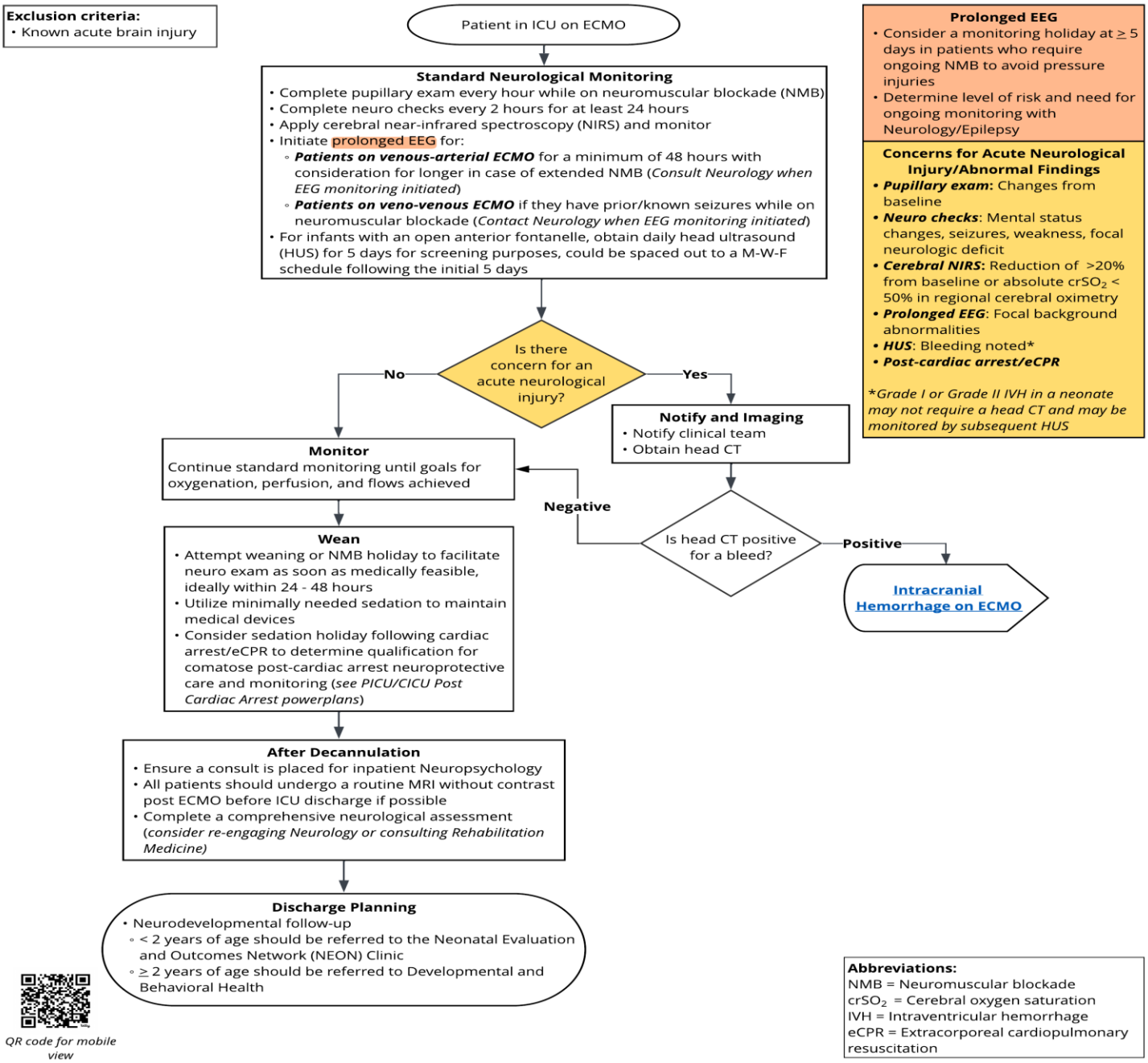
Extracorporeal Membrane Oxygenation (ECMO) Neuromonitoring and Acute Brain Injury Clinical Pathway Synopsis

