AUSTRALIAN RESUSCITATION COUNCIL

NEW ZEALAND Resuscitation Council WHAKAHAUORA AOTEAROA

# ANZCOR Newborn Guideline Changes April 2021

| ANZCOR Guideline Number | ANZCOR Guideline Title | 2021 Significant Changes |
|---|---|---|
| **All guidelines 13.1-13.10** | | • Updates of wording for clarity and consistency with contemporary good practice.<br>• Updating of review evidence, references, and terminology to increase consistency with GRADE terminology. |
| **13.1** | Introduction to Resuscitation of the Newborn | • For infants born at less than 34 weeks' gestational age who do not require immediate resuscitation after birth, ANZCOR suggests deferring clamping the cord for at least 30 seconds.<br>• For term and late preterm infants born at ≥34 weeks' gestation who are vigorous or deemed not to require immediate resuscitation at birth, ANZCOR suggests later (delayed or deferred) clamping of the cord at ≥ 60 seconds.<br>• ANZCOR suggests against intact cord milking for infants born at less than 28+0 weeks' gestational age. |
| **13.4** | Airway Management and Mask Ventilation of the Newborn | • For all newborns exposed to meconium-stained amniotic fluid, ANZCOR suggests against routine direct laryngoscopy immediately after birth, with or without tracheal suctioning. |
| **13.7** | Medication or Fluids for the Resuscitation of the Newborn | • ANZCOR suggests that intraosseous lines can be used as an alternative, especially if umbilical or direct venous access is not available. The choice of route may depend on local availability of equipment, training and experience. |
| **13.8** | The Resuscitation of the Newborn in Special Circumstances | • For preterm infants born at less than 35 weeks' gestation ANZCOR suggests commencing resuscitation either using room air or blended air and oxygen up to an oxygen concentration of 30% rather than higher initial oxygen concentration (60%–100%). |
| **13.10** | Ethical Issues in Resuscitation of the Newborn | • If, despite provision of all the recommended steps of resuscitation and excluding reversible causes, a newborn requires ongoing cardiopulmonary resuscitation (CPR) after birth, we suggest discussion of discontinuing resuscitative efforts with the clinical team and family. ANZCOR suggests that a reasonable time frame to consider this change in goals of care is around 20 minutes after birth. |

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# ANZCOR Guideline 13.1 – Introduction to Resuscitation of the Newborn

## Summary

Guidelines 13.1-13.10 and the Newborn Life Support algorithm are provided to assist in the resuscitation of newborn infants. Differences from the adult and paediatric guidelines reflect differences in the anatomy and physiology and the causes of cardiorespiratory arrest for newborns, older infants, children and adults. These guidelines draw from Neonatal Life Support 2020 and 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations (CoSTR) [1, 2] the development of which included representation from ANZCOR. The 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Care [3] and local practices have also been taken into account.

### To whom do these guidelines apply?

The term 'newborn' or 'newborn infant' refers to the infant in the first minutes to hours following birth. In contrast, the neonatal period is defined as the first 28 days of life. Infancy includes the neonatal period and extends through the first 12 months of life.

ANZCOR Guidelines 13.1 to 13.10 and the Newborn Life Support algorithm are mainly for the care of newborns. The exact age at which paediatric techniques and in particular, compression-ventilation ratios, should replace the techniques recommended for newborns is unknown, especially in the case of very small preterm infants. For term infants beyond the first minutes to hours following birth, and particularly in those with known or suspected cardiac aetiology of their arrest, paediatric techniques may be used (refer to Paediatric Advanced Life Support Guidelines 12.1 to 12.7).

### Who is the audience for these guidelines?

ANZCOR Guidelines 13.1 to 13.10 and the Newborn Life Support algorithm are for health professionals and those who provide healthcare in environments where equipment and drugs are available (such as a hospital). When parents are taught CPR for their infants who are being discharged from birth hospitals, the information in Basic Life Support Guidelines (ANZCOR Guidelines 2 to 8) is appropriate.

## Recommendations

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

1. Newborns should be assessed for the need for basic and advanced life support and receive care using the Newborn Life Support algorithm and according to these guidelines. [Good Practice Statement]
2. Healthcare providers should implement policies and protocols that utilise this algorithm and these guidelines. [Good Practice Statement]
3. Term newborns who have had low or no risk factors for needing resuscitation interventions, who are breathing or crying and who have good tone must be dried and kept warm. These actions can be provided on the mother's chest (skin-to-skin) and should not require separation of mother and infant. This does not preclude the need for ongoing vigilant clinical assessment of all newborns, as problems of adaptation may manifest as secondary apnoea, persistent cyanosis, or persistence or onset of breathing difficulties. [Good Practice Statements]
4. A suitable location, equipment and personnel trained to resuscitate a newborn must be available at all times, and in all places, where infants are born. [Good Practice Statement]
5. At least one person should be responsible for the care of each newborn. If it is anticipated that the newborn is at high risk of requiring advanced resuscitation more than one experienced person should be present. [Good Practice Statements]
6. All personnel who attend births should be trained in newborn resuscitation skills which include basic measures to maintain an open airway, ventilation via a facemask or supraglottic airway (SGA) device and chest compressions. [Good Practice Statement].
7. Organised programs to develop and maintain standards, skills and teamwork are required for newborn resuscitation and are essential for health care providers and institutions caring for mothers and newborns. [Good Practice Statement]
8. A complete set of resuscitation equipment and drugs should always be available for all births. Equipment should be regularly checked to ensure it is complete and operational. [Good Practice Statements]
9. Preparation for a high-risk birth requires communication between the people caring for the mother and those responsible for the newborn. This should include any factors that may affect the resuscitation and management of the newborn including maternal conditions, antenatal diagnoses and assessments of fetal wellbeing. [Good Practice Statement]
10. The newborn should be cared for in a warm, draft-free area. For term and near-term newborn infants, drying and removing the wet linen reduce heat loss. When resuscitation is not required the mother's body can keep the newborn warm, using her as a heat source by placing the newborn skin-to-skin on her chest or abdomen in a position that maintains airway patency and covering both with a warm blanket or towel. If resuscitation is necessary, place the newborn under a preheated radiant warmer or if unavailable, an alternative heat source. [Good Practice Statements]

11. ANZCOR recommends that non-asphyxiated newborns of all gestations should be maintained with a temperature of between 36.5 and 37.5° C. [CoSTR 2015, strong recommendation, very low certainty of evidence]

12. ANZCOR recommends that admission temperatures to newborn units are predictors of outcome and should be recorded as a quality-of-care measure. [CoSTR 2015, strong recommendation, moderate certainty of evidence]

13. For term and near-term infants at risk of hypoxic ischaemic encephalopathy, the target during resuscitation and stabilisation should be to maintain normothermia (with care to avoid hyperthermia), until a decision has been made that the newborn has signs of encephalopathy and meets criteria for induced hypothermia. Any newborn who is considered a possible candidate for therapeutic hypothermia should be discussed as soon as possible after initial resuscitation with a neonatal intensive care specialist, and plans should be made for prompt admission to a neonatal intensive care unit. If indicated, whole body cooling can be initiated without specialised equipment. Local guidelines should be in place to ensure that newborns that meet criteria for induced hypothermia are promptly recognised and referred. [Good Practice Statements]

14. Prior preparation of standardised kits containing the equipment needed for procedures such as umbilical catheterisation can save considerable time in emergencies. [Good Practice Statement]

15. Providers should ensure that all equipment is approved and suitable for purpose. [Good Practice Statement]

16. For term and late preterm infants born at ≥34 weeks' gestation who are vigorous or deemed not to require immediate resuscitation at birth, ANZCOR suggests later (delayed) clamping of the cord at ≥ 60 seconds rather than immediate cord clamping. [Weak recommendation, very low certainty of evidence.]

17. For infants born at less than 34 weeks' gestational age who do not require immediate resuscitation after birth, ANZCOR suggests deferring clamping the cord for at least 30 seconds. [Weak recommendation, low certainty of evidence]

18. In infants born at any gestational age who require immediate resuscitation, there is insufficient evidence to make a recommendation with respect to cord management.

19. There is insufficient evidence to make recommendations on cord management for maternal, fetal, or placental conditions that were considered exclusion criteria in many studies (in particular, multiple fetuses, congenital anomalies, placental abnormalities, alloimmunization and/or fetal anemia, fetal compromise, and maternal illness). In these situations, ANZCOR suggests individualized decisions based on severity of the condition and assessment of maternal and neonatal risk. [Weak recommendation; very low certainty of evidence]

20. ANZCOR suggests that there is insufficient evidence to recommend milking of the intact cord for term and late preterm infants (≥34 weeks' gestation), or the cut cord for infants of any gestation.

21. ANZCOR suggests against intact cord milking for infants born at less than 28+0 weeks' gestational age. [Weak recommendation; very low certainty of evidence]

22. Practitioners involved in resuscitation should always be alert to errors of assembly or use of resuscitation equipment and should have checking processes to minimise these risks before equipment is used.

They should also respond to unexpected situations with further checking procedures, and in the case of unexplained hypoxia, change gas supply and circuits and include removing the patient from ventilators and gas supplies by using a self-inflating bag with room air. In this situation oxygen analysis of delivered gases should be considered and an oxygen analyser should be available. [Good Practice Statements]

## Abbreviations

| Abbreviation | Meaning/Phrase |
|---|---|
| ANZCOR | Australian and New Zealand Committee on Resuscitation |
| CI | Confidence interval (95%) |
| CoSTR | International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations |
| CPR | Cardiopulmonary resuscitation |
| $I^2$ | I squared statistic; measure of percentage of variability in effect estimates that is due to heterogeneity rather than sampling error (chance) [4] |
| IV | Intravenous |
| RR | Risk Ratio |
| UVC | Umbilical venous catheter |

# Guideline

## 1 Need for Newborn Resuscitation Interventions

Approximately 85 percent of babies born at term will initiate spontaneous respirations within 10 to 30 seconds of birth.[5] An additional 10 percent will respond during drying and stimulation, approximately three percent will initiate respirations following positive pressure ventilation, two percent will be intubated to support respiratory function and 0.1 percent will receive chest compressions and/or adrenaline (epinephrine) to achieve this transition.[6-10]} Resuscitation is defined as the preservation or restoration of life by the establishment and/or maintenance of airway, breathing and circulation, and related emergency care (refer to ANZCOR Guideline 1.1). For most newborns, resuscitation manoeuvres are administered as part of a graded strategy to support their own physiological efforts to adapt after birth. Only a very few appear lifeless and require the full range of newborn resuscitation interventions described in these guidelines. Since in most cases, breathing support is all that is needed, terms such as 'initial stabilisation' and 'support during transition' are also used in the literature. However, for the purposes of these guidelines, 'stabilisation' is reserved for processes after resuscitation (refer to ANZCOR Guideline 13.9).

Term newborns who have had low or no risk factors for needing resuscitation interventions, who are breathing or crying and who have good tone must be dried and kept warm. These actions can be provided on the mother's chest (skin-to-skin) and should not require separation of mother and infant. This does not preclude the need for ongoing vigilant clinical assessment of all newborns, as problems of adaptation may manifest as secondary apnoea, persistent cyanosis, or persistence or onset of breathing difficulties. [Good Practice Statement]

The keys to successful newborn resuscitation include assessment of perinatal risk and a system to rapidly assemble team members with skills that are appropriate to the anticipated need for resuscitation on the basis of that risk. Other critical components of successful resuscitation include an organised resuscitation area that ensures immediate access to all needed supplies and equipment and the standardisation of behavioural skills that foster optimal teamwork and communication. Although the need for resuscitation of the newborn can often be anticipated, and the need for resuscitation in low-risk births may be 1% or less, there remain many occasions when it is unexpected. Therefore, a suitable location, equipment and personnel trained to resuscitate a newborn must be available at all times, and in all places, where infants are born. [Good Practice Statement]

## 2 Unique Physiology of Newborns

The transition from fetal to extrauterine life is characterised by a series of unique physiological events. Among these, the lungs change from liquid-filled to air-filled, pulmonary blood flow increases dramatically, and intracardiac and extracardiac shunts cease.

During the normal onset of breathing, newborns exert negative pressure on the lung with each breath. For the first few breaths, these pressures are greater than those needed for subsequent breaths, due to the need to clear liquid from the airways and begin lung aeration.[11] If the newborn does not achieve this initial lung aeration and positive pressure ventilation needs to be used, higher peak inspiratory pressures may be needed for the first inflations than subsequently.

The level of pressure will vary from newborn to newborn, depending on the maturity of the lungs and any lung disease that is present. Suggested starting pressures provided in Guideline 13.4 are only a guide, and subsequently, pressures need to be individually adjusted according to the newborn's response.

The fetal lung liquid moves from the airways to the lung tissue, and then reabsorbs more slowly (over several hours) into the circulation. In newborns who are preterm or who have difficulty breathing, lung liquid can move back from the lung tissue into the airways, whereupon it needs to be cleared again, perhaps repeatedly. Continuous positive end expiratory pressure can help prevent this.

Aeration of the lungs triggers a fall in pulmonary vascular resistance and increase in pulmonary blood flow,[12] which rises 5 to 6 fold after birth. In healthy newborns, oxygen levels rise over several minutes, typically taking 5 to10 minutes for oxygen saturation of haemoglobin to reach 90%.[13-19] Uncompromised fetuses (at sea level) have oxygen saturation levels of about 60% during labour. The 25$^{th}$ centile for oxygen saturation is approximately 80% at 5 minutes.[19] Normal newborns should have a heart rate >100 bpm by 2 minutes after birth. [20]

Adaptation to extrauterine life depends on many coordinated and interdependent physiological events, failure of any of which can impair successful transition. Inadequate lung aeration can cause respiratory failure and prevent the normal increase in pulmonary blood flow. [12] If pulmonary vascular resistance does not fall, the consequence is persistent pulmonary hypertension, with inadequate blood flow through the lungs and hypoxaemia. Haemorrhage from the fetus before birth can cause hypovolaemia and hypotension in the newborn. Acidosis and hypoxia before or during birth can depress respiratory drive and cardiac function.

In preterm infants there are additional considerations. Surfactant deficiency reduces lung compliance.[21] Preterm infants also typically have weaker respiratory muscles, immature airway protective reflexes, and a chest wall that deforms easily. Very preterm newborns and those born by caesarean section, without the effect of labour, may not clear fetal lung liquid and therefore, may not aerate their lungs as easily as term newborns born by vaginal delivery.

In advanced gestation, passage of meconium into the amniotic fluid becomes more common and, in some cases, it is associated with fetal compromise. If meconium is passed into the amniotic fluid, it may be inhaled before or during delivery and lead to inflammation of the lungs and airway obstruction. Complications of meconium aspiration are more likely in newborns who are small for their gestation, and those born after term or with significant perinatal compromise. [22, 23]

Perinatal infections and congenital anomalies are among other potential causes of impaired adaptation at birth.

# 3 Anticipating the Need for Resuscitation

## 3.1 Personnel

At least one person should be responsible for the care of each newborn. Guideline 13.2 lists examples of maternal, fetal, and intrapartum circumstances that place the newborn at increased risk of needing resuscitation. If it is anticipated that the newborn is at high risk of requiring

advanced resuscitation more than one experienced person should be present. [Good Practice Statements]

### 3.2 Training

All personnel who attend births should be trained in newborn resuscitation skills which include basic measures to maintain an open airway, ventilation via a facemask or supraglottic airway device and chest compressions. [Good Practice Statement]

A person trained in advanced newborn resuscitation (all of the above skills plus endotracheal intubation and ventilation, vascular cannulation and the use of drugs and fluids) may be needed even for low-risk births and should be in attendance for all births considered at high risk for needing newborn resuscitation. [Good Practice Statement]

Organised programs to develop and maintain standards, skills and teamwork are required for newborn resuscitation and are essential for health care providers and institutions caring for mothers and newborns. [24, 25] [Good Practice Statement]

### 3.3 Equipment

The need for resuscitation at birth cannot always be anticipated. [26-28] Therefore, a complete set of resuscitation equipment and drugs should always be available for all births. This equipment should be regularly checked to ensure it is complete and operational births. [Good Practice Statement] A list of suggested resuscitation equipment and drugs is provided at the end of this guideline.

### 3.4 Communication

Preparation for a high-risk birth requires communication between the people caring for the mother and those responsible for the newborn. This should include any factors that may affect the resuscitation and management of the newborn including;

- maternal conditions
- antenatal diagnoses
- assessments of fetal wellbeing.

[Good Practice Statement]

## 4 Environment

### 4.1 Temperature

Newborns are at risk of hypothermia or hyperthermia, so prevention of both heat loss and overheating is important. Hypothermia can increase oxygen consumption and impede effective resuscitation.[29-31] The newborn should be cared for in a warm, draft-free area. For term and near-term newborn infants, drying and removing the wet linen reduce heat loss. When resuscitation is not required the mother's body can keep the newborn warm, using her as a heat source by placing the newborn skin-to-skin on her chest or abdomen in a position that maintains airway patency and covering both with a warm blanket or towel. If resuscitation is necessary, place the newborn under a preheated radiant warmer or if unavailable, an alternative heat source. [Good Practice Statements]

ANZCOR recommends that non-asphyxiated newborns of all gestations should be maintained with a temperature of between 36.5 and 37.5° C. [2] [CoSTR 2015, strong recommendation, very low certainty of evidence]

ANZCOR recommends that admission temperatures to newborn units are predictors of outcome and should be recorded as a quality of care measure. [2] [CoSTR 2015, strong recommendation, moderate certainty of evidence] Hypothermia is associated with an increased risk of mortality. There is evidence of a dose effect with mortality increasing by 28% for each degree below 36.5 $^{0}$C at admission. [2]

Hypothermia on admission is also associated with worse respiratory outcomes and greater likelihood of hypoglycaemia, late onset sepsis and intraventricular haemorrhage. [2]

For special considerations for preterm infants, refer to ANZCOR Guideline 13.8.

### 4.2 Hyperthermia

No studies have examined the effects of hyperthermia after resuscitation of newborn infants. However, newborns born to febrile mothers (temperature >38° C) have an increased risk of death, perinatal respiratory depression, neonatal seizures and cerebral palsy. [32-34]

### 4.3 Induced Hypothermia for Hypoxic Ischaemic Encephalopathy

Inducing hypothermia in newborns of 35 weeks' gestation and above with evolving moderate to severe hypoxic ischaemic encephalopathy will reduce the degree of brain injury in some (refer to guideline 13.9).[35-40] The target during resuscitation and stabilisation should be to maintain normothermia (with care to avoid hyperthermia), until a decision has been made that the newborn has signs of encephalopathy and meets criteria for induced hypothermia. Any newborn who is considered a possible candidate for therapeutic hypothermia should be discussed as soon as possible after initial resuscitation with a neonatal intensive care specialist, and plans should be made for prompt admission to a neonatal intensive care unit. If indicated, whole body cooling can be initiated without specialised equipment.[39] Local guidelines should be in place to ensure that newborns that meet criteria for induced hypothermia are promptly recognised and referred. [Good Practice Statements]

## 5 Recommended Equipment and Drugs for Resuscitation of the Newborn

Resuscitation equipment and drugs should be readily available in the areas of hospitals where infants are born or receive neonatal care. Equipment should be checked regularly according to local policy and before any resuscitation to ensure it is complete and operational. A clear record documenting the checking procedure should be maintained for each set of resuscitation equipment and drugs. [24] [Good Practice Statements]

Prior preparation of standardised kits containing the equipment needed for procedures such as umbilical catheterisation can save considerable time in emergencies.[24] [Good Practice Statement]

Providers should ensure that all equipment is approved and suitable for purpose. [Good Practice Statement]

## 5.1 Recommended equipment and drugs

### General

- Firm, horizontal, padded resuscitation surface
- Overhead warmer
- Light for the area
- Clock with timer in seconds
- Warmed towels or similar covering
- Polyethylene bag or sheet, big enough for a newborn less than 32 weeks' gestation or <1500g birth weight
- Stethoscope, neonatal size preferred
- Pulse oximeter plus neonatal probe
- Electrocardiographic monitor and leads (where available)

### Equipment for **airway** management

- Suction apparatus and suction catheters (6F, 8F, and either 10F or 12F)
- Oropharyngeal airways (sizes 0 and 00)
- Intubation equipment:
    - Laryngoscopes with infant blades (00, 0, 1)
    - Spare bulbs, and batteries
    - Endotracheal tubes (sizes 2.5mm, 3 mm, 3.5 mm and 4 mm internal diameter, uncuffed, no eye)
    - Endotracheal stylet or introducer
    - Supplies for fixing endotracheal tubes (e.g., scissors, tape)
- End-tidal carbon dioxide detector (to confirm intubation)
- Meconium suction device (to apply suction directly to endotracheal tube) (optional)
- Magill forceps, neonatal size (optional)
- Supraglottic airway device size 1

### Equipment for supporting **breathing**

- Face masks (range of sizes suitable for premature and term newborn infants)
- Positive-pressure ventilation device:
    - T-piece resuscitator device (or Flow-inflating bag with a pressure safety valve and manometer)
    - Self-inflating bag (< 300mL) with a removable oxygen reservoir
- Medical gases:
    - Source of medical oxygen (reticulated and/or cylinder, allowing flow of up to 10 L/min) with flow meter and tubing
    - Source of medical air plus air/oxygen blender
- Feeding tubes for gastric decompression (e.g., size 6F & 8F)

### Equipment for supporting the **circulation**

- Umbilical venous catheter (UVC) kit (including UVC size 5F)
- Peripheral IV cannulation kit
- Skin preparation solution suitable for newborn skin
- Tapes/devices to secure UVC/IV cannula
- Syringes and needles (assorted sizes)
- Intraosseous needles

### Drugs and fluids

- Adrenaline (epinephrine): 1:10 000 concentration (0.1 mg/mL)
- Sodium chloride 0.9%
- Blood suitable for emergency transfusion needs to be readily available for a profoundly anaemic newborn

### Documentation

- Resuscitation record sheet

# 6 Cord Clamping

The umbilical cord can be clamped at different times after birth. Later (also referred to as delayed or deferred) cord clamping is defined as application of a clamp to the cord greater than 30 seconds after birth or based on physiologic observations (such as when cord pulsation has ceased or breathing has been initiated), without cord milking.

