Part 13: Neonatal Resuscitation

Web-based Integrated 2010 & 2015 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Key Words: cardiopulmonary resuscitation   neonatal

1 Highlights & Introduction

1.1 Highlights

Summary of Key Issues and Major Changes

Neonatal cardiac arrest is predominantly asphyxial, so initiation of ventilation remains the focus of initial resuscitation. The following were the major neonatal topics in 2015:

- The order of the 3 assessment questions has changed to (1) Term gestation? (2) Good tone? and (3) Breathing or crying?
- The Golden Minute (60-second) mark for completing the initial steps, reevaluating, and beginning ventilation (if required) is retained to emphasize the importance of avoiding unnecessary delay in initiation of ventilation, the most important step for successful resuscitation of the newly born who has not responded to the initial steps.
- There is a new recommendation that delayed cord clamping for longer than 30 seconds is reasonable for both term and preterm infants who do not require resuscitation at birth, but there is insufficient evidence to recommend an approach to cord clamping for infants who require resuscitation at birth, and a suggestion against the routine use of cord milking (outside of a research setting) for infants born at less than 29 weeks of gestation, until more is known of benefits and complications.
- Temperature should be recorded as a predictor of outcomes and as a quality indicator.
- Temperature of newly born nonasphyxiated infants should be maintained between 36.5°C and 37.5°C after birth through admission and stabilization.
- A variety of strategies (radiant warmers, plastic wrap with a cap, thermal mattress, warmed humidified gases, and increased room temperature plus cap plus thermal mattress) may be reasonable to prevent hypothermia in preterm infants. Hyperthermia (temperature greater than 38°C) should be avoided because it introduces potential associated risks.
- In resource-limited settings, simple measures to prevent hypothermia in the first hours of life (use of plastic wraps, skinto-skin contact, and even placing the infant after drying in a clean food-grade plastic bag up to the neck) may reduce mortality.
- If an infant is born through meconium-stained amniotic fluid and presents with poor muscle tone and inadequate breathing efforts, the infant should be placed under a radiant warmer and PPV should be initiated if needed. Routine intubation for tracheal suction is no longer suggested because there is insufficient evidence to continue this recommendation. Appropriate intervention to support ventilation and oxygenation should be initiated as indicated for each individual infant. This may include intubation and suction if the airway is obstructed.
- Assessment of heart rate remains critical during the first minute of resuscitation and the use of a 3-lead ECG may be reasonable, because providers may not assess heart rate accurately by auscultation or palpation, and pulse oximetry may underestimate heart rate. Use of the ECG does not replace the need for pulse oximetry to evaluate the newborn's oxygenation.
- Resuscitation of *preterm* newborns of less than 35 weeks of gestation should be initiated with low oxygen (21% to 30%) and the oxygen titrated to achieve preductal oxygen saturation approximating the range achieved in healthy term infants.
- There are insufficient data about the safety and the method of application of sustained inflation of greater than 5 seconds' duration for the transitioning newborn.
- A laryngeal mask may be considered as an alternative to tracheal intubation if face-mask ventilation is unsuccessful, and a laryngeal mask is recommended during resuscitation of newborns 34 weeks or more of gestation when tracheal intubation is unsuccessful or not feasible.
- Spontaneously breathing preterm infants with respiratory distress may be supported with continuous

positive airway pressure initially rather than with routine intubation for administering PPV.
- Recommendations about chest compression technique (2 thumb–encircling hands) and compression-to-ventilation ratio (3:1 with 90 compressions and 30 breaths per minute) remain unchanged. As in the 2010 recommendations, rescuers may consider using higher ratios (e.g., 15:2) if the arrest is believed to be of cardiac origin.
- ==Although there are no available clinical studies about oxygen use during CPR, the Neonatal Guidelines Writing Group continues to endorse the use of 100% oxygen whenever chest compressions are provided. It is reasonable to wean the oxygen concentration as soon as the heart rate recovers.==
- Recommendations about use of epinephrine during CPR and volume administration were not reviewed in 2015, so the 2010 recommendations remain in effect.
- Induced therapeutic hypothermia in resource-abundant areas, for infants born at more than 36 weeks of gestation with evolving moderate to severe hypoxic-ischemic encephalopathy, was not reviewed in 2015, so the 2010 recommendations remain in effect.
- In resource-limited settings, use of therapeutic hypothermia may be considered under clearly defined protocols similar to those used in clinical trials and in facilities with the capabilities for multidisciplinary care and follow-up.
- In general, no new data have been published to justify a change in the 2010 recommendations about withholding or withdrawing resuscitation. An Apgar score of 0 at 10 minutes is a strong predictor of mortality and morbidity in late preterm and term infants, but decisions to continue or discontinue resuscitation efforts must be individualized.
- It is suggested that neonatal resuscitation task training occur more frequently than the current 2-year interval.

Umbilical Cord Management: Delayed Cord Clamping

2015 (Updated): Delayed cord clamping after 30 seconds is suggested for both term and preterm infants who do not require resuscitation at birth. There is insufficient evidence to recommend an approach to cord clamping for infants who require resuscitation at birth.

2010 (Old): There is increasing evidence of benefit of delaying cord clamping for at least 1 minute in term and preterm infants not requiring resuscitation. There is insufficient evidence to support or refute a recommendation to delay cord clamping in infants requiring resuscitation.

Why: In infants who do not require resuscitation, delayed cord clamping is associated with less intraventricular hemorrhage, higher blood pressure and blood volume, less need for transfusion after birth, and less necrotizing enterocolitis. The only adverse consequence found was a slightly increased level of bilirubin, associated with more need for phototherapy.

Suctioning Nonvigorous Infants Through Meconium-Stained Amniotic Fluid

2015 (Updated): If an infant born through meconiumstained amniotic fluid presents with poor muscle tone and inadequate breathing efforts, the initial steps of resuscitation should be completed under the radiant warmer. PPV should be initiated if the infant is not breathing or the heart rate is less than 100/min after the initial steps are completed. Routine intubation for tracheal suction in this setting is not suggested, because there is insufficient evidence to continue recommending this practice. However, a team that includes someone skilled in intubation of the newborn should still be present in the delivery room.

2010 (Old): There was insufficient evidence to recommend a change in the current practice of performing endotracheal suctioning of nonvigorous infants with meconium-stained amniotic fluid.

Why: Review of the evidence suggests that resuscitation should follow the same principles for infants with meconium-stained fluid as for those with clear fluid; that is, if poor muscle tone and inadequate breathing effort are present, the initial steps of resuscitation (warming and maintaining temperature, positioning the infant, clearing the airway of secretions if needed, drying, and stimulating the infant) should be completed under an overbed warmer. PPV should be initiated if the infant is not breathing or the heart rate is less than 100/min after the initial steps are completed. Experts placed greater value on harm avoidance (ie, delays in providing bag-mask ventilation, potential harm of the procedure) over the unknown benefit of the intervention of routine tracheal intubation and suctioning. Appropriate intervention to support ventilation and oxygenation should be initiated as indicated for each individual infant. This may include intubation and suction if the airway is obstructed.

Assessment of Heart Rate: Use of 3-Lead ECG

2015 (Updated): During resuscitation of term and preterm newborns, the use of 3-lead ECG for the rapid and accurate measurement of the newborn's heart rate may be useful. The use of ECG does not replace the need for pulse oximetry to evaluate the newborn's oxygenation.

2010 (Old): Although use of ECG was not mentioned in 2010, the issue of how to assess the heart rate was addressed: Assessment of heart rate should be done by intermittently auscultating the precordial pulse. When a pulse is detectable, palpation of the umbilical pulse can also provide a rapid estimate of the pulse and is more accurate than palpation at other sites. A pulse oximeter can provide a continuous assessment of the pulse without interruption of other resuscitation measures, but the device takes 1 to 2 minutes to apply and may not function during states of very poor cardiac output or perfusion.

Why: Clinical assessment of heart rate in the delivery room has been found to be both unreliable and inaccurate. Underestimation of the heart rate may lead to unnecessary resuscitation. The ECG has been found to display an accurate heart rate faster than pulse oximetry. Pulse oximetry more often displayed a lower rate in the first 2 minutes of life, often at levels that suggest the need for intervention.

Administration of Oxygen to Preterm Newborns

2015 (Updated): Resuscitation of preterm newborns of less than 35 weeks of gestation should be initiated with low oxygen (21% to 30%), and the oxygen concentration should be titrated to achieve a preductal oxygen saturation approximating the interquartile range measured in healthy term infants after vaginal birth at sea level. Initiating resuscitation of preterm newborns with high oxygen (65% or greater) is not recommended. This recommendation reflects a preference for not exposing preterm newborns to additional oxygen without data demonstrating a proven benefit for important outcomes.

2010 (Old): It is reasonable to initiate resuscitation with air (21% oxygen at sea level). Supplementary oxygen may be administered and titrated to achieve a preductal oxygen saturation approximating the interquartile range measured in healthy term infants after vaginal birth at sea level. Most data were from term infants not during resuscitation, with a single study of preterm infants during resuscitation.

Why: Data are now available from a meta-analysis of 7 randomized studies demonstrating no benefit in survival to hospital discharge, prevention of bronchopulmonary dysplasia, intraventricular hemorrhage, or retinopathy of prematurity when preterm newborns (less than 35 weeks of gestation) were resuscitated with high (65% or greater) compared with low (21% to 30%) oxygen concentration.

Postresuscitation Therapeutic Hypothermia: Resource-Limited Settings

2015 (Updated): It is suggested that the use of therapeutic hypothermia in resource-limited settings (ie, lack of qualified staff, inadequate equipment, etc) may be considered and offered under clearly defined protocols similar to those used in published clinical trials and in facilities with the capabilities for multidisciplinary care and longitudinal follow-up.

2010 (Old): It is recommended that infants born at 36 weeks or more of gestation with evolving moderate to severe hypoxic-ischemic encephalopathy should be offered therapeutic hypothermia. Therapeutic hypothermia should be administered under clearly defined protocols similar to those used in published clinical trials and in facilities with the capabilities for multidisciplinary care and longitudinal follow-up.

Why: While the recommendation for therapeutic hypothermia in the treatment of moderate to severe hypoxicischemic encephalopathy in resource-abundant settings remains unchanged, a recommendation was added to guide the use of this modality in settings where resources may limit options for some therapies.

1.2 Introduction

These Web-based Integrated Guidelines incorporate the relevant recommendations from 2010 and the new or updated recommendations from 2015.

The new or updated guidelines are a summary of the evidence presented in the *2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations* (CoSTR).[,1] Throughout the online version of this publication, live links are provided so the reader can connect directly to systematic reviews on the International Liaison Committee on Resuscitation

(ILCOR) Scientific Evidence Evaluation and Review System (SEERS) website. These links are indicated by a combination of letters and numbers (eg, NRP 787). We encourage readers to use the links and review the evidence and appendices.

These guidelines apply primarily to newly born infants transitioning from intrauterine to extrauterine life. The recommendations are also applicable to neonates who have completed newborn transition and require resuscitation during the first weeks after birth.[2] Practitioners who resuscitate infants at birth or at any time during the initial hospitalization should consider following these guidelines. For purposes of these guidelines, the terms *newborn* and *neonate* apply to any infant during the initial hospitalization. The term *newly born* applies specifically to an infant at the time of birth.[2]

Immediately after birth, infants who are breathing and crying may undergo delayed cord clamping ([see Umbilical Cord Management section](#)). However, until more evidence is available, infants who are not breathing or crying should have the cord clamped (unless part of a delayed cord clamping research protocol), so that resuscitation measures can commence promptly.

Approximately 10% of newborns require some assistance to begin breathing at birth. Less than 1% require extensive resuscitation measures,[3] such as cardiac compressions and medications. Although most newly born infants successfully transition from intrauterine to extrauterine life without special help, because of the large total number of births, a significant number will require some degree of resuscitation.[2]

Newly born infants who do not require resuscitation can be generally identified upon delivery by rapidly assessing the answers to the following 3 questions:

- Term gestation?
- Good tone?
- Breathing or crying?

If the answer to all 3 questions is "yes," the newly born infant may stay with the mother for routine care. Routine care means the infant is dried, placed skin to skin with the mother, and covered with dry linen to maintain a normal temperature. Observation of breathing, activity, and color must be ongoing.

If the answer to any of these assessment questions is "no," the infant should be moved to a radiant warmer to receive 1 or more of the following 4 actions in sequence:

A. Initial steps in stabilization (warm and maintain normal temperature, position, clear secretions only if copious and/or obstructing the airway, dry, stimulate)

B. Ventilate and oxygenate

C. Initiate chest compressions

D. Administer epinephrine and/or volume

Approximately 60 seconds ("the Golden Minute") are allotted for completing the initial steps, reevaluating, and beginning ventilation if required (Figure 1). Although the 60-second mark is not precisely defined by science, it is important to avoid unnecessary delay in initiation of ventilation, because this is *the* most important step for successful resuscitation of the newly born who has not responded to the initial steps. The decision to progress beyond the initial steps is determined by simultaneous assessment of 2 vital characteristics: respirations (apnea, gasping, or labored or unlabored breathing) and heart rate (less than 100/min). Methods to accurately assess the heart rate will be discussed in detail in the section on Assessment of Heart Rate. Once positive-pressure ventilation (PPV) or supplementary oxygen administration is started, assessment should consist of simultaneous evaluation of 3 vital characteristics: heart rate, respirations, and oxygen saturation, as determined by pulse oximetry and discussed under Assessment of Oxygen Need and Administration of Oxygen. The most sensitive indicator of a successful response to each step is an increase in heart rate.[2]

2 Anticipation of Resuscitation Need

Readiness for neonatal resuscitation requires assessment of perinatal risk, a system to assemble the appropriate personnel based on that risk, an organized method for ensuring immediate access to supplies and equipment, and standardization of behavioral skills that help assure effective teamwork and communication.
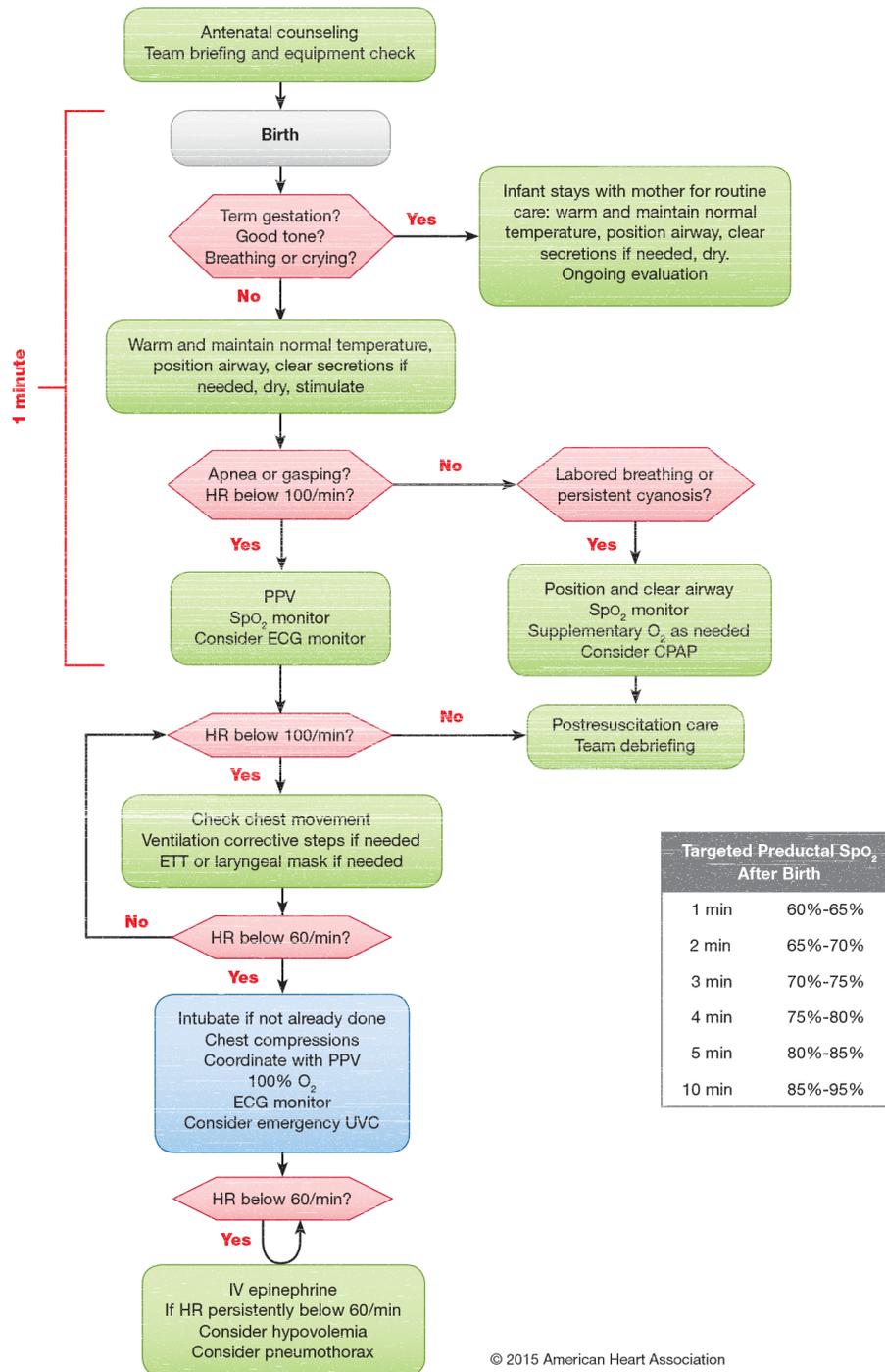
Every birth should be attended by at least 1 person who can perform the initial steps of newborn resuscitation and PPV, and whose only responsibility is care of the newborn. In the presence of significant perinatal risk factors that increase the likelihood of the need for resuscitation,[4,5] additional personnel with resuscitation skills, including chest compressions, endotracheal intubation, and umbilical vein catheter insertion, should be immediately available. Furthermore, because a newborn without apparent risk factors may unexpectedly require resuscitation, each institution should have a procedure in place for rapidly mobilizing a team with complete newborn resuscitation skills for any birth.

