# Out of hospital Cardiac Arrest (OOHCA) guideline for patients less than 16 years of age

**Target audience:**

Medical and nursing staff Leeds Children's Hospital PICU and Sheffield Children's Hospital PCCU.

Embrace Yorkshire & Humber Neonatal and Paediatric Transport Service.

Medical and nursing staff in hospitals encompassed by the Yorkshire and Humber Paediatric Critical Care Operational Delivery Network.

**Date of issue**:

August 2021

**Date of review**:

August 2024

**Author**:

Dr Mark Winton, ST8 PICM Yorkshire, LGI PICU/Embrace Yorkshire and Humber Neonatal and Paediatric Transport Service.

**Peer reviewers:**

Dr Sian Cooper, Consultant Paediatric Intensivist, PICU, Leeds Children's Hospital.

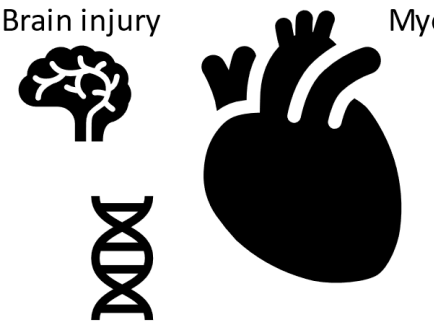
Dr Fatemah Rajah, Consultant Embrace Yorkshire and Humber Neonatal and Paediatric Transport Service.

Ann Kelly, Advanced Clinical Practitioner, PICU, Leeds Children's Hospital.

**Contents** **Page Number**

## Guideline overview

# POST CARDIAC ARREST SYNDROME




## Phase 1

ROSC – 6 hours post arrest

- Cuffed ETT
- Avoid hypo/ hyperoxia
- Avoid hypotension
- DO NOT ACTIVELY RE-WARM
- Avoid hyperthermia (>37.5 °C)
- Normocarbia ($PaCO_2$ 4.5-5.5)
- Nurse in midline
- 30 degree head elevation
- Urinary catheter
- Urgent CT head if diagnostic uncertainty
- Muscle relaxation
- Consider SNOD referral

## Phase 2

6 - 72 hours post arrest

- Normocarbia ($PaCO_2$ 4.5-5.5)
- Avoid hyperthermia (>37.5 °C)
- Active temperature target 36 – 36.5 °C with cooling
- Nurse in midline
- 30 degree head elevation
- Investigate underlying cause
- CFAM
- Muscle relaxation
- Optimise electrolytes
- Enteral feeding
- Consider SNOD referral

## Phase 3

72 hours post arrest and beyond

- Formal neurological assessment 72 hours
- MRI head 3 – 5 days post arrest
- Potential for parallel planning with palliative care and SNOD
- Neuro rehabilitation input as appropriate

**Consider the appropriateness of on-going care in a situation which could be futile**



## Phase 1: Return Of Circulation (ROSC) – 6 hours post arrest

| | |
|---|---|
| **Airway** | Appropriately sized cuffed oral ETT positioned at T2 on chest film (appendix 1 size/length guide). |
| **Breathing** | Initially 100% $O_2$ at time of arrest then target $O_2$ saturations 94-98%.<br>Target $PaCO_2$ 4.5 - 5.5. Hypoxia should be avoided. |
| **Circulation** | Fluid resuscitation, monitoring of central venous pressure to avoid fluid overload. Targeting of normal for age blood pressure (appendix 2) and perfusion. Avoid hypotension in first 12 hours post ROSC.<br>Consider adrenaline for inotropy (avoiding further vasoconstriction). |
| **Disability** | Temperature target of 36 - 36.5°C for 72 hours.<br>Avoid hyperthermia (core temp ≥ 37.5°C).<br>CT head - consider performing soon after ROSC if cause is unknown.<br>Documentation of best GCS and pupil examination.<br>Commence morphine (analgesia) and consider midazolam (sedation) infusions.<br>Nurse 30 degrees head elevation in the midline. |
| **Environment** | Muscle relaxation with rocuronium infusion to prevent shivering.<br>Urinary catheter insertion to prevent bladder distension and discomfort<br>Restrict to 80% maintenance daily fluids.<br>Consider and treat sepsis as underlying cause. |