In both animal and human studies, deferring cord clamping for 30-60 seconds, when compared with immediate cord clamping is associated with increased placental transfusion, increased cardiac output, and higher and more stable neonatal blood pressure. There is good evidence from animal studies that among the benefits, placental transfusion can fill the expanding pulmonary vascular bed, obviating the need for it to fill by "left to right" flow from the aorta across the ductus arteriosus.[12] However, there remains controversy about how long it is appropriate to delay cord clamping if the newborn is perceived to require resuscitation. In addition, other methods aiming to achieve a placental transfusion to the newborn (cord milking or "stripping") have been investigated. These include (single or repeated) compression of the unclamped and uncut (intact cord) or a long segment of clamped and cut umbilical cord towards the newborn, or passive drainage of a long segment of clamped and cut cord towards the newborn.

For the uncomplicated term or near-term birth (≥ 34 weeks' gestation), a meta-analysis of studies comparing an intention to delay cord clamping after birth for a time ranging from 30 seconds until the cord stops pulsating with an intention for immediate cord clamping (usually within 15 seconds) showed higher neonatal haemoglobin levels and improved iron status in early infancy, but higher rates of polycythemia (haematocrit >64%, although higher rates of exchange transfusion were not found). For the outcomes of survival to discharge, need for resuscitation or admission to a neonatal unit, for jaundice treated with phototherapy and for major maternal outcomes, the review could not exclude benefit or harm. [41]

For term and late preterm infants born at ≥34 weeks' gestation who are vigorous or deemed not to require immediate resuscitation at birth, ANZCOR suggests later (delayed or deferred) clamping of the cord at ≥ 60 seconds. [41] [Weak recommendation, very low certainty of evidence]

For the uncomplicated preterm birth <34 weeks' gestation, a systematic review showed evidence of moderate certainty that delaying cord clamping for a minimum time of 30 seconds, when compared to immediate cord clamping may improve neonatal survival (risk ratio [RR]: 1.02, 95% confidence interval [CI]: 1.00 to 1.04; Number needed for benefit: 50, 95% CI: 25 to no benefit). [42]

For the important outcomes of severe intraventricular haemorrhage and jaundice treated with phototherapy the review found no difference with narrow confidence intervals, suggesting that a large benefit or harm was unlikely. For necrotising enterocolitis and bronchopulmonary dysplasia, the review could not rule out benefit or harm.[42]

The review also found that later cord clamping probably improves haematologic measures including haemoglobin and haematocrit values during first week after birth, reduces the risk of needing inotropic support for hypotension during the first 24 hours of life, reduces the number of infants who receive a blood transfusion and the total number of blood transfusions per infant hospital course. [42] The review found no increase in risk of adverse maternal outcomes, including postpartum haemorrhage, infection or manual removal of the placenta. [42]

A physiology-based approach to timing of cord clamping, where cord clamping is performed after the onset of breathing, based on specific vital signs or after cessation of pulsation of the cord may have advantages over time-based clamping of the cord, but there is insufficient evidence to draw strong conclusions.

For infants born at less than 34 weeks' gestational age who do not require immediate resuscitation after birth, ANZCOR suggests deferring clamping the cord for at least 30 seconds. [42] [Weak recommendation, low certainty of evidence]

In infants born at less than 34 weeks' gestational age who require immediate resuscitation, there is insufficient evidence to make a recommendation with respect to cord management. [42]

Although on theoretical grounds, the depressed newborn might receive greater benefit from deferred cord clamping,[43] constriction of uterine arteries normally occurs immediately after birth. Therefore, it is unclear whether the placenta can be relied upon to provide compensatory gas exchange in the newborn who does not begin breathing soon after birth. Furthermore, a depressed newborn may have experienced impaired placental gas exchange even before birth. Small and sick newborns who received immediate resuscitation were generally excluded from the randomised trials conducted to date. Therefore, there is insufficient evidence to recommend the optimal timing of cord clamping in the compromised newborn. [41, 42] The more severely compromised the newborn, the more likely it is that resuscitation measures need to take priority over delayed cord clamping. The efficacy of cardiac compressions in improving the systemic and coronary perfusion if the cord remains unclamped and the low resistance placenta is still connected is unknown.

There is insufficient evidence to make recommendations on cord management for maternal, fetal, or placental conditions that were considered exclusion criteria in many studies (in particular, multiple fetuses, congenital anomalies, placental abnormalities, alloimmunization and/or fetal anemia, fetal compromise, and maternal illness). In these situations, ANZCOR suggests individualized decisions based on severity of the condition and assessment of maternal and neonatal risk. [41, 42] [Weak recommendation; very low certainty of evidence]

## 6.1 Cord Milking

Milking of the umbilical cord from the placental side to the newborn either before (intact cord milking) or after clamping and cutting the umbilical cord (cut cord milking) have been studied as alternatives to immediate or delayed cord clamping without cord milking.

While cord milking may achieve a transfusion of blood from the cord (and in the case of intact cord milking, also from the placenta), it is uncertain whether it achieves the same improvements in the postnatal cardiovascular transition as later (delayed) cord clamping.

For term and late preterm infants ≥34 weeks' gestation, a systematic review found insufficient evidence to draw strong conclusions about the role of either intact or cut cord milking when compared to early cord clamping. [41]

For term and late preterm infants, when comparing delayed cord clamping to cut cord milking, no differences were found for neonatal mortality, admission for neonatal intensive or special care, or jaundice treated with phototherapy. Cut cord milking resulted in slightly higher haemoglobin concentrations and haematocrit values in the first week. [41]

There is insufficient evidence to recommend milking of the intact or cut cord for term and late preterm infants. [41]

A systematic review of studies of preterm infants (<34 weeks' gestation) found that when compared to early cord clamping, intact cord milking probably results in little to no difference in survival and major neonatal morbidities but may improve haemoglobin and haematocrit within the first week after birth. [42] There was insufficient evidence to determine the role of cut cord milking.

One large clinical trial comparing intact-cord milking with later (delayed) cord clamping closed recruitment before completion because of an increased rate of severe intraventricular haemorrhage in infants born at <28 weeks gestational age who received intact-cord milking.[44] However, for this outcome, meta-analysis of 4 trials involving 761 infants could not exclude benefit or harm from later (delayed) cord clamping compared to intact-cord milking (RR 0.60, 95% CI 0.32 to 1.12; $I^2$=23%).[44-47]

ANZCOR suggests against intact cord milking for infants born at less than 28+0 weeks' gestational age. [42] [Weak recommendation; very low certainty of evidence]

# 7 Checking Resuscitation Equipment

ANZCOR guidelines should be considered in conjunction with accepted National Standards and local policies. ANZCOR is aware of cases where equipment failure (e.g., oxygen pipes being incorrectly connected resulting in hypoxic gases being administered, and resuscitation bag valve devices incorrectly assembled) has led to adverse outcomes.

The checking and maintenance of hospital and resuscitation equipment is covered by National Standards and local policies. Practitioners involved in resuscitation should always be alert to errors of assembly or use and have checking processes to minimise these risks before equipment is used. They should also respond to unexpected situations with further checking procedures, and in the case of unexplained hypoxia change gas supply and circuits, and include removing the patient from ventilators and gas supplies by using a self-inflating bag with room air. In this situation oxygen analysis of delivered gases should be considered and an oxygen analyser should be available. [Good Practice Statement]

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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. [1, 2] |
| **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. |
| **Principal reviewers:** | Helen Liley, Lindsay Mildenhall, Marta Thio and Callum Gately |
| **Main changes:** | Changes in recommendations for umbilical cord management at birth. Updates for clarity and consistency with contemporary good practice. Updating of review evidence, references, and terminology to increase consistency with GRADE terminology. |
| **Approved:** | April 2021 |

AUSTRALIAN RESUSCITATION COUNCIL

NEW ZEALAND Resuscitation Council WHAKAHAUORA AOTEAROA

# ANZCOR Guideline 13.2 – Planning for Newborn Resuscitation and Identification of the Newborn at Risk

## Summary

Guidelines 13.1-13.10 and the Newborn Life Support algorithm are provided to assist in the resuscitation of newborn infants. Differences from the adult and paediatric guidelines reflect differences in the anatomy and physiology and the causes of cardiorespiratory arrest for newborns, older infants, children and adults. These guidelines draw from Neonatal Life Support 2020 and 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations (CoSTR) [1, 2] the development of which included representation from ANZCOR. The 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Care [3] and local practices have also been taken into account.

### To whom do these guidelines apply?

The term 'newborn' or 'newborn infant' refers to the infant in the first minutes to hours following birth. In contrast, the neonatal period is defined as the first 28 days of life. Infancy includes the neonatal period and extends through the first 12 months of life.

ANZCOR Guidelines 13.1 to 13.10 and the Newborn Life Support algorithm are mainly for the care of newborns. The exact age at which paediatric techniques and in particular, compression-ventilation ratios, should replace the techniques recommended for newborns is unknown, especially in the case of very small preterm infants. For term infants beyond the first minutes to hours following birth, and particularly in those with known or suspected cardiac aetiology of their arrest, paediatric techniques may be used (refer to Paediatric Advanced Life Support Guidelines 12.1 to 12.7).

### Who is the audience for these guidelines?

ANZCOR Guidelines 13.1 to 13.10 and the Newborn Life Support algorithm are for health professionals and those who provide healthcare in environments where equipment and drugs are available (such as a hospital). When parents are taught CPR for their infants who are being discharged from birth hospitals, the information in Basic Life Support Guidelines (ANZCOR Guidelines 2 to 8) is appropriate.

## Recommendations

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

1. All those who may need to provide resuscitation of the newborn should undertake training that specifically includes the necessary individual and teamwork skills. [Good Practice Statement]
2. ANZCOR suggests that training of resuscitation instructors should incorporate timely, objective, structured, individually targeted, verbal and/or written feedback. [CoSTR 2015, weak recommendation, low certainty of evidence]
3. ANZCOR suggests that training should occur more frequently than annually. This retraining may consist of specific tasks and/or behavioural skills depending on the needs of the trainee. [CoSTR 2015, weak recommendation, low certainty of evidence]
4. A person trained in newborn resuscitation should be available for normal, low-risk births and someone trained in advanced resuscitation should attend all births considered at high risk for newborn resuscitation. If it is anticipated that the newborn is at high risk of requiring advanced resuscitation more than one experienced person should be present at the birth. Local guidelines should be developed specifying who should attend which births with allocation of roles within the team such as leadership, airway management, circulation, monitoring and support (including documentation). [Good Practice Statements]
5. Whenever the need for resuscitation is anticipated, there should be a consistent and coordinated approach from the obstetric and paediatric/neonatal teams in applying these guidelines and when possible, communicating with the parents to develop a management plan. [Good Practice Statement]

## Abbreviations

| Abbreviation | Meaning/Phrase |
|---|---|
| ANZCOR | Australian and New Zealand Committee on Resuscitation |
| CoSTR | International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations |
| CPR | Cardiopulmonary resuscitation |
| CTG | Cardiotocograph |

# Guideline

## 1 Training and improving resuscitation team performance

All those who may need to provide resuscitation of the newborn should undertake training that specifically includes the necessary individual and teamwork skills. [Good Practice Statement] Additional recommendations are provided in ANZCOR Guideline 10.2 – Advanced Life Support Training.

Simulation is a methodology in resuscitation education that allows multiple participants to practice and be assessed in these skills without risk to vulnerable patients. Use of simulation as an adjunct to traditional education methodologies may enhance performance of healthcare professionals in actual clinical settings. The most effective interventions and evaluation methodologies for training, and for training of resuscitation instructors remain to be defined. [4] ANZCOR suggests that training of resuscitation instructors should incorporate timely, objective, structured, individually targeted, verbal and/or written feedback. [2] [CoSTR 2015, weak recommendation, low certainty of evidence]

Training requires regular reinforcement in clinical practice, and/or refresher courses. ANZCOR suggests that training should occur more frequently than annually. This retraining may consist of specific tasks and/or behavioural skills depending on the needs of the trainee. [2] [CoSTR 2015, weak recommendation, low certainty of evidence]

Briefings and debriefings during learning activities while caring for simulated patients, and during clinical activities may also be helpful in improving individual and team skills. [1]

## 2 Anticipation

A person trained in newborn resuscitation should be available for normal, low-risk births and someone trained in advanced resuscitation should attend all births considered at high risk for newborn resuscitation. If it is anticipated that the newborn is at high risk of requiring advanced resuscitation more than one experienced person should be present at the birth. Local guidelines should be developed specifying who should attend which births with allocation of roles within the team such as leadership, airway management, circulation, monitoring and support (including documentation). [Good Practice Statements] The list below contains examples of maternal, fetal, and intrapartum circumstances that place the newborn at risk of needing resuscitation.

The list is not exhaustive, and the magnitudes of these risks vary considerably, but the list is included to encourage planning. The need for an advanced resuscitation expert at the birth will depend on the number and severity of problems.

Whenever the need for resuscitation is anticipated, there should be a consistent and coordinated approach from the obstetric and paediatric/neonatal teams in applying these guidelines and when possible, communicating with the parents to develop a management plan. [Good Practice Statement]

# 3 Risk Factors

## 3.1 Maternal Risk Factors

1 Prolonged rupture of membranes (> 18 hours)
2 Bleeding in second or third trimester
3 Pregnancy-induced hypertension
4 Chronic hypertension
5 Substance abuse
6 Drug therapy (e.g., lithium, magnesium, adrenergic blocking agents, narcotics, selective serotonin reuptake inhibitors)
7 Diabetes mellitus
8 Chronic illness (e.g., anaemia, cyanotic congenital heart disease)
9 Maternal pyrexia
10 Maternal infection
11 Chorioamnionitis
12 Heavy sedation
13 Previous fetal or neonatal death
14 No antenatal care

## 3.2 Fetal Risk Factors

1. Multiple gestation (e.g., twins, triplets, etc.)
2. Preterm gestation (especially <35 weeks)
3. Post-term gestation (>41 weeks)
4. Large for dates
5. Fetal growth restriction
6. Alloimmune haemolytic disease (e.g., anti-D, anti-Kell, or other antibody known to cause haemolytic disease of the fetus and newborn, especially if fetal anaemia or hydrops fetalis is present)
7. Polyhydramnios, oligohydramnios
8. Reduced fetal movement before onset of labour
9. Congenital abnormalities which may affect breathing, cardiovascular function or other aspects of perinatal transition
10. Intrauterine infection
11. Hydrops fetalis

## 3.3 Intrapartum Risk Factors

1. Non-reassuring fetal heart rate patterns on cardiotocograph (CTG)
2. Abnormal presentation
3. Prolapsed cord
4. Prolonged labour (or prolonged second stage of labour)
5. Precipitate labour
6. Antepartum haemorrhage (abruption, placenta praevia, vasa praevia)
7. Meconium in the amniotic fluid
8. Narcotic administration to mother within 4 hours of delivery
9. Forceps delivery
10. Vacuum-assisted (ventouse) delivery
11. Maternal general anaesthesia

# References

1. Wyckoff MH, Wyllie J, Aziz K, de Almeida MF, Fabres JW, Fawke J, et al. Neonatal Life Support 2020 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. Resuscitation. 2020;156:A156-A87.

2. Wyllie J, Perlman JM, Kattwinkel J, Wyckoff MH, Aziz K, Guinsburg R, et al. Part 7: Neonatal resuscitation: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. Resuscitation. 2015;95:e169-201.

3. Aziz K, Lee HC, Escobedo MB, Hoover AV, Kamath-Rayne BD, Kapadia VS, et al. Part 5: Neonatal Resuscitation: 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2020;142(16_suppl_2):S524-s50.

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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. [1, 2] |
| **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. |
| **Principal reviewers:** | Helen Liley, Lindsay Mildenhall, Marta Thio and Callum Gately |
| **Main changes** | Update to include suggestion for role allocation in anticipation of need for newborn resuscitation. No major changes to other clinical recommendations. Updating of review evidence, references, and terminology to increase consistency with GRADE terminology. |
| **Approved:** | April 2021 |

# ANZCOR Guideline 13.3 – Assessment of the Newborn

## Summary

ANZCOR Guidelines 13.1 to 13.10 and the Newborn Life Support algorithm are provided to assist in the resuscitation of newborn infants. Differences from the adult and paediatric guidelines reflect differences in the anatomy and physiology and the causes of cardiorespiratory arrest for newborns, older infants, children and adults. These guidelines draw from Neonatal Life Support 2020 and 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations (CoSTR) [1, 2] the development of which included representation from ANZCOR. The 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Care [3] and local practices have also been taken into account.

### To whom do these guidelines apply?

The term 'newborn' or 'newborn infant' refers to the infant in the first minutes to hours following birth. In contrast, the neonatal period is defined as the first 28 days of life. Infancy includes the neonatal period and extends through the first 12 months of life.

ANZCOR Guidelines 13.1 to 13.10 and the Newborn Life Support algorithm are mainly for the care of newborns. The exact age at which paediatric techniques and in particular, compression-ventilation ratios, should replace the techniques recommended for newborns is unknown, especially in the case of very small preterm infants. For term infants beyond the first minutes to hours following birth, and particularly in those with known or suspected cardiac aetiology of their arrest, paediatric techniques may be used (refer to Paediatric Advanced Life Support ANZCOR Guidelines 12.1 to 12.7).

### Who is the audience for these guidelines?

ANZCOR Guidelines 13.1 to 13.10 and the Newborn Life Support algorithm are for health professionals and those who provide healthcare in environments where equipment and drugs are available (such as a hospital). When parents are taught CPR for their infants who are being discharged from birth hospitals, the information in Basic Life Support Guidelines (ANZCOR Guidelines 2 to 8) is appropriate.

### Recommendations

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

1. Evaluating the need to initiate and continue resuscitation should begin immediately after birth and proceed throughout the resuscitation. The initial assessment should address; tone,

breathing and heart rate. Subsequent assessment throughout the resuscitation is based on the newborn's heart rate, breathing, tone and oxygenation, (which is preferably assessed using pulse oximetry). [Good Practice Statements] A prompt increase in heart rate remains the most sensitive indicator of resuscitation efficacy. [Extrapolated evidence]

2. Most newborns will commence movement of all extremities, start breathing and their heart rates will rise to over 100 beats per minute soon after birth. They do not require any assistance and should not be separated unnecessarily from their mothers. If these responses are absent or weak, brisk but gentle drying with a soft warmed towel should be used to stimulate the newborn to breathe. The wet towel should then be replaced with a warm, dry one to prevent inadvertent heat loss. For preterm or very low birth weight infants who are placed in/under a polyethylene bag/sheet to prevent evaporative heat loss (refer to ANZCOR Guideline 13.8), only the newborn's head needs drying. Drying the body and limbs beforehand is unnecessary and potentially counterproductive, but tactile stimulation can be provided through the bag or sheet, if needed. [Good Practice Statements]
3. Slapping, shaking, spanking, or holding the newborn upside down are potentially dangerous and should not be used. During all handling, care should be taken to ensure that the newborn's head and neck are supported in a neutral position, especially if muscle tone is low. [Good Practice Statements]
4. If the newborn has good tone and can maintain a heart rate >100 beats per min, immediate intervention may not be required, apart from ensuring that the head is in or near the midline and in a neutral position to maintain airway patency. If the tone is low and the heart rate is not maintained at >100 beats per min or if the newborn is not breathing, positive pressure ventilation is required. [Good Practice Statement]
5. ANZCOR suggests that continuous positive airway pressure (CPAP) can be used in the newborn who has begun regular respiratory effort but has recession, retraction or indrawing of the lower ribs and sternum, or onset of persistent expiratory grunting. [Weak recommendation, moderate certainly of evidence]
6. Persistent apnoea, particularly associated with hypotonia (floppiness), and a heart rate <100 beats per min is a serious sign and the newborn urgently requires positive pressure ventilation. [Good Practice Statement]
7. Prompt use of pulse oximetry should be implemented when the need for resuscitation is anticipated, when persistent cyanosis is suspected, when CPAP, positive pressure ventilation or supplemental oxygen is used, because it can give information about both heart rate and oxygenation. The device should be switched on and the sensor should be placed on the newborns right hand or wrist before connecting the sensor to the cable instrument. Heart rate monitored using an oximeter should be checked intermittently during resuscitation by ECG or auscultation. [Good Practice Statements]
8. ANZCOR suggests that ECG monitoring can also be used to more rapidly and accurately display heart rate in the first 3 minutes of life. [CoSTR 2015, weak recommendation; very low certainty of evidence]

## Abbreviations

| Abbreviation | Meaning/Phrase |
|---|---|

| | |
|---|---|
| ANZCOR | Australian and New Zealand Committee on Resuscitation |
| CoSTR | International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations |
| CPR | Cardiopulmonary resuscitation |
| CPAP | Continuous positive airway pressure |
| ECG | Electrocardiography |

# Guideline

Evaluating the need to initiate and continue resuscitation should begin immediately after birth and proceed throughout the resuscitation.

The initial assessment should address;

- tone
- breathing
- heart rate.

Subsequent assessment throughout the resuscitation is based on the newborn's heart rate, breathing, tone and oxygenation, (which is preferably assessed using pulse oximetry). [Good Practice Statements] A prompt increase in heart rate remains the most sensitive indicator of resuscitation efficacy. [4] [Extrapolated evidence]

Evaluation and intervention are simultaneous processes, especially when more than one resuscitator is present. However, for clarity, this process is described as a sequence of distinct steps shown in the algorithm.

## 1 Tone and Response to Stimulation

The assessment of tone is subjective and dependent on gestation, but a newborn with good tone (moving the limbs and with a flexed posture) is unlikely to be severely compromised whereas a newborn who is very floppy and not moving is very likely to need active resuscitation.