The neonatal resuscitation provider and/or team is at a major disadvantage if supplies are missing or equipment is not functioning. A standardized checklist to ensure that all necessary supplies and equipment are present and functioning may be helpful. A known perinatal risk factor, such as preterm birth, requires preparation of supplies specific to thermoregulation and respiratory support for this vulnerable population.

When perinatal risk factors are identified, a team should be mobilized and a team leader identified. As time permits, the leader should conduct a preresuscitation briefing, identify interventions that may be required, and assign roles and responsibilities to the team members.[6,7] During resuscitation, it is vital that the team demonstrates effective communication and teamwork skills to help ensure quality and patient safety.

Figure 1: Neonatal Resuscitation Algorithm—2015 Update

Neonatal Resuscitation Algorithm—2015 Update

Antenatal counseling
Team briefing and equipment check

Birth

Term gestation?
Good tone?
Breathing or crying?

Yes → Infant stays with mother for routine care: warm and maintain normal temperature, position airway, clear secretions if needed, dry. Ongoing evaluation

No

Warm and maintain normal temperature, position airway, clear secretions if needed, dry, stimulate

Apnea or gasping?
HR below 100/min?

No → Labored breathing or persistent cyanosis?

Yes (Apnea): PPV
SpO_2 monitor
Consider ECG monitor

Yes (Labored): Position and clear airway
SpO_2 monitor
Supplementary O_2 as needed
Consider CPAP

HR below 100/min?

No → Postresuscitation care
Team debriefing

Yes

Check chest movement
Ventilation corrective steps if needed
ETT or laryngeal mask if needed

HR below 60/min?

No

Yes

Intubate if not already done
Chest compressions
Coordinate with PPV
100% O_2
ECG monitor
Consider emergency UVC

HR below 60/min?

Yes

IV epinephrine
If HR persistently below 60/min
Consider hypovolemia
Consider pneumothorax

1 minute

Targeted Preductal SpO_2 After Birth	
1 min	60%-65%
2 min	65%-70%
3 min	70%-75%
4 min	75%-80%
5 min	80%-85%
10 min	85%-95%

© 2015 American Heart Association

3 Umbilical Cord Management - NRP 787   NRP 849

Until recent years, a common practice has been to clamp the umbilical cord soon after birth to quickly transfer the infant to the neonatal team for stabilization. This immediate clamping was deemed particularly important for infants at high risk for difficulty with transition and those most likely to require resuscitation, such as infants born preterm. During the 2010 CoSTR review, evidence began to emerge suggesting that delayed cord clamping (DCC) might be beneficial for infants who did not need immediate resuscitation at birth.[6]

The 2015 ILCOR systematic review NRP 787 confirms that DCC is associated with less intraventricular hemorrhage (IVH) of any grade, higher blood pressure and blood volume, less need for transfusion after birth, and less necrotizing enterocolitis. There was no evidence of decreased mortality or decreased incidence of severe IVH.[,1]

The studies were judged to be very low quality (downgraded for imprecision and very high risk of bias). The only negative consequence appears to be a slightly increased level of bilirubin, associated with more need for phototherapy. These findings have led to national recommendations that DCC be practiced when possible.[8,9] A major problem with essentially all of these studies has been that infants who were thought to require resuscitation were either withdrawn from the randomized controlled trials or electively were not enrolled. Therefore, there is no evidence regarding safety or utility of DCC for infants requiring resuscitation and some concern that the delay in establishing ventilation may be harmful. Some studies have suggested that cord "milking" might accomplish goals similar to DCC,[10-12] but there is insufficient evidence of either its safety or utility to suggest its routine use in the newly born, particularly in extremely preterm infants.

In summary, from the evidence reviewed in the 2010 CoSTR[6] and subsequent review of DCC and cord milking in preterm newborns in the 2015 ILCOR systematic review,,[1] DCC for longer than 30 seconds is reasonable for both term and preterm infants who do not require resuscitation at birth. *(Class IIa, LOE C-LD)*

There is insufficient evidence to recommend an approach to cord clamping for infants who require resuscitation at birth, and more randomized trials involving such infants are encouraged. In light of the limited information regarding the safety of rapid changes in blood volume for extremely preterm infants, we suggest against the routine use of cord milking for infants born at less than 29 weeks of gestation outside of a research setting. Further study is warranted because cord milking may improve initial mean blood pressure and hematologic indices and reduce intracranial hemorrhage, but thus far there is no evidence for improvement in long-term outcomes. (Class IIb, LOE C-LD)

4 Initial Steps

The initial steps of newborn resuscitation are to maintain normal temperature of the infant, position the infant in a "sniffing" position to open the airway, clear secretions if needed with a bulb syringe or suction catheter, dry the infant (unless preterm and covered in plastic wrap), and stimulate the infant to breathe. Current examination of the evidence for these practices is summarized below.

4.1 Importance of Maintaining Normal Temperature in the Delivery Room - Updated NRP 589

It has long been recognized (since Budin's 1907 publication of The Nursling)[13] that the admission temperature of newly born nonasphyxiated infants is a strong predictor of mortality at all gestational ages.[14-48] Preterm infants are especially vulnerable. Hypothermia is also associated with serious morbidities, such as increased risk of IVH,[18,25,38,49-53] respiratory issues,[14,18,20,49,54-59] hypoglycemia,[14,43,59-63] and late-onset sepsis.[32,64]

Because of this, admission temperature should be recorded as a predictor of outcomes as well as a quality indicator. *(Class I, LOE B-NR)*

It is recommended that the temperature of newly born nonasphyxiated infants be maintained between 36.5°C and 37.5°C after birth through admission and stabilization.[65] *(Class I, LOE C-LD)*

4.1.1 Interventions to Maintain Newborn Temperature in the Delivery Room - Updated NRP 599

The use of radiant warmers and plastic wrap with a cap has improved but not eliminated the risk of hypothermia in preterm infants in the delivery room. Other strategies have been introduced, which include increased room temperature, thermal mattresses, and the use of warmed humidified resuscitation gases. Various combinations of these strategies may be reasonable to prevent hypothermia in infants born at less than 32 weeks of gestation. (Class IIb, LOE B-R, B-NR, C-LD)

All resuscitation procedures, including endotracheal intubation, chest compression, and insertion of intravenous lines, can be performed with these temperature-controlling interventions in place.
(Class IIb, LOE C)

Compared with plastic wrap and radiant warmer, the addition of a thermal mattress,[66-70] warmed humidified gases,[71,72] and increased room temperature plus cap plus thermal mattress[54,56,58,73] were all effective in reducing hypothermia. For all the studies, hyperthermia was a concern, but harm was not shown.

Hyperthermia (greater than 38.0°C) should be avoided due to the potential associated risks.
(Class III: Harm, LOE C-EO)

4.1.1.1 Warming Hypothermic Newborns to Restore Normal Temperature - Updated NRP 858

The traditional recommendation for the method of rewarming neonates who are hypothermic after resuscitation has been that slower is preferable to faster rewarming to avoid complications such as apnea and arrhythmias. However, there is insufficient current evidence to recommend a preference for either rapid (0.5°C/h or greater) or slow rewarming (less than 0.5°C/h) of unintentionally hypothermic newborns (temperature less than 36°C) at hospital admission. Either approach to rewarming may be reasonable (Class IIb, LOE C-LD)

4.1.1.2 Effect of Maternal Hypothermia and Hyperthermia on the Neonate - Updated NRP 804

Maternal hyperthermia in labor is associated with adverse neonatal effects. These include increased mortality,[74,75] neonatal seizures,[74-80] and adverse neurologic states like encephalopathy.[81-84] Maternal hypothermia in labor has not been shown to be associated with clinically significant adverse neonatal outcomes at the time of birth.[85-89] Although maternal hyperthermia is associated with adverse neonatal outcomes, there is insufficient evidence to make a recommendation on the management of maternal hyperthermia.

4.1.2 Maintaining Normothermia in Resource-Limited Settings - Updated NRP 793

The ability to maintain temperature in resource-limited settings after birth is a significant problem,[39] with a dose-dependent increase in mortality for temperatures below 36.5°C. Premature newborns are at much higher risk than those born at term. Simple interventions to prevent hypothermia during transition (birth until 1 to 2 hours of life) reduce mortality. During transition, the use of plastic wraps[90-92] and the use of skin-to-skin contact[93-100] reduce hypothermia.

In resource-limited settings, to maintain body temperature or prevent hypothermia during transition (birth until 1 to 2 hours of life) in well newborn infants, it may be reasonable to put them in a clean food-grade plastic bag up to the level of the neck and swaddle them after drying. (Class IIb, LOE C-LD)

Another option that may be reasonable is to nurse such newborns with skin-to-skin contact or kangaroo mother care. (Class IIb, LOE C-LD)

There are no data examining the use of plastic wraps or skin-to-skin contact during resuscitation/stabilization in resource-limited settings.

4.2 Clearing the Airway

4.2.1 When Amniotic Fluid is Clear - Updated

This topic was last reviewed in 2010.[2] Suctioning immediately after birth, whether with a bulb syringe or suction catheter, may be considered only if the airway appears obstructed or if PPV is required.

Therefore it is recommended that suctioning immediately following birth (including suctioning with a bulb syringe) should be reserved for babies who have obvious obstruction to spontaneous breathing or who require positive-pressure ventilation (PPV). (Class IIb, LOE C)

Avoiding unnecessary suctioning helps prevent the risk of induced bradycardia due to suctioning of the nasopharynx.[101,102] Deterioration of pulmonary compliance, oxygenation, and cerebral blood flow velocity shown to accompany tracheal suction in intubated infants in the neonatal intensive care unit also suggests the need for caution in the use of suction immediately after birth.[103-105] This recommendation remains unchanged. Please refer to the 2010 CoSTR for the latest science review.[6,7]

4.2.2 When Meconium is Present - Updated[NRP 865]

Since the mid-1970s, interventions to decrease the mortality and morbidity of meconium aspiration syndrome in infants who are born through meconium-stained amniotic fluid have been recommended. The practice of universal oropharyngeal suctioning of the fetus on the perineum followed by routine intubation and suctioning of the trachea at birth was generally practiced for many years. This practice was abandoned over a decade ago after a large multicenter, multinational randomized clinical trial provided evidence that newborns born through meconium-stained amniotic fluid who were vigorous at birth did not benefit from intervention and could avoid the risk of intubation.[106]

Because the presence of meconium-stained amniotic fluid may indicate fetal distress and increases the risk that the infant will require resuscitation after birth, a team that includes an individual skilled in tracheal intubation should be present at the time of birth. If the infant is vigorous with good respiratory effort and muscle tone, the infant may stay with the mother to receive the initial steps of newborn care. Gentle clearing of meconium from the mouth and nose with a bulb syringe may be done if necessary.

However, if the infant born through meconium-stained amniotic fluid presents with poor muscle tone and inadequate breathing efforts, the initial steps of resuscitation should be completed under the radiant warmer. PPV should be initiated if the infant is not breathing or the heart rate is less than 100/min after the initial steps are completed. Routine intubation for tracheal suction in this setting is not suggested, because there is insufficient evidence to continue recommending this practice. (Class IIb, LOE C-LD)

In making this suggested change, greater value has been placed on harm avoidance (ie, delays in providing bag-mask ventilation, potential harm of the procedure) over the unknown benefit of the intervention of routine tracheal intubation and suctioning. Therefore, emphasis should be made on initiating ventilation within the first minute of life in nonbreathing or ineffectively breathing infants.

Although a definitive randomized clinical trial is still needed, current published human evidence does not support a recommendation for routine intervention of intubation and suction for the nonvigorous newborn with meconium-stained amniotic fluid.[107-116] Appropriate intervention to support ventilation and oxygenation should be initiated as indicated for each individual infant. This may include intubation and suction if the airway is obstructed.

4.3 Assessment of Heart Rate - Updated[NRP 898]

Immediately after birth, assessment of the newborn's heart rate is used to evaluate the effectiveness of spontaneous respiratory effort and determine the need for subsequent interventions. During resuscitation, an increase in the newborn's heart rate is considered the most sensitive indicator of a successful response to each intervention. Therefore, identifying a rapid, reliable, and accurate method to measure the newborn's heart rate is critically important. In previous treatment guidelines, auscultation of the precordium was recommended as the preferred physical examination method, and pulse oximetry was recommended as an adjunct to provide a noninvasive, rapid, and continuous assessment of heart rate during resuscitation.[2]

The 2015 ILCOR systematic review evaluated 1 study comparing clinical assessment with electrocardiography (ECG) in the delivery room[117] and 5 studies comparing simultaneous pulse oximetry and ECG.[118-122] Clinical assessment was found to be both unreliable and inaccurate. Among healthy newborns, providers frequently could not palpate the umbilical pulse and underestimated the newborn's heart rate by auscultation or palpation.[117] Four studies found that 3-lead ECG displayed a reliable heart rate faster than pulse oximetry.[118,120-122] In 2 studies, ECG was more likely to detect the newborn's heart rate during the first minute of life.[120,121] Although

the mean differences between the series of heart rates measured by ECG and pulse oximetry were small, pulse oximetry tended to underestimate the newborn's heart rate and would have led to potentially unnecessary interventions.[118,119,122] During the first 2 minutes of life, pulse oximetry frequently displayed the newborn's heart rate below either 60/ min or 100/min, while a simultaneous ECG showed the heart rate greater than 100/min.[122]

Many of the newborns included in the studies did not require resuscitation, and very few required chest compressions. The majority of the studies did not report any difficulties with applying the leads.[118-120]

During resuscitation of term and preterm newborns, the use of 3-lead ECG for the rapid and accurate measurement of the newborn's heart rate may be reasonable. (Class IIb, LOE C-LD)

The use of ECG does not replace the need for pulse oximetry to evaluate the newborn's oxygenation.

4.4 Assessment of Oxygen Need and Administration of Oxygen - Updated

There is a large body of evidence that blood oxygen levels in uncompromised babies generally do not reach extrauterine values until approximately 10 minutes following birth. Oxyhemoglobin saturation may normally remain in the 70% to 80% range for several minutes following birth, thus resulting in the appearance of cyanosis during that time. Other studies have shown that clinical assessment of skin color is a very poor indicator of oxyhemoglobin saturation during the immediate neonatal period and that lack of cyanosis appears to be a very poor indicator of the state of oxygenation of an uncompromised baby following birth.

Optimal management of oxygen during neonatal resuscitation becomes particularly important because of the evidence that either insufficient or excessive oxygenation can be harmful to the newborn infant. Hypoxia and ischemia are known to result in injury to multiple organs. Conversely there is growing experimental evidence, as well as evidence from studies of babies receiving resuscitation, that adverse outcomes may result from even brief exposure to excessive oxygen during and following resuscitation.

