Great Ormond Street NHS
Hospital for Children
NHS Trust

	Document Control Sheet
Guideline Title	Management of post cardiac arrest state
Purpose of Guideline/ Assurance Statement	Guide the management of a child of a child on the PICU following a cardiac arrest
Target Audience	All PICU staff
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Name of Originator/ author and job title	Dr Harish Bangalore, PICU Consultant
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Amendments:	
Links to other policies or relevant documentation	Death by Neurological Criteria
If draft	***[only complete remaining boxes]***
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Management of post cardiac arrest state

Return of Spontaneous Circulation (ROSC): defined as return of a perfusing heart rhythm accompanied by the presence of a palpable central pulse, either from a spontaneous perfusing heart rhythm or the initiation of Extra-Corporeal Life Support (ECLS).

Components: The components of post-cardiac arrest syndrome are- *brain injury, myocardial dysfunction, systemic ischemia/reperfusion injury, and persistent precipitating pathology.*

Outcomes:

Type	***ROSC***	***Survival at 1 year***	***Good Neurological outcome***	***Comments***
OHCA[1]	About 36 %	29-38% at 1 year	12% to 20% at 1 year	No significant change in outcome over few years
IHCA[2]	About 70%	46-49% at 1 year	36-39% at 1 year	Improved over years

1- Out of Hospital Cardiac arrest
2- In Hospital Cardiac arrest

Clinical pathophysiology:

Component	***Pathology***	***Clinical correlate***	***Clinical manifestations***
Brain injury	Oxidative stress, free radical injury, calcium accumulation, apoptosis and necrosis	Hypotension, Hypoxia, Hypoglycaemia, hyperoxia, hypo/hyper-ventilation may worsen outcome PaO_2 >8 and < 40 kPa favourable $PaCO_2$ < 4 and > 6.5 kPa unfavourable	Coma, seizures, myoclonus, sympathetic hyperarousal, long term cognitive and neurobehavioral issues
Myocardial dysfunction	Ischemia-reperfusion, cytokine medicated injury, catecholamine induced injury	Begins in hours, worse at 8 hours, improves after 24 hours. Left and Right Ventricular systolic and diastolic dysfunction	Decreased cardiac output Arrhythmia, pulmonary oedema, hypotension
Systemic ischemia-reperfusion	Similar to sepsis with endothelial leak, hyperglycaemia, alterations in coagulation cascade, intense inflammatory response	Multi-organ dysfunction similar to sepsis	Hypovolaemia, vasoplegia, coagulopathy, hyperglycaemia, adrenal insufficiency, impaired oxygen utilisation
Persistent Precipitating Pathophysiology	Related to pathology leading to cardiac arrest	Features of underlying condition	Example-sepsis, ARDS, shock, trauma

Relevant history:

- IHCA or OHCA
- Details of possible precipitating pathology(including Non Accidental Injury when suspected)
- Time to first response and initiation of resuscitation
- Time to ROSC
- First lactate and pH

Investigations:

The list is not exhaustive and should be considered based on the probable cause of underlying cardiac arrest. Important investigations to consider are:

1. ECG and echocardiogram
2. Investigations for NAI if relevant especially with a traumatic head injury
3. Toxicology urine and blood
4. Neuro-imaging and EEG
5. Infection markers-blood cultures, NPA, viral studies
6. Urine HCG if relevant
7. Metabolic screen
8. Cardiology consult especially if arrhythmias are suspected to be a cause of the cardiac arrest

Treatment:

1. Treatment of underlying possible precipitating pathology is paramount-example treatment of sepsis if infection is suspected, prompt identification of toxicity/poisoning
2. System specific management:
    - CNS:
        -The child or infant ***must not*** be allowed to become hyperthermic
        - Temperature control post-cardiac arrest is called targeted temperature management
        - Unit policy is for normothermia of 36-36.5 ^{0}C
        -Do not actively rewarm a successfully resuscitated child with hypothermia unless the core temperature is below 32°C when warming should be at about 0.25– 0.5°C per hour
        -Monitor and consider treatment for seizures, EEG when possible and repeated as necessary (suspicion of seizure or prognostication or screening for seizures when clinically suspected)
        -Sedation for 48-72 hours
        -Muscle relaxation if needed to prevent shivering
        -Use train of four to assess depth of paralysis when NMB is used
        -Discontinue sedation, analgesia and paralysis if clinical exam consistent with brain death at any stage for assessment