Most newborns will commence movement of all extremities, start breathing and their heart rates will rise to over 100 beats per minute soon after birth. They do not require any assistance and should not be separated unnecessarily from their mothers. [Good Practice Statement]

If these responses are absent or weak, brisk but gentle drying with a soft warmed towel should be used to stimulate the newborn to breathe. [Good Practice Statement] The wet towel should then be replaced with a warm, dry one to prevent inadvertent heat loss. For preterm or very low birth weight infants who are placed in/under a polyethylene bag/sheet to prevent evaporative heat loss, only the newborn's head needs drying if not covered with plastic (refer to ANZCOR Guideline 13.8). Drying the body and limbs beforehand is unnecessary and potentially counterproductive, but tactile stimulation can be provided through the bag or sheet, if needed. [Good Practice Statements] For infants born under meconium-stained amniotic fluid, (refer to ANZCOR Guideline 13.4).

**Slapping, shaking, spanking, or holding the newborn upside down are potentially dangerous and should not be used. During all handling, care should be taken to ensure that the newborn's head and neck are supported in a neutral position, especially if muscle tone is low.** [Good Practice Statements]

If the newborn does not breathe, assisted ventilation should be started (refer to ANZCOR Guideline 13.4).

# 2 Breathing

The newborn should establish regular breaths sufficient to maintain the heart rate more than 100 beats per minute within 2 minutes after birth. Breathing may be difficult to assess well in the first minute or two after birth.[5] 85% of term and near term newborn infants start breathing within 30 seconds of birth and 95% within 45 seconds of birth.[6] If the newborn has good tone and can maintain a heart rate >100/min, immediate intervention may not be required, apart from ensuring that the head is in or near the midline and in a neutral position to maintain airway patency. If the tone is low and the heart rate is not maintained at >100 beats per min or if the newborn is not breathing, positive pressure ventilation is required. ANZCOR suggests that continuous positive airway pressure (CPAP) can be used in the newborn who has begun regular respiratory effort. [1, 2] [Weak recommendation, moderate certainty of evidence]

Recession, retraction or indrawing of the lower ribs and sternum, or onset of persistent expiratory grunting are important signs that the newborn is having difficulty expanding the lungs. If they persist, the newborn may benefit from CPAP rather than positive pressure ventilation. [7, 8]

Persistent apnoea, particularly associated with hypotonia (floppiness), and a heart rate <100 beats per min is a serious sign and the newborn urgently requires positive pressure ventilation. [Good Practice Statement]

# 3 Heart Rate

Heart rate can be determined by listening to the heart with a stethoscope (more reliable than cord palpation) or in the first few minutes after birth, by feeling for pulsations at the base of the umbilical cord if a pulse is not felt at the base of the cord this is not a reliable sign that the heart rate is absent. Other central and peripheral pulses are difficult to feel in newborns making the absence of these pulses an unreliable sign.[9-11] Pulse oximetry can provide a continuous display of the heart rate within about a half a minute of application [12, 13], and electrocardiography (ECG) even more quickly. Prompt use of pulse oximetry should be used in any newborn needing resuscitation because it can also give information about oxygenation. [Good Practice Statement]

ANZCOR suggests that ECG monitoring can also be used to more rapidly and accurately display heart rate in the first 3 minutes of life.[2] [CoSTR 2015, weak recommendation; very low certainty of evidence] Therefore it has the potential to reduce inappropriate interventions that might be implemented based on falsely low estimates of heart rates as assessed by pulse oximetry or auscultation. However, there is as yet no evidence whether outcomes are improved by early initiation of ECG monitoring. [1, 2]

Heart rate should be consistently more than 100 beats per min within two minutes of birth in an uncompromised newborn.[5] An increasing or decreasing heart rate is the best sign that the newborn's condition is improving or deteriorating. [2] [Extrapolated evidence] If the heart rate is persistently less than 100 beats per min, CPAP or assisted ventilation should be commenced.

# 4 Colour

Colour is difficult to assess accurately and is a poor means of judging oxygenation.[14] Normal newborns are blue at birth but start to look pink soon after the onset of breathing. Cyanosis can be difficult to recognise and is determined by examining the gums and mucous membranes in good ambient light. Bluish hands and feet are a normal finding after birth. If a newborn appears persistently blue, it is important to check oxygenation with a pulse oximeter. [Good Practice Statement]

Extreme pallor, especially if it persists after ventilation, can indicate severe acidosis, hypotension due to poor cardiac output with or without hypovolaemia, or sometimes, severe anaemia.

# 5 Pulse Oximetry

For newborns requiring resuscitation and/or respiratory support, pulse oximetry is recommended both to monitor heart rate and to assess oxygenation. [2] The device should be switched on and the sensor should be placed on the newborns right hand or wrist before connecting the sensor to the cable instrument. [13, 15] Heart rate monitored using an oximeter should be checked intermittently during resuscitation by ECG or auscultation. [2] [Good Practice Statement]

Modern pulse oximeters, with probes designed specifically for newborns can provide readings of heart rate in less than a minute of application and saturations by 90 seconds, as long as there is sufficient cardiac output and peripheral blood flow for the oximeter to detect a pulse.[5, 12, 13] Oximetry is recommended when the need for resuscitation is anticipated, when CPAP or positive pressure ventilation is used, when persistent cyanosis is suspected, or when supplemental oxygen is used. [Good Practice Statement] In newborns resuscitated using supplemental oxygen, oximetry can play an important role in avoiding hyperoxaemia.

# References


1. Wyckoff MH, Wyllie J, Aziz K, de Almeida MF, Fabres JW, Fawke J, et al. Neonatal Life Support 2020 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. Resuscitation. 2020;156:A156-A87.

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# About this Guideline

| | |
|---|---|
| **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. [1, 2] |
| **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. |
| **Main changes:** | Updating of review evidence, references, and terminology to increase consistency with GRADE terminology. |
| **Principal reviewers:** | Helen Liley, Lindsay Mildenhall, Marta Thio, Callum Gately |
| **Approved:** | April 2021 |

AUSTRALIAN RESUSCITATION COUNCIL

NEW ZEALAND Resuscitation Council WHAKAHAUORA AOTEAROA

# ANZCOR Guideline 13.4 – Airway Management and Mask Ventilation of the Newborn

## Summary

ANZCOR Guidelines 13.1 to 13.10 and the Newborn Life Support algorithm are provided to assist in the resuscitation of newborn infants. Differences from the adult and paediatric guidelines reflect differences in the anatomy and physiology and the causes of cardiorespiratory arrest for newborns, older infants, children and adults. These guidelines draw from Neonatal Life Support 2020 and 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations (CoSTR), [1, 2] the development of which included representation from ANZCOR. The 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Care [3] and local practices have also been taken into account.

### To whom do these guidelines apply?

The term 'newborn' or 'newborn infant' refers to the infant in the first minutes to hours following birth. In contrast, the neonatal period is defined as the first 28 days of life. Infancy includes the neonatal period and extends through the first 12 months of life.

ANZCOR Guidelines 13.1 to 13.10 and the Newborn Life Support algorithm are mainly for the care of newborns. The exact age at which paediatric techniques and in particular, compression-ventilation ratios, should replace the techniques recommended for newborns is unknown, especially in the case of very small preterm infants. For term infants beyond the first minutes to hours following birth, and particularly in those with known or suspected cardiac aetiology of their arrest, paediatric techniques may be used (refer to Paediatric Advanced Life Support ANZCOR Guidelines 12.1 to 12.7).

### Who is the audience for these guidelines?

ANZCOR Guidelines 13.1 to 13.10 and the Newborn Life Support algorithm are for health professionals and those who provide healthcare in environments where equipment and drugs are available (such as a hospital). When parents are taught CPR for their infants who are being discharged from birth hospitals, the information in Basic Life Support Guidelines (ANZCOR Guidelines 2 to 8) is appropriate.

## Recommendations

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

1. The newborn who needs resuscitation should be placed on their back with the head in a neutral or slightly extended position (the sniffing position). Particularly if moulding during birth has caused a very prominent occiput, a 2 cm thickness of blanket or towel placed under the shoulders may be helpful in maintaining good positioning. If respiratory efforts are present but not producing effective ventilation (the heart rate does not rise above 100 beats per min) the airway may be obstructed and consideration should be given to other methods to improve airway patency, including support of the lower jaw, opening the mouth, or in some cases upper airway suction. [Good Practice Statements]
2. In general, mouth and pharyngeal suction should not be used except when newborns show obvious signs of obstruction either to spontaneous breathing or to positive pressure ventilation and it should be done briefly and with care. Pharyngeal suction may be required to visualise the vocal cords during intubation. [Good Practice Statements]
3. Aspiration of meconium before or during birth, or during resuscitation can cause meconium aspiration syndrome (MAS) and all newborns born through meconium-stained fluid must be regarded as at risk. [Good Practice Statement]
4. Suctioning the newborns mouth and pharynx before the delivery of the shoulders makes no difference to the outcome of newborns with meconium-stained liquor and is not recommended. [Good practice statement NHMRC LOE II 2015]
5. For newborns who are vigorous after exposure to meconium-stained liquor, (breathing or crying, good muscle tone), routine endotracheal suctioning is discouraged because it does not alter their outcome and may cause harm. [Good practice statement NHMRC LOE II 2015]
6. For all newborns exposed to meconium-stained amniotic fluid, ANZCOR suggests against routine direct laryngoscopy immediately after birth, with or without tracheal suctioning. [CoSTR 2020 Weak recommendation, low-certainty evidence]
7. For the newborn needing assisted ventilation, the primary measure of effectiveness is a prompt improvement in heart rate, which is then sustained. Oxygen saturation levels should also improve. Chest wall movement and other indicators (for example auscultation, colorimetric $CO^2$ detector, respiratory function monitoring if available) of adequacy of lung inflation should be assessed if the heart rate does not improve. [Good Practice Statement]
8. If there is little or no visible chest wall movement the technique of ventilation should be improved. This includes assuring the facemask fits well on the face with minimal leak, and that the head and jaw position are correct. Two people may be able to provide mask ventilation more effectively than one, with one person supporting the jaw and holding the mask in place with two hands, and the other providing positive pressure inflations. If these manoeuvres are ineffective in moving the chest wall and increasing the heart rate, the inflating pressure must be increased until chest wall movement is seen and the heart rate increases. Suctioning of the airway is sometimes required. Occasionally an oropharyngeal airway may be helpful, such as when the newborn has an abnormally small jaw or large tongue. A nasopharyngeal airway may be a suitable alternative for those experienced in using them. [Good Practice Statements]
9. For spontaneously breathing term newborns with respiratory distress, a trial of CPAP may be considered, although there are no studies to support this recommendation. [Good Practice Statement]
10. A T-piece resuscitator device, a self-inflating bag (approximately 240 mL), and a flow-inflating bag are all acceptable devices to ventilate newborns either via a facemask, supraglottic airway or endotracheal tube. [Good Practice Statement]
11. ANZCOR suggests the use of a T-piece device for delivery of Intermittent Positive Pressure Ventilation (IPPV) or Continuous Positive Airway Pressure (CPAP) during newborn

resuscitation. [Weak recommendation, very low certainty of evidence] A self-inflating bag must always be available for back-up in case of failure of pressurised gas delivery. [Good Practice Statement]

12. An appropriate size of facemask should be selected to seal around the mouth and nose but not cover the eyes or overlap the chin. Therefore, a range of sizes must be available for different sized babies. Masks with a cushioned rim are preferable to masks without one. The face mask should be applied using a rolling motion from chin to nose bridge and held in place using a suitable grip that minimises leaks. The optimal technique for mask grip varies with type of mask. Suction masks are not recommended. [Good Practice Statements]
13. For commencing intermittent positive pressure ventilation in newborns, the suggested initial pressures are 30 cm $H_2O$ for term newborns and 20 to 25 cm $H_2O$ for premature newborns. On devices that can deliver PEEP, 5 cm $H_2O$ is the suggested initial setting. Pressures should be adjusted up or down according to response. For preterm newborns, it is particularly important to avoid creation of excessive lung expansion during ventilation immediately after birth. Although measured peak inspiratory pressure (PIP) does not correlate well with volume delivered in the context of changing respiratory mechanics, monitoring of inflation pressure may help provide consistent inflations and avoid unnecessarily high pressures and excessive volumes. [Good Practice Statements]
14. Higher inflation pressures may be required to aerate the lungs during the first few inflations than for subsequent inflations, particularly in newborns who have not made any respiratory effort. The minimal inflation required to achieve visible chest wall movement and an increase in heart rate should be used. When it becomes evident that the newborn is responding to ventilation, in many cases inflation pressures and rate can (and should) be decreased. [Good Practice Statements]
15. Subsequent ventilation should be provided at 40 to 60 inflations per minute with an inspiratory time of 0.3 to 0.5 seconds. For most newborns, ventilation can be accomplished with progressively lower pressures and rates as resuscitation proceeds. [Good Practice Statements]
16. ANZCOR suggests the use of PEEP (commencing at 5 to 8 cm $H_2O$ pressure) during resuscitation of newborns wherever appropriate equipment is available. [Weak recommendation, very low certainty of evidence.]
17. High levels of PEEP (>8 cm H2O) have the potential to reduce pulmonary blood flow and cause pneumothorax and should be used with caution [Good Practice Statement].
18. If the chest and abdomen do not rise with each inflation, or the heart rate does not increase above 100 beats per minute, the technique of ventilation needs to be improved. Tracheal intubation (or use of a supraglottic airway) should be considered if ventilation via a facemask is still ineffective despite the above measures. [Good Practice Statements].
19. Oximetry is recommended when the need for resuscitation is anticipated, when CPAP or positive pressure ventilation is used, when persistent cyanosis is suspected, or when supplemental oxygen is used. [Good Practice Statement]
20. Use the following target range for oxygen saturations during newborn resuscitation. [Good Practice Statement]

| Time from birth | Target saturations for newborns during resuscitation in % |
|---|---|
| 1 min | 60-70 |
| 2 min | 65-85 |
| 3 min | 70-90 |
| 4 min | 75-90 |
| 5 min | 80-90 |
| 10 min | 85-90 |

21. For term and near-term newborn infants ANZCOR suggests that air should be used initially with supplemental oxygen reserved for those whose saturations do not meet the lower end of the targets despite respiratory support. [CoSTR 2020, weak recommendation, low certainty of evidence] If, despite effective ventilation there is no increase in oxygenation (assessed by oximetry wherever possible) or heart rate, a higher concentration of oxygen should be used. If the saturations reach 90% while supplemental oxygen is being administered, the concentration of oxygen should be decreased. [Good Practice Statement] (For considerations for very preterm infants refer to ANZCOR Guideline 13.8).
22. In all cases, the first priority is to ensure adequate inflation of the lungs, followed by increasing the concentration of inspired oxygen only if needed. [Good Practice Statement]
23. In all newborns, resuscitators should aim to ensure that effective spontaneous or assisted ventilation of the lungs has been established by 1 minute. The response to each set of actions in the algorithm should be assessed. If heart rate, breathing, tone and oxygenation do not improve or the newborn is deteriorating, progress to the next step. [Good Practice Statement]

## Abbreviations

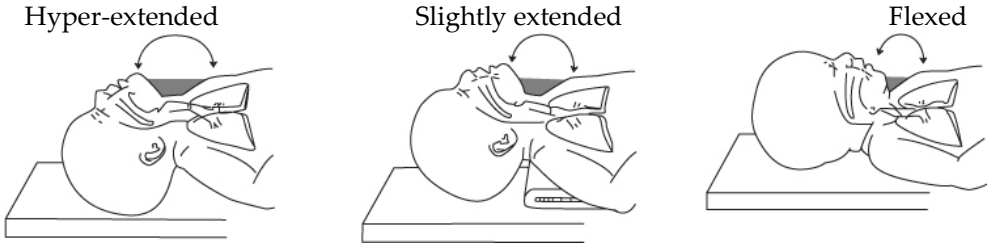
| Abbreviation | Meaning/Phrase |
|---|---|
| ANZCOR | Australian and New Zealand Committee on Resuscitation |
| CI | Confidence interval (95%) |
| CoSTR | International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations |
| CPAP | Continuous positive airway pressure |
| CPR | Cardiopulmonary resuscitation |
| IPPV | Intermittent Positive Pressure Ventilation |
| ILCOR | International Liaison Committee on Resuscitation |
| LOE | Level of evidence |
| MAS | Meconium aspiration syndrome |
| NHMRC | National Health and Medical Research Council |
| PEEP | Positive end expiratory pressure |
| PIP | Peak inspiratory pressure |
| RCT | Randomised controlled trial |

**EFFECTIVE VENTILATION IS THE KEY TO SUCCESSFUL NEWBORN RESUSCITATION**

All personnel involved in the birth and care of newborns must be familiar with the ventilation equipment and be proficient in its use.

# 1 Positioning and the Airway

The newborn who needs resuscitation should be placed on their back with the head in a neutral or slightly extended position (the sniffing position). Particularly if moulding during birth has caused a very prominent occiput, a 2 cm thickness of blanket or towel placed under the shoulders may be helpful in maintaining good positioning. [Good Practice Statements]




The slightly extended, or sniffing position of the newborn illustrated in the middle panel results in optimal airway patency for resuscitation.

If respiratory efforts are present but not producing effective ventilation (the heart rate does not rise above 100 beats per min) the airway may be obstructed and consideration should be given to other methods to improve airway patency, including support of the lower jaw, opening the mouth, or in some cases upper airway suction. [Good Practice Statement]

## 1.1 Mouth and Pharyngeal Suction

Newborns do not usually require suctioning of the nose, mouth or pharynx after birth. They clear their airways very effectively, and suctioning can delay the normal rise in oxygenation.[4] Evidence in relation to oropharyngeal and nasopharyngeal suctioning is limited, but overall, suggests it should not be used as a routine step in newborns receiving resuscitation. It is not expected to impact on liquid removal from the lungs. It may reduce oxygen saturation levels.[4, 5] and cause bradyarrhythmia.[6] It can take up time [7] that could result in clinically important delays in the newborn receiving other interventions, such as face mask ventilation.[8]

However, the airway is sometimes obstructed by particulate meconium, blood clots, tenacious mucous or vernix and these may need to be cleared.

In general, suction should not be used except when newborns show obvious signs of obstruction either to spontaneous breathing or to positive pressure ventilation and it should be done briefly and with care. Pharyngeal suction may be required to visualise the vocal cords during intubation. [Good Practice Statements]

### 1.2 Management of the Airway in the Presence of Meconium-Stained Liquor

Aspiration of meconium before or during birth, or during resuscitation can cause meconium aspiration syndrome (MAS) and all newborns born through meconium-stained fluid must be regarded as at risk. [Good Practice Statement]

### 1.3 Intrapartum pharyngeal suction

Suctioning the newborns mouth and pharynx before the delivery of the shoulders makes no difference to the outcome of newborns with meconium-stained liquor and is not recommended. [9, 10] [Good practice statement NHMRC LOE II 2015]

### 1.4 Endotracheal suction

For newborns who are vigorous after exposure to meconium-stained liquor, (breathing or crying, good muscle tone), routine endotracheal suctioning is discouraged because it does not alter their outcome and may cause harm. [11, 12] [Good practice statement NHMRC LOE II 2015]

For non-vigorous infants (no breathing or crying, low muscle tone) a systematic review of tracheal suctioning (e.g. via an endotracheal tube) that included three randomised controlled trials (RCTs; 449 newborns) [13-15] and one observational study (231 newborns) [16] found no benefit for routine endotracheal suctioning for survival, neurodevelopmental outcomes, hypoxic ischaemic encephalopathy, meconium aspiration syndrome, need for chest compressions, use of various forms of respiratory support, need for treatment for pulmonary hypertension, or length of hospital stay. [17]

Emphasis should be placed on initiating ventilation rapidly in non-breathing or ineffectively breathing newborns. Rarely, a newborn may require intubation and tracheal suctioning to relieve airway obstruction. Meconium-stained amniotic fluid remains a significant risk factor for receiving advanced resuscitation at birth and for developing meconium aspiration syndrome.[18-20]

For all newborns exposed to meconium-stained amniotic fluid, ANZCOR suggests against routine direct laryngoscopy immediately after birth, with or without tracheal suctioning. [1] [CoSTR 2020 Weak recommendation, low-certainty evidence]

## 2 Tactile Stimulation

Drying and stimulation are both assessment and resuscitative interventions. However, if in response, the term or preterm newborn fails to establish effective respirations and heart rate is below 100 beats per min by 1 minute of age and not increasing, Continuous Positive Airway Pressure (CPAP) or positive pressure ventilation should be commenced. If the newborn is breathing, CPAP may be sufficient to augment endogenous effort. In the non-breathing newborn Intermittent Positive Pressure Ventilation (IPPV) should be started. (Refer to ANZCOR Guideline 13.3).

# 3 Positive Pressure Ventilation

After stimulation, positive pressure ventilation should be started if the heart rate is less than 100 beats per min and not increasing and either the newborn remains apnoeic or the breathing is inadequate. (Refer to ANZCOR Guideline 13.3).