4.4.1 Use of Pulse Oximetry - Updated

This topic was last reviewed in 2010.[2]

It is recommended that oximetry be used when resuscitation can be anticipated, when PPV is administered, when central cyanosis persists beyond the first 5 to 10 minutes of life, or when supplementary oxygen is administered.

To appropriately compare oxygen saturations to similar published data, the probe should be attached to a preductal location (ie, the right upper extremity, usually the wrist or medial surface of the palm).[123]

4.4.2 Administration of Oxygen - Updated

4.4.2.1 Term Infants - Updated

This topic was last reviewed in 2010.[2]

Two meta-analyses of several randomized controlled trials comparing neonatal resuscitation initiated with room air versus 100% oxygen showed increased survival when resuscitation was initiated with air.[124,125] There are no studies in term infants comparing outcomes when resuscitations are initiated with different concentrations of oxygen other than 100% or room air.

It is reasonable to initiate resuscitation with air (21% oxygen at sea level).

If blended oxygen is not available, resuscitation should be initiated with air. (Class IIb, LOE B)

In the absence of studies comparing outcomes of neonatal resuscitation initiated with other oxygen concentrations or targeted at various oxyhemoglobin saturations, it is recommended that the goal in babies being resuscitated at birth, whether born at term or preterm, should be an oxygen saturation value in the interquartile range of preductal saturations (see table in Figure) measured in healthy term babies following vaginal birth at sea level. (Class IIb, LOE B)

These targets may be achieved by initiating resuscitation with air or a blended oxygen and titrating the oxygen concentration to achieve an SpO2 in the target range as described above using pulse oximetry. (Class IIb, LOE C)

If the baby is bradycardic (HR (Class IIb, LOE B)

4.4.2.2 Preterm - Updated [NRP 864]

Meta-analysis of 7 randomized trials that compared initiating resuscitation of preterm newborns (less than 35 weeks of gestation) with high oxygen (65% or greater) and low oxygen (21% to 30%) showed no improvement in survival to hospital discharge with the use of high oxygen.[126-132] Similarly, in the subset of studies that evaluated these outcomes, no benefit was seen for the prevention of bronchopulmonary dysplasia,[127,129-132] IVH,[127,130,131] or retinopathy of prematurity.[127,130,131] When oxygen targeting was used as a cointervention, the oxygen concentration of resuscitation gas and the preductal oxygen saturation were similar between the high-oxygen and low-oxygen groups within the first 10 minutes of life.[127,130,131]

In all studies, irrespective of whether air or high oxygen (including 100%) was used to initiate resuscitation, most infants were in approximately 30% oxygen by the time of stabilization.

Resuscitation of preterm newborns of less than 35 weeks of gestation should be initiated with low oxygen (21% to 30%), and the oxygen concentration should be titrated to achieve preductal oxygen saturation approximating the interquartile range measured in healthy term infants after vaginal birth at sea level.[133] (Class I, LOE B-R)

Initiating resuscitation of preterm newborns with high oxygen (65% or greater) is not recommended. (Class III—No Benefit, LOE B-R)

This recommendation reflects a preference for not exposing preterm newborns to additional oxygen without data demonstrating a proven benefit for important outcomes.

5 Positive Pressure Ventilation (PPV)

5.1 Initial Breaths [NRP 809]

Several recent animal studies have suggested that a longer sustained inflation may be beneficial for establishing functional residual capacity during transition from fluid-filled to air-filled lungs after birth.[134,135] Some clinicians have suggested applying this technique for transition of human newborns. Review of the literature in 2015 identified 3 randomized controlled trials[136-138] and 2 cohort studies[139,140] that demonstrated a benefit of sustained inflation for reducing need for mechanical ventilation (very low quality of evidence, downgraded for variability of interventions). However, no benefit was found for reduction of mortality, bronchopulmonary dysplasia, or air leak. One cohort study[139] suggested that the need for intubation was less after sustained inflation.

There is insufficient data regarding short and long-term safety and the most appropriate duration and pressure of inflation to support routine application of sustained inflation of greater than 5 seconds' duration to the transitioning newborn. (Class IIb, LOE B-R)

Further studies using carefully designed protocols are needed.

The 2010 recommendations are as follows:

Initial inflations following birth, either spontaneous or assisted, create a functional residual capacity (FRC).[141-144] The optimal pressure, inflation time, and flow rate required to establish an effective FRC when PPV is administered during resuscitation have not been determined. Evidence from animal studies indicates that preterm lungs are easily injured by large-volume inflations immediately after birth.[145,146] Assisted ventilation rates of 40 to 60 breaths per minute are commonly used, but the relative efficacy of various rates has not been investigated.

The primary measure of adequate initial ventilation is prompt improvement in heart rate.[147] Chest wall movement should be assessed if heart rate does not improve. The initial peak inflating pressures needed are variable and unpredictable and should be individualized to achieve an increase in heart rate or movement of the chest with each breath.

Inflation pressure should be monitored; an initial inflation pressure of 20 cm H2O may be effective, but ?30 to 40 cm H2O may be required in some term babies without spontaneous ventilation.[142,144,148] (Class IIb, LOE C)

If circumstances preclude the use of pressure monitoring, the minimal inflation required to achieve an increase in heart rate should be used. There is insufficient evidence to recommend an optimum inflation time.

In summary, assisted ventilation should be delivered at a rate of 40 to 60 breaths per minute to promptly achieve or maintain a heart rate >100 per minute. (Class IIb, LOE C)

The use of colorimetric CO_2 detectors during mask ventilation of small numbers of preterm infants in the intensive care unit and in the delivery room has been reported, and such detectors may help to identify airway obstruction.[149,150]

However, it is unclear whether the use of CO2 detectors during mask ventilation confers additional benefit above clinical assessment alone. (Class IIb, LOE C)

5.2 End-Expiratory Pressure NRP 897

Administration of PPV is the standard recommended treatment for both preterm and term infants who are apneic. A flow-inflating or self-inflating resuscitation bag or T-piece resuscitator are appropriate devices to use for PPV. In the 2010 Guidelines[2] and based on experience with delivering PPV in the neonatal intensive care unit, the use of positive end-expiratory pressure (PEEP) was speculated to be beneficial when PPV is administered to the newly born, but no published evidence was available to support this recommendation. PEEP was evaluated again in 2015, and 2 randomized controlled trials[151,152] suggested that addition of PEEP during delivery room resuscitation of preterm newborns resulted in no improvement in mortality, no less need for cardiac drugs or chest compressions, no more rapid improvement in heart rate, no less need for intubation, no change in pulmonary air leaks, no less chronic lung disease, and no effect on Apgar scores, although the studies were underpowered to have sufficient confidence in a no-difference conclusion. However, 1 of the trials[152] provided low-quality evidence that the maximum amount of supplementary oxygen required to achieve target oxygen saturation may be slightly less when using PEEP.

In 2015, the Neonatal Resuscitation ILCOR and Guidelines Task Forces repeated their 2010

recommendation that, when PPV is administered to preterm newborns, approximately 5 cm H2O PEEP is suggested. (Class IIb, LOE B-R)

This will require the addition of a PEEP valve for self-inflating bags.

5.3 Assisted-Ventilation Devices and Advanced Airways _{NRP 870, NRP 806}

PPV can be delivered effectively with a flow-inflating bag, self-inflating bag, or T-piece resuscitator.[151], [152](Class IIa, LOE B-R)

PPV can be delivered effectively with a flow-inflating bag, self-inflating bag, or T-piece resuscitator.138,139 (Class IIa, LOE B-R)

The most appropriate choice may be guided by available resources, local expertise, and preferences. The self-inflating bag remains the only device that can be used when a compressed gas source is not available. Unlike flow-inflating bags or T-piece resuscitators, self-inflating bags cannot deliver continuous positive airway pressure (CPAP) and may not be able to achieve PEEP reliably during PPV, even with a PEEP valve.[153-156] However, it may take more practice to use a flow-inflating bag effectively. In addition to ease of use, T-piece resuscitators can consistently provide target inflation pressures and longer inspiratory times in mechanical models,[157-159] but there is insufficient evidence to suggest that these qualities result in improved clinical outcomes.[151,152]

It is likely that inflation pressures will need to change as compliance improves following birth, but the relationship of pressures to delivered volume and the optimal volume to deliver with each breath as FRC is being established have not been studied.

Resuscitators are insensitive to changes in lung compliance, regardless of the device being used.[160] (Class IIb, LOE C)

Use of respiratory mechanics monitors have been reported to prevent excessive pressures and tidal volumes[161] and exhaled CO2 monitors may help assess that actual gas exchange is occurring during face-mask PPV attempts.[162] Although use of such devices is feasible, thus far their effectiveness, particularly in changing important outcomes, has not been established. (Class IIb, LOE C-LD)

5.3.1 Laryngeal Mask - Updated _{NRP 618}

Laryngeal masks, which fit over the laryngeal inlet, can achieve effective ventilation in term and preterm newborns at 34 weeks or more of gestation. Data are limited for their use in preterm infants delivered at less than 34 weeks of gestation or who weigh less than 2000 g. A laryngeal mask may be considered as an alternative to tracheal intubation if face-mask ventilation is unsuccessful in achieving effective ventilation.[163](Class IIb, LOE B-R)

A laryngeal mask is recommended during resuscitation of term and preterm newborns at 34 weeks or more of gestation when tracheal intubation is unsuccessful or is not feasible. (Class I, LOE C-EO)

Use of the laryngeal mask has not been evaluated during chest compressions or for administration of emergency medications.

5.3.2 Endotracheal Tube Placement

During neonatal resuscitation, endotracheal intubation may be indicated when bag-mask ventilation is ineffective or prolonged, when chest compressions are performed, or for special circumstances such as congenital diaphragmatic hernia. When PPV is provided through an endotracheal tube, the best indicator of successful

endotracheal intubation with successful inflation and aeration of the lungs is a prompt increase in heart rate. Although last reviewed in 2010,[2] exhaled CO detection remains the most reliable method of confirmation of endotracheal tube placement.[6,7]

Exhaled CO2 detection is effective for confirmation of endotracheal tube placement in infants, including very low-birth-weight infants.[164-167] *(Class IIa, LOE B)*

A positive test result (detection of exhaled CO_2) in patients with adequate cardiac output confirms placement of the endotracheal tube within the trachea, whereas a negative test result (ie, no CO_2 detected) strongly suggests esophageal intubation.[164-168]

Exhaled CO2 detection is the recommended method of confirmation of endotracheal tube placement. *(Class IIa, LOE B)*

Failure to detect exhaled CO2 in neonates with adequate cardiac output strongly suggests esophageal intubation. Poor or absent pulmonary blood flow (eg, during cardiac arrest) may result in failure to detect exhaled CO2 despite correct tube placement in the trachea and may result in unnecessary extubation and reintubation in these critically ill newborns.[2] Clinical assessment such as chest movement, presence of equal breath sounds bilaterally, and condensation in the endotracheal tube are additional indicators of correct endotracheal tube placement.

Clinical assessment such as chest movement, presence of equal breath sounds bilaterally, and condensation in the endotracheal tube are additional indicators of correct endotracheal tube placement.

5.4 Continuous Positive Airway Pressure (CPAP) NRP 590

Three randomized controlled trials enrolling 2358 preterm infants born at less than 30 weeks of gestation demonstrated that starting newborns on CPAP may be beneficial when compared with endotracheal intubation and PPV.[169-171] Starting CPAP resulted in decreased rate of intubation in the delivery room, decreased duration of mechanical ventilation with potential benefit of reduction of death and/or bronchopulmonary dysplasia, and no significant increase in air leak or severe IVH.

Based on this evidence, spontaneously breathing preterm infants with respiratory distress may be supported with CPAP initially rather than routine intubation for administering PPV. *(Class IIb, LOE B-R)*

6 Chest Compressions NRP 605   NRP 895   NRP 738   NRP 862

If the heart rate is less than 60/min despite adequate ventilation (via endotracheal tube if possible), chest compressions are indicated. Because ventilation is the most effective action in neonatal resuscitation and because chest compressions are likely to compete with effective ventilation, rescuers should ensure that assisted ventilation is being delivered optimally before starting chest compressions.[2]

Compressions are delivered on the lower third of the sternum[172-175] to a depth of approximately one third of the anterior-posterior diameter of the chest.[176] *(Class IIb, LOE C-LD)*

Two techniques have been described: compression with 2 thumbs with the fingers encircling the chest and supporting the back (the 2-thumb technique) or compression with 2 fingers with a second hand supporting the back (the 2-finger technique).

Because the 2-thumb technique generates higher blood pressures and coronary perfusion pressure with less rescuer fatigue, the 2 thumb–encircling hands technique is suggested as the preferred method.[177-191]*(Class IIb, LOE C-LD)*

Because the 2-thumb technique can be continued from the head of the bed while the umbilicus is accessed for insertion of an umbilical catheter, the 2-finger technique is no longer needed.

It is still suggested that compressions and ventilations be coordinated to avoid simultaneous delivery. The chest should be allowed to re-expand fully during relaxation, but the rescuer's thumbs should not leave the chest. The Neonatal Resuscitation ILCOR and Guidelines Task Forces continue to support use of a 3:1 ratio of compressions to ventilation, with 90 compressions and 30 breaths to achieve approximately 120 events per minute to maximize ventilation at an achievable rate.[192-197] *(Class IIa, LOE C-LD)*

Thus each event will be allotted approximately 1/2 second, with exhalation occurring during the first compression after each ventilation. (Class IIb, LOE C)

A 3:1 compression-to-ventilation ratio is used for neonatal resuscitation where compromise of gas exchange is nearly always the primary cause of cardiovascular collapse, but rescuers may consider using higher ratios (eg, 15:2) if the arrest is believed to be of cardiac origin. (Class IIb, LOE C-EO)

Respirations, heart rate, and oxygenation should be reassessed periodically, and coordinated chest compressions and ventilations should continue until the spontaneous heart rate is ?60 per minute. (Class IIb, LOE C)

However, frequent interruptions of compressions should be avoided, as they will compromise artificial maintenance of systemic perfusion and maintenance of coronary blood flow. (Class IIb, LOE C)

The Neonatal Guidelines Writing Group endorses increasing the oxygen concentration to 100% whenever chest compressions are provided. (Class IIa, LOE C-EO)

There are no available clinical studies regarding oxygen use during neonatal CPR. Animal evidence shows no advantage to 100% oxygen during CPR.[198-205] However, by the time resuscitation of a newborn infant has reached the stage of chest compressions, efforts to achieve return of spontaneous circulation using effective ventilation with low-concentration oxygen should have been attempted. Thus, it would appear sensible to try increasing the supplementary oxygen concentration.

To reduce the risks of complications associated with hyperoxia the supplementary oxygen concentration should be weaned as soon as the heart rate recovers. (Class I, LOE C-LD)

The current measure for determining successful progress in neonatal resuscitation is to assess the heart rate response. Other devices, such as end-tidal CO_2 monitoring and pulse oximetry, may be useful techniques to determine when return of spontaneous circulation occurs.[206-210]

However, in asystolic/bradycardic neonates, we suggest against the routine use of any single feedback device such as ETCO2 monitors or pulse oximeters for detection of return of spontaneous circulation as their usefulness for this purpose in neonates has not been well established. *(Class IIb, LOE C-LD)*

7 Medications

Drugs are rarely indicated in resuscitation of the newly born infant. Bradycardia in the newborn infant is usually the result of inadequate lung inflation or profound hypoxemia, and establishing adequate ventilation is the most important step to correct it. However, if the heart rate remains less than 60/min despite adequate ventilation with 100% oxygen (preferably through an endotracheal tube) and chest compressions, administration of epinephrine or volume, or both, is indicated.[2]

7.1 Epinephrine

This topic was last reviewed in 2010.[2] Dosing recommendations remain unchanged from 2010.[6,7] Intravenous administration of epinephrine may be considered at a dose of 0.01 to 0.03 mg/kg of 1:10 000 epinephrine. If endotracheal administration is attempted while intravenous access is being established, higher dosing at 0.05 to 0.1 mg/kg may be reasonable. Given the lack of supportive data for endotracheal epinephrine, it is reasonable to provide drugs by the intravenous route as soon as venous access is established.

The 2010 Guidelines are as follows:

Epinephrine is recommended to be administered intravenously. *(Class IIb, LOE C)*

Given the lack of supportive data for endotracheal epinephrine, the IV route should be used as soon as venous access is established. *(Class IIb, LOE C)*

The recommended IV dose is 0.01 to 0.03 mg/kg per dose. Higher IV doses are not recommended because animal[211,212] and pediatric[213,214] studies show exaggerated hypertension, decreased myocardial function, and worse neurological function after administration of IV doses in the range of 0.1 mg/kg. If the endotracheal route is used, doses of 0.01 or 0.03 mg/kg will likely be ineffective.