    - Cardiovascular:
        -Management of shock as per sepsis/shock guidelines
        -Aim for systolic blood pressure at least > 5th centile for age
        -Consider need and screen for ECLS for persistent cardio-vascular instability and if high-risk of repeated cardiac arrest
        -Monitor for arrhythmias, optimise electrolytes
        -Assess for prolonged QTc and avoid drugs which prolong them

    - Respiratory:
        -Use lung-protective strategies: Tidal volume < 6 mls/kg ideal body weight
        -Avoid hyperoxia and hypoxia

-Target of 94-96% with minimal oxygen needed for support
-Maintain PaO2 of > 8kPa and < 40 kPa

-Maintain PaCO2 of > 4.5 kPa and < 6.5 kPa

-Renal:
-Avoid nephrotoxic medications
-Renal Replacement Therapy may be needed rarely (about 5% of children)
-Sedatives and Neuro-muscular blocking agents may have a prolonged action

-Others:
-Avoid hypoglycaemia
-Treat hyperglycaemia as per protocol
-Consider stress dose steroid in refractory shock
-Vigilance for hospital acquired infections such as Ventilator associated pneumonia
-Platelet transfusion, correction of coagulopathy particularly with procedures and with risk of bleeding as per guidelines (usual target, Hb > 7 g/dl, platelet target > 25,000 or > 100000 or therapeutic procedures with risk of bleeding)
-Consider initiating enteral feeds within 24 hours if no contra-indications
-Comatose children with ROSC receiving mechanical ventilation who fulfill neurological criteria for death, or in whom withdrawal of life-sustaining treatments is planned should be considered as potential organ donors

Prognostication:

-Serial examination and a multimodal approach are important
-Always involve specialist neurologists and other relevant specialities where necessary
-A combination of tests and investigations is more helpful in prognostication than the yield of single test.

1. Serial neurological examinations:
- Combination of GCS < 5, absence of spontaneous respiratory activity and absence of pupillary reflexes has a high positive predictive value for poor prognosis
- The effects of medications have to be taken into account before interpreting neurological signs particularly in children with poor renal function
- Serial neurological examination is beneficial

2. Electroencephalogram:
- Interpretation by a trained electrophysiologist is important
- Children with severe abnormal background (example burst suppression or featureless) on EEG likely to have a worse neurological outcome
- Should not be used as the sole criteria

3. Somatosensory evoked potentials (SSEP):
- Not affected by sedation or hypothermia
- Tests the integrity of the peripheral nerve (Median), spinal cord, brain stem and cerebral cortex
- Bilateral absence of the N 20 wave is associated with poor neurological outcome
- Important to consider lesions in the other parts of the pathway may affect the N 20 wave
- Brain stem Evoked potentials (BAEP) and visual evoked potentials (VEP) test only the auditory and visual pathways and may lack utility to predict Neuro-cognitive outcome

4. CT scan of the brain:
- Obtained early < 24 hours may be helpful to ascertain cause of cardiac arrest (bleeding, stroke, mass lesions, cerebral oedema etc)
- Unlikely to be useful as a single modality particularly when done < 24 hours after ROSC to predict neurological outcome

5. MRI brain:

- More sensitive than CT scan for detecting ischemic abnormalities
- Interpretation by a Neuro-radiologist is essential
- Diffusion restriction in the cerebral cortex and basal ganglia is usually associated with poor prognosis
- MRI done at 3-7 days after ROSC may be helpful as a supplemental examination in prognostication

References:

1. Topjian AA, de Caen A, et al. Pediatric Post-Cardiac Arrest Care: A Scientific Statement From the American Heart Association. Circulation. 2019 Aug 6; 140(6):e194-e233
2. Moler FW, Silverstein FS, THAPCA Trial Investigators. Therapeutic Hypothermia after In-Hospital Cardiac Arrest in Children. N Engl J Med. 2017 Jan 26; 376(4):318-329
3. Moler FW, Silverstein FS, THAPCA Trial Investigators. Therapeutic hypothermia after out-of-hospital cardiac arrest in children. N Engl J Med. 2015 May 14; 372(20):1898-908