

Guideline 12.5 - Management after Return of Spontaneous Circulation (ROSC)

Summary

ANZCOR Guidelines 12.1 to 12.5 are provided to assist health professionals in the resuscitation of children. Differences from the adult and newborn guidelines reflect differences in the causes of cardiorespiratory arrest in, and anatomy and physiology of newborns, older infants, children and adults. These guidelines draw from Paediatric Life Support 2020 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations¹ the development of which included representation from ANZCOR. The 2020 European Resuscitation Council Paediatric Life Support guidelines², 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Care³, previous Paediatric Life Support International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations⁴⁻⁶ statements and local practices have also been taken into account.

ANZCOR Guideline 12.5 focuses on the management of the infant or child after cardiorespiratory arrest in cases where return of spontaneous circulation has been achieved. It should be read in conjunction with the other paediatric guidelines (ANZCOR Guidelines 12.1 to 12.4).

To whom does this guideline apply?

This guideline applies to infants and children (refer to ANZCOR Guideline 12.1 for definitions) who have return of spontaneous circulation (ROSC) after cardiorespiratory arrest.

Who is the audience for this guideline?

This guideline is intended for health professionals who care for infants and children in healthcare environments where resuscitation equipment and medications are available.

It represents the next steps in the continuum of care from bystander basic life support (BLS) and/or health professional paediatric basic life support (PBLs) and paediatric advanced life support (PALS) through to recovery and steps to optimise long term outcome.

Summary of Recommendations

The Australian and New Zealand Committee on Resuscitation (ANZCOR) makes the following

recommendations:

1. ANZCOR suggests that infants and children with ROSC who have been resuscitated after cardiorespiratory arrest must be admitted to a facility with the necessary resources for proper post-ROSC neuroprotective care, organ- and/or life-supporting treatments, comprehensive neurological assessment and psychosocial support [Good Practice Statement].
2. ANZCOR recommends that for infants and children after ROSC, parenteral fluids and/or inotropes or vasopressors should be used to maintain a systolic blood pressure of at least greater than the fifth percentile for age [CoSTR 2015, strong recommendation, very low-quality evidence].
3. ANZCOR suggests that rescuers measure PaCO₂ after ROSC and target normocapnia [CoSTR 2020, weak recommendation, very low-certainty evidence]. Consider adjustments to the target PaCO₂ for specific patient populations where normocapnia may not be desirable (eg. chronic lung disease with chronic hypercapnia, congenital heart disease with single-ventricle physiology, increased intracranial pressure with impending herniation).
4. ANZCOR suggests that rescuers measure PaO₂ after ROSC and target a value appropriate to the specific patient condition. In the absence of specific patient data, we suggest rescuers target normoxemia after ROSC [CoSTR 2020, weak recommendation, very low-quality evidence]. Given the availability of continuous pulse oximetry, targeting an oxygen saturation of 94% to 99% may be a reasonable alternative to measuring PaO₂ and titrating oxygen when feasible to achieve normoxia [CoSTR 2020, Good Practice Statement].
5. ANZCOR suggests that for infants and children who remain comatose following ROSC from OHCA or IHCA, active control of temperature be used to maintain a central temperature of $\leq 5^{\circ}\text{C}$ [CoSTR 2020, weak recommendation, moderate-certainty evidence].
6. ANZCOR suggests that blood glucose levels should be monitored after cardiac arrest with the aim of maintaining normoglycaemia. If insulin is used to control hyperglycaemia, care should be taken to avoid hypoglycaemia [Good Practice Statement].
7. ANZCOR suggests that practitioners use multiple variables when attempting to predict outcomes for infants and children after cardiac arrest [CoSTR 2015, weak recommendation, very low-quality evidence].
8. ANZCOR suggests data-driven, performance-focused debriefing of rescuers after in-hospital cardiac arrest (IHCA) or OHCA in children [CoSTR 2020, weak recommendation, very low-certainty evidence].

Abbreviations

| Abbreviation | Meaning/Phrase |
|--------------|---|
| AED | automated external defibrillator |
| ALS | advanced life support |
| ANZCOR | Australian and New Zealand Committee on Resuscitation |
| ARC | Australian Resuscitation Council |
| BLS | basic life support |
| BVM | bag-valve-mask |

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| CoSTR | Consensus on Science with Treatment Recommendations |
| CPR | cardiopulmonary resuscitation |
| ECMO | extracorporeal membrane oxygenation |
| EIT | Education, Implementation and Teams |
| ETT | endotracheal tube |
| IHCA | in-hospital cardiac arrest |
| ILCOR | International Liaison Committee on Resuscitation |
| IO | intraosseus |
| IV | intravenous |
| LOE | Level of Evidence |
| NZRC | New Zealand Resuscitation Council |
| OHCA | out-of-hospital cardiac arrest |
| PALS | paediatric advanced life support |
| PBLS | paediatric basic life support |
| PEA | pulseless electrical activity |
| pVT | pulseless ventricular tachycardia |
| RCT | randomised control trial |
| ROSC | return of spontaneous circulation |
| SGA | supraglottic airway |
| TTM | targeted temperature management |
| VF | ventricular fibrillation |