Therefore, IV administration of 0.01 to 0.03 mg/kg per dose is the preferred route. While access is being obtained, administration of a higher dose (0.05 to 0.1 mg/kg) through the endotracheal tube may be considered, but the safety and efficacy of this practice have not been evaluated. *(Class IIb, LOE C)*

The concentration of epinephrine for either route should be 1:10 000 (0.1 mg/mL).

8 Volume Expansion

This topic was last reviewed in 2010.[2] Dosing recommendations remain unchanged from 2010. [6,7]

Volume expansion should be considered when blood loss is known or suspected (pale skin, poor perfusion, weak pulse) and the infant's heart rate has not responded adequately to other resuscitative measures.[215] *(Class IIb, LOE C)*

An isotonic crystalloid solution or blood may be useful for volume expansion in the delivery room. *(Class IIb, LOE C)*

The recommended dose is 10 mL/kg, which may need to be repeated. When resuscitating premature infants, care should be taken to avoid giving volume expanders rapidly, because rapid infusions of large volumes have been associated with IVH. (Class IIb, LOE C)

9 Postresuscitation Care

Infants who require resuscitation are at risk of deterioration after their vital signs have returned to normal. Once effective ventilation and/or the circulation has been established, the infant should be maintained in or transferred to an environment where close monitoring and anticipatory care can be provided.

9.1 Glucose - Updated

In the 2010 Guidelines, the potential role of glucose in modulating neurologic outcome after hypoxia-ischemia was identified. Lower glucose levels were associated with an increased risk for brain injury, while increased glucose levels may be protective. However, it was not possible to recommend a specific protective target glucose concentration range. There are no new data to change this recommendation.[6,7]

Intravenous glucose infusion should be considered as soon as practical after resuscitation, with the goal of avoiding hypoglycemia. (Class IIb, LOE C)

9.2 Induced Therapeutic Hypothermia

9.2.1 Resource-Abundant Areas

Induced therapeutic hypothermia was last reviewed in 2010.

It is recommended that infants born at more than 36 weeks of gestation with evolving moderate-to-severe hypoxic-ischemic encephalopathy should be offered therapeutic hypothermia under clearly defined protocols similar to those used in published clinical trials and in facilities with the capabilities for multidisciplinary care and longitudinal follow-up.[6,7] (Class IIa, LOE A)

This recommendation remains unchanged.

9.2.2 Resource-Limited Areas [NRP 734]

Evidence suggests that use of therapeutic hypothermia in resource-limited settings (ie, lack of qualified staff, inadequate equipment, etc) may be considered and offered under clearly defined protocols similar to those used in published clinical trials and in facilities with the capabilities for multidisciplinary care and longitudinal follow-up.[216-219] (Class IIb, LOE-B-R)

10 Guidelines for Withholding and Discontinuing

Data reviewed for the 2010 Guidelines regarding management of neonates born at the margins of viability or those with conditions that predict a high risk of mortality or morbidity document wide variation in attitudes and practice by region and availability of resources. Additionally, parents desire a larger role in decisions related to initiation of resuscitation and continuation of support of severely compromised newborns. Noninitiation of resuscitation and discontinuation of life-sustaining treatment during or after resuscitation are considered ethically equivalent. The 2010 Guidelines provide suggestions for when resuscitation is not indicated, when it is nearly always indicated, and that under circumstances when outcome remains unclear, that the desires of the parents should be supported. No new data have been published that would justify a change to these guidelines as published in 2010.[6,7]

Antenatal assignment of prognosis for survival and/or disability of the neonate born extremely preterm has generally been made on the basis of gestational age alone. Scoring systems for including additional variables such as gender, use of maternal antenatal steroids, and multiplicity have been developed in an effort to improve prognostic accuracy. Indeed, it was suggested in the 2010 Guidelines that decisions regarding morbidity and

risks of morbidity may be augmented by the use of published tools based on data from specific populations.

The 2010 Guidelines are as follows:

It is possible to identify conditions associated with high mortality and poor outcome in which withholding resuscitative efforts may be considered reasonable, particularly when there has been the opportunity for parental agreement.[220],[221] *(Class IIb, LOE C)*

A consistent and coordinated approach to individual cases by the obstetric and neonatal teams and the parents is an important goal. Noninitiation of resuscitation and discontinuation of life-sustaining treatment during or after resuscitation are ethically equivalent, and clinicians should not hesitate to withdraw support when functional survival is highly unlikely.[222] The following guideline must be interpreted according to current regional outcomes:

When gestation, birth weight, or congenital anomalies are associated with almost certain early death and when unacceptably high morbidity is likely among the rare survivors, resuscitation is not indicated (Class IIb, LOE C)

10.1 Withholding Resuscitation NRP 805

There is no evidence to support the prospective use of any particular delivery room prognostic score presently available over gestational age assessment alone, in preterm infants at less than 25 weeks of gestation. Importantly, no score has been shown to improve the clinician's ability to estimate likelihood of survival through the first 18 to 22 months after birth.

However, in individual cases, when counseling a family and constructing a prognosis for survival at gestations below 25 weeks, it is reasonable to consider variables such as perceived accuracy of gestational age assignment, the presence or absence of chorioamnionitis, and the level of care available for location of delivery. It is also recognized that decisions about appropriateness of resuscitation below 25 weeks of gestation will be influenced by region-specific guidelines. In making this statement, a higher value was placed on the lack of evidence for a generalized prospective approach to changing important outcomes over improved retrospective accuracy and locally validated counseling policies. The most useful data for antenatal counseling provides outcome figures for infants alive at the onset of labor, not only for those born alive or admitted to a neonatal intensive care unit.[223-227]*(Class IIb, LOE C-LD)*

10.2 Discontinuing Resuscitative Efforts NRP 896

An Apgar score of 0 at 10 minutes is a strong predictor of mortality and morbidity in late preterm and term infants.

We suggest that, in infants with an Apgar score of 0 after 10 minutes of resuscitation, if the heart rate remains undetectable, it may be reasonable to stop assisted ventilation; however, the decision to continue or discontinue resuscitative efforts must be individualized. Variables to be considered may include whether the resuscitation was considered optimal; availability of advanced neonatal care, such as therapeutic hypothermia; specific circumstances before delivery (eg, known timing of the insult); and wishes expressed by the family.[228-233]*(Class IIb, LOE C-LD)*

11 Briefing/Debriefing

This topic was last reviewed in 2010.[2] It is still suggested that briefing and debriefing techniques be used whenever possible for neonatal resuscitation.

Also, studies examining briefings or debriefings of resuscitation team performance have generally shown improved knowledge or skills.[234-239] Interpretation of data is complicated by the heterogeneity and limitations of the studies, including a paucity of data about clinical outcomes.

Based on available evidence, it is recommended that the AAP/AHA Neonatal Resuscitation Program adopt simulation, briefing, and debriefing techniques in designing an education program for the acquisition and maintenance of the skills necessary for effective neonatal resuscitation.
(Class IIb, LOE C)

12 Structure of Educational Programs to Teach Neonatal Resuscitation

12.1 Instructors NRP 867

In studies that looked at the preparation of instructors for the training of healthcare providers, there was no association between the preparation provided and instructor or learner performance.[240-247]

Until more research is available to clarify the optimal instructor training methodology, it is suggested that neonatal resuscitation instructors be trained using timely, objective, structured, and individually targeted verbal and/or written feedback (Class IIb, LOE C-EO)

12.2 Resuscitation Providers NRP 859

The 2010 Guidelines suggested that simulation should become a standard component in neonatal resuscitation training.[2,5,248]

Studies that explored how frequently healthcare providers or healthcare students should train showed no differences in patient outcomes (LOE C-EO) but were able to show some advantages in psychomotor performance (LOE B-R) and knowledge and confidence (LOE C-LD) when focused training occurred every 6 months or more frequently.[249-264](Class IIb, LOE B-R)

It is therefore suggested that neonatal resuscitation task training occur more frequently than the current 2-year interval.[65](Class IIb, LOE B-R)

13 Authorship and Disclosures

13.1 2015 Writing Team

Myra H. Wyckoff, Chair; Khalid Aziz; Marilyn B. Escobedo; Vishal S. Kapadia; John Kattwinkel; Jeffrey M. Perlman; Wendy M. Simon; Gary M. Weiner; Jeanette G. Zaichkin

---

Table 1: Part 13: Neonatal Resuscitation: 2015 Guidelines Update Writing Group Disclosures

Open table in a [new window](#)

Part 13: Neonatal Resuscitation: 2015 Guidelines Update Writing Group Disclosures								
Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Expert Witness	Ownership Interest	Consultant/Advisory Board	Other
Myra H. Wyckoff	UT Southwestern Medical School	None	None	None	None	None	None	None

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Expert Witness	Ownership Interest	Consultant/Advisory Board	Other
Khalid Aziz	Royal Alexandra Hospital	None	None	None	None	None	None	None
Marilyn B. Escobedo	University of Oklahoma Medical School	None	None	None	None	None	None	None
Vishal S. Kapadia	UT Southwestern	None	Neonatal Resuscitation Program*; NIH/NCATS KL2TR00110	None	None	None	None	None
John Kattwinkel	University of Virginia Health System	None	None	None	None	None	None	None
Jeffrey M. Perlman	Weill Cornell Medical College	None	Laerdal Foundation for Global Health*	None	None	None	None	None
Wendy M. Simon	American Academy of Pediatrics	None	None	None	None	None	None	None
Gary M. Weiner	University of Michigan	None	None	None	None	None	American Academy of Pediatrics†	None
Jeannette G. Zaichkin	Self-employed	None	None	None	None	None	American Academy of Pediatrics†	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition. *Modest. †Significant.

13.2 2010 Writing Team

John Kattwinkel, Co-Chair; Jeffrey M. Perlman, Co-Chair; Khalid Aziz; Christopher Colby; Karen Fairchild; John Gallagher; Mary Fran Hazinski; Louis P. Halamek; Praveen Kumar; George Little; Jane E. McGowan; Barbara Nightengale; Mildred M. Ramirez; Steven Ringer; Wendy M. Simon; Gary M. Weiner; Myra Wyckoff; Jeanette

Zaichkin

Table 2: 2010 - Guidelines Part 15: Neonatal Resuscitation Writing Group Disclosures

Open table in a [new window](#)

2010 Guidelines Part 15: Neonatal Resuscitation Writing Group Disclosures							
Writing Group Member	**Employment**	**Research Grant**	**Other Research Support**	**Speakers' Bureau/ Honoraria**	**Ownership Interest**	**Consultant/ Advisory Board**	**Other**
John Kattwinkel	University of Virginia–Professor of Pediatrics	None	None	None	None	None	None
Jeffrey M. Perlman	Weill Cornell-Professor of Pediatrics	†NIH-NIH-Improving antimicrobial prescribing practices in the NICU	None	None	None	None	None
Khalid Aziz	University of Alberta–Associate Professor of Pediatrics	None	None	None	None	None	None
Christopher Colby	Mayo Clinic–physician	None	None	None	None	None	None
Karen Fairchild	University of Virginia Health System–Associate Professor of Pediatrics	None	None	None	None	None	None
John Gallagher	Univ. Hosp of Cleveland-Crit Care Coordinator of Ped.Resp Care	None	None	None	None	None	None

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Ownership Interest	Consultant/ Advisory Board	Other
Mary Fran Hazinski	Vanderbilt University School of Nursing—Professor; AHA ECC Product Development-Senior Science Editor † Significant AHA compensation to write, edit and review documents such as the 2010 AHA Guidelines for CPR and ECC.	None	None	None	None	None	None

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Ownership Interest	Consultant/ Advisory Board	Other
Louis P. Halamek	Stanford University–Assoc Professor	†Laerdal Foundation: The Laerdal Foundation (not company) provided a grant to the Center for Advanced Pediatric and Perinatal Education at Packard Children's Hospital at Stanford during the academic years 2006–07, 2007–08, 2008–09; I develop simulation-based training programs and conduct research at CAPE. This support was provided directly to my institution.	None	*I have received < 10 honoraria in amounts of $500 or less from speaking at various academic meetings in the past 24 months; none of these meetings were conducted by for-profit entities.	None	*Laerdal Medical Advanced Medical Simulation Both of these companies reimburse me directly.	*I provide medical consultation to the legal profession for which I am reimbursed directly.
Praveen Kumar	PEDIATRIC FACULTY FOUNDATION-ATTENDING NEONATOLOGIST	None	None	None	None	None	None
George Little	Dartmouth College-Ped. Professor; Dartmouth Hitchcock Medfont. Center Neonatologist	None	None	None	None	None	None

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Ownership Interest	Consultant/ Advisory Board	Other
Jane E. McGowan	St Christopher's Pediatric Associate/Tenet Healthcare–Attending neonatologist; medical director, NICU	None	None	None	None	None	* reviewed records of cases involving neonatal resuscitation on one or two occasions over the past 5 years. *As co-editor for Textbook of Neonatal Resuscitation 6th edition, to be published by the AAP, being paid a total of $4000 over 3 years by the AAP.
Barbara Nightengale	Univ.Health Assoc,Nurse Practitioner	None	None	None	None	None	None
Mildred M. Ramirez	Univ of Texas Med School Houston-Physician	None	None	*Signed as consultant for Cytokine Pharmasciences, Inc., for a lecture in Mexico City. Product Propress for cervical rippening. $2,000 Money to Univ.	None	None	*Expert for Current expert case of triplets and preterm delivery. Money to the university &lquote;09

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Ownership Interest	Consultant/ Advisory Board	Other
Steven Ringer	Brigham and Women's Hospital–Chief Newborn Medicine	None	None	*Vermont Oxford Neonatal Network, $1000, comes to me	None	*Alere $2000, consultation Dey Pharamaceutic $1000 Consultation Forrest Pharmaceutica $1500 Grant Review Committee	†Several Attorneys, serving as expert witness in Medical malpractice cases
Wendy M. Simon	American Academy of Pediatrics–Director, Life Support Programs	None	None	None	None	None	None
Gary M. Weiner	St. Joseph Mercy Hospital-Ann Arbor Michigan–Atte Neonatologist	None	†Received equipment on-loan (3 resuscitation mannequins, 2 sets of video recording equipment) from Laerdal Medical Corporation to be used to complete a research project evaluating educational methods for teaching neonatal resuscitation. The value of the on-loan equipment is approximately $35,000.	None	None	None	None

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Ownership Interest	Consultant/ Advisory Board	Other
Myra Wyckoff	UT Southwestern Medical Center–Associate Professor of Pediatrics	†American Academy of Pediatrics Neonatal Research Grant-Ergonomics of Neonatal CPR 2008–2009	†Received a SimNewB neonatal simulator for help in Beta testing prior to final production	*Speaker at Symposia on Neonatal Care from University of Miami-honoraria paid to me Speaker at Symposia on Neonatal Care from Columbia/Cornell-honoraria paid directly to me Speaker for Grand Rounds from University of Oklahoma-honoraria paid directly to me	None	None	None
Jeanette Zaichkin	Seattle Children's Hospital–Neonatal Outreach Coordinator	None	None	*I receive honoraria directly to me from the AAP as compensation for editorial activities for NRP instructor ms.	None	None	None

- This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

- ?* Modest.

- ?† Significant.

14 Footnotes

The American Heart Association requests that this document be cited as follows:

American Heart Association. Web-based Integrated Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care – Part 13: Neonatal Resuscitation. ECCguidelines.heart.org.

© Copyright 2015 American Heart Association, Inc.

References

1. Perlman JM, Wyllie J, Kattwinkel J, Wyckoff MH, Aziz K, Guinsburg R, Kim HS, Liley HG, Mildenhall L, Simon WM, Szyld E, Tamura M, Velaphi S; on behalf of the Neonatal Resuscitation Chapter Collaborators. Part 7: neonatal resuscitation: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. Circulation. 2015;132(suppl 1):S204–S241. doi: 10.1161/CIR.0000000000000276.

2. WyllieJ,PerlmanJM,KattwinkelJ,WyckoffMH,AzizK,GuinsburgR,Kim HS, Liley HG, Mildenhall L, Simon WM, Szyld E, Tamura M, Velaphi S; on behalf of the Neonatal Resuscitation Chapter Collaborators. Part 7: neonatal resuscitation: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. Resuscitation. 2015. In press.

