Neurological Care Post Cardiac Arrest (patient at risk for hypoxic ischemic brain injury)

Inclusion Criteria	Exclusion Criteria
CPR >/= 2 minutes	Awake and interactive
Intubated w/ mechanical ventilation	Newborn birth asphyxia (NICU)

Additional Evaluation for Un-explained Arrests:

- EKG
  - Consider dysrhythmias
- Echocardiogram
- Cardiac enzymes
- Metabolic Labs:
  - Urine organic acids
  - Serum amino acids
  - Acetylcarnitine profile
  - Free & total carnitine
  - Lactate/pyruvate battery
  - Ammonia
- Toxicology screen
  - Assess for medications in home

Consults:
Neurology
Genetics: suspected SIDS
Cardiology: if abnormal EKG
Trauma: suspected NAT
CAPC: suspected NAT

Rehab Consults:
PT/OT
PM&R
(consult for dispo planning)

Labs (at minimum):

- **Initial**– CBC, CMP, INR, ABG, lactate, blood Cx
- **Q24 hr**-CBC, INR, AED levels, CMP in AM, BMP in PM
- **Q4-6 hr**– ABG, lactate (if initial is abnl)
- **Q1 hr x4**– glucose then q 4 hr

If medical examiner declines case and family wants an autopsy

- Complete Consent
- Page Pathology
- Consider Genetic/Metabolic

Active Temperature Control:

- See guidelines

Supportive Care (goal: limit secondary injury)	Monitoring
1. Active temp management/Euthermia (35.5-36.5 °C) 2. Hgb goal 7-10 g/dl 3. SaO_2 >/= 95% 4. $PaCO_2$: 35-40 mmHg 5. Serum Na: 135-145 mEq/L 6. Serum Glucose : 80-180 7. MAP at 50%ile for age (see below)	1. Arterial Line/Central Access 2. Continuous EEG 3. Consider cerebral NIRS 4. Obtain HCT if: - Absent brainstem reflexes - Etiology of arrest not established - CPR on arrival to ED

Head CT

- Eval for mass, ICH and catastrophic insult (i.e. irreversible herniation)
- **** Note HCT can be initially normal even after prolonged code (not predictive of outcome)**
- Cerebral edema treatment does NOT improve outcome
  - ***NOT indicated**
  - ICP monitor
  - Hyperosmolar therapy (e.g. mannitol, 3% NS)
  - Pharmacological coma (e.g. **pentobarbital)**

Coma and Absent CN Reflexes AND HCT w/ absent basilar cisterns
Order EEG only if clinical seizures present

Suspected Progression to Brain Death?

- Supportive care for 24 hours then consider 1st brain death exam
- See Brain Death Checklist
- Notify WRTC

2nd exam consistent with brain death?

No → Consider DCD or withdrawal

Yes → PICU to complete shroud packet

EEG Monitoring
For prognosis and characterization of seizures
Obtain read within 1 hour of placement

Seizures Present?

Yes

Seizure Management:

- Benzo followed by
- Fosphenytoin 20 mg PE/kg load
- Obtain <u>total</u> phenytoin level 2 hours after load and daily am trough
- Begin fosphenytoin maintenance: 5 mg PE/kg/day divided q8-12 hrs
- <u>If seizures persist:</u>
  - Consider phenobarbital 20 mg/kg x 1
- <u>If seizures persist:</u>
  - Reassess clinical exam and EEG pattern before escalation of AEDs
  - Caution against use of long acting agents (e.g. **pentobarbital)** for seizure control or neuro-protection
  - <u>Myoclonic status:</u> Continuous infusions not likely to improve outcome. If coma and absent CN reflexes, prepare family for catastrophic outcome . No further tx indicated

- Eval for end organ damage
- Eval for dysautonomia
  - See dysautonomia guide
- MRI brain non contrast
- TPN after 48 hrs of admission