## Phase 2: 6 - 72 hours post arrest

| | |
|---|---|
| **Airway** | Appropriately sized cuffed oral ETT (appendix 1 for size/length guide) at T2 on chest film.<br>Consider nasal ETT if patient less than 5 years and to remain ventilated > 2 days. |
| **Breathing** | Target $O_2$ saturations 94-98%.<br>Target $PaCO_2$ 4.5 - 5.5 |
| **Circulation** | Monitoring central venous pressure to avoid fluid overload.<br>Targeting normal for age blood pressure (appendix 2) and perfusion.<br>Consider Adrenaline for inotropy (avoiding further vasoconstriction).<br>Avoid hypotension in first 12 hours post ROSC. |
| **Disability** | Neuroprotection; targets discussed and documented with bedside PICU nurse. Mid-line at 30 degree head elevation. Minimal handling.<br>**Active** temperature target of 36 - 36.5°C for 72 hours.<br>Avoid hyperthermia (core temp ≥ 37.5°C). CFAM +/- Urgent formal EEG. |
| **Environment** | Continuous temperature monitoring (oesophageal/ rectal).<br>Muscle relaxant infusion to prevent shivering.<br>Magnesium >1, Potassium 3.5 - 5, normoglycaemia (3.5 – 7).<br>Urine output >1ml/kg/hr via urine catheter, fluid restriction to 80% daily maintenance fluids.<br>NGT and nil by mouth for first 24 hours then trophic feeds as tolerated.<br>Consider and treat sepsis as underlying cause. |

## Phase 3: 72 hours post arrest and beyond

- Formal neurological examination should be made at 72 hours to guide waking and weaning or further period of sedation
- Commence neurorehabilitation, encourage enteral feeds
- Neuroimaging MRI head day 3 – 5 post arrest; discuss with neuroradiology consultant

## Investigate the underlying cause of arrest as soon possible

- Baseline; ECG/ CXR/ Cardiology review/ FBC/LFT/ U&E/ Mg/Ca
- Consider; Toxicology screen/ Metabolic screen/ Cardiomyopathy screen /Safeguarding

Dr Mark Winton, ST8 PICM Yorkshire, August 2021

## 3. Abbreviations

| | |
|---|---|
| **CT** | computed tomography |
| **DNC** | death by neurological criteria |
| **DWI** | diffusion weighted imaging |
| **ECG** | electrocardiogram |
| **ETT** | endo tracheal tube |
| **GCS** | Glasgow coma score |
| **LOTA** | limitation of treatment agreement |
| **MRI** | magnetic resonance imaging |
| **OOHCA** | out of hospital cardiac arrest |
| **OR** | odds ratio |
| **PICU** | paediatric intensive care unit |
| **ROSC** | return of spontaneous circulation |
| **SALT** | speech and language therapy |
| **ReSPECT** | recommended summary plan for emergency care and treatment |
| **VF** | ventricular fibrillation |
| **VT** | ventricular tachycardia |

# 4. Introduction

## Definition

Patients aged between 0 – 16 years in whom mechanical heart function has stopped. Confirmed by no palpable central pulse, apnoea and unresponsiveness.

## Scope

All patients aged between 0 – 16 years who suffer a cardiac arrest out of hospital who fulfill the following criteria:

- Cardiopulmonary resuscitation for more than 1 minute.
- Who are mechanically ventilated.
- Who do not have a pre-existing advance care plan or ReSPECT form in place with a plan differing from national resuscitation guidelines.