3. Kattwinkel J, Perlman JM, Aziz K, Colby C, Fairchild K, Gallagher J, Hazinski MF, Halamek LP, Kumar P, Little G, McGowan JE, Nightengale B, Ramirez MM, Ringer S, Simon WM, Weiner GM, Wyckoff M, Zaichkin J. Part 15: neonatal resuscitation: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2010;122(suppl 3):S909–S919. doi: 10.1161/CIRCULATIONAHA.110.971119.

4. BarberCA,WyckoffMH.Useandefficacyofendotrachealversusintrave- nous epinephrine during neonatal cardiopulmonary resuscitation in the deliv- ery room. Pediatrics. 2006;118:1028–1034. doi: 10.1542/peds.2006-0416.

5. Aziz K, Chadwick M, Baker M, Andrews W. Ante- and intra-partum fac- tors that predict increased need for neonatal resuscitation. Resuscitation. 2008;79:444–452. doi: 10.1016/j.resuscitation.2008.08.004.

6. Zaichkin J, ed. Instructor Manual for Neonatal Resuscitation. Chicago, IL: American Academy of Pediatrics;2011.

7. Perlman JM, Wyllie J, Kattwinkel J, Atkins DL, Chameides L, Goldsmith JP, Guinsburg R, Hazinski MF, Morley C, Richmond S, Simon WM, Singhal N, Szyld E, Tamura M, Velaphi S; Neonatal Resuscitation Chapter Collaborators. Part 11: neonatal resuscitation: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. Circulation. 2010;122(suppl 2): S516–S538. doi: 10.1161/CIRCULATIONAHA.110.971127.

8. Wyllie J, Perlman JM, Kattwinkel J, Atkins DL, Chameides L, Goldsmith JP, Guinsburg R, Hazinski MF, Morley C, Richmond S, Simon WM, Singhal N, Szyld E, Tamura M, Velaphi S; Neonatal Resuscitation Chapter Collaborators. Part 11: neonatal resuscitation: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. Resuscitation. 2010;81 suppl 1:e260–e287. doi: 10.1016/j.resuscitation.2010.08.029.

9. Committee Opinion No.543: Timing of umbilical cord clamping after birth. Obstet Gynecol. 2012;120:1522–1526.

10. American Academy of Pediatrics. Statement of endorsement: timing of umbilical cord clamping after birth. Pediatrics. 2013;131:e1323.

11. Hosono S, Mugishima H, Fujita H, Hosono A, Minato M, Okada T, Takahashi S, Harada K. Umbilical cord milking reduces the need for red cell transfusions and improves neonatal adaptation in infants born at less than 29 weeks' gestation: a randomised controlled trial. Arch Dis Child Fetal Neonatal Ed. 2008;93:F14–F19. doi: 10.1136/adc.2006.108902.

12. Katheria AC, Leone TA, Woelkers D, Garey DM, Rich W, Finer NN. The effects of umbilical cord milking on hemodynamics and neonatal out- comes in premature neonates. J Pediatr. 2014;164:1045–1050.e1. doi: 10.1016/j.jpeds.2014.01.024.

13. MarchMI,HackerMR,ParsonAW,ModestAM,deVecianaM.Theeffects of umbilical cord milking in extremely preterm infants: a randomized con- trolled trial. J Perinatol. 2013;33:763–767. doi: 10.1038/jp.2013.70.

14. BudinP.TheNursling.TheFeedingandHygieneofPrematureandFull-term Infants. Translation by WJ Maloney. London: The Caxton Publishing Co;1907.

15. A Abd-El Hamid S, Badr-El Din MM, Dabous NI, Saad KM. Effect of the use of a polyethylene wrap on the morbidity and mortality of very low birth weight infants in Alexandria University Children's Hospital. J Egypt Public Health Assoc. 2012;87:104–108.

16. AcoletD,ElbourneD,McIntoshN,WeindlingM,KorkodilosM,HavilandJ, Modder J, Macintosh M; Confidential Enquiry Into Maternal and Child Health. Project 27/28: inquiry into quality of neonatal care and its effect on the survival of infants who were born at 27 and 28 weeks in England, Wales, and Northern Ireland. Pediatrics. 2005;116:1457–1465. doi: 10.1542/peds.2004-2691.

17. Bateman DA, O'Bryan L, Nicholas SW, Heagarty MC. Outcome of unattended out-of-hospital births in Harlem. Arch Pediatr Adolesc Med. 1994;148:147–152.

18. Bhoopalam PS, Watkinson M. Babies born before arrival at hospital. Br J Obstet Gynaecol. 1991;98:57–64.

19. Boo NY, Guat-Sim Cheah I; Malaysian National Neonatal Registry. Admission hypothermia among VLBW infants in Malaysian NICUs. J Trop Pediatr. 2013;59:447–452. doi: 10.1093/tropej/fmt051.

20. Buetow KC, Kelein SW. Effects of maintenenance of "normal" skin temperature on survival of infants of low birth weight. Pediatr. 1964;33:163–169.

21. Costeloe K, Hennessy E, Gibson AT, Marlow N, Wilkinson AR. The EPICure study: outcomes to discharge from hospital for infants born at the threshold of viability. Pediatrics. 2000;106:659–671.

22. Costeloe KL, Hennessy EM, Haider S, Stacey F, Marlow N, Draper ES. Short term outcomes after extreme preterm birth in England: compari- son of two birth cohorts in 1995 and 2006 (the EPICure studies). BMJ. 2012;345:e7976.

23. da Mota Silveira SM, Gonçalves de Mello MJ, de Arruda Vidal S, de Frias PG, Cattaneo A. Hypothermia on admission: a risk factor for death in new- borns referred to the Pernambuco Institute of Mother and Child Health. J Trop Pediatr. 2003;49:115–120.

24. Daga AS, Daga SR, Patole SK. Determinants of death among admissions to intensive care unit for newborns. J Trop Pediatr. 1991;37:53–56.

25. de Almeida MF, Guinsburg R, Sancho GA, Rosa IR, Lamy ZC, Martinez FE, da Silva RP, Ferrari LS, de Souza Rugolo LM, Abdallah VO, Silveira Rde C; Brazilian Network on Neonatal Research. Hypothermia and early neonatal mortality in preterm infants. J Pediatr. 2014;164:271–5.e1. doi: 10.1016/j.jpeds.2013.09.049.

26. García-Muñoz Rodrigo F, Rivero Rodríguez S, Siles Quesada C. [Hypothermia risk factors in the very low weight newborn and associ- ated morbidity and mortality in a neonatal care unit]. An Pediatr (Barc). 2014;80:144–150. doi: 10.1016/j.anpedi.2013.06.029.

27. Harms K, Osmers R, Kron M, Schill M, Kuhn W, Speer CP, Schröter W. [Mortality of premature infants 1980-1990: analysis of data from the Göttingen perinatal center]. Z Geburtshilfe Perinatol. 1994;198:126–133.

28. Hazan J, Maag U, Chessex P. Association between hypothermia and mortality rate of premature infants–revisited. Am J Obstet Gynecol. 1991;164(1 pt 1):111–112.

29. Jones P, Alberti C, Julé L, Chabernaud JL, Lodé N, Sieurin A, Dauger S. Mortality in out-of-hospital premature births. Acta Paediatr. 2011;100:181–187. doi: 10.1111/j.1651-2227.2010.02003.x.

30. Kalimba E, Ballot D. Survival of extremely low-birth-weight infants. South African Journal of Child Health. 2013;7:13–16.

31. Kambarami R, Chidede O. Neonatal hypothermia levels and risk factors for mortality in a tropical country. Cent Afr J Med. 2003;49:103–106.

32. Kent AL, Williams J. Increasing ambient operating theatre temperature and wrapping in polyethylene improves admission temperature in premature infants. J Paediatr Child Health. 2008;44:325–331. doi: 10.1111/j.1440-1754.2007.01264.x.

33. Laptook AR, Salhab W, Bhaskar B; Neonatal Research Network. Admission temperature of low birth weight infants: predictors and associated morbidities. Pediatrics. 2007;119:e643–e649. doi: 10.1542/ peds.2006-0943.

34. Lee HC, Ho QT, Rhine WD. A quality improvement project to improve admission temperatures in very low birth weight infants. J Perinatol. 2008;28:754–758. doi: 10.1038/jp.2008.92.

35. Levi S, Taylor W, Robinson LE, Levy LI. Analysis of morbidity and outcome of infants weighing less than 800 grams at birth. South Med J. 1984;77:975–978.

36. Manani M, Jegatheesan P, DeSandre G, Song D, Showalter L, Govindaswami B. Elimination of admission hypothermia in preterm very low-birth-weight infants by standardization of delivery room manage- ment. Perm J. 2013;17:8–13. doi: 10.7812/TPP/12-130.

37. Manji KP, Kisenge R. Neonatal hypothermia on admission to a special care unit in Dar-es-Salaam, Tanzania: a cause for concern. Cent Afr J Med. 2003;49:23–27.

38. Mathur NB, Krishnamurthy S, Mishra TK. Evaluation of WHO classifica- tion of hypothermia in sick extramural neonates as predictor of fatality. J Trop Pediatr. 2005;51:341–345. doi: 10.1093/tropej/fmi049.

39. Miller SS, Lee HC, Gould JB. Hypothermia in very low birth weight infants: distribution, risk factors and outcomes. J Perinatol. 2011;31 suppl 1:S49–S56. doi: 10.1038/jp.2010.177.

40. Mullany LC, Katz J, Khatry SK, LeClerq SC, Darmstadt GL, Tielsch JM. Risk of mortality associated with neonatal hypothermia in south- ern Nepal. Arch Pediatr Adolesc Med. 2010;164:650–656. doi: 10.1001/ archpediatrics.2010.103.

41. Nayeri F, Nili F. Hypothermia at birth and its associated complications in newborn infants: a follow-up study. Iran J Public Health. 2006;35:48–52.

42.

Obladen M, Heemann U, Hennecke KH, Hanssler L. [Causes of neona- tal mortality 1981-1983: a regional analysis]. Z Geburtshilfe Perinatol. 1985;189:181–187.

43. Ogunlesi TA, Ogunfowora OB, Adekanmbi FA, Fetuga BM, Olanrewaju DM. Point-of-admission hypothermia among high-risk Nigerian new- borns. BMC Pediatr. 2008;8:40. doi: 10.1186/1471-2431-8-40.

44. Pal DK, Manandhar DS, Rajbhandari S, Land JM, Patel N, de L Costello AM. Neonatal hypoglycaemia in Nepal 1. Prevalence and risk factors. Arch Dis Child Fetal Neonatal Ed. 2000;82:F46–F51.

45. Shah S, Zemichael O, Meng HD. Factors associated with mortality and length of stay in hospitalised neonates in Eritrea, Africa: a cross-sectional study. BMJ Open. 2012;2. doi: 10.1136/bmjopen-2011-000792.

46. Singh A, Yadav A, Singh A. Utilization of postnatal care for newborns and its association with neonatal mortality in India: an analytical appraisal. BMC Pregnancy Childbirth. 2012;12:33. doi: 10.1186/1471-2393-12-33.

47. Sodemann M, Nielsen J, Veirum J, Jakobsen MS, Biai S, Aaby P. Hypothermia of newborns is associated with excess mortality in the first 2 months of life in Guinea-Bissau, West Africa. Trop Med Int Health. 2008;13:980–986. doi: 10.1111/j.1365-3156.2008.02113.x.

48. Stanley FJ, Alberman EV. Infants of very low birthweight. I: Perinatal fac- tors affecting survival. Dev Med Child Neurol. 1978;20:300–312.

49. Wyckoff MH, Perlman JM. Effective ventilation and temperature control are vital to outborn resuscitation. Prehosp Emerg Care. 2004;8:191–195.

50. Bartels DB, Kreienbrock L, Dammann O, Wenzlaff P, Poets CF. Population based study on the outcome of small for gestational age new- borns. Arch Dis Child Fetal Neonatal Ed. 2005;90:F53–F59. doi: 10.1136/ adc.2004.053892.

51. Carroll PD, Nankervis CA, Giannone PJ, Cordero L. Use of polyethylene bags in extremely low birth weight infant resuscitation for the prevention of hypothermia. J Reprod Med. 2010;55:9–13.

52. Gleissner M, Jorch G, Avenarius S. Risk factors for intraventricular hemorrhage in a birth cohort of 3721 premature infants. J Perinat Med. 2000;28:104–110. doi: 10.1515/JPM.2000.013.

53. Herting E, Speer CP, Harms K, Robertson B, Curstedt T, Halliday HL, Compagnone D, Gefeller O, McClure G, Reid M. Factors influencing morbidity and mortality in infants with severe respiratory distress syn- drome treated with single or multiple doses of a natural porcine surfactant. Biol Neonate. 1992;61 suppl 1:26–30.

54. Van de Bor M, Van Bel F, Lineman R, Ruys JH. Perinatal factors and periventricular-intraventricular hemorrhage in preterm infants. Am J Dis Child. 1986;140:1125–1130.

55. DeMauro SB, Douglas E, Karp K, Schmidt B, Patel J, Kronberger A, Scarboro R, Posencheg M. Improving delivery room management for very preterm infants. Pediatrics. 2013;132:e1018–e1025. doi: 10.1542/ peds.2013-0686.

56. Harms K, Herting E, Kron M, Schill M, Schiffmann H. [Importance of pre- and perinatal risk factors in respiratory distress syndrome of prema- ture infants. A logical regression analysis of 1100 cases]. Z Geburtshilfe Neonatol. 1997;201:258–262.

57. Lee HC, Powers RJ, Bennett MV, Finer NN, Halamek LP, Nisbet C, Crockett M, Chance K, Blackney D, von Köhler C, Kurtin P, Sharek PJ. Implementation methods for delivery room management: a quality improvement comparison study. Pediatrics. 2014;134:e1378–e1386. doi: 10.1542/peds.2014-0863.

58. Reilly MC, Vohra S, Rac VE, Dunn M, Ferrelli K, Kiss A, Vincer M, Wimmer J, Zayack D, Soll RF; Vermont Oxford Network Heat Loss Prevention (HeLP) Trial Study Group. Randomized trial of occlusive wrap for heat loss prevention in preterm infants. J Pediatr. 2015;166:262–8.e2. doi: 10.1016/j.jpeds.2014.09.068.

59. Russo A, McCready M, Torres L, Theuriere C, Venturini S, Spaight M, Hemway RJ, Handrinos S, Perlmutter D, Huynh T, Grunebaum A, Perlman J. Reducing hypothermia in preterm infants following delivery. Pediatrics. 2014;133:e1055–e1062. doi: 10.1542/peds.2013-2544.

60. Zayeri F, Kazemnejad A, Ganjali M, Babaei G, Khanafshar N, Nayeri F. Hypothermia in Iranian newborns. Incidence, risk factors and related com- plications. Saudi Med J. 2005;26:1367–1371.

61. Anderson S, Shakya KN, Shrestha LN, Costello AM. Hypoglycaemia: a common problem among uncomplicated newborn infants in Nepal. J Trop Pediatr. 1993;39:273–277.

62. Lazic?-Mitrovic? T, Djukic? M, Cutura N, Andjelic? S, Curkovic? A, Soldo V, Radlovic? N. [Transitory hypothermia as early prognostic factor in term newborns with intrauterine growth retardation]. Srp Arh Celok Lek. 2010;138:604–608.

63. Lenclen R, Mazraani M, Jugie M, Couderc S, Hoenn E, Carbajal R, Blanc P, Paupe A. [Use of a polyethylene bag: a way to improve the thermal envi- ronment of the premature newborn at the delivery room]. Arch Pediatr. 2002;9:238–244.

64. Sasidharan CK, Gokul E, Sabitha S. Incidence and risk factors for neona- tal hypoglycaemia in Kerala, India. Ceylon Med J. 2004;49:110–113.

65. Mullany LC. Neonatal hypothermia in low-resource settings. Semin Perinatol. 2010;34:426–433. doi: 10.1053/j.semperi.2010.09.007.

66. Frascone RJ, Wayne MA, Swor RA, Mahoney BD, Domeier RM, Olinger ML, Tupper DE, Setum CM, Burkhart N, Klann L, Salzman JG, Wewerka SS, Yannopoulos D, Lurie KG, O'Neil BJ, Holcomb RG, Aufderheide TP. Treatment of non-traumatic out-of-hospital cardiac arrest with active compression decompression cardiopulmonary resuscitation plus an impedance threshold device. Resuscitation. 2013;84:1214–1222. doi: 10.1016/j. resuscitation.2013.05.002.