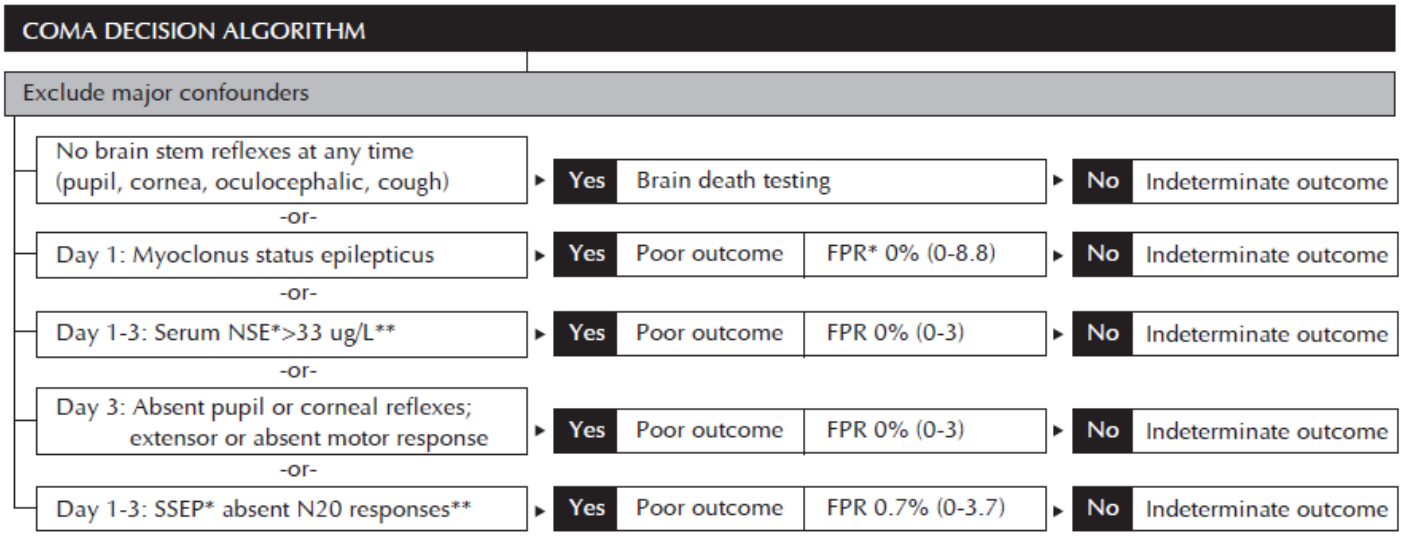
Age	Premie	Neonate	1-2 yrs	3-4 yrs	5-6 yrs	7-8 yrs	9-10 yrs	11-12 yrs	13-14 yrs	> 14 yrs
MAP Goal	Gest Age	45 mmHg	56 mmHg	63 mmHg	68 mmHg	71 mmHg	74 mmHg	76 mmHg	78 mmHg	82 mmHg

Neurological Care Post Cardiac Arrest

Supportive Care
Dysautonomia: Per PM&R and neurology **Hypothermia** : In comatose children who survived out-of hospital cardiac arrest, therapeutic hypothermia, as compared with therapeutic normothermia, did not confer a significant benefit in survival with good functional outcome at 1 year (THAPCA). **Hyperosmolar therapies:** In patients with anoxic brain injury, there is no clear evidence to support use of hyperosmolar therapy including in cases of cerebral herniation

Guidelines for Prognosis
Biochemical markers: Lower pH, higher lactate, and higher glucose within 12 hours of cardiac arrest is associated with increased mortality. **Clinical Exam:** The prognosis is invariably poor in comatose patients with absent pupillary or corneal reflexes, or absent or extensor motor responses 3 days after cardiac arrest. **Radiographic:** There are inadequate data to support or refute whether neuroimaging is indicative of poor outcome. **EEG:** Patients with myoclonus status epilepticus within first day after primary circulatory arrest have poor prognosis. Burst suppression or generalized epileptiform discharges on EEG predicted poor outcomes but with insufficient prognostic accuracy. **ICP Monitoring:** There are inadequate data to support or refute the prognostic value of ICP monitoring and use of pentobarbital. **Resuscitation :** Prognosis cannot be assessed on the circumstances of CPR.