## Post cardiac arrest syndrome

2009 consensus statement from International Liaison Committee on Resuscitation (1, 2):

*"The 4 key components of post-cardiac arrest syndrome were identified as:*

*(1) post-cardiac arrest brain injury*

*(2) post-cardiac arrest myocardial dysfunction*

*(3) systemic ischaemia/reperfusion response*

*(4) persistent precipitating pathology*

*A growing body of knowledge suggests that the individual components of the post-cardiac arrest syndrome are potentially treatable"*

**Please refer to Appendix 4 for discussion of the current evidence base and clinical controversies related to this guideline.**

**3 phases to management post arrest**

1. Early post arrest phase (ROSC – 6 hours post arrest); referring unit, Embrace transport team and PICU.

2. Intermediate phase; PICU (6 -72 hours post arrest).

3. Assessment and recovery phase; PICU, neurology ward with neurorehabilitation input.

## 5. Short Term Management; (ROSC – 6 hours post arrest)

Consider the appropriateness of on-going care if significantly prolonged downtime and degree of acidosis on blood gas. Continuing active treatment is futile in some clinical situations. Discuss with a Paediatric Intensivist via the Embrace transport service. Not transferring to a tertiary centre may be in the patient's best interests.

Transfer to a tertiary centre should be made safely and emergently to an environment where neuroprotective measures can be appropriately delivered.

Document a thorough history of events surrounding the cardiac arrest, the subsequent resuscitation, and a complete medical history from a parent/ care giver. Handover this information to the receiving PICU team.

| | |
|---|---|
| **Airway** | Appropriately sized cuffed oral ETT positioned at T2 on chest film (appendix 1. size/length guide). |
| **Breathing** | Initially 100% $O_2$ at time of arrest then target $O_2$ saturations 94-98%.<br>Target $PaCO_2$ 4.5 - 5.5.<br>Hypoxia should be avoided. |
| **Circulation** | Fluid resuscitation, ideally monitoring of central venous pressure to avoid overload.<br>Targeting of normal for age blood pressure (appendix 2) and perfusion.<br>Avoid hypotension in first 12 hours post ROSC.<br>Consider adrenaline for inotropy (avoiding further vasoconstriction). |
| **Disability** | Temperature target of 36 - 36.5°C for 72 hours.<br>Avoid hyperthermia (core temp ≥ 37.5°C).<br>CT head -consider performing soon after ROSC if cause is unknown, to diagnose/rule out acute intra-ventricular bleed, extra-axial bleed or hydrocephalus.<br>Documentation of best GCS and pupil examination.<br>Commence morphine (analgesia) and midazolam (sedation) infusions (sedation agents may differ between PICU's)<br>Nurse 30 degrees head elevation in the midline. |
| **Environment** | Muscle relaxation with rocuronium infusion to prevent shivering.<br>Urinary catheter insertion.<br>Consider and treat sepsis as underlying cause.<br>Restriction to 80% daily maintenance fluids. |

## 6. Medium term management; (6 – 72 hours post arrest)

Clarity of treatment targets for neuroprotection to bedside nurse, documented and agreed on ward round.

| | |
|---|---|
| **Airway** | Appropriately sized cuffed oral ETT (see appendix 1 for size/length guide) at T2 on chest film.<br>Consider switching to nasal ETT if patient less than 5 years and to remain ventilated for more than 2 days. |
| **Breathing** | Target $O_2$ saturations 94-98%.<br>Target $PaCO_2$ 4.5 - 5.5. |
| **Circulation** | Monitoring of central venous pressure to avoid fluid overload.<br>Targeting of normal for age blood pressure (appendix 2) and perfusion.<br>Consider Adrenaline for inotropy (avoiding further vasoconstriction).<br>Avoid hypotension in first 12 hours post ROSC. |
| **Disability** | **Neuroprotection – specific targets should be discussed and documented with bedside PICU nurse.**<br>Nurse in mid-line at 30 degree head elevation.<br>Minimal handling.<br>Temperature target of 36 - 36.5°C for 72 hours.<br>Avoid hyperthermia (core temp ≥ 37.5°C).<br>**Normothermia needs to be actively achieved** (appendix 3 cooling flowchart).<br>CFAM (cerebral function analysing monitoring) should be commenced.<br>If concerns regarding seizures then urgent EEG should be requested (in hours). |
| **Environment** | Continuous temperature monitoring with central temperature probe (oesophageal/ rectal).<br>Muscle relax with rocuronium infusion to prevent shivering.<br>Magnesium >1 reduces shivering, Potassium 3.5 - 5, normoglycaemia (3.5 – 7).<br>Urine output >1ml/kg/hr via urine catheter, restriction to 80% daily maintenance fluids.<br>NGT and nil by mouth for first 24 hours then trophic feeds as tolerated.<br>Consider and treat sepsis as underlying cause. |

## 7. On-going management (72 hours post arrest and beyond)

Duration of neuroprotective measures following OOHCA is contentious and will depend on the clinical condition of the patient, the likelihood of survival, long term neurological prognosis and treatment expectations of family members.