1.0 | Continuing Support

Supportive therapy should be provided until there is recovery of function of vital organs. This may include the provision of oxygen therapy, mechanical ventilation, parenteral fluids, inotrope infusion and renal support for several days or longer. Recovery in infants and children is often

slow because cardiorespiratory arrest is usually secondary to prolonged global hypoxaemia and ischaemia. This implies that other organs have sustained damage before cardiorespiratory arrest. Particular care should be taken to ensure adequate cerebral perfusion with oxygenated blood and a blood pressure within appropriate limits for age.

The likely causes of cardiorespiratory arrest should be sought and treated. Reversible causes (the “4Hs and 4Ts”) include hypoxaemia, hypovolaemia, hypo/hyperthermia, hyper/hypokalaemia or other metabolic disorder, cardiac tamponade, tension pneumothorax and toxins, poisons and drugs. A membrane ion channelopathy should be considered in the case of sudden unexpected cardiac arrest.

Complications of CPR should also be sought, especially if secondary deterioration occurs. A chest radiograph should be obtained to check the position of the endotracheal tube, to detect pneumothorax, lung collapse, rib fracture or aspiration and to check if tamponade is suggested (by the cardiac silhouette). Blood should be obtained for measurement of haemoglobin, pH, gas tensions, electrolytes and glucose. Echocardiography is useful to monitor recovery of contractility and exclude tamponade.

Regular monitoring includes that of haemodynamics, ECG, oxygenation, blood and expired carbon dioxide, blood glucose, temperature and end-organ functions.

Frequent clinical assessments should be performed and tests may be conducted to help determine neurological status and to assist in determining likely prognosis.

Evidence on the impact of treatment facility characteristics on outcome of children with ROSC after IHCA or OHCA is conflicting and difficult to interpret because of many confounders.²

ANZCOR suggests that infants and children with ROSC who have been resuscitated after cardiorespiratory arrest should be admitted to a facility with the necessary resources for proper post-ROSC neuroprotective care, organ- and/or life supporting treatments, comprehensive neurological assessment and psychosocial support [Good Practice Statement].

2.0 | Blood Pressure Maintenance

Peripheral circulatory failure (shock) is common after ROSC.

The topic of post-ROSC blood pressure control was most recently reviewed as part of the CoSTR 2015 process.⁴ In 2020, an evidence update was performed to identify new evidence published in the most recent 5 years.¹ The update identified evidence to suggest that post-cardiorespiratory arrest hypotension below the fifth percentile for age is associated with poorer outcomes when compared with post-cardiorespiratory arrest normotension, and those patients requiring higher inotropic medication support have lower rates of survival to hospital discharge. The ILCOR PLS taskforce agreed that the evidence update identified sufficient new evidence to suggest the need for a systematic review. Until such time as a systematic review is completed and evaluated, the 2015 treatment recommendations remain in effect.⁴

ANZCOR recommends that for infants and children after ROSC, parenteral fluids and/or inotropes or vasopressors should be used to maintain a systolic blood pressure of at least greater than the fifth percentile for age [strong recommendation, very low-quality evidence].

3.0 | Ventilation and Carbon Dioxide Control

Although cerebral oedema may be expected after cardiac arrest, and hyperventilation is sometimes used as a temporary measure to reduce intracranial hypertension, hyperventilation results in hypocarbia which causes cerebral vasoconstriction and may impede venous return thus compromising blood pressure and consequently cerebral perfusion.⁴

Accurate targeting of post-ROSC carbon dioxide should be performed in the in-hospital critical care setting. Serial assessment of ventilation through arterial blood gas analysis may be facilitated by arterial catheterisation, which may also assist targeting post-ROSC blood pressure targets. Correlation of PaCO₂ and ETCO₂ should allow ongoing monitoring of ventilation with continuous capnography (and performance of ABG sampling when indicated).¹

As a part of the ILCOR 2020 CoSTR process, a systematic review⁷ of oxygen and carbon dioxide targets in adults and children with ROSC after cardiac arrest was conducted with involvement of clinical content experts from both the ALS and PLS Task Forces. Evidence from adult and pediatric literature was sought and considered by the ALS and PLS Task Forces, respectively.

No paediatric RCTs were identified on this topic but two observational studies were identified^{8,9}, 1 of which⁸ was published in the interval after the search was completed for the 2015 CoSTR. The studies showed an increase in hospital mortality associated with both hypocapnia and hypercapnia after ROSC compared with normocapnia.

