ANZCOR Guideline 13.1 – Introduction to Resuscitation of the Newborn Infant

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 causes of cardiorespiratory arrest in, and anatomy and physiology of newborns, older infants, children and adults. These guidelines draw from the consensus on resuscitation and treatment recommendations issued by the International Liaison Committee on Resuscitation (ILCOR)[1], which included representation from ARC and NZRC. The 2015 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care (Neonatal)[2], the European Resuscitation Council Guidelines for Resuscitation 2015[3] and local practices have also been taken into account.

To whom do these guidelines apply?

The term "newborn" 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.

Guidelines 13.1-13.10 and the Newborn Life Support algorithm are specifically for the care of infants during the neonatal period, and particularly for newborn infants. The exact age at which paediatric techniques and in particular, compression-ventilation ratios, should replace neonatal methods is unknown, especially for very small premature infants. For term neonates beyond the newborn period, and particularly in those with known or suspected cardiac aetiology of their arrest, paediatric techniques may be used (see Paediatric Advanced Life Support Guidelines 12.1-12.7).

Who is this audience for these guidelines?

Guidelines 13.1-13.10 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 (Guidelines 1-8) is appropriate.

Recommendations

The Australian and New Zealand Resuscitation Committee on Resuscitation (ANZCOR) recommends that:

1. Newborn infants 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.

2. Healthcare providers implement policies and protocols that utilise this algorithm and these guidelines.

Guideline

1   Need for Neonatal Resuscitation

Approximately 85 percent of babies born at term will initiate spontaneous respirations within 10 to 30 seconds of birth. 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 require chest compressions and/or adrenaline (epinephrine) to achieve this transition.[4-6] 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. (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 neonatal resuscitation interventions described in these guidelines.

Term infants who have had low or no risk factors for needing resuscitation, 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 baby.

Although the need for resuscitation of the newborn infant 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 place, equipment and personnel trained to resuscitate a newborn infant must be available at all times, and in all places, where infants are born.

2   Unique Physiology of Newborn Infants

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.[7] If the baby 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 baby to baby, depending on the maturity of the lungs and any lung disease that is present. (For this reason, the suggested starting pressures provided in Guideline 13.4 are only a guide, and pressures need to be individually adjusted according to the baby'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 babies 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,[8] which rises 5 to 6 fold after birth. In healthy newborn infants, oxygen levels rise over several minutes, typically taking 5-10 minutes for oxygen saturation of haemoglobin to reach 90%.[9-15] Uncompromised babies born at sea level have oxygen saturation levels of about 60% during labour. The 25th centile for oxygen saturation is approximately 80% at 5 minutes.[15] Normal newborn infants have a heart rate within 3-4 minutes after birth varying between 110 and 160/min.[16,17]

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. 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 neonatal hypovolaemia and hypotension. 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.[18] Preterm infants also typically have weaker respiratory muscles, immature airway protective reflexes, and a chest wall that deforms easily. Very premature infants and infants 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 babies 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 infants who are small for their gestation, and those born after term or with significant perinatal compromise.[19]

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

3 Anticipating the Need for Resuscitation

3.1 Personnel

All personnel who attend births should be trained in neonatal resuscitation skills which include: basic measures to maintain an open airway, ventilation via a facemask / laryngeal mask and chest compressions. At least one person should be responsible for the care of each infant.

A person trained in advanced neonatal 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 neonatal resuscitation.

Guideline 13.2 lists examples of maternal, fetal, and intrapartum circumstances that place the newborn infant at increased risk of needing resuscitation. If it is anticipated that the infant is at high risk of requiring advanced resuscitation more than one experienced person should be present.