The primary measure of effectiveness of ventilation is a prompt improvement in heart rate, which is then sustained. Oxygen saturation levels should also improve. Chest wall movement and other indicators (e.g., auscultation, colorimetric $CO_2$ detector, respiratory function monitoring) of adequacy of lung inflation should be assessed if the heart rate does not improve. [Good Practice Statement]

If there is little or no visible chest wall movement the technique of ventilation should be improved. This includes assuring the facemask fits well on the face with minimal leak, and that the head and jaw position are correct. Two people may be able to provide mask ventilation more effectively than one, with one person supporting the jaw and holding the mask in place with two hands, and the other providing positive pressure inflations. [21, 22] If these manoeuvres are ineffective in moving the chest wall and increasing the heart rate, the inflating pressure must be increased until chest wall movement is seen and the heart rate increases. Suctioning of the airway is sometimes required. Occasionally an oropharyngeal airway may be helpful, such as when the newborn has an abnormally small jaw or large tongue. A nasopharyngeal airway may be a suitable alternative for those experienced in using them. [Good Practice Statements]

## 3.1 Manual Ventilation Devices

A T-piece device, a self-inflating bag (approximately 240 mL), and a flow-inflating bag are all acceptable devices to ventilate newborns either via a facemask, supraglottic airway or endotracheal tube. [23-30] [Good Practice Statement]

| | T-piece resuscitation device (with manometer) | Self-inflating bag | Flow-inflating bag (with manometer) |
|---|---|---|---|
| Needs pressurised gas source | Yes | No | Yes |
| Assists user to detect mask leak | Yes | No | Yes |
| Peak inflation pressures | Consistent, adjustable | Inconsistent, may be very high | Consistency depends on user skills |
| Delivers PEEP or CPAP | Yes | No | Depends on user skills |
| Can deliver sustained inflation | Yes | No | Depends on user skills |

## 3.2 Effectiveness of T-piece Resuscitator Devices Versus Self-Inflating Bags

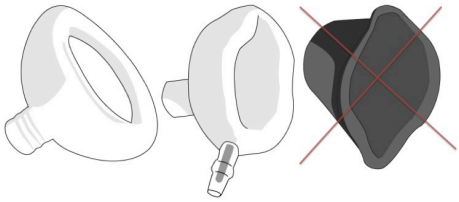
ANZCOR suggests using a T-piece device for delivery of Intermittent Positive Pressure Ventilation (IPPV) or Continuous Positive Airway Pressure (CPAP) during newborn resuscitation. [23] [Weak recommendation, very low certainty of evidence] In making this suggestion, we have diverged from the 2020 CoSTR Treatment Recommendation, which did not change a 2010 ILCOR conclusion that there was insufficient evidence to recommend T-piece resuscitators over self-inflating bags. [1, 2] In doing so, we take into account a recently published ILCOR systematic review which found evidence suggesting reduced rates of mortality, bronchopulmonary dysplasia and rates of intubation for resuscitation when using a T-piece resuscitator, [23] as well as the level of resources for health care in Australia and New Zealand. We also place value on the demonstrated benefits of positive end expiratory pressure (PEEP) in recruiting lung volume, the routine use of manometry to adjust inflating pressures and the reliable titration of oxygen concentration.

A flow-inflating bag with manometer is also suitable. The T-piece device or flow-inflating bag should be used with a blender and both compressed air and oxygen, to allow accurate titration of inspired oxygen concentration to meet the newborn's needs.

A self-inflating bag must always be available for back-up in case of failure of pressurised gas delivery. [Good Practice Statement] A self-inflating bag cannot deliver CPAP and may not be able to achieve PEEP even with a PEEP valve in place. [31]

## 3.3 Facemasks

The appropriate size of facemask must seal around the mouth and nose but not cover the eyes or overlap the chin. Therefore, a range of sizes must be available for different sized babies. Masks with a cushioned rim are preferable to masks without one. [32] [Good Practice Statements] With face mask ventilation it can be difficult to establish and maintain a good seal between the mask and the infant's face [33] and so it cannot be assumed that just because the mask is on the face, there is a good seal.



Suitable facemasks, with cushioned rims, are shown on the left. The one in the centre has an inflatable rim, which should be filled with air using a syringe until the rim is firm. The Rendell Baker style mask on the right should not be used.

The face mask should be applied using a rolling motion from chin to nose bridge and held in place using a suitable grip that minimises leaks. [22, 34] The optimal technique for mask grip varies with type of mask. Suction masks are not recommended. [35] [Good Practice Statements]

## 3.4 Initiating Ventilation

The aim of ventilation is initially to clear lung liquid, establish lung aeration and enable gas exchange.[36-39] The optimal strategy for this in newborns needing resuscitation has not been established. There is evidence from animal studies to support sustained inflations and positive end expiratory pressure, [40]particularly in preterm lungs. However, care must be taken to avoid high tidal volumes during resuscitation, which can cause sustained damage to immature lungs. [41]

For term or late preterm newborns, it is not possible to recommend any specific duration for initial inflations because there are no published comparative trials.[1, 42] For advice for ≤ 32 week preterm newborns who receive positive pressure ventilation at birth, refer to ANZCOR Guideline 13.8.

For commencing intermittent positive pressure ventilation in newborns, the suggested initial pressures are 30 cm $H_2O$ for term newborns and 20 to 25 cm $H_2O$ for premature newborns.

On devices that can deliver PEEP, 5 cm $H_2O$ is the suggested initial setting. Pressures should be adjusted up or down according to response. For preterm newborns, it is particularly important to avoid creation of excessive lung expansion during ventilation immediately after birth. Although measured peak inspiratory pressure (PIP) does not correlate well with volume delivered in the context of changing respiratory mechanics, monitoring of inflation pressure may help provide consistent inflations and avoid unnecessarily high pressures and excessive volumes. [43] [Good Practice Statements]

Higher inflation pressures may be required to aerate the lungs during the first few inflations than for subsequent inflations, particularly in newborns who have not made any respiratory effort. The minimal inflation required to achieve visible chest wall movement and an increase in heart rate should be used. When it becomes evident that the newborn is responding to ventilation, in many cases inflation pressures and rate can (and should) be decreased. [Good Practice Statements]

Subsequent ventilation should be provided at 40 to 60 inflations per minute with an inspiratory time of 0.3 to 0.5 seconds. ***For most newborns, ventilation can be accomplished with progressively lower pressures and rates as resuscitation proceeds.*** [Good Practice Statements]

## 3.5 PEEP during Resuscitation

PEEP has been shown to be very effective for improving lung volume, reducing oxygen requirements and reducing the incidence of apnoea in preterm infants with respiratory distress syndrome. [44] Studies in intubated premature animals demonstrate that it helps establish aerated lung volume. [45, 46]

There is low certainty evidence indicating that PEEP produces a modest reduction in maximum oxygen concentration during preterm infant's resuscitation. [47] Most human newborn trials compare devices that can deliver PEEP (such as T-piece devices) with devices that cannot deliver PEEP (such as self-inflating bags), [48-52] These devices cause other major differences in the inflation pressure profile that may confound any relationship between the use of PEEP and clinical outcomes. Therefore, we place higher value on the evidence for routine use of PEEP during ventilation in newborns receiving subsequent newborn intensive care, the demonstrated benefits of PEEP in establishing lung aeration in newborn preterm animal models and the much stronger evidence that CPAP can be used to support spontaneous breathing in term and preterm newborns with a variety of lung disorders. We place lower value on the absence of evidence of other benefits from human infant trials. [2, 53] Therefore, ANZCOR suggests the use of PEEP (commencing at 5 to 8 cm $H_2O$ pressure) during resuscitation of newborns wherever appropriate equipment is available. [1, 2] [Weak recommendation, very low certainty of evidence]

High levels of PEEP (>8 cm $H_2O$) have the potential to reduce pulmonary blood flow and cause pneumothorax, and should be used with caution. [50] [Good Practice Statement]

## 3.6 Assessing the Effectiveness of Ventilation

The effectiveness of ventilation is confirmed by observing three things:

1. Increase in the heart rate above 100 beats per minute.
2. A slight rise of the chest and upper abdomen with each inflation.
3. Oxygenation improves.

If the chest and abdomen do not rise with each inflation, or the heart rate does not increase above 100 beats per minute, the technique of ventilation needs to be improved. Tracheal intubation (or use of a supraglottic airway) should be considered if ventilation via a facemask is still ineffective despite the above measures. [Good Practice Statements]

### 3.7 Continuous Positive Airway Pressure (CPAP)

For spontaneously breathing term newborns with respiratory distress, a trial of CPAP may be considered, although there are no randomised trials to support this recommendation. [54, 55] [Good Practice Statement] For preterm newborns, refer to ANZCOR Guideline 13.8.

### 3.8 Mouth-to-Mouth/Nose and Mouth-to-Mask Ventilation

Where newborn inflation devices are not available, mouth-to-mouth-and-nose ventilation can be used. [56] Maternal blood and other body fluids should first be wiped from the face of the newborn. The rescuer should then apply the mouth over the mouth and nose of the newborn and give small puffs at a rate of 40 to 60 breaths per minute to produce a small rise and fall of the chest, until the newborn improves.

## 4 Supplemental Oxygen during Resuscitation

There are now many studies showing that the blood oxygen levels of normal newborns can take up to 10 minutes to rise above 90%. [57-63] While insufficient oxygenation can impair organ function or cause permanent injury, there is increasing evidence that even brief exposure to excessive oxygenation can be harmful to the newborn during and after resuscitation. [64-68]

Furthermore, visual assessment of the presence or absence of cyanosis bears a poor relationship to oxyhaemoglobin saturation measured with an oximeter. [69]

### 4.1. Pulse oximetry

Oximetry is recommended when the need for resuscitation is anticipated, when CPAP or positive pressure ventilation is used, when persistent cyanosis is suspected, or when supplemental oxygen is used. [Good Practice Statement] (Refer to ANZCOR Guideline 13.3)

### 4.2 Administration of supplemental oxygen

Meta-analyses of randomized controlled trials comparing newborn resuscitation initiated in 21% versus 100% oxygen showed increased survival in newborns for whom resuscitation was initiated with air. [70, 71 72] In the studies of term newborns receiving resuscitation with intermittent positive pressure ventilation, 100% oxygen conferred no short term advantage and resulted in increased time to first breath and/or cry. [73, 74] However, there are no studies in term newborns that compare commencing on oxygen concentrations other than 21% or 100%.

It is suggested that regardless of gestation, the goal of oxygen administration should be to aim for oxygen saturations resembling those of healthy term newborns. The interquartile range of pre-ductal saturations measured in normal term newborns at sea level are suitable targets. [68] Use the following target range. [Good Practice Statement] Although the 75$^{th}$ centile for normal newborns rises above 90%[63], in the following table the upper saturation targets while administering oxygen have been capped at 90%, to avoid risk of exposing newborns to excessive oxygen, as when the $SpO_2$ is >90%, the arterial partial pressure of oxygen ($PaO_2$) can be very high. Some newborns achieve saturations over 90% without supplemental oxygen.

| Time from birth | Target saturations for newborns during resuscitation in % |
|---|---|
| 1 min | 60-70 |
| 2 min | 65-85 |
| 3 min | 70-90 |
| 4 min | 75-90 |
| 5 min | 80-90 |
| 10 min | 85-90 |

For term and near-term newborn infants ANZCOR suggests that air should be used initially with supplemental oxygen reserved for those whose saturations do not meet the lower end of the targets despite respiratory support. [1, 72] [CoSTR 2020, weak recommendation, low certainty of evidence] If, despite effective ventilation there is no increase in oxygenation (assessed by oximetry wherever possible) or heart rate, a higher concentration of oxygen should be used. [2, 75-77] If the saturations reach 90% while supplemental oxygen is being administered, the concentration of oxygen should be decreased. [Good Practice Statement]

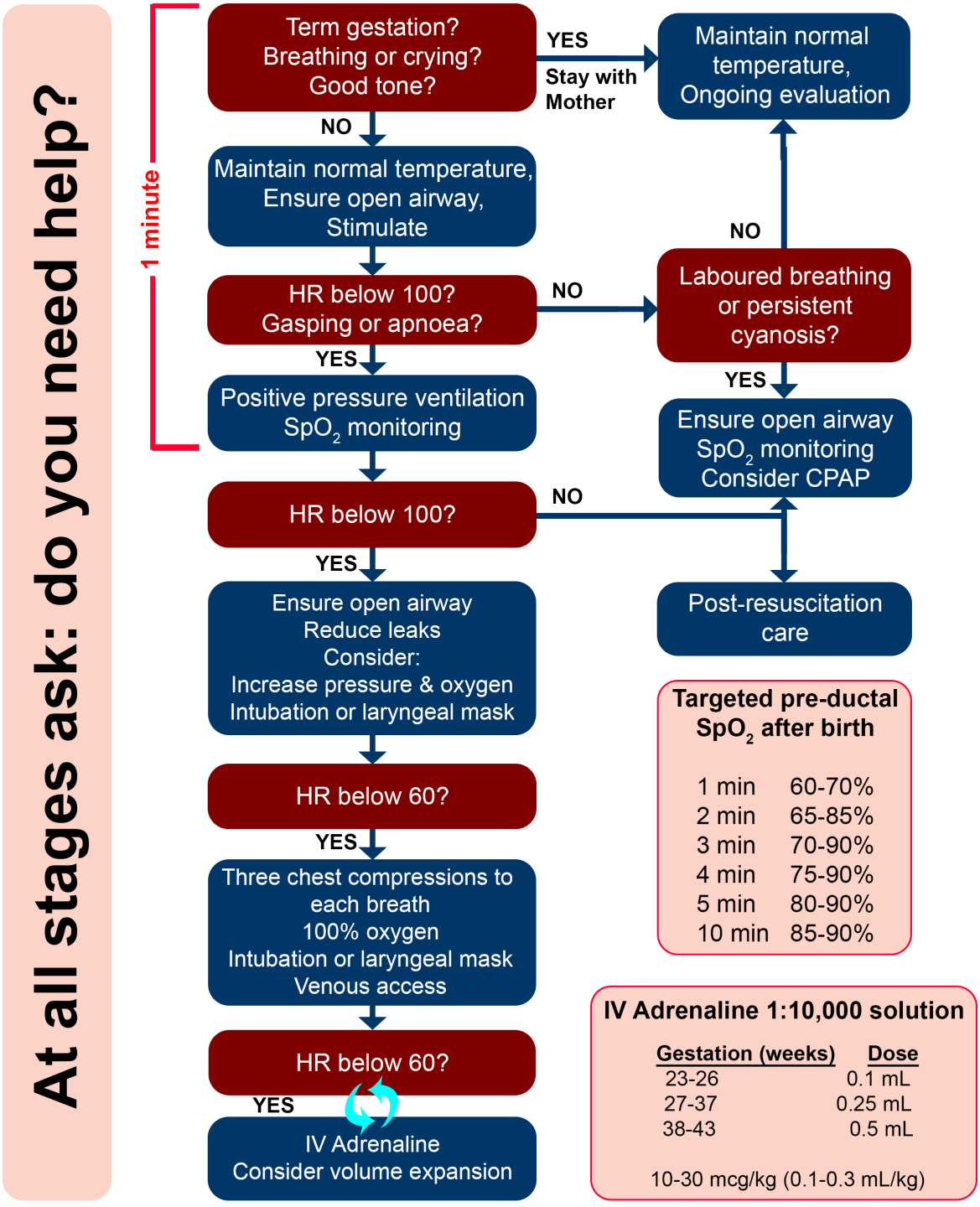
For considerations of very preterm infants, refer to ANZCOR Guideline 13.8.

***In all cases, the first priority is to ensure adequate inflation of the lungs, followed by increasing the concentration of inspired oxygen only if needed.*** [Good Practice Statement]

# 5 Pace of Resuscitation

In all newborns, resuscitators should aim to ensure that effective spontaneous or assisted ventilation of the lungs has been established by 1 minute. The response to each set of actions in the algorithm should be assessed. If heart rate, breathing, tone and oxygenation do not improve or the newborn is deteriorating, progress to the next step. [Good Practice Statement]

# Newborn Life Support




Footnote; Laryngeal mask is synonymous with supraglottic airway.

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# About this Guideline

| | |
|---|---|
| **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. [1, 2] |
| **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. |
| **Principal reviewers:** | Helen Liley, Lindsay Mildenhall, Marta Thio, Callum Gately |
| **Main changes:** | Changes in recommendations for non-vigorous infants exposed to meconium-stained amniotic fluid. Updates for clarity and consistency with contemporary good practice. Updating of review evidence, references, and terminology to increase consistency with GRADE terminology. |
| **Approved:** | April 2021 |

# ANZCOR Guideline 13.5 – Tracheal Intubation and Ventilation of the Newborn

## Summary

ANZCOR Guidelines 13.1 to 13.10 and the Newborn Life Support algorithm are provided to assist in the resuscitation of newborn infants. Differences from the adult and paediatric guidelines reflect differences in the anatomy and physiology and the causes of cardiorespiratory arrest for newborns, older infants, children and adults. These guidelines draw from Neonatal Life Support 2020 and 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations (CoSTR), [1, 2] the development of which included representation from ANZCOR. The 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Care [3] and local practices have also been taken into account.

### To whom do these guidelines apply?

The term 'newborn' or 'newborn infant' refers to the infant in the first minutes to hours following birth. In contrast, the neonatal period is defined as the first 28 days of life. Infancy includes the neonatal period and extends through the first 12 months of life.

ANZCOR Guidelines 13.1 to 13.10 and the Newborn Life Support algorithm are mainly for the care of newborns. The exact age at which paediatric techniques and in particular, compression-ventilation ratios, should replace the techniques recommended for newborns is unknown, especially in the case of very small preterm infants. For term infants beyond the first minutes to hours following birth, and particularly in those with known or suspected cardiac aetiology of their arrest, paediatric techniques may be used. (Refer to Paediatric Advanced Life Support ANZCOR Guidelines 12.1 to 12.7).

### Who is the audience for these guidelines?

ANZCOR Guidelines 13.1 to 13.10 and the Newborn Life Support algorithm are for health professionals and those who provide healthcare in environments where equipment and drugs are available (such as a hospital). When parents are taught CPR for their infants who are being discharged from birth hospitals, the information in Basic Life Support Guidelines (ANZCOR Guidelines 2 to 8) is appropriate.

## Recommendations

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

1. A decision to perform tracheal intubation will depend on the gestation of the infant, degree of respiratory depression, response to facemask (or supraglottic airway) ventilation, and the skill and experience of the resuscitator. Preterm gestation or very low birth weight should not be the only factor that drives the decision to intubate. Tracheal intubation may need to be performed; if ventilation via a facemask (or supraglottic airway) has been unsuccessful (heart rate remains low, oxygen saturation falling or failing to rise) or prolonged, in special circumstances, such as congenital diaphragmatic hernia, or extremely low birth weight, or newborns born without a detectable heartbeat, consideration should be given to intubation as soon as possible after birth. [Good Practice Statements]
2. Endotracheal tube (ETT) internal diameter in millimetres (mm) can be calculated as gestational age in weeks divided by 10. Typically, a 2.5 mm tube is appropriate for infants <1kg weight, a 3.0 mm tube for infants weighing 1 to 2 kg, a 3.5 mm tube for infants weighing 2 to 3 kg, and a 3.5 or 4.0 mm tube for infants over 3 kg. [Good Practice Statements]
3. A laryngoscope with a straight blade (size 1 [10 cm] for term infants and larger preterm infants, size 0 [7.5 cm] for preterm infants < 32 weeks' gestation or 00 [6cm] for extremely low birth weight infants) is preferred. Some experienced operators use curved blades. [Good Practice Statements]
4. The approximate depth of insertion of the endotracheal tube from the middle of the upper lip, in centimetres, can be calculated as weight in kg plus 6 cm. However, the following table is likely to result in greater precision. Use the recommendations in the table for extremely low birth weight infants and preterm infants after the newborn period. [Good practice statement, NHMRC LOE IV.]

| Corrected gestation (weeks) | Actual weight (kg) | ETT mark at lip (cm) |
|---|---|---|
| 23–24 | 0.5–0.6 | 5.5 |
| 25–26 | 0.7–0.8 | 6.0 |
| 27–29 | 0.9–1.0 | 6.5 |
| 30–32 | 1.1–1.4 | 7.0 |
| 33–34 | 1.5–1.8 | 7.5 |
| 35–37 | 1.9–2.4 | 8.0 |
| 38–40 | 2.5–3.1 | 8.5 |
| 41–43 | 3.2–4.2 | 9.0 |

Table: Recommended ETT length to the nearest 0.5 cm by corrected gestation (gestation at birth plus postnatal age) and weight at time of intubation.

5. Appropriate depth of insertion must always be verified by comparing the markings on the tube with the formula or table. [Good Practice Statement]
6. If the chest does not move and the heart rate does not increase, the location of the endotracheal tube and technique of ventilation need to be re-evaluated. A colorimetric $CO_2$ detector, attached to the endotracheal tube adaptor, is recommended as the most reliable method to confirm endotracheal tube placement in neonates who have spontaneous circulation. [Good practice statement, NHMRC 2015 LOE IV 2015]

However, false negative readings may occur in infants if there is very low or absent pulmonary blood flow so if the chest wall is moving well in a very depressed infant, some caution is needed to avoid unnecessary extubation and reintubation. [Good practice statement, NHMRC LOE IV 2015.]

7. Devices to monitor gas flow and volume have been shown to improve mask ventilation technique in simulation training and there is limited evidence of feasibility in clinical settings. However, to date, there is insufficient evidence of clinical benefit, so ANZCOR suggests against the routine use of flow and volume monitoring or end tidal $CO_2$ monitoring during newborn resuscitation. [CoSTR 2015, weak recommendation, low certainty of evidence]
8. ANCOR suggests that a supraglottic airway should be considered during resuscitation of the term and near-term newborn (>34 weeks, approximately 2000 grams) if facemask ventilation is unsuccessful. [CoSTR 2015, weak recommendation, low certainty of evidence]
9. In particular, a supraglottic airway should be considered as an alternative to tracheal intubation if facemask ventilation is unsuccessful and tracheal intubation is unsuccessful or not feasible. The supraglottic airway may be considered as a primary alternative to a facemask for positive pressure ventilation among newborns weighing more than 2000 grams or delivered ≥34 weeks' gestation, although there is insufficient evidence to support its routine use in this setting. A size 1 supraglottic airway is suitable for newborns up to 5 kg. [Good Practice Statement]
10. Effectiveness of ventilation should be checked using signs similar to those used for endotracheal ventilation (chest wall movement, improvement in heart rate, improvement in oxygenation). In addition, the chest should be auscultated. [Good Practice Statement]

## Abbreviations

| Abbreviation | Meaning/Phrase |
|---|---|
| ANZCOR | Australian and New Zealand Committee on Resuscitation |
| CoSTR | International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations |
| LOE | Level of evidence |
| NHMRC | National Health and Medical Research Council |

# Guideline

# 1 Tracheal Intubation and Ventilation

## 1.1. Indications

A decision to perform tracheal intubation will depend on the gestation of the infant, degree of respiratory depression, response to facemask (or supraglottic airway) ventilation, and the skill and experience of the resuscitator. Preterm gestation or very low birth weight should not be the only factor that drives the decision to intubate.