Formal neurological examination should be made at 72 hours. This will be impacted by any on-going sedation, analgesic and muscle relaxant infusions.

Options then include:

1. Neuroprotection can be continued for a further 48 hours if there is clinical benefit.

2. Weaning sedation and waking the patient.

Initiating neurorehabilitation and ensuring investigations completed for identifying underlying cause of cardiac arrest. Parallel planning with palliative care team may also need to be considered depending on prognosis.

**Feeding**

Start enteral feeds. Consider nasojejunal feeds and early referral to SALT.

**Neuro-imaging**

Early discussion with on-call the neuroradiology consultant will aid the logistics of organising an MRI head scan. MRI head diffusion weighted imaging (DWI) and apparent diffusion coefficient (ADC) are sensitive for picking up changes within 24 hours of hypoxic ischaemic insult, but may be normal or underestimate extent of injury. Diffusion changes peak 3-5 days after hypoxic ischaemic insult and pseudo-normalise at the end of 1$^{st}$ week. Normal DWI at 3 days after hypoxic ischaemic insult has been associated with good prognosis(2).

**Diagnosis of Death by Neurological Criteria (DNC)**

A code of practice for the diagnosis and confirmation of death has been published by the Academy of Royal Colleges:

https://aomrc.org.uk/wp content/uploads/2016/04/Code_Practice_Confirmation_Diagnosis_Death_1008-4.pdf

RCPCH guidance exists for those patients under 2 months of age:

https://www.rcpch.ac.uk/resources/diagnosis-death-neurological-criteria-dnc-infants-less-two-months-old-clinical-guideline

Information on making a referral to specialist nurse for organ donation (SNOD)

https://www.odt.nhs.uk/deceased-donation/best-practice-guidance/donor-identification-and-referral/

## 8. Investigating underlying cause of cardiac arrest

Causes for cardiac arrest in children are broad and require thorough investigation, which should be commenced as soon as possible. The following should be completed:

Plain chest film.

Full blood count, clotting screen, sodium, potassium, urea and creatinine, liver function tests, magnesium, calcium.

Cardiology review including echo and 12 lead ECG.

Neuroimaging:

- Early CT (as soon as patient clinically stable following ROSC) imaging to rule out an acute intraventricular bleed, extra-axial bleed or hydrocephalus (cause or consequence of arrest).

- MRI head day 3 – 5 post arrest. Discuss timing and protocol of scan and with neuroradiologist.

Toxicology screen (urine and blood), cardiomyopathy screen if indicated, inborn error of metabolism screen if indicated.

Consider safeguarding referral and subsequent child protection investigations.