3.2 Training

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 infants at the time of birth.[20]

3.3 Equipment

The need for resuscitation at birth cannot always be anticipated.[21] 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. 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 infant. This should include any factors that may affect the resuscitation and management of the infant including:

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

4 Environment

4.1 Temperature

Newborns are at risk from hypothermia or hyperthermia so prevention of both heat loss and overheating is important. Hypothermia can increase oxygen consumption and impede effective resuscitation.[22,23] The infant should be cared for in a warm, draft-free area. For term and near term infants, drying the infant and removing the wet linen reduce heat loss [Class A, expert consensus opinion]. When resuscitation is not required the mother's body can keep the infant warm, using her as a heat source by placing the infant skin-to-skin on the 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 infant under a preheated radiant warmer or if unavailable, an alternative heat source.

Non asphyxiated babies of all gestations, should be maintained with a temperature of between 36.5 and 37.5° C. [CoSTR 2015, strong recommendation, very low quality of evidence]

Admission temperatures to newborn units are predictors of outcome and should be recorded as a quality of care measure. [CoSTR 2015, strong recommendation, moderate quality of evidence] [1] 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. [1]

Hypothermia on admission is also associated with worse respiratory outcomes and greater likelihood of hypoglycaemia, late onset sepsis and intraventricular haemorrhage.[1]

For special considerations for preterm infants see Guideline 13.8.

4.2 Hyperthermia

No studies have examined the effects of hyperthermia after resuscitation of newborn infants. However, babies born to febrile mothers (temperature >38^0 C) have an increased risk of death, perinatal respiratory depression, neonatal seizures and cerebral palsy.[24,25]

4.3 Induced Hypothermia for Hypoxic Ischaemic Encephalopathy

Inducing hypothermia in infants of 35 weeks gestation and above with evolving moderate to severe hypoxic ischaemic encephalopathy will reduce the degree of brain injury in some (see guideline 13.9).[26-30] The target during resuscitation and stabilisation should be to maintain normothermia (with care to avoid hyperthermia), until a decision has been made that the baby has signs of encephalopathy and meets criteria for induced hypothermia. Any infant 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.[31] Local guidelines should be in place to ensure that infants that meet criteria for induced hypothermia are promptly recognised and referred. [Class A, expert consensus opinion]

5 Recommended Equipment and Drugs for Resuscitation of the Newborn Infant

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.[20]

Prior preparation of standardized kits containing the equipment needed for procedures such as umbilical catheterization can save considerable time in emergencies [Class B, expert consensus opinion].[20]

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 baby less than 1500g birth weight
- Stethoscope, neonatal size preferred
- Pulse oximeter plus neonatal probe

Equipment for **airway** management

- Suction apparatus and suction catheters (6F, 8F, and either 10F or 12F)
- Oropharyngeal airways (sizes 0 and 00)
- Intubation equipment:
  - o Laryngoscopes with infant blades (00, 0, 1)
  - o Spare bulbs, and batteries
  - o Endotracheal tubes (sizes 2.5, 3, 3.5, and 4 mm ID, uncuffed, no eye)
  - o Endotracheal stylet or introducer
  - o 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)
- Magill forceps, neonatal size (optional)
- Laryngeal Mask airway, size 1

Equipment for supporting **breathing**

- Face masks (range of sizes suitable for premature and term infants)
- Positive-pressure ventilation device, either:
  - o T-piece device, or;
  - o Flow-inflating bag with a pressure safety valve and manometer; and
  - o Self-inflating bag (approximately 240 ml) with a removable oxygen reservoir
- Medical gases:
  - o Source of medical oxygen (reticulated and/or cylinder, allowing flow rate of up to 10 L/min) with flow meter and tubing
  - o Source of medical air plus air/oxygen blender
- Feeding tubes for gastric decompression (e.g. size 6 & 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)
- Volume expanders
- Normal saline
- Blood suitable for emergency neonatal transfusion needs to be readily available for a profoundly anaemic baby

Documentation

- Resuscitation record sheet

6 Cord Clamping

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.[8] However, there remains controversy about how long it is appropriate to delay clamping if the baby is perceived to require resuscitation.