ECMO Neuromonitoring and Acute Brain Injury: Neurological Monitoring Algorithm



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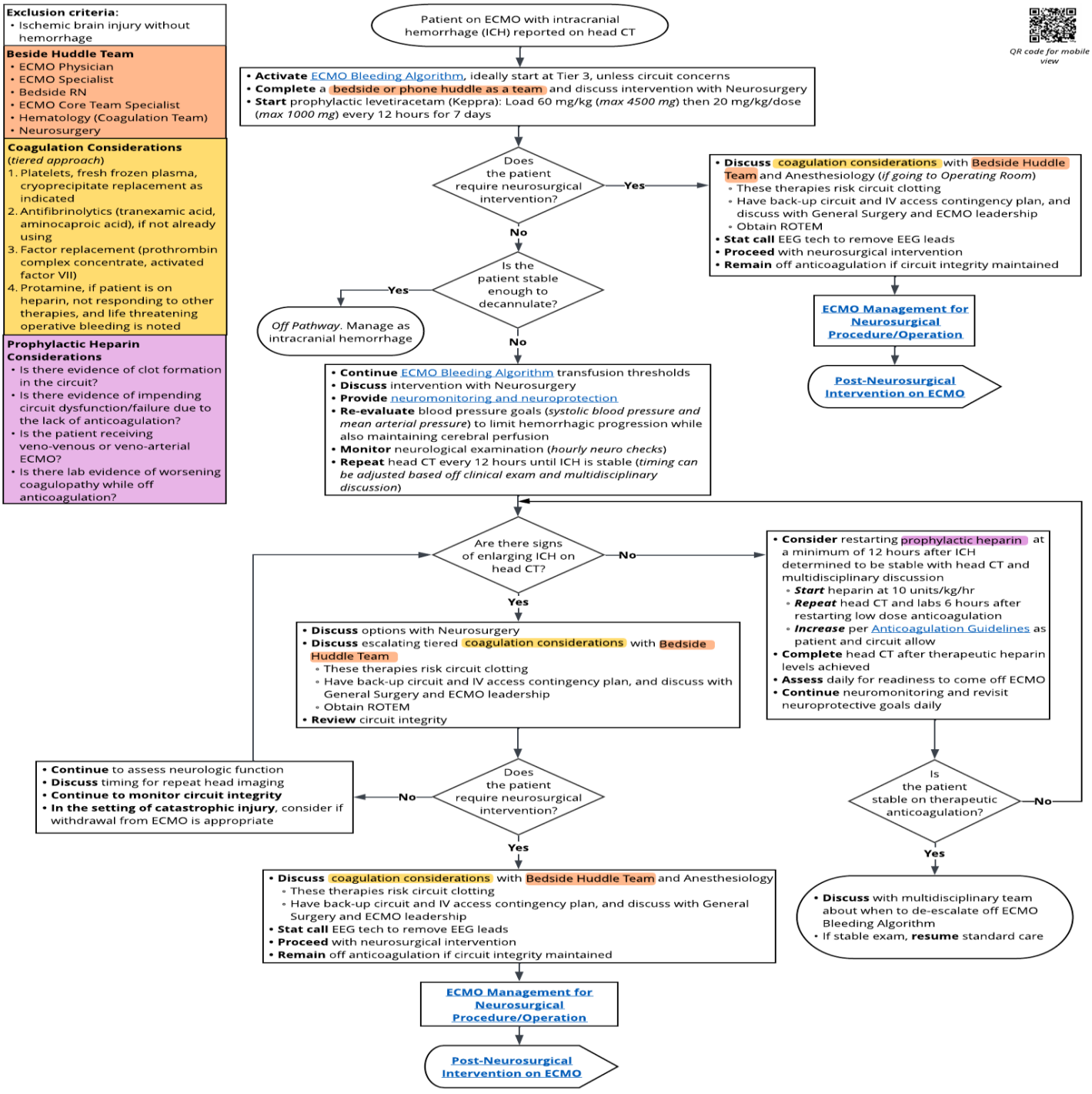
ECMO Neuromonitoring and Acute Brain Injury: Intracranial Hemorrhage on ECMO Algorithm