# 9. Appendices

## Embrace airway size and length guide

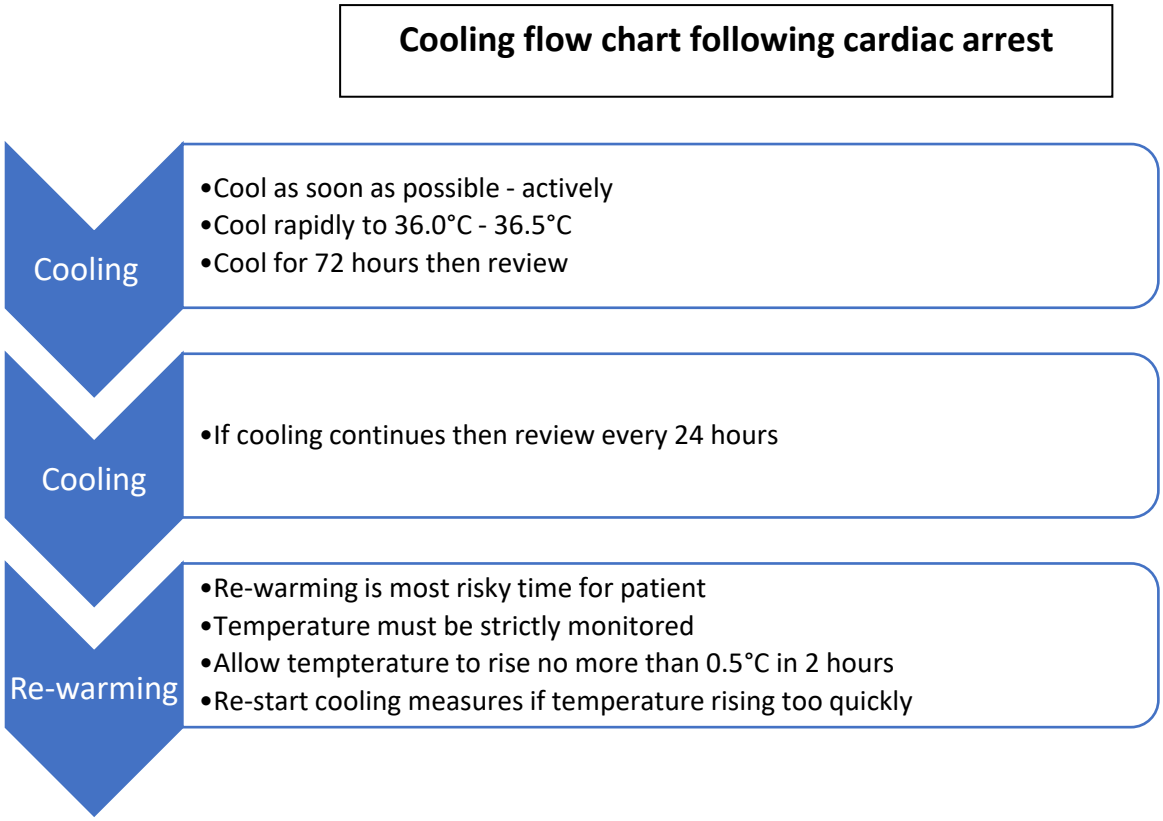
http://sheffieldchildrens.nhs.uk/embrace

| Age | Weight | ETT size | At lips (cm) | At nose (cm) | Suction (fg) |
|---|---|---|---|---|---|
| 3 months | 5.5 | 3.5 -4.0 | 10 | 12 | 8 |
| 1 year | 10 | 4.0 | 11 | 14 | 8 |
| 2 years | 12 | 4.5 | 12 | 15 | 8 |
| 3 years | 14 | 4.5 | 13 | 16 | 8 |
| 4 years | 16 | 5.0 | 14 | 17 | 10 |
| 6 years | 25 | 5.5 | 15 | 19 | 10 |
| 8 years | 31 | 6.0 | 16 | 20 | 10 |
| 10 years | 37 | 6.5 | 17 | 21 | 12 |
| 12 years | 43 | 7.0 | 18 | 22 | 12 |
| 14 years | 50 | 7.5 | 19 | 23 | 12 |
| Adult | 60 | 8.0 | 20 | 24 | 12 |
| Adult | 70 | 9.0 | 21 | 25 | 12 |

## Normal blood pressure reference ranges 5th and 50th centile systolic, Advanced Paediatric Life Support: A Practical Approach to Emergencies, Sixth Edition, 2016.

| Age (years) | Heart rate | Respiratory rate | Systolic blood pressure (mmHg) | |
|---|---|---|---|---|
| | | | 5th centile | 50th centile |
| < 1 | 110-160 | 30-40 | 65-75 | 80-90 |
| 1 -2 | 100-150 | 25-35 | 70-75 | 85-95 |
| 2 – 5 | 95-140 | 25-30 | 70-80 | 85-100 |
| 5 – 12 | 80 – 120 | 20-25 | 80-90 | 90-110 |
| >12 | 60-100 | 15-20 | 90-105 | 100-120 |

## Cooling flow chart.



## Evidence base and clinical controversies

### Therapeutic hypothermia

Initial adult critical care evidence suggested that therapeutic hypothermia to 33°C inferred benefit to patients, this was subsequently refuted in other studies:

Bernard 2002; 77 patients, therapeutic hypothermia (33°C)in patients with out of hospital VF arrest favoured 'improved discharge disposition and trend towards improved mortality' (4).