ANZCOR suggests that rescuers measure PaCO₂ after ROSC and target normocapnia [weak recommendation, very low-certainty evidence]. Consider adjustments to the target PaCO₂ for specific patient populations where normocapnia may not be desirable (eg. chronic lung disease with chronic hypercapnia, congenital heart disease with single-ventricle physiology, increased intracranial pressure with impending herniation).

4.0 | Oxygenation

Both hypoxaemia and hyperoxaemia may be harmful.

Accurate targeting of post-ROSC normoxemia guided by pulse oximetry is standard practice in the hospital setting, but the use of pulse oximetry to titrate oxygen administration to target normoxemia in the out-of-hospital setting has not been studied and is not without risk of inadvertent patient hypoxemia. Given the known risks of hypoxemia and the uncertain risks of hyperoxia, any titration of oxygen delivery to children after ROSC must be balanced against the risk of inadvertent hypoxemia stemming from overzealous weaning of FiO₂. Further challenges include identifying the appropriate targets for specific paediatric patient subpopulations (eg. infants and children with cyanotic heart disease).¹

As a part of the ILCOR 2020 CoSTR process, a systematic review⁷ of oxygen and carbon dioxide targets in adults and children with ROSC after cardiac arrest was conducted with involvement of clinical content experts from both the ALS and PLS Task Forces. Evidence from adult and

pediatric literature was sought and considered by the ALS and PLS Task Forces, respectively.

The systematic review identified no paediatric RCTs on this topic but did identify 2 observational studies published in the 5 years after the previous (2015) review.^{8,10} One of these⁸ (deemed at critical risk of bias) included 253 patients and found no association between hyperoxemia and clinical outcomes in adjusted analyses. Of all studies identified (including those reviewed in 2015), only 3 paediatric studies,⁹⁻¹¹ including a total of 618 patients, were deemed to have only serious risk of bias, and in all of these studies only adjusted results were reported.

For the critical outcomes of survival to hospital discharge⁹ and survival to hospital discharge with good neurological outcome^{10,11} in paediatric patients with ROSC after cardiac arrest, no benefit was found for hyperoxemia compared with normoxemia.

One large registry-based study¹² found that hyperoxemia was associated with higher mortality when compared with normoxemia.

ANZCOR suggests that rescuers measure PaO₂ after ROSC and target a value appropriate to the specific patient condition. In the absence of specific patient data, we suggest rescuers target normoxemia after ROSC [weak recommendation, very low-quality evidence]. Given the availability of continuous pulse oximetry, targeting an oxygen saturation of 94% to 99% may be a reasonable alternative to measuring PaO₂ and titrating oxygen when feasible to achieve normoxia [Good Practice Statement].

In the setting of cyanotic heart disease, appropriate aims for PaO₂ and SpO₂ are approximately 40 to 50 mmHg and 75 to 85% respectively.

In settings of smoke inhalation (potential carbon monoxide poisoning) or severe anaemia, delivery of high concentration oxygen should be maintained to support oxygen transport to tissues until the underlying condition is resolved.

5.0 | Temperature Management

A systematic review addressing targeted temperature management (TTM) was published in 2019,¹³ and an ILCOR Paediatric CoSTR was published as part of the 2019 CoSTR summary.¹⁴ In 2021, an evidence update was performed by the ILCOR PLS task force but did not identify sufficient new data to warrant repeating a systematic review.

On the basis of 2 randomised trials and multiple retrospective observational cohort studies that provided comparative data on favourable neurological outcome, survival, and in-hospital adverse events, there was inconclusive evidence to support or refute the use of induced hypothermia (32 °C to 34 °C) compared with active control of temperature at normothermia (36 °C to 37.5 °C) (or an alternative temperature) for children who achieve ROSC but remain comatose after OHCA or IHCA.

ANZCOR suggests that for infants and children who remain comatose following ROSC from OHCA or IHCA, active control of temperature be used to maintain a central temperature of ≤37.5 °C [weak recommendation, moderate-certainty evidence].

6.0 | Glucose Control

Poor neurological outcomes in adults after cardiac arrest are associated with spontaneous and induced elevated blood glucose levels while hypoglycaemia in the newborn infant exacerbates hypoxic induced brain injury.^{5,6}

ANZCOR suggests that blood glucose levels should be monitored after cardiac arrest with the aim of maintaining normoglycaemia. If insulin is used to control hyperglycaemia, care should be taken to avoid hypoglycaemia [Good Practice Statement].

7.0 | Investigation of causes of sudden cardiac arrest in infants & children

In infants and children, the cause of cardiorespiratory arrest is usually the result of progressive hypoxaemia or hypotension (or both) which may be the end result of a number of various illnesses or traumatic events. Occasionally, cardiac arrest occurs unexpectedly in an apparently healthy child.