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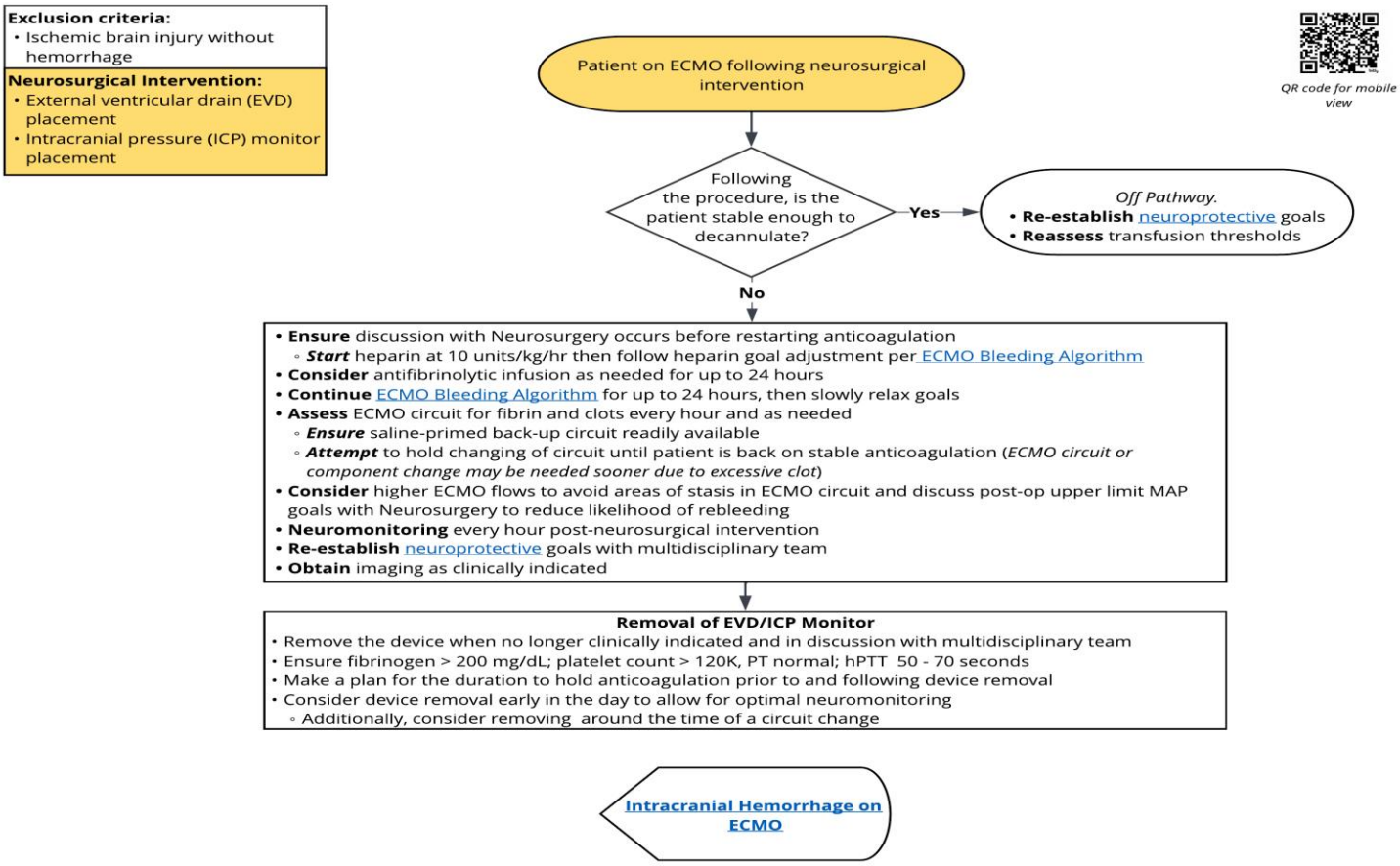
ECMO Neuromonitoring and Acute Brain Injury: Post-Neurosurgical Intervention on ECMO Algorithm



ECMO Neuromonitoring and Acute Brain Injury: Ischemic Injury on ECMO Algorithm

Under Development

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Objective of Clinical Pathway

This clinical pathway standardizes the approach to neuromonitoring in patients at high risk for acute brain injury with the goal of early detection. The ECMO Neuromonitoring and Acute Brain Injury Clinical Pathway will outline special needs and considerations when an intracranial hemorrhage or ischemic brain injury is suspected as the patient is supported on ECMO.

Background

ECMO supports critically ill patients with cardiopulmonary failure as an advanced lifesaving support technique (Cho et al., 2019; Hanalioglu et al., 2024; Khanduja et al., 2023; Said et al., 2020). Over the past 20 years, the use of ECMO in children has demonstrated a four-fold increase, particularly for those children with severe and refractory cardiac and pulmonary failure (Hanalioglu et al., 2024; Said et al., 2020). While ECMO has life-saving benefits, this support intervention presents a risk of neurological complications, specifically intracranial hemorrhage, ischemic brain injury, cerebral edema, and seizures (Hanalioglu et al., 2024; Khanduja et al., 2023; Pandiyan et al., 2023; Said et al., 2020). Standard neurological monitoring for the early recognition of findings suggestive of a possible acute neurological injury is critical to preventing or limiting the extent of injury (Cho et al., 2019; Pandiyan et al., 2023).