For the uncomplicated term birth, a meta-analysis of studies comparing delaying cord clamping after birth for a time ranging from 30 seconds until the cord stops pulsating with immediate cord clamping (usually within 15 seconds) showed higher neonatal haemoglobin levels and improved iron status through early infancy, but a greater likelihood of needing phototherapy for jaundice.[32]

For the uncomplicated preterm birth, delaying cord clamping for a minimum time of 30 seconds increases the infant's blood pressure during stabilization and at 4 hours after birth, reduces risk of periventricular leukomalacia and intraventricular haemorrhage (although there is insufficient evidence to determine whether there is an effect on severe IVH), lowers the incidence of necrotising enterocolitis, increases blood volume and lowers the chance of needing a blood transfusion.[1] Although this evidence is from randomised trials, it is very low quality, having been downgraded for imprecision and very high risk of bias. In preterm infants, there is also low quality evidence that delayed cord clamping increases peak bilirubin levels but without increasing the likelihood of needing phototherapy.[1]

We *suggest* delayed umbilical cord clamping for preterm infants not requiring immediate resuscitation after birth. (CoSTR 2015, weak recommendation, very low quality of evidence)[1]

Although on theoretical grounds, the depressed infant might receive greater benefit from deferred cord clamping,[8] 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 infant 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 infants 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.[1] The more severely compromised the infant, the more likely it is that resuscitation measures need to take priority over delayed cord clamping. It stands to reason that cardiac compressions will not improve the systemic and coronary perfusion if the cord remains unclamped and the low resistance placenta is still connected.

6.1 Cord Milking

Milking of the umbilical cord from the placental side to the newborn has been studied as an alternative method to increase the newborn's intravascular blood volume.

We suggest against the routine use of cord milking because there is insufficient published human evidence of benefit. (CoSTR 2015, weak recommendation, very low quality of evidence).[1]

7 Checking Resuscitation Equipment

ANZCOR and ARC 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.

References

1. Wyllie J, Perlman JM, Kattwinkel J, 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.

2. Wyckoff MH, Aziz K, Escobedo MB, et al. Part 13: Neonatal Resuscitation: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation 2015;132:S543-60.

3. Wyllie J, Bruinenberg J, Roehr CC, Rudiger M, Trevisanuto D, Urlesberger B. European Resuscitation Council Guidelines for Resuscitation 2015: Section 7. Resuscitation and support of transition of babies at birth. Resuscitation 2015;95:249-63.

4. Barber CA, Wyckoff MH. Use and efficacy of endotracheal versus intravenous epinephrine during neonatal cardiopulmonary resuscitation in the delivery room. Pediatrics 2006;118:1028-34.

5. Ersdal HL, Mduma E, Svensen E, Perlman JM. Early initiation of basic resuscitation interventions including face mask ventilation may reduce birth asphyxia related mortality in low-income countries: a prospective descriptive observational study. Resuscitation 2012;83:869-73.

6. Perlman JM, Risser R. Cardiopulmonary resuscitation in the delivery room: associated clinical events. Archives of pediatrics & adolescent medicine 1995;149:20-5.

7. Hooper SB, te Pas AB, Kitchen MJ. Respiratory transition in the newborn: a three-phase process. Archives of Disease in Childhood-Fetal and Neonatal Edition. 2015 Nov 5:fetalneonatal-2013

8. Hooper SB, te Pas AB, Lang J, et al. Cardiovascular transition at birth: a physiological sequence. Pediatr Res 2015;77:608-14.

9. Altuncu E, Ozek E, Bilgen H, Topuzoglu A, Kavuncuoglu S. Percentiles of oxygen saturations in healthy term newborns in the first minutes of life. Eur J Pediatr 2008;167:687-8.

10. Gonzales GF, Salirrosas A. Arterial oxygen saturation in healthy newborns delivered at term in Cerro de Pasco (4340 m) and Lima (150 m). Reprod Biol Endocrinol 2005;3:46.

11. Kamlin CO, O'Donnell CP, Davis PG, Morley CJ. Oxygen saturation in healthy infants immediately after birth. J Pediatr 2006;148:585-9.