67. McCarthy LK, Molloy EJ, Twomey AR, Murphy JF, O'Donnell CP. A ran- domized trial of exothermic mattresses for preterm newborns in polyethyl- ene bags. Pediatrics. 2013;132:e135–e141. doi: 10.1542/peds.2013-0279.

68. Billimoria Z, Chawla S, Bajaj M, Natarajan G. Improving admission temperature in extremely low birth weight infants: a hospital-based multi- intervention quality improvement project. J Perinat Med. 2013;41:455–460. doi: 10.1515/jpm-2012-0259.

69. Chawla S, Amaram A, Gopal SP, Natarajan G. Safety and efficacy of Trans-warmer mattress for preterm neonates: results of a randomized controlled trial. J Perinatol. 2011;31:780–784. doi: 10.1038/jp.2011.33.

70. Ibrahim CP, Yoxall CW. Use of self-heating gel mattresses eliminates admission hypothermia in infants born below 28 weeks gestation. Eur J Pediatr. 2010;169:795–799. doi: 10.1007/s00431-009-1113-y.

71. Singh A, Duckett J, Newton T, Watkinson M. Improving neonatal unit admission temperatures in preterm babies: exothermic mattresses, poly- thene bags or a traditional approach? J Perinatol. 2010;30:45–49. doi: 10.1038/jp.2009.94.

72. Meyer MP, Payton MJ, Salmon A, Hutchinson C, de Klerk A. A clinical comparison of radiant warmer and incubator care for preterm infants from birth to 1800 grams. Pediatrics. 2001;108:395–401.

73. te Pas AB, Lopriore E, Dito I, Morley CJ, Walther FJ. Humidified and heated air during stabilization at birth improves temperature in preterm infants. Pediatrics. 2010;125:e1427–e1432. doi: 10.1542/peds.2009-2656.

74. Pinheiro JM, Furdon SA, Boynton S, Dugan R, Reu-Donlon C, Jensen S. Decreasing hypothermia during delivery room stabilization of preterm neonates. Pediatrics. 2014;133:e218–e226. doi: 10.1542/peds.2013-1293.

75. 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;98:20–27.

76. Alexander JM, McIntire DM, Leveno KJ. Chorioamnionitis and the prognosis for term infants. Obstet Gynecol. 1999;94:274–278.

77. Greenwell EA, Wyshak G, Ringer SA, Johnson LC, Rivkin MJ, Lieberman E. Intrapartum temperature elevation, epidural use, and adverse out- come in term infants. Pediatrics. 2012;129:e447–e454. doi: 10.1542/ peds.2010-2301.

78. Goetzl L, Manevich Y, Roedner C, Praktish A, Hebbar L, Townsend DM. Maternal and fetal oxidative stress and intrapartum term fever. Am J Obstet Gynecol. 2010;202:363.e1–363.e5. doi: 10.1016/j.ajog.2010.01.034.

79. Glass HC, Pham TN, Danielsen B, Towner D, Glidden D, Wu YW. Antenatal and intrapartum risk factors for seizures in term newborns: a population-based study, California 1998-2002. J Pediatr. 2009;154:24–28.e1. doi: 10.1016/j.jpeds.2008.07.008.

80. Lieberman E, Lang J, Richardson DK, Frigoletto FD, Heffner LJ, Cohen A. Intrapartum maternal fever and neonatal outcome. Pediatrics. 2000;105(1 pt 1):8–13.

81. Lieberman E, Eichenwald E, Mathur G, Richardson D, Heffner L, Cohen A. Intrapartum fever and unexplained seizures in term infants. Pediatrics. 2000;106:983–988.

82. Badawi N, Kurinczuk JJ, Keogh JM, Alessandri LM, O'Sullivan F, Burton PR, Pemberton PJ, Stanley FJ. Intrapartum risk factors for new- born encephalopathy: the Western Australian case-control study. BMJ. 1998;317:1554–1558.

83. Impey L, Greenwood C, MacQuillan K, Reynolds M, Sheil O. Fever in labour and neonatal encephalopathy: a prospective cohort study. BJOG. 2001;108:594–597.

84. Impey LW, Greenwood CE, Black RS, Yeh PS, Sheil O, Doyle P. The rela- tionship between intrapartum maternal fever and neonatal acidosis as risk factors for neonatal encephalopathy. Am J Obstet Gynecol. 2008;198:49. e1–49.e6. doi: 10.1016/j.ajog.2007.06.011.

85. Linder N, Fridman E, Makhoul A, Lubin D, Klinger G, Laron-Kenet T, Yogev Y, Melamed N. Management of term newborns following maternal intrapartum fever. J Matern Fetal Neonatal Med. 2013;26:207–210. doi: 10.3109/14767058.2012.722727.

86. Butwick AJ, Lipman SS, Carvalho B. Intraoperative forced air-warming during cesarean delivery under spinal anesthesia does not prevent mater- nal hypothermia. Anesth Analg. 2007;105:1413–1419, table of contents. doi: 10.1213/01.ane.0000286167.96410.27.

87. Fallis WM, Hamelin K, Symonds J, Wang X. Maternal and new- born outcomes related to maternal warming during cesarean delivery. J Obstet Gynecol Neonatal Nurs. 2006;35:324–331. doi: 10.1111/ j.1552-6909.2006.00052.x.

88. Horn EP, Schroeder F, Gottschalk A, Sessler DI, Hiltmeyer N, Standl T, Schulte am Esch J. Active warming during cesarean delivery. Anesth Analg. 2002;94:409–414, table of contents.

89. Woolnough M, Allam J, Hemingway C, Cox M, Yentis SM. Intra- operative fluid warming in elective caesarean section: a blinded randomised controlled trial. Int J Obstet Anesth. 2009;18:346–351. doi: 10.1016/j.ijoa.2009.02.009.

90. Yokoyama K, Suzuki M, Shimada Y, Matsushima T, Bito H, Sakamoto A. Effect of administration of pre-warmed intravenous flu- ids on the frequency of hypothermia following spinal anesthesia for Cesarean delivery. J Clin Anesth. 2009;21:242–248. doi: 10.1016/j.jclinane.2008.12.010.

91. Belsches TC, Tilly AE, Miller TR, Kambeyanda RH, Leadford A, Manasyan A, Chomba E, Ramani M, Ambalavanan N, Carlo WA. Randomized trial of plastic bags to prevent term neonatal hypothermia in a resource-poor setting. Pediatrics. 2013;132:e656–e661. doi: 10.1542/ peds.2013-0172.

92. Leadford AE, Warren JB, Manasyan A, Chomba E, Salas AA, Schelonka R, Carlo WA. Plastic bags for prevention of hypothermia in preterm and low birth weight infants. Pediatrics. 2013;132:e128–e134. doi: 10.1542/ peds.2012-2030.

93. Raman S, Shahla A. Temperature drop in normal term newborn infants born at the University Hospital, Kuala Lumpur. Aust N Z J Obstet Gynaecol. 1992;32:117–119.

94. Bergman NJ, Linley LL, Fawcus SR. Randomized controlled trial of skin-to-skin contact from birth versus conventional incubator for physi- ological stabilization in 1200- to 2199-gram newborns. Acta Paediatr. 2004;93:779–785.

95. Fardig JA. A comparison of skin-to-skin contact and radiant heat- ers in promoting neonatal thermoregulation. J Nurse Midwifery. 1980;25:19–28.

96. Christensson K, Siles C, Moreno L, Belaustequi A, De La Fuente P, Lagercrantz H, Puyol P, Winberg J. Temperature, metabolic adaptation and crying in healthy full-term newborns cared for skin-to-skin or in a cot. Acta Paediatr. 1992;81:488–493.

97. Christensson K. Fathers can effectively achieve heat conservation in healthy newborn infants. Acta Paediatr. 1996;85:1354–1360.

98. Bystrova K, Widström AM, Matthiesen AS, Ransjö-Arvidson AB, Welles-Nyström B, Wassberg C, Vorontsov I, Uvnäs-Moberg K. Skin-to-skin contact may reduce negative consequences of "the stress of being born": a study on temperature in newborn infants, subjected to different ward routines in St. Petersburg. Acta Paediatr. 2003;92:320–326.

99. Gouchon S, Gregori D, Picotto A, Patrucco G, Nangeroni M, Di Giulio P. Skin-to-skin contact after cesarean delivery: an experimental study. Nurs Res. 2010;59:78–84. doi: 10.1097/NNR.0b013e3181d1a8bc.

100. Marín Gabriel MA, Llana Martín I, López Escobar A, Fernández Villalba E, Romero Blanco I, Touza Pol P. Randomized controlled trial of early skin-to-skin contact: effects on the mother and the newborn. Acta Paediatr. 2010;99:1630–1634. doi: 10.1111/j.1651-2227.2009.01597.x.

101. Nimbalkar SM, Patel VK, Patel DV, Nimbalkar AS, Sethi A, Phatak A. Effect of early skin-to-skin contact following normal delivery on inci- dence of hypothermia in neonates more than 1800 g: randomized control trial. J Perinatol. 2014;34:364–368. doi: 10.1038/jp.2014.15.

102. Gungor S, Kurt E, Teksoz E, Goktolga U, Ceyhan T, Baser I. Oronasopharyngeal suction versus no suction in normal and term infants delivered by elective cesarean section: a prospective random- ized controlled trial. Gynecol Obstet Invest. 2006;61:9–14. doi: 10.1159/000087604.

103. Waltman PA, Brewer JM, Rogers BP, May WL. Building evidence for practice: a pilot study of newborn bulb suctioning at birth. J Midwifery Womens Health. 2004;49:32–38. doi: 10.1016/j.jmwh.2003.10.003.

104. Carrasco M, Martell M, Estol PC. Oronasopharyngeal suction at birth: effects on arterial oxygen saturation. J Pediatr. 1997;130:832–834.

105. Perlman JM, Volpe JJ. Suctioning in the preterm infant: effects on cerebral blood flow velocity, intracranial pressure, and arterial blood pressure. Pediatrics. 1983;72:329–334.

106. Simbruner G, Coradello H, Fodor M, Havelec L, Lubec G, Pollak A. Effect of tracheal suction on oxygenation, circulation, and lung mechanics in newborn infants. Arch Dis Child. 1981;56:326–330.

107. Vain NE, Szyld EG, Prudent LM, Wiswell TE, Aguilar AM, Vivas NI. Oropharyngeal and nasopharyngeal suctioning of meconium-stained neonates before delivery of their shoulders: multicentre, ran- domised controlled trial. Lancet. 2004;364:597–602. doi: 10.1016/S0140-6736(04)16852-9.

108. Al Takroni AM, Parvathi CK, Mendis KB, Hassan S, Reddy I, Kudair HA. Selective tracheal suctioning to prevent meconium aspiration syn- drome. Int J Gynaecol Obstet. 1998;63:259–263.

109. Chettri S, Adhisivam B, Bhat BV. Endotracheal suction for nonvigor- ous neonates born through meconium stained amniotic fluid: a random- ized controlled trial. J Pediatr. 2015;166:1208–1213.e1. doi: 10.1016/j. jpeds.2014.12.076.

110. Davis RO, Philips JB 3rd, Harris BA Jr, Wilson ER, Huddleston JF. Fatal meconium aspiration syndrome occurring despite airway management considered appropriate. Am J Obstet Gynecol. 1985;151:731–736.

111. Dooley SL, Pesavento DJ, Depp R, Socol ML, Tamura RK, Wiringa KS. Meconium below the vocal cords at delivery: correlation with intrapar- tum events. Am J Obstet Gynecol. 1985;153:767–770.

112. Hageman JR, Conley M, Francis K, Stenske J, Wolf I, Santi V, Farrell EE. Delivery room management of meconium staining of the amniotic fluid and the development of meconium aspiration syndrome. J Perinatol. 1988;8:127–131.

113. Manganaro R, Mamì C, Palmara A, Paolata A, Gemelli M. Incidence of meconium aspiration syndrome in term meconium-stained babies managed at birth with selective tracheal intubation. J Perinat Med. 2001;29:465–468. doi: 10.1515/JPM.2001.065.

114. Peng TC, Gutcher GR, Van Dorsten JP. A selective aggressive approach to the neonate exposed to meconium-stained amniotic fluid. Am J Obstet Gynecol. 1996;175:296–301; discussion 301.

115. Rossi EM, Philipson EH, Williams TG, Kalhan SC. Meconium aspiration syndrome: intrapartum and neonatal attributes. Am J Obstet Gynecol. 1989;161:1106–1110.

116. Suresh GK, Sarkar S. Delivery room management of infants born through thin meconium stained liquor. Indian Pediatr. 1994;31:1177–1181.

117. Yoder BA. Meconium-stained amniotic fluid and respiratory complications: impact of selective tracheal suction. Obstet Gynecol. 1994;83:77–84.

118. Kamlin CO, O'Donnell CP, Everest NJ, Davis PG, Morley CJ. Accuracy of clinical assessment of infant heart rate in the delivery room. Resuscitation. 2006;71:319–321. doi: 10.1016/j.resuscitation.2006.04.015.

119. Dawson JA, Saraswat A, Simionato L, Thio M, Kamlin CO, Owen LS, Schmölzer GM, Davis PG. Comparison of heart rate and oxygen satura- tion measurements from Masimo and Nellcor pulse oximeters in newly born term infants. Acta Paediatr. 2013;102:955–960. doi: 10.1111/ apa.12329.

120. Kamlin CO, Dawson JA, O'Donnell CP, Morley CJ, Donath SM, Sekhon J, Davis PG. Accuracy of pulse oximetry measurement of heart rate of newborn infants in the delivery room. J Pediatr. 2008;152:756–760. doi: 10.1016/j.jpeds.2008.01.002.

121. Katheria A, Rich W, Finer N. Electrocardiogram provides a continuous heart rate faster than oximetry during neonatal resuscitation. Pediatrics. 2012;130:e1177–e1181. doi: 10.1542/peds.2012-0784.

122. Mizumoto H, Tomotaki S, Shibata H, Ueda K, Akashi R, Uchio H, Hata D. Electrocardiogram shows reliable heart rates much earlier than pulse oximetry during neonatal resuscitation. Pediatr Int. 2012;54:205–207. doi: 10.1111/j.1442-200X.2011.03506.x.

123. van Vonderen JJ, Hooper SB, Kroese JK, Roest AA, Narayen IC, van Zwet EW, te Pas AB. Pulse oximetry measures a lower heart rate at birth compared with electrocardiography. J Pediatr. 2015;166:49–53. doi: 10.1016/j.jpeds.2014.09.015.

124. Dawson JA, Kamlin CO, Wong C, te Pas AB, O'Donnell CP, Donath SM, Davis PG, Morley CJ. Oxygen saturation and heart rate during delivery room resuscitation of infants h30 weeks' gestation with air or 100% oxygen. Arch Dis Child Fetal Neonatal Ed. 2009;94:F87–F91.

125. Davis PG, Tan A, O'Donnell CP, Schulze A. Resuscitation of newborn infants with 100% oxygen or air: a systematic review and meta-analysis. Lancet. 2004;364:1329–1333.

126. Rabi Y, Rabi D, Yee W. Room air resuscitation of the depressed newborn: a systematic review and meta-analysis. Resuscitation. 2007;72:353–363.

127. Armanian AM, Badiee Z. Resuscitation of preterm newborns with low concentration oxygen versus high concentration oxygen. J Res Pharm Pract. 2012;1:25–29. doi: 10.4103/2279-042X.99674.

128. Kapadia VS, Chalak LF, Sparks JE, Allen JR, Savani RC, Wyckoff MH. Resuscitation of preterm neonates with limited versus high oxygen strat- egy. Pediatrics. 2013;132:e1488–e1496. doi: 10.1542/peds.2013-0978.

129. Lundstrøm KE, Pryds O, Greisen G. Oxygen at birth and prolonged cere- bral vasoconstriction in preterm infants. Arch Dis Child Fetal Neonatal Ed. 1995;73:F81–F86.

130. Rabi Y, Singhal N, Nettel-Aguirre A. Room-air versus oxygen adminis- tration for resuscitation of preterm infants: the ROAR study. Pediatrics. 2011;128:e374–e381. doi: 10.1542/peds.2010-3130.

131. Rook D, Schierbeek H, Vento M, Vlaardingerbroek H, van der Eijk AC, Longini M, Buonocore G, Escobar J, van Goudoever JB, Vermeulen MJ. Resuscitation of preterm infants with different inspired oxygen fractions. J Pediatr. 2014;164:1322–6.e3. doi: 10.1016/j.jpeds.2014.02.019.