Tracheal intubation may need to be performed;

- if ventilation via a facemask (or supraglottic airway) has been unsuccessful (heart rate remains low, oxygen saturation falling or failing to rise) or prolonged
- in special circumstances, such as congenital diaphragmatic hernia, or extremely low birth weight
- for newborns born without a detectable heartbeat, consideration should be given to intubation as soon as possible after birth.

[Good Practice Statement]

## 1.2 Laryngoscope and endotracheal tube size and depth of insertion

Endotracheal tube (ETT) internal diameter in millimetres (mm) can be calculated as gestational age in weeks divided by 10. Typically, a 2.5 mm tube is appropriate for infants <1kg weight, a 3.0 mm tube for infants weighing 1 to 2 kg, a 3.5 mm tube for infants weighing 2 to 3 kg, and a 3.5 or 4.0 mm tube for infants over 3 kg. [Good Practice Statement]

A laryngoscope with a straight blade (size 1 [10 cm] for term infants and larger preterm infants, size 0 [7.5 cm] for preterm infants < 32 weeks' gestation or 00 [6cm] for extremely low birth weight infants) is preferred. Some experienced operators use curved blades. [Good Practice Statement]

The approximate depth of insertion of the endotracheal tube from the middle of the upper lip, in centimetres, can be calculated as weight in kg plus 6 cm.[4] However, the following table is likely to result in greater precision.[5] Use this table for extremely low birth weight infants and preterm infants after the newborn period. [Good practice statement NHMRC LOE IV 2015]

| Corrected gestation (weeks) | Actual weight (kg) | ETT mark at lip (cm) |
|---|---|---|
| 23–24 | 0.5–0.6 | 5.5 |
| 25–26 | 0.7–0.8 | 6.0 |
| 27–29 | 0.9–1.0 | 6.5 |
| 30–32 | 1.1–1.4 | 7.0 |
| 33–34 | 1.5–1.8 | 7.5 |
| 35–37 | 1.9–2.4 | 8.0 |
| 38–40 | 2.5–3.1 | 8.5 |
| 41–43 | 3.2–4.2 | 9.0 |

Table: Recommended ETT length to the nearest 0.5 cm by corrected gestation (gestation at birth plus postnatal age) and weight at time of intubation.[5]

Appropriate depth of insertion must always be verified by comparing the markings on the tube with the formula or table (see also "Verification of endotracheal tube position" below). [Good Practice Statement]

## 1.3 Equipment to Prepare for and Perform Endotracheal Intubation

- T-piece resuscitator (or flow-inflating bag) and self-inflating bag (approximately 240 mL)
- neonatal facemasks (range of sizes suitable for premature and term newborn infants)
- Medical gases:
    - a source of medical oxygen (reticulated and/or cylinder, allowing flow rate of up to 10 L/min) with flow meter and tubing
    - a source of medical air plus air/oxygen blender

  Suction apparatus and suction catheters (6Fr, 8Fr, and either 10Fr or 12Fr)
- Laryngoscopes with neonatal blades (size 00, 0, 1) plus spare bulbs and batteries. Ensure end light is bright
- Endotracheal tubes (sizes 2.5, 3,3.5, and 4mm internal diameter). Important characteristics of the tube include:
    - uniform diameter, without a shoulder
    - no eye
    - uncuffed
    - standard curve
    - clear or translucent
    - radio-opaque
    - centimetre markings along the length to indicate depth of insertion
- Endotracheal stylet or introducer (optional for oral intubation, not used for nasal intubation)
- Supplies for securing endotracheal tubes (e.g., scissors, tape)
- Neonatal stethoscope
- Exhaled $CO_2$ detector
- Magill neonatal forceps (optional)

## 1.4 Ventilation technique

Considerations are similar to those for ventilation via a facemask (Refer to ANZCOR Guideline 13.4).

## 1.5 Verification of endotracheal tube position

The effectiveness of ventilation via an endotracheal tube is confirmed by three observations, which tend to occur in the following sequence;

1. chest moves with each inflation
2. increase in the heart rate to above 100 beats per min
3. oxygen saturations improve.

If the chest does not move and the heart rate does not increase, the location of the endotracheal tube and technique of ventilation need to be re-evaluated.

### Other signs to verify correct endotracheal tube position

- By visual inspection of the endotracheal tube passing through the larynx.
- Mist may condense on the inside of the endotracheal tube during exhalation.

- Colour change in a colorimetric end-tidal $CO_2$ detector. A $CO_2$ detector, attached to the endotracheal tube adaptor, is recommended as the most reliable method to confirm endotracheal tube placement in neonates who have spontaneous circulation. [6] [Good practice statement, NHMRC LOE IV 2015] However, false negative readings may occur in infants if there is very low or absent pulmonary blood flow [6] so if the chest wall is moving well in a very depressed infant, some caution is needed to avoid unnecessary extubation and reintubation. [Good practice statement, NHMRC LOE IV 2015] False positives may occur with colorimetric devices contaminated with adrenaline (epinephrine) or surfactant. [7]
- Symmetrical air entry over lung fields (upper chest) auscultated with a stethoscope.

### Signs that the endotracheal tube is not in the trachea

- No chest movement with inflations.
- A heart rate <100 beats per minute that does not increase soon after intubation and inflation is started.
- No expired $CO_2$ detected.
- No improvement in oxygenation.
- The absence of breath sounds in the axillae.

The lack of symmetrical chest movement with adequate inflating pressure may indicate that the endotracheal tube is too far down. The depth of insertion should be checked.

Devices to monitor gas flow and volume have been shown to improve mask ventilation technique in simulation training and there is limited evidence of feasibility in clinical settings. However to date, there is insufficient evidence of clinical benefit, so ANZCOR suggests against the routine use of flow and volume monitoring or end tidal $CO_2$ monitoring during newborn resuscitation. [2] [CoSTR 2015, Weak recommendation, low certainty of evidence.]

# 2 Supraglottic Airways

ANZCOR suggests that a supraglottic airway should be considered during resuscitation of the term and near term newborn (>34 weeks, approximately 2000 grams) if facemask ventilation is unsuccessful. [2] [CoSTR 2015, weak recommendation, low certainty of evidence]

In particular, it should be considered as an alternative to tracheal intubation if facemask ventilation is unsuccessful and tracheal intubation is unsuccessful or not feasible. [2] [Good Practice Statement] The supraglottic airway may be considered as a primary alternative to a facemask for positive pressure ventilation among newborns weighing more than 2000 grams or delivered ≥34 weeks' gestation, although there is insufficient evidence to support its routine use in this setting. [2] A size 1 supraglottic airway is suitable for newborns up to 5 kg.

Effectiveness of ventilation should be checked using signs indicated above for endotracheal ventilation (chest wall movement, improvement in heart rate, improvement in oxygenation). In addition, the chest should be auscultated. For newborns receiving ventilation via a supraglottic airway the accuracy of colorimetric $CO_2$ detectors to confirm position and seal has not been reported. The supraglottic airway has not been evaluated during chest compressions.

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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. [1, 2] |
| **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. |
| **Principal reviewers:** | Helen Liley, Lindsay Mildenhall, Marta Thio and Callum Gately |
| **Main changes:** | Updating of review evidence, references, and terminology to increase consistency with GRADE terminology. |
| **Approved:** | April 2021 |

# ANZCOR Guideline 13.6 – Chest Compressions during Resuscitation of the Newborn

## Summary

ANZCOR Guidelines 13.1to 13.10 and the Newborn Life Support algorithm are provided to assist in the resuscitation of newborn infants. Differences from the adult and paediatric guidelines reflect differences in the anatomy and physiology and the causes of cardiorespiratory arrest for newborns, older infants, children and adults. These guidelines draw from Neonatal Life Support 2020 and 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations (CoSTR) [1, 2] the development of which included representation from ANZCOR. The 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Care [3] and local practices have also been taken into account.

### To whom do these guidelines apply?

The term 'newborn' or 'newborn infant' refers to the infant in the first minutes to hours following birth. In contrast, the neonatal period is defined as the first 28 days of life. Infancy includes the neonatal period and extends through the first 12 months of life.

ANZCOR Guidelines 13.1 to 13.10 and the Newborn Life Support algorithm are mainly for the care of newborns. The exact age at which paediatric techniques and in particular, compression-ventilation ratios, should replace the techniques recommended for newborns is unknown, especially in the case of very small preterm infants. For term infants beyond the first minutes to hours following birth, and particularly in those with known or suspected cardiac aetiology of their arrest, paediatric techniques may be used. (Refer to Paediatric Advanced Life Support ANZCOR Guidelines 12.1 to 12.7).

### Who is the audience for these guidelines?

ANZCOR Guidelines 13.1 to 13.10 and the Newborn Life Support algorithm are for health professionals and those who provide healthcare in environments where equipment and drugs are available (such as a hospital). When parents are taught CPR for their infants who are being discharged from birth hospitals, the information in Basic Life Support Guidelines (ANZCOR Guidelines 2 to 8) is appropriate.

## Recommendations

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

1. Because ventilation is the most effective action in newborn resuscitation and because chest compressions are likely to compete with the performance and assessment of effective ventilation, resuscitators should ensure that assisted ventilation is being delivered optimally before starting chest compressions. [Good Practice Statement]
2. Once compressions are started, they should be continued with as little interruption as possible until there is clear evidence of improvement in spontaneous heart rate. [Good Practice Statement]
3. As soon as a decision has been made to perform chest compressions, preparation should commence to establish vascular access and administer intravenous adrenaline (epinephrine). [Good Practice Statement]
4. Chest compressions should be centred over the lower third of the sternum (above the xiphisternum and just below the nipples) and should compress the chest one third of the chest anterior-posterior diameter. [Good practice statement, extrapolated evidence]
5. ANZCOR suggests a technique using two thumbs on the lower third of the sternum, superimposed or adjacent to each other according to the size of the infant, with the fingers surrounding the thorax to support the back. [CoSTR 2015 and 2020, Weak recommendation, very low certainty of evidence]
6. ANZCOR suggests the two-thumb technique over the two-finger technique because it achieves superior peak systolic and coronary perfusion pressure, provides compressions more consistently over long periods of time, and it is easier and less tiring for the resuscitator. [CoSTR 2015, Weak recommendation, very low certainty of evidence] The only circumstance in which the two-finger technique should be considered is when only a single resuscitator is available. [Good Practice Statement]
7. ANZCOR suggests that inflations and chest compressions should be performed with a 3:1 ratio of 90 compressions per minute and a half second pause after each 3rd compression to deliver an inflation. [CoSTR 2015, weak recommendation, very low certainty of evidence] Compressions and inflations should be coordinated to avoid simultaneous delivery of a compression and a breath. (Good practice statement, extrapolated evidence] Continuous chest compressions at 120 compressions per minute without interruptions for breaths can be considered in the intubated newborn. [Good Practice Statement]
8. The chest should fully expand between compressions, but the rescuer's hands should not leave the chest. [Good Practice Statement]
9. As soon as chest compressions are commenced, it is usual practice to increase inspired oxygen to 100% if a lower concentration has previously been used. ANZCOR suggests that if 100% oxygen is used then it should be weaned as soon as possible after the heart rate has recovered. [CoSTR 2015 and 2020, Weak recommendation, very low certainty of evidence]
10. Once chest compressions have been commenced, they should be performed with as little interruption as possible. Do not stop unless assessment is needed to make treatment

decisions. Signs of improvement in spontaneous cardiac output may include improvement in spontaneous heart rate, a rise in oxygen saturation, and commencement of some spontaneous movement or breaths. Chest compressions should continue until it is obvious that the heart rate is >60 beats per minute. [Good Practice Statements]

## Abbreviations

| Abbreviation | Meaning/Phrase |
|---|---|
| ANZCOR | Australian and New Zealand Committee on Resuscitation |
| CI | Confidence interval (95%) |
| CoSTR | International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations |
| CPR | Cardiopulmonary resuscitation |

The normal newborn has a heart rate above 100 beats per min once breathing has been established, usually within two minutes of birth..[4] The normal range of heart rate thereafter is 110 to 160 beats per minute..[4] In newborns cardiac output is rate dependent. If the heart rate is too slow the circulation will be inadequate to support tissue oxygenation.

# 1 Indications for starting chest compressions

Chest compressions are indicated when the heart rate is <60 beats per minute despite adequate assisted ventilation provided for 30 seconds (chest wall obviously moving with each inflation).

Because ventilation is the most effective action in newborn resuscitation and because chest compressions are likely to compete with the performance and assessment of effective ventilation, resuscitators should ensure that assisted ventilation is being delivered optimally before starting chest compressions. [1] [Good Practice Statement]

Once compressions are started, they should be continued with as little interruption as possible until there is clear evidence of improvement in spontaneous heart rate. [Good Practice Statement]

As soon as a decision has been made to perform chest compressions, preparation should commence to establish vascular access and administer intravenous adrenaline (epinephrine). [Good Practice Statement] Refer to ANZCOR Guideline 13.7.

# 2 Chest compression technique

Chest compressions should be centred over the lower third of the sternum (above the xiphisternum and just below the nipples)[2, 5] and should compress the chest one third of the chest anterior-posterior diameter. [5, 6] [Good practice statement, extrapolated evidence]

ANZCOR suggests a technique using two thumbs on the lower third of the sternum, superimposed or adjacent to each other according to the size of the infant, with the fingers surrounding the thorax to support the back. [1, 2] [CoSTR 2015 and 2020, Weak recommendation, very low certainty of evidence]

Usually, the resuscitator faces the newborn's head (figure 1), but in special circumstances, such as when access is needed to the newborn's abdomen, this position can be reversed (figure 2). [2]

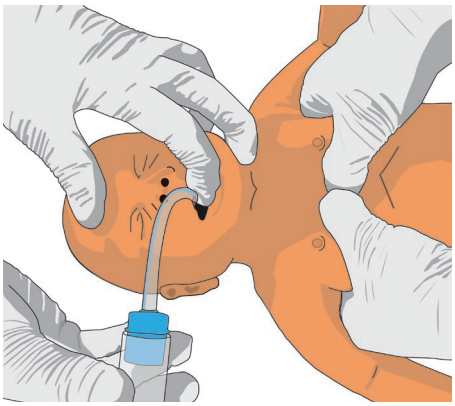

Figure 1.

Figure 2.

ANZCOR suggests the two-thumb technique over the two-finger technique because it achieves superior peak systolic and coronary perfusion pressure, provides compressions more consistently over long periods of time, and it is easier and less tiring for the resuscitator. [2] [CoSTR 2015, Weak recommendation, very low certainty of evidence] The only circumstance in which the two-finger technique should be considered is when only a single resuscitator is available. [Good Practice Statement]

ANZCOR suggests that inflations and chest compressions should be performed with a 3:1 ratio of 90 compressions per minute and a half second pause after each 3rd compression to deliver an inflation. [2] [CoSTR 2015, Weak recommendation, very low certainty of evidence] Compressions and inflations should be coordinated to avoid simultaneous delivery of a compression and a breath. [2] [extrapolated evidence] There is no compelling evidence suggesting a benefit to other ratios for the newborn. Since asphyxia is the predominant cause of cardiovascular collapse in the newborn, effective resuscitation requires significant focus on ventilation. [2] Continuous chest compressions at 120 compressions per minute without interruptions for breaths can be considered in the intubated newborn. [Good Practice Statement]

The chest should fully expand between compressions, [7] but the rescuer's hands should not leave the chest. [2] [Good Practice Statement]

# 3 Oxygen During Chest Compressions

Effectively delivered chest compressions will result in pulsations evident on an oximeter. As soon as chest compressions are commenced, it is usual practice to increase inspired oxygen to 100% if a lower concentration has previously been used. By the time chest compressions are deemed to be needed, then the steps of trying to achieve return of spontaneous circulation with lower oxygen concentrations should already have been attempted and would have failed to increase the heart rate. Thus, it seems prudent to try increasing the supplementary oxygen concentration. However, animal studies show no advantage of 100% oxygen over air in terms of return of spontaneous circulation in these circumstances and there are no human studies. ANZCOR suggests that if 100% oxygen is used then it should be weaned as soon as possible after the heart rate has recovered. [1, 2] [CoSTR 2015 and 2020, weak recommendation, very low certainty of evidence]

# References


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# About this Guideline

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|---|---|
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AUSTRALIAN RESUSCITATION COUNCIL

NEW ZEALAND Resuscitation Council WHAKAHAUORA AOTEAROA

# ANZCOR Guideline 13.7 – Medication or Fluids for the Resuscitation of the Newborn

## Summary

Guidelines 13.1-13.10 and the Newborn Life Support algorithm are provided to assist in the resuscitation of newborn infants. Differences from the adult and paediatric guidelines reflect differences in the anatomy and physiology and the causes of cardiorespiratory arrest for newborns, older infants, children and adults. These guidelines draw from Neonatal Life Support 2020 and 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations (CoSTR) [1, 2] the development of which included representation from ANZCOR. The 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Care [3] and local practices have also been taken into account.

### To whom do these guidelines apply?

The term 'newborn' or 'newborn infant' refers to the infant in the first minutes to hours following birth. In contrast, the neonatal period is defined as the first 28 days of life. Infancy includes the neonatal period and extends through the first 12 months of life.

ANZCOR Guidelines 13.1 to 13.10 and the Newborn Life Support algorithm are mainly for the care of newborns. The exact age at which paediatric techniques and in particular, compression-ventilation ratios, should replace the techniques recommended for newborns is unknown, especially in the case of very small preterm infants. For term infants beyond the first minutes to hours following birth, and particularly in those with known or suspected cardiac aetiology of their arrest, paediatric techniques may be used (refer to Paediatric Advanced Life Support Guidelines 12.1 to 12.7).

### Who is the audience for these guidelines?

ANZCOR Guidelines 13.1 to 13.10 and the Newborn Life Support algorithm are for health professionals and those who provide healthcare in environments where equipment and drugs are available (such as a hospital). When parents are taught CPR for their infants who are being discharged from birth hospitals, the information in Basic Life Support Guidelines (ANZCOR Guidelines 2 to 8) is appropriate.

## Recommendations

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

1. Ventilation and chest compressions must be delivered continuously during preparation to administer IV medication or fluids. [Good Practice Statement]
2. An umbilical vein catheter (UVC) is the suggested intravascular route for adrenaline (epinephrine) and it can also be used for fluid administration. [CoSTR 2020, weak recommendation, very low certainty evidence] It can also be used for continued vascular access until an alternative route is established after admission to a neonatal unit. [Good Practice Statement]
3. ANZCOR suggests that if the heart rate has not increased to 60 beats per minute or greater after optimising ventilation and chest compressions, then intravascular adrenaline (epinephrine) should be given as soon as possible. [CoSTR 2020, weak recommendation, very low certainty evidence]
4. ANZCOR suggest that the recommended intravenous dose is 10 to 30 microgram/kg (0.1 to 0.3 mL/kg of a 1:10,000 solution) by a quick push [Weak recommendation, very low certainty of evidence] (1 mL contains 0.1mg of adrenaline (epinephrine), so 0.1 mL = 10 microgram of adrenaline (epinephrine)). It should be followed by a small 0.9% sodium chloride flush. ANZCOR suggests that this dose can be repeated every 3 to 5 minutes if the heart rate remains <60 beats per minute despite effective ventilation and cardiac compressions. [1, 4] [CoSTR 2020, weak recommendation, very low certainty of evidence]
5. If vascular access is not yet available, ANZCOR suggests administering endotracheal adrenaline (epinephrine). [CoSTR 2020, weak recommendation, very low certainty evidence] If the endotracheal dose fails to increase heart rate to > 60 beats per min then an intravascular dose should be given as soon as feasible, and administration of endotracheal adrenaline (epinephrine) should not delay attempts to establish vascular access. [Good Practice Statement]
6. ANZCOR suggests that intraosseous lines can be used as an alternative, especially if umbilical or direct venous access is not available. The choice of route may depend on local availability of equipment, training and experience. [CoSTR 2020, weak recommendation, very low certainty of evidence]
7. There is insufficient evidence for the use of endotracheal adrenaline (epinephrine), but it is likely that a higher dose will be required to achieve similar blood levels and effect. ANZCOR suggests that if the tracheal route is used, doses of 50-100 microgram /kg (0.5-1 mL/kg of a 1:10,000 solution) should be given. [CoSTR 2020, weak recommendation, very low certainty of evidence]
8. Intravascular fluids should be considered when there is suspected blood loss, the newborn appears to be in shock (pale, poor perfusion, weak pulse) and has not responded adequately to other resuscitative measures. [1] [Good Practice Statement] Isotonic crystalloid (e.g. 0.9% sodium chloride or Hartmann's solution) should be used in the first instance, but may need to be followed with red cells and other blood products suitable for emergency

transfusion, in the setting of critical blood loss. Use of a specific protocol is suggested whenever critical blood loss is suspected. [Good Practice Statements]

9. Since blood loss may be occult, in the absence of history of blood loss, a trial of volume administration may be considered in newborns who are not responding to resuscitation. [Good Practice Statement]
10. The initial dose of intravascular volume expanding fluid is 10 mL/kg given by IV push (over several minutes). This dose may be repeated after observation of the response. [Good Practice Statements]

## Abbreviations

| Abbreviation | Meaning/Phrase |
|---|---|
| ANZCOR | Australian and New Zealand Committee on Resuscitation |
| CI | Confidence interval (95%) |
| CoSTR | International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations |
| CPR | Cardiopulmonary resuscitation |
| IO | Intraosseous |
| IV | Intravenous |
| UVC | Umbilical venous catheter |

Medications and fluids are rarely indicated for resuscitation of newborn infants. [1, 2, 5]

Bradycardia is usually caused by hypoxia and inadequate ventilation. Apnoea is due to insufficient oxygenation of the brainstem. Therefore, establishing adequate ventilation is the most important step to improve the heart rate. However, if the heart rate remains less than 60 beats per min despite adequate ventilation (chest is seen to move with inflations) and chest compressions, adrenaline (epinephrine) may be needed. As adrenaline (epinephrine) exerts part of its effect by action on the heart it is important to give it as close to the heart as possible, ideally as a rapid bolus through an umbilical venous catheter.