The ECMO Neuromonitoring and Acute Brain Injury Clinical Pathway Committee recognizes that a framework is needed to assist providers in complex decision-making when managing a child on ECMO support and an acute brain injury is detected. The ECMO Neuromonitoring and Acute Brain Injury Clinical Pathway aims to provide this framework by detailing standard neurological monitoring recommendations and the considerations surrounding the care of these patients.

Target Users

- Physicians (Intensivists [ICN, PICU, CICU], Neurosurgery, Neurology, Hematology, Fellows, Residents)
- Advanced Practice Neonatal/Pediatric Critical Care Nurses
- Nurses (ICN, PICU, CICU)
- ECMO Support Team (ECMO Physician, ECMO Specialist, ECMO Core Team Specialist)

Target Population

Inclusion Criteria

- Patients on ECMO, veno-venous or veno-arterial

AGREE II

The National Institute of Neurological Disorders and Stroke of the National Institutes of Health national guideline provided guidance to the ECMO Neuromonitoring and Acute Brain Injury Clinical Pathway Committee (Pandiyan et al., 2023). See Table 1 for AGREE II.

Table 1

AGREE II Summary for the Clinical Guidelines for Routine Neuromonitoring in Neonatal and Pediatric Patients Supported on Extracorporeal Membrane Oxygenation (Pandiyan et al., 2023)

Domain	Percent Agreement	Percent Justification^
Scope and purpose	77%	The aim of the guideline, the clinical questions posed, and the target populations **were** identified.
Stakeholder involvement	26%	The guideline **did not** include appropriate stakeholders (such as Hematology) nor the viewpoints of the intended user.
Rigor of development	21%	The guideline developers **did not** provide information on how the evidence was gathered and synthesized, how the recommendations were formulated, or how the guidelines would be updated.
Clarity and presentation	81%	The guideline recommendations **are** clear, unambiguous, and easily identified; in addition, different management options are presented.

Applicability	50%	Barriers and facilitators to implementation and resource implications **were addressed** in the guideline. The guideline **did not** address utilization strategies.
Editorial independence	48%	It is **unclear** if the recommendations were biased by competing interests.
Overall guideline assessment	50%	
See Practice Recommendations		

Note: Four EBP Scholars completed the AGREE II on this guideline.
^ Percentage justification is an interpretation based on the Children's Mercy EBP Department standards.

Practice Recommendations

When a neonate or pediatric patient is supported on ECMO, please refer to the National Institute of Neurological Disorders and Stroke clinical guideline (Pandiyan et al., 2023) for neuromonitoring recommendations.

Additional Questions Posed by the Clinical Pathway Committee

No clinical questions were posed for this review.

Recommendation Specific for Children's Mercy

Children's Mercy adopted the majority of the practice recommendations made by the National Institute of Neurological Disorders and Stroke Clinical Guideline (Pandiyan et al., 2023). Variations/Additions include:

- Ensuring a consult is placed for inpatient Neuropsychology following ECMO decannulation
- Guidance regarding discharge recommendations for neurodevelopmental follow-up

Measures

- Use of the ECMO Neuromonitoring and Acute Brain Injury Clinical Pathway
- Process Metrics
  - Rates of electroencephalogram (EEG) monitoring
  - Rates of post-decannulation magnetic resonance imaging
- Outcome Metrics
  - Rates of brain death/withdrawal of life-sustaining therapy due to brain injury
  - Rates of herniation as surrogates for earlier detection of acute brain injury

Value Implications

The following improvements may increase value by reducing healthcare costs and non-monetary costs (e.g., missed school/work, loss of wages, stress) for patients and families and reducing costs and resource utilization for healthcare facilities.

- Decreased delay of neuroprotective strategies
- Decreased unwarranted variation in care

Organizational Barriers and Facilitators

Potential Barriers

- Variability of the acceptable level of risk among providers
- Challenges with follow-up faced by some families

Potential Facilitators

- Collaborative engagement across care continuum settings during clinical pathway development
- Anticipated high rate of use of the clinical pathway

Power Plans

- ECMO Cannulation
- ECMO Maintenance

- ECMO Decannulation
- ECMO Bleeding Algorithm
- Extracorporeal Cardiopulmonary Resuscitation
- PICU Post Cardiac Arrest
- CICU Post Cardiac Arrest

Associated Policies

- ECMO Anticoagulation Guidelines
- Excessive Bleeding in Infant/Child on ECMO Treatment Guidelines

Clinical Pathway Preparation

This pathway was prepared by the Evidence Based Practice (EBP) Department in collaboration with the ECMO Neuromonitoring and Acute Brain Injury Clinical Pathway Committee, composed of content experts at Children's Mercy Kansas City. If a conflict of interest is identified, the conflict will be disclosed next to the committee member's name.