132. Vento M, Moro M, Escrig R, Arruza L, Villar G, Izquierdo I, Roberts LJ 2nd, Arduini A, Escobar JJ, Sastre J, Asensi MA. Preterm resusci- tation with low oxygen causes less oxidative stress, inflammation, and chronic lung disease. Pediatrics. 2009;124:e439–e449. doi: 10.1542/ peds.2009-0434.

133. Wang CL, Anderson C, Leone TA, Rich W, Govindaswami B, Finer NN. Resuscitation of preterm neonates by using room air or 100% oxygen. Pediatrics. 2008;121:1083–1089. doi: 10.1542/peds.2007-1460.

134. Mariani G, Dik PB, Ezquer A, Aguirre A, Esteban ML, Perez C, Fernandez Jonusas S, Fustiñana C. Pre-ductal and post-ductal O2 satura- tion in healthy term neonates after birth. J Pediatr. 2007;150:418–421. doi: 10.1016/j.jpeds.2006.12.015.

135. Klingenberg C, Sobotka KS, Ong T, Allison BJ, Schmölzer GM, Moss TJ, Polglase GR, Dawson JA, Davis PG, Hooper SB. Effect of sus- tained inflation duration; resuscitation of near-term asphyxiated lambs. Arch Dis Child Fetal Neonatal Ed. 2013;98:F222–F227. doi: 10.1136/ archdischild-2012-301787.

136. te Pas AB, Siew M, Wallace MJ, Kitchen MJ, Fouras A, Lewis RA, Yagi N, Uesugi K, Donath S, Davis PG, Morley CJ, Hooper SB. Effect of sustained inflation length on establishing functional residual capacity at birth in ventilated premature rabbits. Pediatr Res. 2009;66:295–300. doi: 10.1203/PDR.0b013e3181b1bca4.

137. Harling AE, Beresford MW, Vince GS, Bates M, Yoxall CW. Does sus- tained lung inflation at resuscitation reduce lung injury in the preterm infant? Arch Dis Child Fetal Neonatal Ed. 2005;90:F406–F410. doi: 10.1136/adc.2004.059303.

138. Lindner W, Högel J, Pohlandt F. Sustained pressure-controlled inflation or intermittent mandatory ventilation in preterm infants in the delivery room? A randomized, controlled trial on initial respiratory support via nasopharyngeal tube. Acta Paediatr. 2005;94:303–309.

139. Lista G, Boni L, Scopesi F, Mosca F, Trevisanuto D, Messner H, Vento G, Magaldi R, Del Vecchio A, Agosti M, Gizzi C, Sandri F, Biban P, Bellettato M, Gazzolo D, Boldrini A, Dani C; SLI Trial Investigators. Sustained lung inflation at birth for preterm infants: a randomized clini- cal trial. Pediatrics. 2015;135:e457–e464. doi: 10.1542/peds.2014-1692.

140. Lindner W, Vossbeck S, Hummler H, Pohlandt F. Delivery room manage- ment of extremely low birth weight infants: spontaneous breathing or intubation? Pediatrics. 1999;103(5 pt 1):961–967.

141. Lista G, Fontana P, Castoldi F, Cavigioli F, Dani C. Does sustained lung inflation at birth improve outcome of preterm infants at risk for respiratory distress syndrome? Neonatology. 2011;99:45–50. doi: 10.1159/000298312.

142. Karlberg P, Koch G. Respiratory studies in newborn infants. III. Development of mechanics of breathing during the first week of life. A longitudinal study. Acta Paediatr. 1962;(Suppl 135):121–129.

143. Vyas H, Milner AD, Hopkin IE, Boon AW. Physiologic responses to prolonged and slow-rise inflation in the resuscitation of the asphyxiated newborn infant. J Pediatr. 1981;99:635–639.

144. Vyas H, Field D, Milner AD, Hopkin IE. Determinants of the first inspiratory volume and functional residual capacity at birth. Pediatr Pulmonol. 1986;2:189–193.

145. Boon AW, Milner AD, Hopkin IE. Lung expansion, tidal exchange, and formation of the functional residual capacity during resuscitation of asphyxiated neonates. J Pediatr. 1979;95:1031–1036.

146. Hillman NH, Moss TJ, Kallapur SG, Bachurski C, Pillow JJ, Polglase GR, Nitsos I, Kramer BW, Jobe AH. Brief, large tidal volume ventilation initiates lung injury and a systemic response in fetal sheep. Am J Respir Crit Care Med. 2007;176:575–581.

147. Polglase GR, Hooper SB, Gill AW, Allison BJ, McLean CJ, Nitsos I, Pillow JJ, Kluckow M. Cardiovascular and pulmonary consequences of airway recruitment in preterm lambs. J Appl Physiol. 2009;106:1347–1355.

148. Dawes GS. Foetal and Neonatal Physiology. A Comparative Study of the Changes at Birth. Chicago: Year Book Medical Publishers, Inc; 1968.

149. Lindner W, Vossbeck S, Hummler H, Pohlandt F. Delivery room management of extremely low birth weight infants: spontaneous breathing or intubation? Pediatrics. 1999;103():961–967.

150. Leone TA, Lange A, Rich W, Finer NN. Disposable colorimetric carbon dioxide detector use as an indicator of a patent airway during noninvasive mask ventilation. Pediatrics. 2006;118:e202–204.

151. Finer NN, Rich W, Wang C, Leone T. Airway obstruction during mask ventilation of very low birth weight infants during neonatal resuscitation. Pediatrics. 2009;123:865–869.

152. Dawson JA, Schmölzer GM, Kamlin CO, Te Pas AB, O'Donnell CP, Donath SM, Davis PG, Morley CJ. Oxygenation with T-piece versus self-inflating bag for ventilation of extremely preterm infants at birth: a randomized controlled trial. J Pediatr. 2011;158:912–918.e1. doi: 10.1016/j.jpeds.2010.12.003.

153. Szyld E, Aguilar A, Musante GA, Vain N, Prudent L, Fabres J, Carlo WA; Delivery Room Ventilation Devices Trial Group. Comparison of devices for newborn ventilation in the delivery room. J Pediatr. 2014;165: 234–239.e3. doi: 10.1016/j.jpeds.2014.02.035.

154. Dawson JA, Gerber A, Kamlin CO, Davis PG, Morley CJ. Providing PEEP during neonatal resuscitation: which device is best? J Paediatr Child Health. 2011;47:698–703. doi: 10.1111/j.1440-1754.2011.02036.x.

155. Morley CJ, Dawson JA, Stewart MJ, Hussain F, Davis PG. The effect of a PEEP valve on a Laerdal neonatal self-inflating resusci- tation bag. J Paediatr Child Health. 2010;46:51–56. doi: 10.1111/ j.1440-1754.2009.01617.x.

156. Bennett S, Finer NN, Rich W, Vaucher Y. A comparison of three neonatal resuscitation devices. Resuscitation. 2005;67:113–118. doi: 10.1016/j. resuscitation.2005.02.016.

157. Kelm M, Proquitté H, Schmalisch G, Roehr CC. Reliability of two common PEEP-generating devices used in neonatal resuscitation. Klin Padiatr. 2009;221:415–418. doi: 10.1055/s-0029-1233493.

158. Oddie S, Wyllie J, Scally A. Use of self-inflating bags for neona- tal resuscitation. Resuscitation. 2005;67:109–112. doi: 10.1016/j. resuscitation.2005.05.004.

159. Hussey SG, Ryan CA, Murphy BP. Comparison of three manual ven- tilation devices using an intubated mannequin. Arch Dis Child Fetal Neonatal Ed. 2004;89:F490–F493. doi: 10.1136/adc.2003.047712.

160. Finer NN, Rich W, Craft A, Henderson C. Comparison of methods of bag and mask ventilation for neonatal resuscitation. Resuscitation. 2001;49:299–305.

161. Kattwinkel J, Stewart C, Walsh B, Gurka M, Paget-Brown A. Responding to compliance changes in a lung model during manual ventilation: perhaps volume, rather than pressure, should be displayed. Pediatrics. 2009;123:e465–470.

162. Schmölzer GM, Morley CJ, Wong C, Dawson JA, Kamlin CO, Donath SM, Hooper SB, Davis PG. Respiratory function monitor guidance of mask ventilation in the delivery room: a feasibility study. J Pediatr. 2012;160:377–381.e2. doi: 10.1016/j.jpeds.2011.09.017.

163. Kong JY, Rich W, Finer NN, Leone TA. Quantitative end-tidal carbon dioxide monitoring in the delivery room: a randomized controlled trial. J Pediatr. 2013;163:104–8.e1. doi: 10.1016/j.jpeds.2012.12.016.

164. Esmail N, Saleh M, et al. Laryngeal mask airway versus endotracheal intubation for Apgar score improvement in neonatal resuscitation. Egypt J Anesth. 2002;18:115–121.

165. Hosono S, Inami I, Fujita H, Minato M, Takahashi S, Mugishima H. A role of end-tidal CO monitoring for assessment of tracheal intubations in very low birth weight infants during neonatal resuscitation at birth. J Perinat Med. 2009;37:79–84.

166. Repetto JE, Donohue P-CP, Baker SF, Kelly L, Nogee LM. Use of capnography in the delivery room for assessment of endotracheal tube placement. J Perinatol. 2001;21:284–287.

167. Roberts WA, Maniscalco WM, Cohen AR, Litman RS, Chhibber A. The use of capnography for recognition of esophageal intubation in the neonatal intensive care unit. Pediatr Pulmonol. 1995;19:262–268.

168. Aziz HF, Martin JB, Moore JJ. The pediatric disposable end-tidal carbon dioxide detector role in endotracheal intubation in newborns. J Perinatol. 1999;19:110–113.

169. Garey DM, Ward R, Rich W, Heldt G, Leone T, Finer NN. Tidal volume threshold for colorimetric carbon dioxide detectors available for use in neonates. Pediatrics. 2008;121:e1524–1527.

170. Morley CJ, Davis PG, Doyle LW, Brion LP, Hascoet JM, Carlin JB; COIN Trial Investigators. Nasal CPAP or intubation at birth for very preterm infants. N Engl J Med. 2008;358:700–708. doi: 10.1056/ NEJMoa072788.

171. SUPPORT Study Group of the Eunice Kennedy Shriver NICHD Neonatal Research Network, Finer NN, Carlo WA, Walsh MC, Rich W, Gantz MG, Laptook AR, Yoder BA, Faix RG, Das A, Poole WK, Donovan EF, Newman NS, Ambalavanan N, Frantz ID 3rd, Buchter S, Sanchez PJ, Kennedy KA, Laroia N, Poindexter BB, Cotten CM, Van Meurs KP, Duara S, Narendran V, Sood BG, O'Shea TM, Bell EF, Bhandari V, Watterberg KL, Higgins RD. Early CPAP versus surfactant in extremely preterm infants. N Engl J Med. 2010;362:1970–1979.

172. Dunn MS, Kaempf J, de Klerk A, de Klerk R, Reilly M, Howard D, Ferrelli K, O'Conor J, Soll RF; Vermont Oxford Network DRM Study Group. Randomized trial comparing 3 approaches to the initial respi- ratory management of preterm neonates. Pediatrics. 2011;128:e1069– e1076. doi: 10.1542/peds.2010-3848.

173. Orlowski JP. Optimum position for external cardiac compression in infants and young children. Ann Emerg Med. 1986;15:667–673.

174. Phillips GW, Zideman DA. Relation of infant heart to sternum: its signifi- cance in cardiopulmonary resuscitation. Lancet. 1986;1:1024–1025.

175. Saini SS, Gupta N, Kumar P, Bhalla AK, Kaur H. A comparison of two- fingers technique and two-thumbs encircling hands technique of chest compression in neonates. J Perinatol. 2012;32:690–694. doi: 10.1038/ jp.2011.167.

176. You Y. Optimum location for chest compressions during two-rescuer infant cardiopulmonary resuscitation. Resuscitation. 2009;80:1378– 1381. doi: 10.1016/j.resuscitation.2009.08.013.

177. Meyer A, Nadkarni V, Pollock A, Babbs C, Nishisaki A, Braga M, Berg RA, Ades A. Evaluation of the Neonatal Resuscitation Program's recommended chest compression depth using computerized tomog- raphy imaging. Resuscitation. 2010;81:544–548. doi: 10.1016/j. resuscitation.2010.01.032.

178. Christman C, Hemway RJ, Wyckoff MH, Perlman JM. The two-thumb is superior to the two-finger method for administering chest compres- sions in a manikin model of neonatal resuscitation. Arch Dis Child Fetal Neonatal Ed. 2011;96:F99–F101. doi: 10.1136/adc.2009.180406.

179. David R. Closed chest cardiac massage in the newborn infant. Pediatrics. 1988;81:552–554.

180. Dellimore K, Heunis S, Gohier F, Archer E, de Villiers A, Smith J, Scheffer C. Development of a diagnostic glove for unobtrusive measurement of chest compression force and depth during neonatal CPR. Conf Proc IEEE Eng Med Biol Soc. 2013;2013:350–353. doi: 10.1109/ EMBC.2013.6609509.

181. Dorfsman ML, Menegazzi JJ, Wadas RJ, Auble TE. Two-thumb vs. two- finger chest compression in an infant model of prolonged cardiopulmo- nary resuscitation. Acad Emerg Med. 2000;7:1077–1082.

182. Houri PK, Frank LR, Menegazzi JJ, Taylor R. A randomized, con- trolled trial of two-thumb vs two-finger chest compression in a swine infant model of cardiac arrest [see comment]. Prehosp Emerg Care. 1997;1:65–67.

183. Martin PS, Kemp AM, Theobald PS, Maguire SA, Jones MD. Do chest compressions during simulated infant CPR comply with international recommendations? Arch Dis Child. 2013;98:576–581. doi: 10.1136/ archdischild-2012-302583.

184. Martin PS, Kemp AM, Theobald PS, Maguire SA, Jones MD. Does a more "physiological" infant manikin design effect chest compression quality and create a potential for thoracic over-compression during simulated infant CPR? Resuscitation. 2013;84:666–671. doi: 10.1016/j. resuscitation.2012.10.005.

185. Martin P, Theobald P, Kemp A, Maguire S, Maconochie I, Jones M. Real-time feedback can improve infant manikin cardiopulmonary resus- citation by up to 79%–a randomised controlled trial. Resuscitation. 2013;84:1125–1130. doi: 10.1016/j.resuscitation.2013.03.029.

186. Menegazzi JJ, Auble TE, Nicklas KA, Hosack GM, Rack L, Goode JS. Two-thumb versus two-finger chest compression during CRP in a swine infant model of cardiac arrest. Ann Emerg Med. 1993;22:240–243.

187. MOYA F, JAMES LS, BURNARD ED, HANKS EC. Cardiac massage in the newborn infant through the intact chest. Am J Obstet Gynecol. 1962;84:798–803.

188. Park J, Yoon C, Lee JC, Jung JY, Kim do K, Kwak YH, Kim HC. Manikin-integrated digital measuring system for assessment of infant cardiopulmonary resuscitation techniques. IEEE J Biomed Health Inform. 2014;18:1659–1667. doi: 10.1109/JBHI.2013.2288641.

189. Thaler MM, Stobie GH. An improved technic of external cardiac compression in infants and young children. N Engl J Med. 1963;269: 606–610. doi: 10.1056/NEJM196309192691204.

190. Todres ID, Rogers MC. Methods of external cardiac massage in the newborn infant. J Pediatr. 1975;86:781–782.

191. Udassi S, Udassi JP, Lamb MA, Theriaque DW, Shuster JJ, Zaritsky AL, Haque IU. Two-thumb technique is superior to two-finger technique dur- ing lone rescuer infant manikin CPR. Resuscitation. 2010;81:712–717. doi: 10.1016/j.resuscitation.2009.12.029.

192. Whitelaw CC, Slywka B, Goldsmith LJ. Comparison of a two-finger ver- sus two-thumb method for chest compressions by healthcare providers in an infant mechanical model. Resuscitation. 2000;43:213–216.

193. Dannevig I, Solevåg AL, Saugstad OD, Nakstad B. Lung injury in asphyxiated newborn pigs resuscitated from cardiac arrest—the impact of supplementary oxygen, longer ventilation intervals and chest com- pressions at different compression-to-ventilation ratios. Open Respir Med J. 2012;6:89–96. doi: 10.2174/1874306401206010089.

194. Dannevig I, Solevåg AL, Sonerud T, Saugstad OD, Nakstad B. Brain inflammation induced by severe asphyxia in newborn pigs and the impact of alternative resuscitation strategies on the newborn central sys- tem. Pediatr Res. 2013;73:163–170. doi: 10.1038/pr.2012.167.