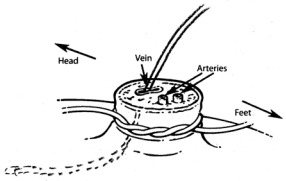
**Ventilation and chest compressions must be delivered continuously during preparation to administer IV medication or fluids.** [Good Practice Statement]

# 1. Routes of Administration

## 1.1. Umbilical vein

An umbilical vein catheter (UVC) is the suggested intravascular route for adrenaline (epinephrine) and it can also be used for fluid administration. It can also be used for continued vascular access until an alternative route is established after admission to a neonatal unit. [Good Practice Statement] Blood gases obtained from the UVC during resuscitation are sometimes useful in guiding treatment decisions.

UVC, 3-way stopcock & syringe prepared for use




Umbilical venous catheter in situ

## 1.2. Endotracheal tube

Vascular access for adrenaline (epinephrine) is a high priority in any newborn receiving chest compressions. There is little research to support the use of endotracheal adrenaline (epinephrine) and there are concerns that even in higher doses, it may still result in lower levels of adrenaline (epinephrine) and have lower efficacy than the intravenous route.[6] If vascular access is not yet available, ANZCOR suggests administering endotracheal adrenaline (epinephrine). [1] [CoSTR 2020 Weak recommendation, very low certainty evidence.] If the endotracheal dose fails to increase heart rate to > 60 beats per min then an intravascular dose should be given as soon as feasible, and administration of endotracheal adrenaline (epinephrine) should not delay attempts to establish vascular access. [Good Practice Statement]

### 1.3. Peripheral vein

Inserting a peripheral venous cannula can be very difficult in a shocked newborn and can take too long.

### 1.4. Intraosseous lines

Intraosseous (IO) lines are not commonly used in newborns because of the more readily accessible umbilical vein, the fragility of small bones and the small intraosseous space, particularly in a preterm infant. However, ANZCOR suggests this route can be used as an alternative, especially if umbilical or direct venous access is not available. [1, 7] [CoSTR 2020, Weak recommendation, very low certainty of evidence]

Outside of a hospital birthing suite setting, we suggest that either venous or IO routes may be used to administer fluids and medications during newborn resuscitation. ANZCOR suggests the choice of route may depend on local availability of equipment, training and experience. [1, 7] [CoSTR 2020, Weak recommendation, very low certainty of evidence]

There are a number of case reports of serious adverse effects of IO access in newborns, including tibial fractures and extravasation of fluids or medications resulting in compartment syndrome and amputation. In contrast, the rate of adverse effects attributable to emergency umbilical venous access is unknown. [1, 7]

### 1.5 Umbilical artery

The umbilical artery is not recommended for administration of resuscitation drugs. There are serious concerns that complications may result if hypertonic or vasoactive drugs (e.g., adrenaline (epinephrine)) are given into an artery.

## 2. Types and Doses of Medications

### 2.1. Adrenaline (epinephrine)

#### Indications

ANZCOR suggest that if the heart rate has not increased to 60 beats per minute or greater after optimising ventilation and chest compressions, then intravascular adrenaline (epinephrine) should be given as soon as possible. [1] [CoSTR 2020, weak recommendation, very low certainty evidence]

Animal research indicates that chest compressions without adrenaline (epinephrine) are insufficient to increase cerebral blood flow.[8] There is the potential for long delays (up to several minutes) in establishing intravascular access and administering adrenaline (epinephrine). Nevertheless, an animal study suggests plasma concentrations are higher and are achieved sooner after administration, and there are higher rates of return of spontaneous circulation when the intravascular route is used, (despite lower intravascular than endotracheal doses). [6] We have put lower value on the absence of human newborn studies that clearly demonstrate benefit of adrenaline (epinephrine) administration, or that demonstrate advantage of intravascular vs. endotracheal epinephrine. [4]

### Dosage

The suggested intravenous dose is 10 to 30 microgram/kg (0.1 to 0.3 mL/kg of a 1:10,000 solution) by a quick push [weak recommendation, very low certainty of evidence] (1 mL contains 0.1mg of adrenaline (epinephrine), so 0.1 mL = 10 microgram of adrenaline (epinephrine)). It should be followed by a small 0.9% sodium chloride flush. ANZCOR suggests that this dose can be repeated every 3 to 5 minutes if the heart rate remains <60 beats per minute despite effective ventilation and cardiac compressions. [1, 4] [CoSTR 2020, Weak recommendation, very low certainty of evidence]

The studies in newborns are inadequate to recommend routine use of higher doses of adrenaline (epinephrine). Based on studies in children and young animals, higher doses may increase risk of post-resuscitation mortality and risk of intracranial haemorrhage and are not recommended. [4, 9-11]

There is insufficient evidence for the use of endotracheal adrenaline (epinephrine), but it is likely that a higher dose will be required to achieve similar blood levels and effect. ANZCOR suggests that if the tracheal route is used, doses of 50-100 microgram/kg (0.5-1 mL/kg of a 1:10,000 solution) should be given. [1, 4, 12, 13] [CoSTR 2020, Weak recommendation, very low certainty of evidence]

## 2.2 Volume Expanding Fluids

### Indications

Intravascular fluids should be considered when there is suspected blood loss, the newborn appears to be in shock (pale, poor perfusion, weak pulse) and has not responded adequately to other resuscitative measures. [1] [Good Practice Statement] Isotonic crystalloid (e.g. 0.9% sodium chloride or Hartmann's solution) should be used in the first instance, but may need to be followed with red cells and other blood products suitable for emergency transfusion, in the setting of critical blood loss. Use of a specific protocol is suggested whenever critical blood loss is suspected. [14] [Good Practice Statements]

Since blood loss may be occult, in the absence of history of blood loss, a trial of volume administration may be considered in newborns who are not responding to resuscitation. [1] [Good Practice Statement] However, in the absence of history of blood loss, there is limited evidence of benefit from administration of volume during resuscitation unresponsive to chest compressions and adrenaline (epinephrine) [15] [LOE IV], and some suggestion of harm from animal studies [16, 17] [Extrapolated evidence]

### Dosage

The initial dose is 10 mL/kg given by IV push (over several minutes). This dose may be repeated after observation of the response. [1] [Good Practice Statements]

# References

1. Wyckoff MH, Wyllie J, Aziz K, de Almeida MF, Fabres JW, Fawke J, et al. Neonatal Life Support 2020 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. Resuscitation. 2020;156:A156-A87.

2. Wyllie J, Perlman JM, Kattwinkel J, Wyckoff MH, Aziz K, Guinsburg R, et al. Part 7: Neonatal resuscitation: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. Resuscitation. 2015;95:e169-201.

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## About this Guideline

| | |
|---|---|
| **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. [1, 2] |
| **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. |
| **Principal reviewers:** | Helen Liley, Lindsay Mildenhall, Marta Thio and Callum Gately |
| **Main changes** | Updated statements about use of intraosseous lines and use of adrenaline (epinephrine). Updating of review evidence, references, and terminology to increase consistency with GRADE terminology. |
| **Approved:** | April 2021 |

# ANZCOR Guideline 13.8 – The Resuscitation of the Newborn in Special Circumstances

## Summary

Guidelines 13.1-13.10 and the Newborn Life Support algorithm are provided to assist in the resuscitation of newborn infants. Differences from the adult and paediatric guidelines reflect differences in the anatomy and physiology and the causes of cardiorespiratory arrest for newborns, older infants, children and adults. These guidelines draw from Neonatal Life Support 2020 and 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations (CoSTR) [1, 2] the development of which included representation from ANZCOR. The 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Care [3] and local practices have also been taken into account.

### To whom do these guidelines apply?

The term 'newborn' or 'newborn infant' refers to the infant in the first minutes to hours following birth. In contrast, the neonatal period is defined as the first 28 days of life. Infancy includes the neonatal period and extends through the first 12 months of life.

ANZCOR Guidelines 13.1 to 13.10 and the Newborn Life Support algorithm are mainly for the care of newborns. The exact age at which paediatric techniques and in particular, compression-ventilation ratios, should replace the techniques recommended for newborns is unknown, especially in the case of very small preterm infants. For term infants beyond the first minutes to hours following birth, and particularly in those with known or suspected cardiac aetiology of their arrest, paediatric techniques may be used (refer to Paediatric Advanced Life Support Guidelines 12.1 to 12.7).

### Who is the audience for these guidelines?

ANZCOR Guidelines 13.1 to 13.10 and the Newborn Life Support algorithm are for health professionals and those who provide healthcare in environments where equipment and drugs are available (such as a hospital). When parents are taught CPR for their infants who are being discharged from birth hospitals, the information in Basic Life Support Guidelines (ANZCOR Guidelines 2 to 8) is appropriate.

## Recommendations

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

1. For all newborns who are at high risk of needing resuscitation or subsequent neonatal intensive care, leaving at least a 3-4 cm length of umbilical cord below the cord clamp is helpful in case umbilical access is needed. [Good Practice Statement]

2. ANZCOR suggests that to maintain normothermia (body temperature between 36.5 and 37.5°C) for very preterm newborns, use a radiant warmer and place the newborn immediately after birth immediately after birth (without drying) in a polyethylene bag or under a polyethylene sheet (appropriate size, food or medical grade, heat resistant), up to the neck. [CoSTR 2015, weak recommendation, very low certainty evidence] The bag or sheet should not be removed during resuscitation and it should be kept in place until temperature has been checked and other measures (e.g., pre-warmed, humidified incubator) are ready to ensure that heat loss does not ensue. [Good Practice Statement]

3. ANZCOR suggests that additional measures that may be needed either alone or in combination include; establishing an ambient temperature of at least 26°C, exothermic warming mattresses, warmed humidified resuscitation gases, covering the head (except the face) with a hat or folded bedding. [CoSTR 2015, weak recommendation, very low certainty evidence]

4. Hyperthermia (defined in newborns as body temperature >37.5°C) should also be avoided. To prevent burns, care should be taken with external heat sources. [Good Practice Statements]

5. Gentle handling is essential for all newborns, but especially preterm infants, who are at greater risk of damage, both to skin and to internal organs. If vascular access is required, antiseptic solutions should be applied sparingly, particularly those containing alcohols, detergent excipients or chlorhexidine, which can cause serious damage to immature skin. For umbilical catheterisation, apply antiseptic solution to the cord and avoid the skin, using a sterile drape to cover other areas. Avoid letting excess solution pool around the newborn's groin and flanks. Adherence to good infection control procedures is essential. [Good Practice Statements]

6. For spontaneously breathing preterm newborns < 32 weeks' gestation who have signs of respiratory distress in the delivery room and require respiratory support, ANZCOR suggests commencing CPAP in the first minutes after birth rather than intubation and ventilation. [CoSTR 2015, weak recommendation, moderate certainty of evidence] A CPAP pressure of at least 5 cm $H_2O$ should be used. [Good Practice Statement]

7. ANZCOR suggests against routine use of an initial sustained inflation (> 5 seconds) in preterm infants but sustained inflations may be considered in individual clinical circumstances or in research settings. [CoSTR 2020, weak recommendation, low certainty of evidence]

8. For newborns who do not commence spontaneous breathing within the first minute after birth positive pressure ventilation is required. For those needing assisted ventilation, the

optimal ventilation strategy is not known, but both animal and human studies suggest the benefits of PEEP (at least 5 cm $H_2O$) and avoidance of high tidal volumes, particularly in preterm infants. Administration of endotracheal surfactant should be considered very early during the stabilisation of preterm infants who have needed intubation for resuscitation. [Good practice statement, NHMRC LOE I]

9. For preterm infants <35 weeks' gestation ANZCOR suggests commencing resuscitation either using room air or blended air and oxygen up to an oxygen concentration of 30% rather than higher initial oxygen concentration (60%–100%). [CoSTR 2019, weak recommendation, very low certainty of evidence]

10. For preterm infants <35 weeks' gestation ANZCOR suggests supplemental oxygen should be given judiciously, ideally guided by pulse oximetry. [CoSTR 2019 and 2020, weak recommendation, very low certainty of evidence] Both hyperoxaemia and hypoxaemia should be avoided. If a blend of oxygen and air is not available, resuscitation should be initiated with air. [Good Practice Statements]

11. In newborns with suspected choanal atresia or other upper airway obstruction, an oral airway may provide adequate relief from obstruction. For a newborn with a small mandible, prone positioning and/or placement of an endotracheal tube via the nostril into the pharynx, as a mechanical stent to prevent the tongue obstructing the airway, may improve the airway. Newborns with compromising craniofacial malformations may require a supraglottic mask airway or tracheal intubation. This can be difficult, and expert assistance may be required. [Good Practice Statements]

12. Newborns with congenital diaphragmatic hernia (CDH) who need respiratory support should not receive bag and mask ventilation. Where respiratory support is needed, early intubation or use of a laryngeal mask is recommended to minimise air entry into the gastrointestinal tract. A wide bore orogastric tube should be placed for intermittent suction. Ventilation should be gentle with low tidal volumes. [Good Practice Statements]

13. Newborns with suspected life-limiting anomalies (unless there has been prior discussion and the development of an alternative care plan with the parents) should usually receive a complete and thorough resuscitation. They are often best evaluated in the neonatal unit after resuscitation when more information will be available, and the parents can be part of management discussions. [Good Practice Statement]

14. If the clinical history suggests lung hypoplasia (which can predispose to pneumothorax) is likely, preparation (before birth) of equipment for bedside diagnosis and emergency treatment of pneumothorax may be advisable. [Good Practice Statement]

15. In the setting of congenital pleural effusions or ascites (including fetal hydrops), emergency thoracentesis or paracentesis is sometimes required. [Good Practice Statement]

16. Congenital pneumonia may result in poor lung compliance, necessitating high ventilation pressures to aerate the lungs. [Good Practice Statement]

17. For newborns with duct-dependent congenital heart defects that have been diagnosed antenatally, target saturation ranges (during resuscitation and thereafter) should be discussed with a cardiologist. Otherwise, the priorities for resuscitation are similar to those of other newborns. [Good Practice Statements]

18. For newborns with chronic heart block, heart rate thresholds for initiating ventilation and chest compressions will usually be lower than in other newborns. Tone, respiratory effort and oxygenation should be assessed as well to determine whether resuscitation manoeuvres are needed. [Good Practice Statements]

19. Where a clinically significant arrythmia has been detected or suspected antenatally, the availability of ECG monitoring may be particularly useful in assessing heart rate. [Good Practice Statement]

20. Early NICU admission and echocardiographic evaluation in cases of suspected or antenatally diagnosed congenital heart disease is essential. [Good Practice Statement]

21. Infants born with gastroschisis or a large omphalocoele a polyethylene wrap (e.g., food wrap) or bag (e.g., a surgical "bowel bag" used to protect bowel during abdominal surgery) can be used to enclose the abdomen or the whole lower body in order to reduce drying, heat loss or contamination. Care should be taken to enclose the bowel lightly and position it so that blood flow is optimised. Caring for the newborn in a right side down, side-lying position can be helpful. A large bore orogastric tube (e.g., 8 to 10 FG) should be inserted to (repeatedly) remove swallowed air. If respiratory support is needed, CPAP or positive pressure ventilation via a facemask or nasal prongs should be avoided and a low threshold for endotracheal intubation is suggested in preference to a facemask or nasal prongs. A supraglottic airway, which promotes tracheal ventilation and oesophageal occlusion may be preferable to a facemask if respiratory support is needed and endotracheal intubation is not possible. [Good Practice Statements]

22. In the case of multiple births, there should always be at least one appropriately skilled resuscitator for each newborn. [Good Practice Statement]

23. In the case of suspected fetal blood loss for which intravenous volume expansion is required, isotonic crystalloid (0.9% sodium chloride or Hartmann's) should be used in the first instance but may need to be followed with blood products suitable for neonatal transfusion. Consider the need to activate a critical bleeding protocol that addresses both restoration of oxygen carrying capacity and the likely accompanying coagulopathy. [Good Practice Statement]

24. Cord blood gases should be measured in every resuscitated newborn as the most objective way to assess the condition just before birth. [Good Practice Statement]

## Abbreviations

| Abbreviation | Meaning/Phrase |
|---|---|
| ANZCOR | Australian and New Zealand Committee on Resuscitation |
| CDH | Congenital diaphragmatic hernia |
| CoSTR | International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations |
| CPAP | Continuous positive airway pressure |
| CPR | Cardiopulmonary resuscitation |
| FG | French gauge |
| INSURE | Intubation-surfactant-extubation procedure |
| LOE | Level of evidence |
| NHMRC | National Health and Medical Research Council |
| PEEP | Positive end expiratory pressure |
| RCT | Randomised controlled trial |
| UVC | Umbilical venous catheter |

# Guideline

# 1 Prematurity

## 1.1 Temperature management

Very preterm newborns are at particular risk of cold stress (defined as body temperature 36.0°C to 36.4°C) and hypothermia (body temperature <36.0°C). Hyperthermia (defined in newborns as body temperature >37.5°C) should also be avoided. [4] Close attention to maintaining their body temperature is essential. To prevent burns, care should be taken with external heat sources. [Good Practice Statements]

ANZCOR suggests that to maintain normothermia (body temperature between 36.5 and 37.5°C [4]) for very preterm newborns, use a radiant warmer and place the newborn immediately after birth (without drying) in a polyethylene bag or under a polyethylene sheet (appropriate size, food or medical grade, heat resistant), up to the neck. [2, 5-9] [CoSTR 2015, weak recommendation, very low certainty of evidence] The bag or sheet should not be removed during resuscitation and it should be kept in place until temperature has been checked and other measures (e.g., pre-warmed, humidified incubator) are ready to ensure that heat loss does not ensue. [Good Practice Statement]

ANZCOR suggests that additional measures that may be needed either alone or in combination [2] include;

- establishing an ambient temperature of at least 26°C
- exothermic warming mattresses
- warmed humidified resuscitation gases
- covering the head (except the face) with a hat or folded bedding.

[CoSTR 2015, weak recommendation, very low certainty evidence.]

## 1.2 Handling and skin protection

Gentle handling is essential for all newborns, but especially preterm infants, who are at greater risk of damage, both to skin and to internal organs. If vascular access is required, antiseptic solutions should be applied sparingly, particularly those containing alcohols, detergent excipients or chlorhexidine, which can cause serious damage to immature skin. [10, 11] For umbilical catheterisation, apply antiseptic solution to the cord and avoid the skin, using a sterile drape to cover other areas. Avoid letting excess solution pool around the newborn's groin and flanks. Adherence to good infection control procedures is essential. [Good Practice Statements]

## 1.3 Respiratory Support

Most very preterm newborns need some respiratory support immediately after birth, but some uncertainty remains as to the best strategy.

## Role of Continuous Positive Airway Pressure (CPAP)

For spontaneously breathing preterm newborns < 32 weeks' gestation who have signs of respiratory distress in the delivery room and require respiratory support, ANZCOR suggests commencing CPAP in the first minutes after birth rather than intubation and ventilation. [2] [CoSTR 2015, weak recommendation, moderate certainty of evidence] The evidence suggests reduction of the combined outcome of death and bronchopulmonary dysplasia but with no benefit to death, BPD, air leak, severe intraventricular haemorrhage, necrotising enterocolitis or severe retinopathy of prematurity. When making this suggestion it is noted that risk reduction of adverse outcomes is small and that preterm infants recruited into the trials had a high rate of antenatal steroids but value is placed on this less invasive approach. (CoSTR 2015, Values and Preferences statement)

A CPAP pressure of at least 5 cm $H_2O$ should be used. One randomised trial (at high of bias) of 617 preterm and term newborns suggests that nasal prongs may be preferable to a facemask to deliver early CPAP for the outcome of reduced need for intubation in the birth suite. [12] CPAP cannot be administered with a self-inflating bag.

During resuscitation immediately after birth, the role of an intubation-surfactant-extubation ("INSURE") approach, or other methods to administer artificial surfactant without endotracheal intubation in order to facilitate early stabilisation on CPAP soon after birth [13] compared to other strategies of respiratory support remains uncertain.[14, 15]

## Role of Initial Sustained Inflation Breaths

To establish initial lung inflation in apnoeic preterm newborns, initiation of intermittent positive pressure ventilation at birth can be accomplished with or without several initial prolonged inflation breaths. Various regimens have been suggested, from 5 breaths lasting 2 to3 seconds to one breath lasting 5 to10 seconds.

A systematic review [16] of 10 RCTs (1502 newborn preterm infants) [17-26] examining the use of sustained inflations found that in those who received positive pressure ventilation for bradycardia or ineffective respirations at birth, for death before discharge, there was no significant benefit or harm from initiating positive pressure ventilation greater than one second compared with initiating positive pressure ventilation with intermittent inflations of once second or less. No studies were identified that addressed later mortality or neurodevelopmental outcomes. Subgroups of the 10 RCTs allowed assessment of other short- and long-term outcomes and also found no benefit or harm.