Prediction of Outcome in Comatose Survivors after Cardiopulmonary Resuscitation:



References
1. Moler, F., Silverstein, F., Holubkov, R., Solmine, B., Christensen, J., Nadkarni, V.,...Dean,M. (2015). Therapeutic hypothermia after out-of-hospital cardiac arrest in children. The New England Journal of Medicine 372;20: 1898-1908. 2. Wijdicks, E., Hijdra, A., Young, G., Bassetti, C., and Wiebe, S. (2006). Practice parameter: Prediction of outcome in comatose survivors after cardiopulmonary resuscitation. American Academy of Neurology 2006;67: 203-210.

Cyanotic Heart Disease—Supportive Care

O2 saturations goals: Establish baseline sats prior to anoxic brain injury. Set goal based on baseline sat combined with expected norms for type of congenital heart disease.

Hemoglobin: Establish baseline hemoglobin prior to anoxic brain injury. Anticipate need for higher hemoglobin in context of chronic hypoxia.

Hematocrit: Establish baseline hematocrit. Set goal based on baseline and expected norms for type of congenital heart disease.

Hemodynamics: Establish blood pressure goals in the context of CV anatomy. Anomalies of pulmonary circulation and/or venous return may impact cerebral perfusion.

Sedation and Paralytics: Medications that limit the neurological exam may need to be used to maintain oxygenation and hemodynamic stability (e.g. in pulmonary HTN). Anticipate limited or no exam for first 48 hours. Recommend limited use of agents with long half life (pentobarbital).

Seizures and Antiepileptics: Establish patients risk for hypotension and/or arrhythmia.

- Risk for hypotension: prefer fosphenytoin over phenobarbital. If phenobarbital needed, administer in 5 mg/kg dose and repeat 5 mg/kg bolus if BP tolerates. Goal 20 mg/kg total bolus but can be spread out over several hours if needed.
- Risk for arrhythmia: prefer phenobarbital over fosphenytoin. Phenytoin should be avoided. Vimpat may worsen arrhythmias and should be used with caution, avoid in infants as well.

ECMO and eCPR

Neuroimaging (*Refer to Routine Neuro monitoring for ECMO patients guideline):*

- HUS: Consider daily x 3 days for infants < 6 months (or if open fontanelle). Assess for change in ventricle size and hemorrhage (note limited detection for SDH).
- CT: To obtain portable scan requires forethought. Limited availability nights and weekends. Best to obtain immediately after arrest/event and next at 48 hours post event. Scan at 24 hours not likely to change management.
- TCD: Limited use but can be used to anticipate impending brain death and/or trend flow in the anterior circulation.
- MRI: Not available for ECMO patients

Seizures and Antiepileptics: Note increased blood volume due to ECMO circuit

- AED load: Critical to obtain level 2 hours post load due to increased blood volume, anticipate need for repeat load.
- Maintenance: Anticipate need for higher maintenance dose due to multiple med interactions and increased blood volume.
- Dialysis: Consider CRRT and other forms of dialysis impact on AED levels.

Anticoagulation:

- ECMO requires anticoagulation. Consider bleeding protocol for patients with intracranial hemorrhage on ECMO. Intracranial hemorrhage alone is not an indication to discontinue ECMO.

References

1. Barrett, Cindy S., et al. "Neurological injury after extracorporeal membrane oxygenation use to aid pediatric cardiopulmonary resuscitation." *Pediatric Critical Care Medicine* 10.4 (2009): 445-451.
2. Huang, Shu-Chien, et al. "Extracorporeal membrane oxygenation rescue for cardiopulmonary resuscitation in pediatric patients." *Critical care medicine* 36.5 (2008): 1607-1613.
3. de Mos, Nienke, et al. "Pediatric in-intensive-care-unit cardiac arrest: incidence, survival, and predictive factors." *Critical care medicine* 34.4 (2006): 1209-1215.