HACA 2002; European hypothermia study for out of hospital arrest. 275 patients. Patient randomised to normothermia or hypothermia (32-34°C). Therapeutic hypothermia improved 6 month outcome and mortality among patients with OOH VT/VF cardiac arrest. Hypothermia associated with increased risks; bleeding and infection(5).

TTM Nielson 2013; 939 patients. Therapeutic hypothermia 33°C vs 36°C for 28 hours. No difference in long term mortality(6). The results of TTM2 (hypothermia vs normothermia, 1900 adult patients randomised) were recently published concluding that "in patients suffering out-of-hospital cardiac arrest, induced hypothermia did not lead to lower mortality" (7)

All the above adult studies do complement each other in that they all demonstrated that active temperature management and avoidance on hyperthermia is important in adult patients post cardiac arrest. Current UK resus council guidance suggests "*Targeted temperature management remains important but the target temperature can be in the range of 32°C to 36°C according to local policy*"(8).

Within paediatrics Bembea et al demonstrated that "*Persistent post arrest hyperthermia was associated with unfavorable neurologic outcomes, even after controlling for potential confounding factors"*. This study of 547 paediatric patients following cardiac arrest, identified episodes of hyperthermia in the first 24 hours post arrest (core temp ≥ 38°C) (9).

The THAPCA study (Therapeutic Hypothermia after in hospital pediatric cardiac arrest) which randomized to 33°C or normothermia was terminated due to futility with the finding that the intervention "*did not confer a significant benefit in survival with a favorable functional outcome at 1 year"* (10). The study team arrived a similar conclusion for their study assessing out of hospital cardiac arrest (11). A recent meta-analysis of 2002 paediatric patients following cardiac arrest demonstrated a "49.7% *survival to hospital discharge in the TTM group, which was higher than in the non-TTM group (43.5%; odds ratio, OR = 1.22; 95% confidence interval, CI: 1.00, 1.50; p = 0.06). There were no differences in the one-year survival rate or the occurrence of adverse events between the TTM and non-TTM groups"*(12)

### Normocarbia

McKenzie et al's systematic review of 9 studies normocarbia was associated with increased hospital survival (odds ratio [OR] 1.30, 95% confidence interval [CI] 1.23, 1.38) (13). Normocarbia defined as $PaCO_2$ 4.5 – 5.5.

### Hypoxia/ hyperoxia

A systematic review of adult patients post-cardiac arrest by Wang et al in 2014 investigated the correlation between hyperoxia and worse outcome in terms of mortality and neurological morbidity. They concluded: "*Hyperoxia appears to be correlated with increased in-hospital mortality of post-ROSC patients. This result should be interpreted cautiously because of the significant heterogeneity and limited number of studies analyzed*" (14)

## Avoiding hypotension

A paediatric study of 383 patients post-cardiac arrest assessed the impact of hypotension on long term outcomes post cardiac arrest. Documented minimum systolic blood pressure < 5th percentile for age and sex within the first 6 hours following ROSC were considered to have early post-resuscitation hypotension. Hypotension in the first 6 hours following ROSC was associated with a significantly increased odds of in-hospital mortality (adjusted OR=1.71; 95%CI, 1.02–2.89; P=0.042) and odds of unfavorable outcome (adjusted OR=1.83; 95%CI, 1.06–3.19; P=0.032)(15).

## Factors associated with an increased risk of mortality

Schofield et al performed an observational study of 827 children admitted to PICU following OHCA. Characteristics at admission associated with increased risk of death included; bilateral unreactive pupils, genetically inherited condition, inter-hospital transfer to PICU, requirement for vasoactive drugs and greater base deficit (16).

## 10. References


1. Neumar RW et al. Post-cardiac arrest syndrome: epidemiology, pathophysiology, treatment, and prognostication. A consensus statement from the International Liaison Committee on Resuscitation. *Circulation.* 2008;118:2452–2483.