However, of note, in a subgroup analysis for newborns <28 weeks' gestation providing evidence from 5 RCTs (862 newborns ), [26-30] for death before discharge there was evidence of potential harm from initiating positive pressure ventilation with sustained inflation(s) >1 second compared with initiating positive pressure ventilation with intermittent inflations lasting 1 second or less. [16]

ANZCOR suggests against routine use of an initial sustained inflation (> 5 seconds) in preterm infants but sustained inflations may be considered in individual clinical circumstances or in research settings. [1] [Weak recommendation, low certainty of evidence] Recent evidence has indicated that in some circumstances, lung inflation during sustained inflation may be impaired by glottis closure. [31-33]

### Positive Pressure Ventilation

For newborns who do not commence spontaneous breathing within the first minute after birth positive pressure ventilation is required. For those needing assisted ventilation, the optimal ventilation strategy is not known, but both animal [34] and human studies suggest the benefits of PEEP (at least 5 cm $H_2O$ [35, 36]) and avoidance of high tidal volumes, particularly in preterm infants. Administration of endotracheal surfactant should be considered very early during the stabilisation of preterm infants who have needed intubation for resuscitation. [37] [Good practice statement, NHMRC LOE I]

### Oxygen

Preterm infants are vulnerable to oxidative stress as a result of reduced antioxidant defences. [38] The causation of many common preterm morbidities, including bronchopulmonary dysplasia, retinopathy of prematurity and intraventricular haemorrhage can include oxygen toxicity. However, the optimal starting oxygen concentration and the most appropriate time-specific target saturations for preterm newborns remain to be determined. [39]

For preterm infants <35 weeks' gestation ANZCOR suggests commencing resuscitation either using room air or blended air and oxygen up to an oxygen concentration of 30% rather than higher initial oxygen concentration (60%–100%). [1, 39, 40] [CoSTR 2019 and 2020, weak recommendation, very low certainty of evidence] The range of 21 to 30% oxygen is suggested because it was used as the "low oxygen concentration" for all clinical trials. We place higher value on reducing oxygen burden on pre term newborns and the absence of benefit of oxygen concentration >60% in reducing mortality or other adverse outcomes, however there is a paucity of evidence for initial oxygen concentrations between 30% and 60%.[39] As for newborn infants ≥35w , ANZCOR suggests that supplemental oxygen should be given judiciously, ideally guided by pulse oximetry. [1, 39, 40] [CoSTR 2019 and 2020, weak recommendation, very low certainty of evidence] Both hyperoxaemia and hypoxaemia should be avoided. If a blend of oxygen and air is not available, resuscitation should be initiated with air.

# 2 Congenital Upper Airway Obstruction

A newborn who is pink when crying but cyanotic, with or without laboured breathing when quiet, should be evaluated for choanal atresia or other upper airway obstruction. An oral airway may provide adequate relief from obstruction. For a newborn with a small pharynx, such as occurs when there is a small mandible, prone positioning and/or placement of an endotracheal tube via the nostril into the pharynx, as a mechanical stent to prevent the tongue obstructing the airway, may improve the airway. Newborns with compromising craniofacial malformations may require a supraglottic mask airway or tracheal intubation. This can be difficult, and expert assistance may be required [Good Practice Statements]

# 3 Congenital Diaphragmatic Hernia

Newborns with congenital diaphragmatic hernia (CDH) who need respiratory support should not receive bag and mask ventilation. Where respiratory support is needed, early intubation or use of a supraglottic airway device is recommended to minimise air entry into the gastrointestinal tract. [Good Practice Statements] Breath sounds following tracheal intubation may be asymmetrical, depending on the location of the CDH (and the endotracheal tube). A wide bore orogastric tube

should be placed for intermittent suction to avoid air accumulation in intrathoracic small bowel and minimise lung compression caused by it. As many of these infants only have one functioning lung the ventilation needs to be gentle with low tidal volumes. [41] [Good Practice Statements]

# 4 Newborn with Unexpected Congenital Anomalies

Unless there has been prior discussion and the development of an alternative care plan with the parents, usually all newborns should receive a complete and thorough resuscitation.

Those infants with life-limiting congenital anomalies are often best evaluated in the neonatal unit after resuscitation when more information will be available, and the parents can be part of management discussions (refer to ANZCOR Guideline 13.10). [Good Practice Statement]

# 5 Pneumothorax

Pneumothorax is a rare cause of failure to respond to resuscitation immediately after birth. Chest recession/retraction, tachypnoea, unilaterally decreased breath sounds, bulging of the chest wall on one side, especially in the setting of deterioration after initial response to resuscitation, may indicate the presence of a pneumothorax. The diagnosis is best confirmed by chest radiograph, but emergency treatment may be required. Transillumination can be helpful in premature newborn, but in term newborn it may be falsely negative. If the clinical history suggests lung hypoplasia (which can predispose to pneumothorax) is likely, preparation (before birth) of equipment for bedside diagnosis and emergency treatment of pneumothorax may be advisable. [Good Practice Statement]

# 6 Pleural Effusions or Ascites (Including Fetal Hydrops)

Severe body wall oedema, pleural effusions and ascites at birth can cause lung hypoplasia and interfere with initial lung expansion. Ventilation can usually be established by using higher pressures, allowing thoracentesis to be done after radiographic and/or ultrasound examination, with cardiorespiratory monitoring and with control of ventilation. However, emergency thoracocentesis or paracentesis is sometimes required. [Good Practice Statement] If fluid is obtained, laboratory analysis is sometimes helpful in diagnosing the cause.

# 7 Pneumonia/Sepsis

Congenital pneumonia can result in very poor lung compliance, necessitating high ventilation pressures during resuscitation to aerate the lungs. [Good Practice Statement] It presents like severe respiratory distress syndrome.

# 8 Congenital Heart Disease

Newborns who remain cyanotic despite adequate ventilation, oxygenation and circulation may have cyanotic congenital heart disease or persistent pulmonary hypertension. For newborns with duct-dependent congenital heart defects that have been diagnosed antenatally, target saturation

ranges (during resuscitation and thereafter) should be discussed with a cardiologist. Otherwise, the priorities for resuscitation are similar to those of other newborns. [Good Practice Statements]

Very rarely, congenital heart block is the cause of persistent bradycardia. For newborns with chronic heart block, heart rate thresholds for initiating ventilation and chest compressions will usually be lower than in other newborns. Tone, respiratory effort and oxygenation should be assessed as well to determine whether resuscitation manoeuvres are needed. [Good Practice Statements]

Where a clinically significant arrythmia has been detected or suspected antenatally, the availability of ECG monitoring may be particularly useful in assessing heart rate. [Good Practice Statement]

Early NICU admission and echocardiographic evaluation in cases of suspected or antenatally diagnosed congenital heart disease is essential. [Good Practice Statement]

# 9 Abdominal Wall Defects

Infants born with gastroschisis or a large omphalocoele require special consideration to protect the exposed abdominal contents from trauma, drying, heat loss or contamination and to prevent expansion of the extra-abdominal bowel with air. A polyethylene wrap (e.g., food wrap) or bag (e.g., a surgical "bowel bag" used to protect bowel during abdominal surgery) can be used to enclose the abdomen or the whole lower body in order to reduce drying, heat loss or contamination. Care should be taken to enclose the bowel lightly and position it so that blood flow is optimised. Caring for the newborn in a right side down, side-lying position can be helpful. A large bore orogastric tube (e.g., 8 to 10 FG) should be inserted to (repeatedly) remove swallowed air. [Good Practice Statements]

If respiratory support is needed, CPAP or positive pressure ventilation via a facemask or nasal prongs should be avoided because they may increase intra-abdominal gas, which can imperil the blood supply to the exterior gut and can increase the difficulty in reducing the bowel into the abdomen later. If respiratory support is required, a low threshold for endotracheal intubation is suggested in preference to a facemask or nasal prongs. There is no literature and little experience in relation to use of a supraglottic airway in these circumstances, but because it promotes tracheal ventilation and oesophageal occlusion, it may be preferable to a facemask if respiratory support is needed and endotracheal intubation is not possible. [Good Practice Statements]

# 10 Multiple Births

Multiple births are more frequently associated with a need for resuscitation because of prematurity, abnormalities of placentation, compromise of cord blood flow, and/or mechanical complications during delivery. Monozygotic multiple fetuses may have discrepant blood volumes from twin-to-twin transfusion syndrome and rarely, one twin may need urgent transfusion, usually after initial resuscitation. There should always be at least one skilled resuscitator for each newborn. [Good Practice Statement]

# 11 Fetal Haemorrhage

Maternal vaginal bleeding before birth may be a sign of placental abruption, placenta praevia or vasa praevia as the source of the bleeding. Although most commonly, the majority of blood loss will be maternal, if even a small portion is fetal, the newborn may be hypovolaemic. Major transplacental haemorrhage into the mother's circulation (feto-maternal haemorrhage) can cause neonatal hypovolaemia or normovolaemic anaemia with no apparent antenatal bleeding.

Exsanguinated newborns are typically very pale even after a good heart rate has been restored. They may be difficult to resuscitate and intravenous fluid is often required before the newborn will respond fully to resuscitative measures. Refer to ANZCOR Guideline 13.7, that advises isotonic crystalloid (0.9% sodium chloride or Hartmann's) should be used in the first instance but may need to be followed with blood products suitable for neonatal transfusion. Some newborns have lost a large proportion of their blood volume and may require activation of a critical bleeding protocol that addresses both restoration of oxygen carrying capacity and the likely accompanying coagulopathy. [42] [Good Practice Statement]

# 12 Umbilical Artery Cord Blood Gases

Cord blood gases should be measured in every resuscitated newborn as the most objective way to assess the condition just before birth. [Good Practice Statement] They are also one of several important criteria for assessing whether there was sufficient depression at birth to initiate screening for hypoxic ischaemic encephalopathy and the possible initiation of therapeutic hypothermia after resuscitation. [43] Comparison of paired samples drawn from both vein and artery is advisable, because of the risk that the umbilical artery has not been correctly identified. Normal umbilical artery values are given in the following table.[44] The effect of deferred cord clamping procedures on these values is uncertain.[45-48]

| | **2.5$^{th}$ centile** | **Mean** | **97.5$^{th}$ centile** |
|---|---|---|---|
| **pH** | 7.1 | 7.27 | 7.38 |
| **Base excess** | -11 | -4 | 1 |
| **$pO_2$ (mm Hg [kPa])** | 6 [0.8] | 17 [2.3] | 30 [4] |
| **$pCO_2$ (mm Hg, kPa)** | 35 [4.7] | 52 [6.9] | 74 [9.8] |

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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. [1, 2] |
| **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. |
| **Principal reviewers:** | Helen Liley, Lindsay Mildenhall, Marta Thio and Callum Gately |
| **Main changes** | Changes in recommendations for sustained inflation breaths and initial concentration of oxygen. Additional good practice statements for infants with congenital heart disease. Updating of review evidence, references, and terminology to increase consistency with GRADE terminology. |
| **Approved:** | April 2021 |

# ANZCOR Guideline 13.9 – After the Resuscitation of a Newborn

## Summary

Guidelines 13.1-13.10 and the Newborn Life Support algorithm are provided to assist in the resuscitation of newborn infants. Differences from the adult and paediatric guidelines reflect differences in the anatomy and physiology and the causes of cardiorespiratory arrest for newborns, older infants, children and adults. These guidelines draw from Neonatal Life Support 2020 and 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations (CoSTR) [1, 2] the development of which included representation from ANZCOR. The 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Care [3] and local practices have also been taken into account.

### To whom do these guidelines apply?

The term 'newborn' or 'newborn infant' refers to the infant in the first minutes to hours following birth. In contrast, the neonatal period is defined as the first 28 days of life. Infancy includes the neonatal period and extends through the first 12 months of life.

ANZCOR Guidelines 13.1 to 13.10 and the Newborn Life Support algorithm are mainly for the care of newborns. The exact age at which paediatric techniques and in particular, compression-ventilation ratios, should replace the techniques recommended for newborns is unknown, especially in the case of very small preterm infants. For term infants beyond the first minutes to hours following birth, and particularly in those with known or suspected cardiac aetiology of their arrest, paediatric techniques may be used (refer to Paediatric Advanced Life Support Guidelines 12.1 to 12.7).

### Who is the audience for these guidelines?

ANZCOR Guidelines 13.1 to 13.10 and the Newborn Life Support algorithm are for health professionals and those who provide healthcare in environments where equipment and drugs are available (such as a hospital). When parents are taught CPR for their infants who are being discharged from birth hospitals, the information in Basic Life Support Guidelines (ANZCOR Guidelines 2 to 8) is appropriate.

## Recommendations

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

1. For clinical and medicolegal reasons, the observations, interventions and times during newborn resuscitation must be fully documented. [Good Practice Statement]

2. Apgar scores quantify and summarise the response of the newborn over the first few minutes of life. The Apgar score is assessed and recorded based on observations made at 1 and 5 minutes after birth and then sequentially every 5 minutes from birth until the heart rate and breathing are normal. Interventions for depressed newborns should not await Apgar scoring. [Good Practice Statements]

3. Once adequate ventilation and circulation have been established, the infant who has required resuscitation remains at risk and is likely to need ongoing assessment in an intensive or special care nursery where monitoring, appropriate evaluation and care can be provided. Fluid balance and nutrition should be monitored carefully for the first few days. [Good Practice Statements]

4. Maintaining normothermia (36.5 to 37.5°C) remains important after resuscitation. If a newborn develops hypothermia unintentionally during resuscitation, limited evidence suggests no disadvantage of rapid rewarming at >0.5°C per hour compared to slow rewarming at <0.5°C per hour. [Good Practice Statements]

5. Usually, any infant who has been intubated and ventilated for resuscitation should not be extubated until the infant has been carefully assessed and the risk of the need for re-intubation has been assessed as being low. Preterm infants and selected others may benefit from surfactant administration. The assessment of infants who have required assisted ventilation should include oxygen saturation, heart rate, respiratory rate and effort. Blood pressure and blood gas analysis are also often indicated. [Good Practice Statements]

6. Blood glucose level should be checked soon after resuscitation. Newborns who require resuscitation are more likely to develop hypoglycaemia. Although no exact threshold level at which outcomes worsen has been identified, maintaining a blood glucose level above 2.5 mmol/L for newborns who have required resuscitation is unlikely to cause harm. A glucose infusion of 4 to 6 mg/kg/min will usually be sufficient. Large bolus doses of glucose (> 200 mg/kg, equivalent to > 2 mL/kg of glucose 10%) should be avoided. [Good Practice Statements]

7. Very soon after resuscitation, consideration should be given to the need for relevant investigations (such as a full blood count and blood culture) and antibiotic treatment. [Good Practice Statement]

8. Inducing hypothermia in infants with evolving moderate to severe hypoxic ischaemic encephalopathy will reduce the degree of brain injury in some. [5] [Good practice statement, LOE I]. Local guidelines should be developed to identify term and near-term newborns (gestation ≥ 35 weeks) who meet any of the following criteria, that resemble those used in clinical trials of induced hypothermia; need for prolonged resuscitation, e.g., need for assisted ventilation with or without chest compressions at 10 min, Apgar score at 10 minutes ≤5 or acidosis as determined by cord blood gas or sample taken from the infant

soon after birth, e.g., pH <7.0 or base excess worse than -12 mmol/L. [Good Practice Statement]

9. Newborns who are at risk should have their neurological status assessed over the first few hours after birth. Those who develop signs of moderate or severe encephalopathy should have induced hypothermia commenced within 6 hours. [Good Practice Statement]
10. Any newborn who is considered a candidate for therapeutic hypothermia should be discussed promptly with a neonatologist, and plans should be made for admission to a neonatal intensive care unit. [Good Practice Statement] Therapeutic hypothermia should be conducted under carefully defined protocols, consistent with those used in the randomised, controlled trials, i.e., commence within 6 hours after birth, cool to 33 to 34˚C, continue for 72 hours and re-warm gradually over at least 4 hours, monitor for known adverse effects of cooling, and plan long term follow-up for all treated newborns. [Good Practice Statement]. ANZCOR suggests if necessary, therapeutic hypothermia can be initiated without specialized equipment. [CoSTR 2015 and 2020, weak recommendation, low certainty of evidence]
11. It is well established that wherever possible, newborns who are likely to require neonatal special or intensive care should be born at a centre that can provide an appropriate level of care. Those born elsewhere who require intensive or special care should be transferred to an appropriate centre. Early consultation should be undertaken to discuss management and arrange transport or retrieval. [Good Practice Statements]
12. Regardless of the outcome, witnessing the resuscitation of their newborn is distressing for parents. Every opportunity should be taken to prepare parents for the possibility of a resuscitative effort when it is anticipated and to keep them informed as much as possible during and certainly after the resuscitation. Whenever possible, discussions with parents should be held with a senior clinician. Early contact between parents and their newborn is important. [Good Practice Statements]
13. Difficult resuscitations are also stressful for the staff involved, regardless of seniority, and efforts should be made to debrief after such events. Well-conducted debriefing also represents an opportunity to improve skills. [Good Practice Statements]

## Abbreviations

| Abbreviation | Meaning/Phrase |
|---|---|
| ANZCOR | Australian and New Zealand Committee on Resuscitation |
| CoSTR | International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations |
| CPR | Cardiopulmonary resuscitation |
| LOE | Level of Evidence |
| NHMRC | National Health and Medical Research Council |

# Guideline

# 1 Documentation of Resuscitation

For clinical and medicolegal reasons, the observations, interventions and times during newborn resuscitation must be fully documented. [Good Practice Statement]

Apgar scores quantify and summarise the response of the newborn over the first few minutes of life.[4, 5] The Apgar score is assessed and recorded based on observations made at 1 and 5 minutes after birth and then sequentially every 5 minutes from birth until the heart rate and breathing are normal. Interventions for depressed newborns should not await Apgar scoring. [Good Practice Statements]

# 2 Continuing Care of the Newborn after Resuscitation

Once adequate ventilation and circulation have been established, the infant who has required resuscitation remains at risk and is likely to need ongoing assessment in an intensive or special care nursery where monitoring, appropriate evaluation and care can be provided.[6, 7] An infant who has experienced perinatal compromise or has ongoing respiratory distress may have dysfunction or delayed perinatal adaptation of brain, heart, gastrointestinal tract, kidneys or other organs. Fluid balance and nutrition should be monitored carefully for the first few days. [Good Practice Statements]

## 2.1 Temperature management

Maintaining normothermia (36.5 to 37.5°C [8]) remains important after resuscitation. If a newborn develops hypothermia unintentionally during resuscitation, limited evidence suggests no disadvantage of rapid rewarming at >0.5°C per hour compared to slow rewarming at <0.5°C per hour. [9, 10] [Good Practice Statements]

## 2.1 Cardiorespiratory management

Usually, any infant who has been intubated and ventilated for resuscitation should not be extubated until the infant has been carefully assessed and the risk of the need for re-intubation has been assessed as being low. Preterm infants and selected others may benefit from surfactant administration. The assessment of infants who have required assisted ventilation should include oxygen saturation, heart rate, respiratory rate and effort. Blood pressure and blood gas analysis are also often indicated. [Good Practice Statements]

## 2.2 Blood glucose management

Blood glucose level should be checked soon after resuscitation. [6, 7] Newborns who require resuscitation are more likely to develop hypoglycaemia. Although no exact threshold level at which outcomes worsen has been identified, maintaining a blood glucose level above 2.5 mmol/L for newborns who have required resuscitation is unlikely to cause harm. A glucose infusion of 4 to 6 mg/kg/min will usually be sufficient. Large bolus doses of glucose (> 200 mg/kg, equivalent to > 2 mL/kg of glucose 10%) should be avoided. [11] [Good Practice Statements]

## 2.3 Antibiotics

The need for resuscitation can be a consequence of the onset of sepsis. Very soon after resuscitation, consideration should be given to the need for relevant investigations (such as a full blood count and blood culture) and antibiotic treatment. [Good Practice Statement]

## 2.4 Induced Hypothermia for Hypoxic Ischaemic Encephalopathy (HIE)

Inducing hypothermia in infants with evolving moderate to severe hypoxic ischaemic encephalopathy will reduce the degree of brain injury in some. [5] [Good practice statement, NHMRC LOE I] Local guidelines should be developed to identify term and near-term newborns (gestation ≥ 35 weeks) who meet any of the following criteria, that resemble those used in clinical trials of induced hypothermia;

- Need for prolonged resuscitation, e.g., need for assisted ventilation with or without chest compressions at 10 min
- Apgar score at 10 minutes ≤5
- Acidosis as determined by cord blood gas or sample taken from the infant soon after birth, e.g., pH <7.0 or base excess worse than -12 mmol/L.

[Good Practice Statement]

Many but not all such newborns will have experienced an intrapartum sentinel event such as cord prolapse, severe abruption, or severe dystocia. The absence of such a recognised event does not preclude the possibility that the newborns will benefit from induced hypothermia.