12. Toth B, Becker A, Seelbach-Gobel B. Oxygen saturation in healthy newborn infants immediately after birth measured by pulse oximetry. Archives of gynecology and obstetrics 2002;266:105-7.

13. Mariani G, Dik PB, Ezquer A, et al. Pre-ductal and post-ductal O2 saturation in healthy term neonates after birth. J Pediatr 2007;150:418-21.

14. Rabi Y, Yee W, Chen SY, Singhal N. Oxygen saturation trends immediately after birth. J Pediatr 2006;148:590-4.

15. Dawson JA, Kamlin CO, Vento M, et al. Defining the reference range for oxygen saturation for infants after birth. Pediatrics 2010;125:e1340-7.

16. Dawson J, Kamlin C, Wong C, et al. Changes in heart rate in the first minutes after birth. Archives of Disease in Childhood - Fetal and Neonatal Edition 2010;95:F177-F81.

17. Dawson JA, Morley CJ. Monitoring oxygen saturation and heart rate in the early neonatal period. Seminars in fetal & neonatal medicine 2010;15:203-7.

18. Jobe A. The Respiratory System. In: Fanarroff AA, Martin RJ, eds. Neonatal Perinatal Medicine. St Louis, MO: CV Mosby; 1997:991-1018.

19. Gregory GA, Gooding CA, Phibbs RH, Tooley WH. Meconium aspiration in infants: a prospective study. J Pediatr 1974;85:848-52.

20. Australian Resuscitation Council Standards for Resuscitation: Clinical Practice and Education A Resource for Healthcare. 2014.

21. Peliowski A, Finer NN. Birth asphyxia in the term infant. In: Sinclair JC, Bracken MB, eds. Effective Care of the Newborn infant. Oxford, UK: Oxford University Press; 1992:249-73.

22. Dahm LS, James LS. Newborn temperature and calculated heat loss in the delivery room. Pediatrics 1972;49:504-13.

23. Gandy GM, Adamsons K, Jr., Cunningham N, Silverman WA, James LS. Thermal environment and acid-base homeostasis in human infants during the first few hours of life. J Clin Invest 1964;43:751-8.

24. Lieberman E, Eichenwald E, Mathur G, Richardson D, Heffner L, Cohen A. Intrapartum fever and unexplained seizures in term infants. Pediatrics 2000;106:983-8.

25. Petrova A, Demissie K, Rhoads GG, Smulian JC, Marcella S, Ananth CV. Association of maternal fever during labor with neonatal and infant morbidity and mortality. Obstet Gynecol 2001;98:20-7.

26. Gluckman PD, Wyatt JS, Azzopardi D, et al. Selective head cooling with mild systemic hypothermia after neonatal encephalopathy: multicentre randomised trial. Lancet 2005;365:663-70.

27. Shankaran S, Laptook AR, Ehrenkranz RA, et al. Whole-body hypothermia for neonates with hypoxic-ischemic encephalopathy. N Engl J Med 2005;353:1574-84.

28. Eicher DJ, Wagner CL, Katikaneni LP, et al. Moderate hypothermia in neonatal encephalopathy: efficacy outcomes. Pediatr Neurol 2005;32:11-7.

29. Azzopardi DV, Strohm B, Edwards AD, et al. Moderate hypothermia to treat perinatal asphyxial encephalopathy. N Engl J Med 2009;361:1349-58.

30. Jacobs SE, Berg M, Hunt R, Tarnow-Mordi WO, Inder TE, Davis PG. Cooling for newborns with hypoxic ischaemic encephalopathy. Cochrane Database Syst Rev 2013;1:CD003311.

31. Jacobs SE, Morley CJ, Inder TE, et al. Whole-body hypothermia for term and near-term newborns with hypoxic-ischemic encephalopathy: a randomized controlled trial. Archives of pediatrics & adolescent medicine 2011;165:692-700.

32. McDonald SJ, Middleton P, Dowswell T, Morris PS. Effect of timing of umbilical cord clamping of term infants on maternal and neonatal outcomes. Cochrane Database Syst Rev 2013;7:CD004074.