Hypertrophic cardiomyopathy, coronary artery anomalies, and arrhythmias are common causes of sudden unexplained cardiac arrest in infants and children. Up to one third of young patients who do not survive sudden unexplained cardiac arrest have no abnormalities found on gross and microscopic autopsy.³

In such cases, in addition to usual clinical investigations and coronial investigation routinely conducted when death is the outcome, the presence of an underlying cardiac dysrhythmia due to a disorder of membrane ion channelopathy (eg. congenital prolonged QT syndrome) should be considered and families referred to a healthcare provider or centre with expertise in cardiac rhythm disturbances.⁵

8.0 | Prognosis and Prediction of Outcome

The most recent ILCOR PLS Task Force review of post-ROSC predictive factors was published in the 2015 CoSTR⁴ but was focused only on the use of electroencephalography (EEG). An evidence update was performed as part of the ILCOR 2020 CoSTR process to determine if sufficient evidence existed to suggest the need for a systematic review. The evidence update identified 8 studies reporting associations of several factors (in addition to EEG) with outcomes after cardiac arrest.

The PLS Task Force have supported the suggestion of a systematic review with a broader search strategy to include studies of additional potential prognostic indicators beyond the electroencephalography. Until the systematic review is completed, the 2015 treatment recommendation remains in effect.

ANZCOR suggests that practitioners use multiple variables when attempting to predict outcomes for infants and children after cardiac arrest [weak recommendation, very low-quality evidence].⁴

9.0 | Cessation of Cardiopulmonary Resuscitation

The decision to cease CPR should be based on a combination of factors including, but not limited to, the pre-arrest status, duration of arrest, response to resuscitation, remediable factors, duration and quality of resuscitation, likely outcome, opinions of experienced personnel, desires of parents and ready availability of extracorporeal life support for in-hospital arrest.

Although there are no highly reliable means of determining outcome, available scientific studies^{5,6} have shown that, in the absence of reversible causes, prolonged resuscitative efforts for children are unlikely to be successful. Severe hypothermia may confound a diagnosis of cardiac arrest. If feasible, a child with OHCA should be transported to hospital if there has been any ROSC during resuscitation.

In a situation where there is no benefit to continuing resuscitation efforts, physicians can legally and ethically withdraw or withhold treatment, preferably with the agreement of a parent or legal guardian.^{15,16} Healthcare professionals are under no legal obligation to persist indefinitely to try to save life in this circumstance^{15,16} (Refer to ANZCOR Guideline 10.5).

10.0 | Post event debriefing for rescuers

The requirement for CPR may be sudden as when a child collapses out-of-hospital and arrives unannounced to the emergency department or when a child's condition deteriorates rapidly on a ward or occurs as a result of mishap. These situations always test the readiness, skills and abilities of individuals and the organisation of institutions. It is prudent to monitor performance with a view to improvement and not ignore the psychological impact that such events have on individuals. Sensitive debriefing sessions should be encouraged along with regular education.

The EIT Taskforce performed a systematic review on debriefing of resuscitation performance as part of the ILCOR 2020 CoSTR process.¹⁷ The review was limited by high inconsistency (heterogeneity) across studies, reflecting variation in instructional design, provider type, and outcome measures. The review did not identify any undesirable effects (eg. emotional trauma) related to debriefing after cardiac arrest in the reviewed studies and concluded that the reported positive effects outweigh any possible undesirable effects. However, defusing emotions of rescuers after stressful or traumatic events has to be taken into account when assessing any potential risks related to debriefing. While the certainty of evidence is very low, the associated costs to implement debriefing are likely to be low in many institutions. The review also considered the high likelihood that this type of intervention is both acceptable to stakeholders (because of potential benefits such as improved teamwork, improved communication, or identification of latent safety threats) and feasible in most institutions.

ANZCOR suggests data-driven, performance-focused debriefing of rescuers after IHCA or OHCA

in children (weak recommendation, very low-certainty evidence).

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About this Guideline

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| Search date/s | ILCOR literature search details and dates are available on the CoSTR page of the ILCOR website (https://costr.ilcor.org) and the relevant CoSTR documents. |
| Questions/PICOs: | Are described in the CoSTR documents (https://costr.ilcor.org) |
| Method: | Mixed methods including ARC NHMRC methodology before 2017 and ILCOR GRADE methodology described in ILCOR publications since 2017. The guideline process includes involvement of stakeholders from member organisations of the ARC & NZRC, and peer review by members of the Australian and New Zealand Committee on Resuscitation (ANZCOR). Details of the guideline development process can be found on the ARC website at https://resus.org.au . |
| Principal reviewers: | Jason Acworth, Richard Aickin, Gabrielle Nuthall |
| Main changes: | This guideline is an update from previous Guideline 12.7 and is focused upon care in the post-resuscitative phase after paediatric cardiac arrest. |
| Approved: | 13 November 2021 |