ECMO Neuromonitoring and Acute Brain Injury Clinical Pathway Committee Members and Representation

- Jessica Wallisch, MD | Critical Care Medicine | Committee Co-Chair
- Jenna Miller, MD | Critical Care Medicine, Pediatric ECMO Director | Committee Co-Chair
- Asdis Finnsdottir Wagner, DO | Critical Care Medicine | Committee Member
- David Garcia, MD | Neurosurgery | Committee Member
- Christian Kaufman, MD, FAANS | Neurosurgery | Committee Member
- Yong Han, MD | Critical Care Medicine | Committee Member
- John Daniel, MD, MS | Neonatology, Neonatal ECMO Director | Committee Member
- Sara McElroy, MD | Hematology/Oncology/BMT | Committee Member
- Shannon Carpenter, MD, MS | Hematology/Oncology/BMT | Committee Member
- Ara Hall, MD | Neurology | Committee Member
- Marcie Files, MD | Neurology | Committee Member
- Jake Arends, MD | Neurology | Committee Member
- Kari Davidson, MSN, RN, CCRN | Critical Care Nursing, Extracorporeal Support Director | Committee Member
- Debra Newton, RN, MSN, CCRN | Critical Care Nursing, Extracorporeal Support Director | Committee Member
- Natalee Perrin, BSN, RN, CCRN | Critical Care Nursing, Pediatric Intensive Care Unit | Committee Member
- Kristin Wiegert, PharmD, BCPPS | Pharmacy | Committee Member
- Sarah Dierking, MSN, RN, CPHQ | Clinical Practice and Quality | Committee Member

EBP Committee Members

- Todd Glenski, MD, MSHA, FASA | Anesthesiology, Evidence Based Practice
- Kelli Ott, OTD, OTR/L | Evidence Based Practice

Clinical Pathway Development Funding

The development of this clinical pathway was underwritten by the following departments/divisions: Critical Care Medicine, Neurosurgery, Neurology, Neonatology, Hematology/Oncology/BMT, ECMO Program, Pediatric Intensive Care Unit, Pharmacy, Clinical Practice and Quality, and Evidence Based Practice

Conflict of Interest

The contributors to the ECMO Neuromonitoring and Acute Brain Injury Clinical Pathway have no conflicts of interest to disclose related to the subject matter or materials discussed.

Approval Process

- This pathway was reviewed and approved by the ECMO Neuromonitoring and Acute Brain Injury Clinical Pathway Committee, content experts, departments/divisions, and the EBP Department; after which, they were approved by the Medical Executive Committee.
- Pathways are reviewed and updated as necessary every 3 years within the EBP Department at CMKC. Content expert teams are involved with every review and update.

Review Requested

Department/Unit	Date Obtained
Critical Care Medicine	July 2025
Neurosurgery	July 2025
Neonatology	July 2025
Neurology	July 2025
Hematology/Oncology/BMT	July 2025
ECMO Program	July 2025
Pharmacy	July 2025
Pediatric Intensive Care Unit	July 2025
Clinical Practice and Quality	July 2025
Evidence Based Practice	June 2025

Version History

Date	Comments
March 2025	Version one – (*Neurological Monitoring algorithm developed; associated powerplans reviewed and updated*)
August 2025	Version two – (*Neurological Monitoring algorithm revised; Intracranial Hemorrhage on ECMO and Post-Neurosurgical Intervention on ECMO algorithms developed; associated powerplans reviewed; synopsis developed*)
November 2025	Version three – (*Neurological Monitoring algorithm revised to further clarify guidance for EEG monitoring*)
Under development	Version four – (*Neurological Monitoring algorithm revised; Ischemic Brain Injury on ECMO algorithm developed; associated powerplans reviewed; synopsis revised*)

Date for Next Review

- August 2028

Implementation & Follow-Up

- Once approved, the pathway was presented to appropriate care teams and implemented. Care measurements will be assessed and shared with appropriate care teams to determine if changes need to occur.
- Order sets/power plans consistent with recommendations were reviewed, and updates were requested.
- Education was provided to all stakeholders:
  - Nursing units where the ECMO Neuromonitoring and Acute Brain Injury Clinical Pathway is used
  - Departments of Neurology, Neurosurgery, and Hematology
  - Providers from ICN, PICU, and CICU
  - Resident physicians
- Additional institution-wide announcements were made via email, the hospital website, and relevant huddles.

Disclaimer

When evidence is lacking or inconclusive, options in care are provided in the supporting documents and the power plan(s) that accompany the clinical pathway.

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