2. Post Cardiac Arrest Guideline, Birmingham Children's Hospital PICU, Krishnan, Schofield, 2016. https://www.networks.nhs.uk/nhs-networks/yorkshire-humber-paediatric-critical-care-odn/clinical-forums/paediatric-critical-care-clinical-forum-presentations-12-march-2019/pcc-clinical-forum-presentation-by-dr-b-schofield-dr-h-krishnan

3. Adapted from Leeds General Infirmary PICU cooling guideline. (http://www.lhp.leedsth.nhs.uk/detail.aspx?id=4569), A. Kelly, Leeds Health Pathways.

4. Bernard SA, et al. Treatment of comatose survivors of out-of-hospital cardiac arrest with induced hypothermia. N Engl J Med. 2002 Feb 21;346(8):557-63. doi: 10.1056/NEJMoa003289. PMID: 11856794.

5. Hypothermia after Cardiac Arrest Study Group. Mild therapeutic hypothermia to improve the neurologic outcome after cardiac arrest. N Engl J Med. 2002 Feb 21;346(8):549-56. doi: 10.1056/NEJMoa012689. Erratum in: N Engl J Med 2002 May 30;346(22):1756. PMID: 11856793.

6. Nielsen et al, Targeted Temperature Management at 33°C versus 36°C after Cardiac Arrest, December 5, 2013, N Engl J Med 2013; 369:2197-2206, DOI: 10.1056/NEJMoa1310519.

7. Hypothermia versus Normothermia after Out-of-Hospital Cardiac Arrest, Dankiewicz J for the TTM2 Trial Investigators. NEJM June 17, 2021 DOI:10.1056/NEJMoa2100591

8. UK resus council adult resuscitation guidelines, 2015, https://www.resus.org.uk/library/2015-resuscitation-guidelines/guidelines-post-resuscitation-care#1-the-guidelines

9. Bembea, et al, Temperature patterns in the early post resuscitation period after pediatric in hospital cardiac arrest, Pediatric Critical Care Medicine: November 2010 - Volume 11 - Issue 6 - p 723-730 doi: 10.1097/PCC.0b013e3181dde659

10. Moler FW et al. Therapeutic Hypothermia after In-Hospital Cardiac Arrest in Children. N Engl J Med. 2017 Jan 26;376(4):318-329. doi: 10.1056/NEJMoa1610493. Epub 2017 Jan 24. PMID: 28118559; PMCID: PMC5310766.

11. Moler FW, et al. Therapeutic hypothermia after out-of-hospital cardiac arrest in children. N Engl J Med. 2015 May 14;372(20):1898-908. doi: 10.1056/NEJMoa1411480. Epub 2015 Apr 25. PMID: 25913022; PMCID: PMC4470472.

12. Wieczorek et al, Efficacy of Targeted Temperature Management after Pediatric Cardiac Arrest: A Meta-Analysis of 2002 Patients, Journal of Clinical Medicine 2021, 10, 1389. https://doi.org/10.3390/jcm10071389

13. McKenzie N et al. A systematic review and meta-analysis of the association between arterial carbon dioxide tension and outcomes after cardiac arrest. Resuscitation. 2017 Feb;111:116-126. doi: 10.1016/j.resuscitation.2016.09.019. Epub 2016 Sep 30. PMID: 27697606.

14. Wang CH, et al. The effect of hyperoxia on survival following adult cardiac arrest: a systematic review and meta-analysis of observational studies. Resuscitation. 2014 Sep;85(9):1142-8. doi: 10.1016/j.resuscitation.2014.05.021. Epub 2014 Jun 2. PMID: 24892265.

15. Topjian AA et al. Early post resuscitation hypotension is associated with increased mortality following pediatric cardiac arrest. Crit Care Med. 2014;42(6):1518-1523. doi:10.1097/CCM.0000000000000216

16. Schofield BR et al. Observational study of children admitted to United Kingdom and Republic of Ireland Paediatric Intensive Care Units after out-of-hospital cardiac arrest. Resuscitation. 2015 Dec;97:122-8. doi: 10.1016/j.resuscitation.2015.07.011. Epub 2015 Jul 20. PMID: 26206597.