Newborns who are at risk should have their neurological status assessed over the first few hours after birth. Those who develop signs of moderate or severe encephalopathy should have induced hypothermia commenced within 6 hours. [Good Practice Statement]

Any newborn who is considered a candidate for therapeutic hypothermia should be discussed promptly with a neonatologist, and plans should be made for admission to a neonatal intensive care unit. [Good Practice Statement] Therapeutic hypothermia should be conducted under carefully defined protocols, consistent with those used in the randomised, controlled trials, i.e., commence within 6 hours after birth, cool to 33 to 34°C, continue for 72 hours and re-warm gradually over at least 4 hours, monitor for known adverse effects of cooling, and plan long term follow-up for all treated newborns. [Good Practice Statement]. ANZCOR suggests if necessary, therapeutic hypothermia can be initiated without specialized equipment. [1, 2, 12] [CoSTR 2015 and 2020, weak recommendation, low certainty of evidence]

## 2.5 Stabilisation and Transfer

It is well established that wherever possible, newborns who are likely to require neonatal special or intensive care should be born at a centre that can provide an appropriate level of care. Those born elsewhere who require intensive or special care should be transferred to an appropriate centre. Early consultation should be undertaken to discuss management and arrange transport or retrieval. [Good Practice Statements]

# 3 Continuing Care of the Family

Regardless of the outcome, witnessing the resuscitation of their newborn is distressing for parents. Every opportunity should be taken to prepare parents for the possibility of a resuscitative effort when it is anticipated and to keep them informed as much as possible during and certainly after the resuscitation. Whenever possible, discussions with parents should be held with a senior clinician. Early contact between parents and their newborn is important. [Good Practice Statements]

Difficult resuscitations are also stressful for the staff involved, regardless of seniority, and efforts should be made to debrief after such events. Well-conducted debriefing also represents an opportunity to improve skills. [Good Practice Statements]

# References


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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. [1, 2] |
| **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. |
| **Principal reviewers:** | Helen Liley, Lindsay Mildenhall, Marta Thio and Callum Gately |
| **Main changes** | Inclusion of WHO definitions of cold stress, hypothermia and hyperthermia in newborns. Inclusion of evidence for rate of rewarming in unintentional hypothermia. Updating of review evidence, references, and terminology to increase consistency with GRADE terminology. |
| **Approved:** | April 2021 |

# ANZCOR Guideline 13.10 – Ethical Issues in Resuscitation of the Newborn

## Summary

Guidelines 13.1-13.10 and the Newborn Life Support algorithm are provided to assist in the resuscitation of newborn infants. Differences from the adult and paediatric guidelines reflect differences in the anatomy and physiology and the causes of cardiorespiratory arrest for newborns, older infants, children and adults. These guidelines draw from Neonatal Life Support 2020 and 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations (CoSTR) [1, 2] the development of which included representation from ANZCOR. The 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Care [3] and local practices have also been taken into account.

### To whom do these guidelines apply?

The term 'newborn' or 'newborn infant' refers to the infant in the first minutes to hours following birth. In contrast, the neonatal period is defined as the first 28 days of life. Infancy includes the neonatal period and extends through the first 12 months of life.

ANZCOR Guidelines 13.1 to 13.10 and the Newborn Life Support algorithm are mainly for the care of newborns. The exact age at which paediatric techniques and in particular, compression-ventilation ratios, should replace the techniques recommended for newborns is unknown, especially in the case of very small preterm infants. For term infants beyond the first minutes to hours following birth, and particularly in those with known or suspected cardiac aetiology of their arrest, paediatric techniques may be used (see Paediatric Advanced Life Support Guidelines 12.1 to 12.7).

### Who is the audience for these guidelines?

ANZCOR Guidelines 13.1 to 13.10 and the Newborn Life Support algorithm are for health professionals and those who provide healthcare in environments where equipment and drugs are available (such as a hospital). When parents are taught CPR for their infants who are being discharged from birth hospitals, the information in Basic Life Support Guidelines (ANZCOR Guidelines 2 to 8 is appropriate).

## Recommendations

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

1. If there is doubt whether to initiate or withhold resuscitation, it is best to start and later withdraw treatment when the situation has been clarified. [Good Practice Statement] Exceptions may include newborns with anencephaly and extremely immature newborns for whom there is very little possibility of intact survival.

2. Together, clinicians and parents may decide to withhold or withdraw treatment on the basis of medical inappropriateness and in the 'best interests' of the infant. [5-7] Determining medical inappropriateness of initiating or continuing interventions includes weighing their potential effectiveness in the infant's clinical situation against the risk of harms (which may include pain, suffering, indignity and separation from parents). These reasons should be discussed with families and their views considered. [Good Practice Statements]

3. When gestation, birth weight, or congenital anomalies are associated with almost certain early death and high morbidity is likely among the rare survivors, it may be reasonable to withhold resuscitation. In conditions associated with a high rate of survival, resuscitation is indicated. Generally, parents' views on resuscitation should be supported, particularly in conditions associated with uncertain prognosis, when there is borderline survival and a relatively high rate of morbidity, and where the burden to the newborn is high. In rare instances, there may be a discordance between parental views and the best interests of the newborn, that require processes including legal and ethical consultation. [Good Practice Statements]

4. Prognostic scores have been developed to assist in decision-making about resuscitation for infants born <25 weeks' gestation. Prognostication should be supported by regional data whenever possible. Even small discrepancies in gestational age estimation may have major implications for survival and long-term morbidity, therefore decisions to withhold resuscitation based on gestation should include consideration of the certainty of the estimate. Other factors such as birthweight for gestation, plurality, receipt of antenatal steroids and circumstances of birth should also be considered, and decisions may need to be revised if circumstances change. [Good Practice Statements]

5. Whenever possible, there should be a consistent and coordinated approach from the obstetric, midwifery and neonatal teams in applying this guideline and in communicating with the parents to develop an agreed-upon management plan which is in the best interests of the newborn. [Good Practice Statement]

6. If, despite provision of all the recommended steps of resuscitation and excluding reversible causes, a newborn requires ongoing cardiopulmonary resuscitation (CPR) after birth, we suggest discussion of discontinuing resuscitative efforts with the clinical team and family. ANZCOR suggests that a reasonable time frame to consider this change in goals of care is around 20 minutes after birth. [CoSTR 2020, weak recommendation, very low-certainty evidence]

7. In resource-limited settings, such as in areas remote from neonatal intensive care, telephone consultation with a neonatologist or paediatrician prior to discontinuing resuscitation is suggested, if possible. [Good Practice Statement]
8. Care should be provided in a way that is focused on the infant's best interest, comfort and dignity, and on support of the parents. This is particularly important when there is a decision to withdraw or withhold resuscitation. [Good Practice Statement]

## Abbreviations

| Abbreviation | Meaning/Phrase |
|---|---|
| ANZCOR | Australian and New Zealand Committee on Resuscitation |
| CoSTR | International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations |
| CPR | Cardiopulmonary resuscitation |

# Guideline

## 1 Initiating Resuscitation

The birth of extremely premature newborn infants and those with severe congenital anomalies raises questions with the parents and among clinicians about initiation of resuscitation. [4, 5] Resuscitation does not mandate continued support. Not starting resuscitation or starting intensive care, which is stopped later, when the details of the newborns condition are known, are ethically and legally equivalent. [6-8] The latter approach allows time to gather more complete clinical information and for discussions with the family. If there is doubt whether to initiate or withhold resuscitation, it is best to start and later withdraw treatment when the situation has been clarified. [Good Practice Statement] Exceptions may include newborns with anencephaly and extremely immature newborns for whom there is very little possibility of intact survival. Together, clinicians and parents may decide to withhold or withdraw treatment on the basis of medical inappropriateness and in the 'best interests' of the infant. [5-7] Determining medical inappropriateness of initiating or continuing interventions includes weighing their potential effectiveness in the infant's clinical situation against the risk of harms (which may include pain, suffering, indignity and separation from parents). [9] These reasons should be discussed with families and their views considered. [Good Practice Statements]

When gestation, birth weight, or congenital anomalies are associated with almost certain early death and high morbidity is likely among the rare survivors, it may be reasonable to withhold resuscitation. In conditions associated with a high rate of survival, resuscitation is indicated. Generally, parents' views on resuscitation should be supported, particularly in conditions associated with uncertain prognosis, when there is borderline survival and a relatively high rate of morbidity, and where the burden to the newborn is high. [6-8, 10] In rare instances, there may be a discordance between parental views and the best interests of the newborn, that require processes including legal and ethical consultation. [11] [Good Practice Statements]

Prognostic scores have been developed to assist in decision-making about resuscitation for infants born < 25 weeks' gestation. Prognostication should be supported by regional data whenever possible. Even small discrepancies in gestational age estimation may have major implications for survival and long-term morbidity, therefore decisions to withhold resuscitation based on gestation should include consideration of the certainty of the estimate. [12] Other factors such as birthweight for gestation, plurality, receipt of antenatal steroids and circumstances of birth should also be considered, and decisions may need to be revised if circumstances change. [Good Practice Statements]

Whenever possible, there should be a consistent and coordinated approach from the obstetric, midwifery and neonatal teams in applying this guideline and in communicating with the parents to develop an agreed-upon management plan which is in the best interests of the newborn. [Good Practice Statement]

# 2 Discontinuing Resuscitation

It can be difficult for clinicians to decide how long resuscitative efforts should continue in a newborn with no heart rate or a very low heart rate with absent respirations after sustained resuscitative efforts. This critical decision involves knowing when to change the goals of care from resuscitation to the provision of comfort and contact with the parents. If such a decision is made too early, some newborns with potential to survive with good neurodevelopmental outcome may die. If the decision is made too late, there is likely to be a diminishing opportunity for parental engagement during end-of-life care.

A systematic review conducted for ILCOR [1] identified 15 studies that included 470 newborns, which reported survival rates to last follow-up ranging from 1.7% to 100% among newborns who had had at least 10 minutes of asystole, bradycardia (HR <60/min) or pulseless electrical activity after birth for which CPR was indicated. However, there was considerable heterogeneity across these studies (very low certainty evidence, downgraded for risk of bias and inconsistency). For neurodevelopmental outcomes among survivors, there was very low certainty evidence (downgraded for risk of bias and inconsistency) from 13 studies including 277 newborns. Thirty newborns among 80 survivors did not have moderate or severe neurodevelopmental disability.

For survival without neurodevelopmental impairment, the review found very low-certainty evidence (downgraded for risk of bias and inconsistency) from 13 studies of 277 newborns reporting neurodevelopmental outcomes. Among all 277 newborns reported in these studies, 69% died before last follow up, 18% survived with moderate to severe impairment, and 11% survived without moderate to severe impairment (2% lost to follow up). There was important heterogeneity between studies (and in some cases, within studies) about the timing and tools used to assess neurodevelopmental outcomes that precluded calculation of confidence intervals. [1]

This review concluded that due to small sample sizes and heterogeneity of study characteristics, there is inadequate evidence on which to base recommendations for specific groups of newborns (e.g., term vs preterm gestation, and whether or not therapeutic hypothermia was used). [1]

Failure to achieve return of spontaneous circulation in newborns despite 10 to 20 minutes of intensive resuscitation is associated with a high risk of mortality and a high risk of moderate-to-severe neurodevelopmental impairment among survivors. However, there is no evidence that any specific duration of resuscitation consistently predicts mortality or moderate-to-severe neurodevelopmental impairment. If, despite provision of all the recommended steps of resuscitation and excluding reversible causes, a newborn requires ongoing cardiopulmonary resuscitation (CPR) after birth, we suggest discussion of discontinuing resuscitative efforts with the clinical team and family. ANZCOR suggests that a reasonable time frame to consider this change in goals of care is around 20 minutes after birth. [1] [CoSTR 2020, weak recommendation, very low-certainty evidence]

In resource-limited settings, such as in areas remote from neonatal intensive care, telephone consultation with a neonatologist or paediatrician prior to discontinuing resuscitation is suggested, if possible. [Good Practice Statement]

Care should be provided in a way that is focused on the infant's best interest, comfort and dignity, and on support of the parents. This is particularly important when there is a decision to withdraw or withhold resuscitation. [Good Practice Statement]

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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. [1, 2] |
| **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. |
| **Principal reviewers:** | Helen Liley, Lindsay Mildenhall, Marta Thio, Callum Gately. |
| **Main changes** | Updating of references and clinical content consistent with contemporary ethical practice. Updating of evidence and recommendations in regard to discontinuing resuscitation. Updating of review evidence, references, and terminology to increase consistency with GRADE terminology. |
| **Approved:** | April 2021 |

NEW ZEALAND
Resuscitation Council
WHAKAHAUORA AOTEAROA

# GUIDELINE

# PHYSIOLOGY OF BIRTH ASPHYXIA

***The newborn is not an adult, nor a child.***

In people of all ages, death can occur from a failure of breathing and / or circulation. The interventions required to aid recovery from these situations are termed resuscitation.

In the absence of circulation or breathing, the interventions required for resuscitation may include the maintenance of respiration using artificial ventilation and the maintenance of an artificial circulation using chest compressions. The combination of chest compressions with artificial ventilation is called cardiopulmonary resuscitation or CPR. Occasionally, when the situation warrants it, additional measures may be required, including the use of artificial airways, defibrillation (almost unheard of in neonates), and the administration of fluid or drugs.

Babies do not suffer from the same diseases and problems that cause cardio-respiratory collapse in adults or children. Newly born babies are not small adults, nor just small children. Their physiology and anatomy are different and so are the reasons why resuscitation may be required.

***The resuscitator must approach a newborn differently from a collapsed adult or child.***

## DIFFERENCES BETWEEN ADULT AND NEWBORN RESUSCITATION

In adults, cardio-respiratory collapse is usually a cardiac event and caused by a sudden failure of circulation. The most common cause of cardiac arrest in adults is the potentially lethal arrhythmia *ventricular fibrillation,* as a result of myocardial infarction or myocardial ischaemia. Following primary cardiac arrest breathing stops because oxygen is no longer being delivered to the respiratory centre in the brain stem. To manage adult cardiac arrest, the rescuer will attempt to provide a temporary artificial circulation of oxygenated blood to the heart and brain using chest compressions combined with lung ventilation (cardiopulmonary resuscitation or CPR). The emphasis in adult CPR is on chest compressions over ventilations. With adult cardiac arrest the circulation immediately ceases but the oxygen level in the left ventricular blood does not fall, because blood is no longer moving to areas of the body where oxygen levels are low. The aim of adult CPR is to establish an adequate coronary perfusion pressure (the difference between aortic diastolic pressure and right atrial pressure; animal studies suggest it needs to be at least 15mmHg) and push LV blood into the ascending aorta. Whenever chest compressions are interrupted the coronary perfusion pressure plummets and takes about 6 chest compressions to return to the pre-interruption level. Having established a temporary circulation of

oxygenated blood using CPR, the resuscitator attempts to identify the problem and provide appropriate treatment. This often requires a defibrillator, and possibly drugs.

In contrast to adults, the need for resuscitation in newly born infants is almost always secondary to hypoxia and a failure of breathing (apnoea), a respiratory arrest. Primary cardiovascular collapse is extraordinarily rare. Newborn resuscitation is always focussed on the initiation and maintenance of ventilation. The neonatal myocardium has a great resilience to ischemia and can keep pumping using (less efficient) anaerobic mechanisms for a number of minutes although at a lower than normal heart rate. Unlike adults, because left ventricular blood in the neonate is still being pumped forward by the beating heart, the oxygen level in that blood rapidly falls as it is not being replenished by blood exposed to effective ventilation or a functioning placenta. If ventilation is restored or established the first sign will be a rise in heart rate. Despite the resilience of the neonatal myocardium, any reserve will eventually be exhausted. If the heart rate drops below 60 chest compressions should be added to the ventilations. The neonatal algorithm of 3 compressions: 1 ventilation emphasises ventilation over compressions, as in most cases the heart rate will rise rapidly once adequate ventilation is restored. The exact age, postnatally, to change from newborn ventilation compression ratios to a paediatric one (15:2) is unknown. Unless the arrest is thought to be of a purely cardiac aetiology, the newborn ratio should be used until the newborn is outside the birthing environment. The compression ventilation ration for cardiac cases or older children is 15:2.

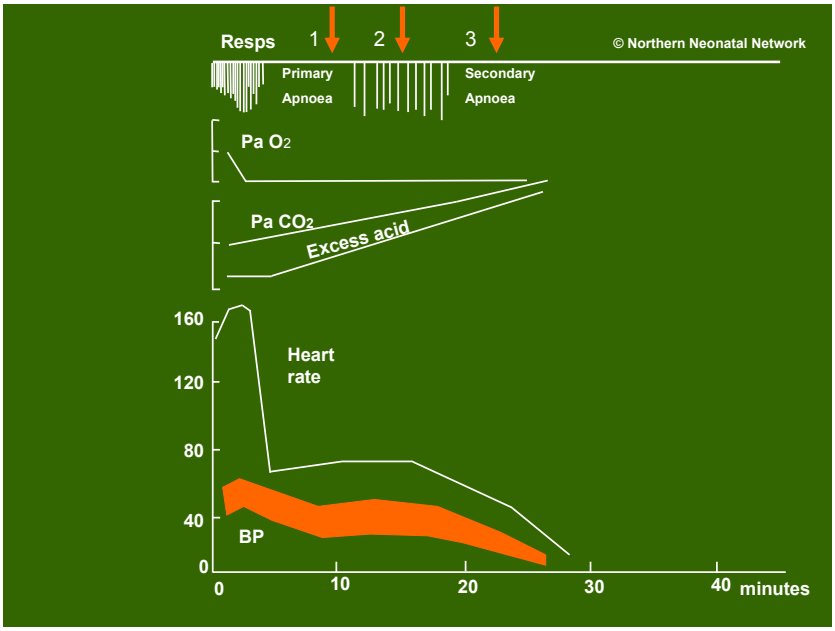
## HYPOXIA

The most important changes at birth involve the discontinuation of feto-placental circulation and the initiation of pulmonary ventilation. The principal danger for the fetus during this transition is the risk of hypoxia. Feto-placental oxygenation may be impaired in utero *prior* to the disruption that will occur at birth itself. Some infants may become profoundly hypoxic in utero before pulmonary oxygenation can be established. A common response to this stress, in term babies, is the passage of meconium into the amniotic fluid prior to delivery.

### The response to hypoxia

The figure below shows the response of fetal mammals to acute hypoxia (cord clamping in the absence of pulmonary ventilation) in utero. Similar responses to acute hypoxia are apparent in the human fetus, and may occur in utero or after birth. Clinical examples of this scenario would be perinatal obstetric conditions such as uterine rupture, placental abruption, cord avulsion or cord compression during shoulder dystocia.

*Figure: Induced hypoxia in newborn mammals. Note that birth may occur at any point such as 1, 2 or 3. The initial status of a baby may not indicate where in this process the physiology is progressing. Only the response to resuscitation will retrospectively indicate the initial status of the baby (primary apnoea, gasping respiration, terminal apnoea).*




**Primary apnoea**

At the onset of hypoxia fetal breathing movements become deeper and more rapid. As arterial oxygen level falls the brain becomes hypoxic. Muscle tone diminishes and, within a few minutes, regular breathing movements cease as the brainstem centre responsible for controlling respiration is unable to function due to lack of oxygen. With termination of breathing the fetus enters a period known as ***primary apnoea***. Although initially heart rate remains reasonably constant, or briefly rises, it soon falls to about half its normal rate. This bradycardia is due to an initial increase in vagal tone but persists because, due to lack of oxygen, heart muscle is increasingly required to contract using anaerobic metabolism.

Despite bradycardia, blood pressure is maintained, initially by two mechanisms: vasoconstriction shuts down the circulation to all but the most vital areas of the body (heart and brain) and blood supply to the gut, kidneys, muscles and skin diminishes. The slow heart rate allows greater time for the ventricles to refill in diastole and stroke volume (volume pumped from the heart with each contraction) increases.

Overall, cardiac output (the product of heart rate and stroke volume) does decrease but the fall is not as great as would be expected from the decrease in heart rate. Although circulation is maintained to the organs most important for immediate survival, release of lactic acid as a by-product of anaerobic metabolism in poorly perfused tissues causes metabolic acidosis and ongoing biochemical deterioration. The majority of term infants born during primary apnoea respond well to tactile

stimulation and having ventilation assisted by the provision of a patent airway. Brain oxygenation will be rapidly restored and therefore induce normal breathing.

**Gasping**

If the hypoxic insult continues, after a variable period of time, primitive spinal centres, released from the inhibition of higher breathing centres, produce shuddering, exaggerated, irregular gasps at a rate of about 12 per minute. The heart rate continues to decrease.

A variable time may elapse before this unconscious gasping activity begins. Anaesthetics and drugs such as maternal opiates can delay the onset of gasping (i.e. increase the duration of primary apnoea) as well as reduce the duration of the subsequent gasping period.

If these gasps successfully aerate the lungs then, because the circulation is still functioning, oxygenated blood will be transported to the coronary arteries and the heart rate will rapidly increase. This will improve the circulation and will facilitate the transport of oxygenated blood to the brain and respiratory centre. Once the respiratory centre is re-oxygenated it will begin to function again, regular breathing will gradually start and gasping will gradually cease.

**Terminal apnoea**

If the period of gasping occurs in utero because of intrauterine hypoxaemia or, after birth, fails to aerate the lung and provide oxygenation, hypoxic damage to the brain and heart will continue. Gasping will become weaker and eventually cease. The baby will progress into ***terminal apnoea***. Although the newborn heart is resilient to hypoxic stress (a consequence of its large glycogen stores) this resilience is finite. The heart rate and blood pressure will start to fall and eventually become undetectable.

**Apnoea at birth**

A baby who is not breathing within a minute or two of birth may be either in a) primary apnoea or b) terminal apnoea having gone through a period of gasping in utero. Clinically, these phases are indistinguishable, and one should assume the baby is in *terminal apnoea*. Resuscitation with ventilation should commence without delay.

In most babies born during *primary apnoea*, tactile stimulation and enabling ventilation by providing a patent airway will rapidly restore normal breathing. Many of these babies will be able to 'resuscitate' themselves provided the airway is open. After a pause, the baby will take the first of a series of gasps that will aerate the lung, provide oxygenation to the heart and brain, and initiate the return of normal breathing.

A baby born in *terminal apnoea* will show no further respiratory effort and will die without intervention and may die despite it. It is possible that the application of effective artificial lung inflation may be enough to produce a rapid recovery, provided there is still a circulation functioning sufficiently to bring oxygenated blood back to the heart.

In a few babies the situation may have progressed to a stage where the circulation is no longer functional and is unable to deliver oxygenated blood from the lungs to the

heart despite adequate lung inflation. In this situation recovery can still occur, in some cases, if lung ventilation is combined with a period of chest compressions. These compressions can successfully deliver a small quantity of oxygenated blood to the heart, provided the heart is still able to respond.

The behaviour exhibited as the baby improves is an indication as to how far the baby has progressed into *terminal apnoea*. Babies who have been in terminal apnoea do not cough or gasp until the circulation is restored and exhibit a period of gasping before normal breathing movements make their appearance. A period of intermittent positive pressure ventilation (IPPV) may be required until normal breathing is established.

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