195. Hemway RJ, Christman C, Perlman J. The 3:1 is superior to a 15:2 ratio in a newborn manikin model in terms of quality of chest compres- sions and number of ventilations. Arch Dis Child Fetal Neonatal Ed. 2013;98:F42–F45. doi: 10.1136/archdischild-2011-301334.

196. Solevåg AL, Dannevig I, Wyckoff M, Saugstad OD, Nakstad B. Extended series of cardiac compressions during CPR in a swine model of perinatal asphyxia. Resuscitation. 2010;81:1571–1576. doi: 10.1016/j. resuscitation.2010.06.007.

197. Solevåg AL, Dannevig I, Wyckoff M, Saugstad OD, Nakstad B. Return of spontaneous circulation with a compression:ventilation ratio of 15:2 versus 3:1 in newborn pigs with cardiac arrest due to asphyxia. Arch Dis Child Fetal Neonatal Ed. 2011;96:F417–F421. doi: 10.1136/ adc.2010.200386.

198. Solevåg AL, Madland JM, Gjærum E, Nakstad B. Minute ventilation at different compression to ventilation ratios, different ventilation rates, and continuous chest compressions with asynchronous ventilation in a newborn manikin. Scand J Trauma Resusc Emerg Med. 2012;20:73. doi: 10.1186/1757-7241-20-73.

199. Lakshminrusimha S, Steinhorn RH, Wedgwood S, Savorgnan F, Nair J, Mathew B, Gugino SF, Russell JA, Swartz DD. Pulmonary hemodynam- ics and vascular reactivity in asphyxiated term lambs resuscitated with 21 and 100% oxygen. J Appl Physiol (1985). 2011;111:1441–1447. doi: 10.1152/japplphysiol.00711.2011.

200. Linner R, Werner O, Perez-de-Sa V, Cunha-Goncalves D. Circulatory recovery is as fast with air ventilation as with 100% oxygen after asphyxia-induced cardiac arrest in piglets. Pediatr Res. 2009;66:391– 394. doi: 10.1203/PDR.0b013e3181b3b110.

201. Lipinski CA, Hicks SD, Callaway CW. Normoxic ventilation dur- ing resuscitation and outcome from asphyxial cardiac arrest in rats. Resuscitation. 1999;42:221–229.

202. Perez-de-Sa V, Cunha-Goncalves D, Nordh A, Hansson S, Larsson A, Ley D, Fellman V, Werner O. High brain tissue oxygen tension during ventilation with 100% oxygen after fetal asphyxia in newborn sheep. Pediatr Res. 2009;65:57–61.

203. Solevåg AL, Dannevig I, Nakstad B, Saugstad OD. Resuscitation of severely asphyctic newborn pigs with cardiac arrest by using 21% or 100% oxygen. Neonatology. 2010;98:64–72. doi: 10.1159/000275560.

204. Temesvári P, Karg E, Bódi I, Németh I, Pintér S, Lazics K, Domoki F, Bari F. Impaired early neurologic outcome in newborn piglets reoxygenated with 100% oxygen compared with room air after pneu- mothorax-induced asphyxia. Pediatr Res. 2001;49:812–819. doi: 10.1203/00006450-200106000-00017.

205. Walson KH, Tang M, Glumac A, Alexander H, Manole MD, Ma L, Hsia CJ, Clark RS, Kochanek PM, Kagan VE, Bayr H. Normoxic ver- sus hyperoxic resuscitation in pediatric asphyxial cardiac arrest: effects on oxidative stress. Crit Care Med. 2011;39:335–343. doi: 10.1097/ CCM.0b013e3181ffda0e.

206. Yeh ST, Cawley RJ, Aune SE, Angelos MG. Oxygen requirement dur- ing cardiopulmonary resuscitation (CPR) to effect return of sponta- neous circulation. Resuscitation. 2009;80:951–955. doi: 10.1016/j. resuscitation.2009.05.001.

207. Berg RA, Henry C, Otto CW, Sanders AB, Kern KB, Hilwig RW, Ewy GA. Initial end-tidal CO2 is markedly elevated during cardiopulmo- nary resuscitation after asphyxial cardiac arrest. Pediatr Emerg Care. 1996;12:245–248.

208. Bhende MS, Karasic DG, Menegazzi JJ. Evaluation of an end-tidal CO2 detector during cardiopulmonary resuscitation in a canine model for pediatric cardiac arrest. Pediatr Emerg Care. 1995;11:365–368.

209. Bhende MS, Thompson AE. Evaluation of an end-tidal CO2 detec- tor during pediatric cardiopulmonary resuscitation. Pediatrics. 1995;95:395–399.

210. Bhende MS, Karasic DG, Karasic RB. End-tidal carbon dioxide changes during cardiopulmonary resuscitation after experimental asphyxial cardiac arrest. Am J Emerg Med. 1996;14:349–350. doi: 10.1016/ S0735-6757(96)90046-7.

211. Chalak LF, Barber CA, Hynan L, Garcia D, Christie L, Wyckoff MH. End-tidal CO2 detection of an audible heart rate during neonatal cardio- pulmonary resuscitation after asystole in asphyxiated piglets. Pediatr Res. 2011;69(5 pt 1):401–405. doi: 10.1203/PDR.0b013e3182125f7f.

212. Berg RA, Otto CW, Kern KB, Hilwig RW, Sanders AB, Henry CP, Ewy GA. A randomized, blinded trial of high-dose epinephrine versus standard-dose epinephrine in a swine model of pediatric asphyxial cardiac arrest. Crit Care Med. 1996;24:1695–1700.

213. Burchfield DJ, Preziosi MP, Lucas VW, Fan J. Effects of graded doses of epinephrine during asphxia-induced bradycardia in newborn lambs. Resuscitation. 1993;25:235–244.

214. Perondi MB, Reis AG, Paiva EF, Nadkarni VM, Berg RA. A comparison of high-dose and standard-dose epinephrine in children with cardiac arrest. N Engl J Med. 2004;350:1722–1730.

215. Patterson MD, Boenning DA, Klein BL, Fuchs S, Smith KM, Hegenbarth MA, Carlson DW, Krug SE, Harris EM. The use of high-dose epinephrine for patients with out-of-hospital cardiopulmonary arrest refractory to prehospital interventions. Pediatr Emerg Care. 2005;21:227–237.

216. Wyckoff MH, Perlman JM, Laptook AR. Use of volume expansion during delivery room resuscitation in near-term and term infants. Pediatrics. 2005;115:950–955.

217. Jacobs SE, Morley CJ, Inder TE, Stewart MJ, Smith KR, McNamara PJ, Wright IM, Kirpalani HM, Darlow BA, Doyle LW; Infant Cooling Evaluation Collaboration. Whole-body hypothermia for term and near- term newborns with hypoxic-ischemic encephalopathy: a randomized controlled trial. Arch Pediatr Adolesc Med. 2011;165:692–700. doi: 10.1001/archpediatrics.2011.43.

218. Bharadwaj SK, Bhat BV. Therapeutic hypothermia using gel packs for term neonates with hypoxic ischaemic encephalopathy in resource-lim- ited settings: a randomized controlled trial. J Trop Pediatr. 2012;58:382– 388. doi: 10.1093/tropej/fms005.

219. Robertson NJ, Hagmann CF, Acolet D, Allen E, Nyombi N, Elbourne D, Costello A, Jacobs I, Nakakeeto M, Cowan F. Pilot randomized trial of therapeutic hypothermia with serial cranial ultrasound and 18-22 month follow-up for neonatal encephalopathy in a low resource hospital setting in Uganda: study protocol. Trials. 2011;12:138. doi: 10.1186/1745-6215-12-138.

220. Thayyil S, Shankaran S, Wade A, Cowan FM, Ayer M, Satheesan K, Sreejith C, Eyles H, Taylor AM, Bainbridge A, Cady EB, Robertson NJ, Price D, Balraj G. Whole-body cooling in neonatal encephalopa- thy using phase changing material. Arch Dis Child Fetal Neonatal Ed. 2013;98:F280–F281. doi: 10.1136/archdischild-2013-303840.

221. Field DJ, Dorling JS, Manktelow BN, Draper ES. Survival of extremely premature babies in a geographically defined population: prospective cohort study of 1994–9 compared with 2000–5. BMJ. 2008;336:1221–1223.

222. Tyson JE, Parikh NA, Langer J, Green C, Higgins RD. Intensive care for extreme prematurity–moving beyond gestational age. N Engl J Med. 2008;358:1672–1681.

223. Paris JJ. What standards apply to resuscitation at the borderline of gestational age? J Perinatol. 2005;25:683–684.

224. Bottoms SF, Paul RH, Mercer BM, MacPherson CA, Caritis SN, Moawad AH, Van Dorsten JP, Hauth JC, Thurnau GR, Miodovnik M, Meis PM, Roberts JM, McNellis D, Iams JD. Obstetric determinants of neonatal survival: antenatal predictors of neonatal survival and morbidity in extremely low birth weight infants. Am J Obstet Gynecol. 1999;180 (3 pt 1):665–669.

225. Ambalavanan N, Carlo WA, Bobashev G, Mathias E, Liu B, Poole K, Fanaroff AA, Stoll BJ, Ehrenkranz R, Wright LL; National Institute of Child Health and Human Development Neonatal Research Network. Prediction of death for extremely low birth weight neonates. Pediatrics. 2005;116:1367–1373. doi: 10.1542/peds.2004-2099.

226. Manktelow BN, Seaton SE, Field DJ, Draper ES. Population-based estimates of in-unit survival for very preterm infants. Pediatrics. 2013;131:e425–e432. doi: 10.1542/peds.2012-2189.

227. Medlock S, Ravelli AC, Tamminga P, Mol BW, Abu-Hanna A. Prediction of mortality in very premature infants: a systematic review of prediction models. PLoS One. 2011;6:e23441. doi: 10.1371/journal.pone.0023441.

228. Tyson JE, Parikh NA, Langer J, Green C, Higgins RD; National Institute of Child Health and Human Development Neonatal Research Network. Intensive care for extreme prematurity–moving beyond gestational age. N Engl J Med. 2008;358:1672–1681. doi: 10.1056/NEJMoa073059.

229. Casalaz DM, Marlow N, Speidel BD. Outcome of resuscitation follow- ing unexpected apparent stillbirth. Arch Dis Child Fetal Neonatal Ed. 1998;78:F112–F115.

230. Harrington DJ, Redman CW, Moulden M, Greenwood CE. The long- term outcome in surviving infants with Apgar zero at 10 minutes: a sys- tematic review of the literature and hospital-based cohort. Am J Obstet Gynecol. 2007;196:463.e1–463.e5. doi: 10.1016/j.ajog.2006.10.877.

231. Kasdorf E, Laptook A, Azzopardi D, Jacobs S, Perlman JM. Improving infant outcome with a 10 min Apgar of 0. Arch Dis Child Fetal Neonatal Ed. 2015;100:F102–F105. doi: 10.1136/archdischild-2014-306687.

232. Laptook AR, Shankaran S, Ambalavanan N, Carlo WA, McDonald SA, Higgins RD, Das A; Hypothermia Subcommittee of the NICHD Neonatal Research Network. Outcome of term infants using apgar scores at 10 minutes following hypoxic-ischemic encephalopathy. Pediatrics. 2009;124:1619–1626. doi: 10.1542/peds.2009-0934.

233. Patel H, Beeby PJ. Resuscitation beyond 10 minutes of term babies born without signs of life. J Paediatr Child Health. 2004;40:136–138.

234. Sarkar S, Bhagat I, Dechert RE, Barks JD. Predicting death despite thera- peutic hypothermia in infants with hypoxic-ischaemic encephalopathy. Arch Dis Child Fetal Neonatal Ed. 2010;95:F423–F428. doi: 10.1136/ adc.2010.182725.

235. Savoldelli GL, Naik VN, Park J, Joo HS, Chow R, Hamstra SJ. Value of debriefing during simulated crisis management: oral versus video-assisted oral feedback. Anesthesiology. 2006;105:279–285.

236. Edelson DP, Litzinger B, Arora V, Walsh D, Kim S, Lauderdale DS, Vanden Hoek TL, Becker LB, Abella BS. Improving in-hospital cardiac arrest process and outcomes with performance debriefing. Arch Intern Med. 2008;168:1063–1069.

237. DeVita MA, Schaefer J, Lutz J, Wang H, Dongilli T. Improving medical emergency team (MET) performance using a novel curriculum and a computerized human patient simulator. Qual Saf Health Care. 2005;14:326–331.

238. Wayne DB, Butter J, Siddall VJ, Fudala MJ, Linquist LA, Feinglass J, Wade LD, McGaghie WC. Simulation-based training of internal medicine residents in advanced cardiac life support protocols: a randomized trial. Teach Learn Med. 2005;17:210–216.

239. Clay AS, Que L, Petrusa ER, Sebastian M, Govert J. Debriefing in the intensive care unit: a feedback tool to facilitate bedside teaching. Crit Care Med. 2007;35:738–754.

240. Blum RH, Raemer DB, Carroll JS, Dufresne RL, Cooper JB. A method for measuring the effectiveness of simulation-based team training for improving communication skills. Anesth Analg. 2005;100:1375–1380,.

241. Breckwoldt J, Svensson J, Lingemann C, Gruber H. Does clinical teacher training always improve teaching effectiveness as opposed to no teacher training? A randomized controlled study. BMC Med Educ. 2014;14:6. doi: 10.1186/1472-6920-14-6.

242. Boerboom TB, Jaarsma D, Dolmans DH, Scherpbier AJ, Mastenbroek NJ, Van Beukelen P. Peer group reflection helps clinical teachers to critically reflect on their teaching. Med Teach. 2011;33:e615–e623. doi: 10.3109/0142159X.2011.610840.

243. Litzelman DK, Stratos GA, Marriott DJ, Lazaridis EN, Skeff KM. Beneficial and harmful effects of augmented feedback on physicians' clinical-teaching performances. Acad Med. 1998;73:324–332.

244. Naji SA, Maguire GP, Fairbairn SA, Goldberg DP, Faragher EB. Training clinical teachers in psychiatry to teach interviewing skills to medical stu- dents. Med Educ. 1986;20:140–147.

245. Schum TR, Yindra KJ. Relationship between systematic feedback to fac- ulty and ratings of clinical teaching. Acad Med. 1996;71:1100–1102.

246.

Skeff KM, Stratos G, Campbell M, Cooke M, Jones HW III. Evaluation of the seminar method to improve clinical teaching. J Gen Intern Med. 1986;1:315–322.

247. Lye P, Heidenreich C, Wang-Cheng R, Bragg D, Simpson D; Advanced Faculty Development Group. Experienced clinical educators improve their clinical teaching effectiveness. Ambul Pediatr. 2003;3:93–97.

248. Regan-Smith M, Hirschmann K, Iobst W. Direct observation of faculty with feedback: an effective means of improving patient-centered and learner-centered teaching skills. Teach Learn Med. 2007;19:278–286. doi: 10.1080/10401330701366739.

249. American Academy of Pediatrics, American Heart Association. Textbook of Neonatal Resuscitation (NRP). Chicago, IL: American Academy of Pediatrics;2011.

250. Berden HJ, Willems FF, Hendrick JM, Pijls NH, Knape JT. How fre- quently should basic cardiopulmonary resuscitation training be repeated to maintain adequate skills? BMJ. 1993;306:1576–1577.

251. Ernst KD, Cline WL, Dannaway DC, Davis EM, Anderson MP, Atchley CB, Thompson BM. Weekly and consecutive day neonatal intubation training: comparable on a pediatrics clerkship. Acad Med. 2014;89:505– 510. doi: 10.1097/ACM.0000000000000150.

252. Kaczorowski J, Levitt C, Hammond M, Outerbridge E, Grad R, Rothman A, Graves L. Retention of neonatal resuscitation skills and knowledge: a randomized controlled trial. Fam Med. 1998;30:705–711.

253. Kovacs G, Bullock G, Ackroyd-Stolarz S, Cain E, Petrie D. A ran- domized controlled trial on the effect of educational interventions in promoting airway management skill maintenance. Ann Emerg Med. 2000;36:301–309. doi: 10.1067/mem.2000.109339.

254. Montgomery C, Kardong-Edgren SE, Oermann MH, Odom-Maryon T. Student satisfaction and self report of CPR competency: HeartCode BLS courses, instructor-led CPR courses, and monthly voice advisory manikin practice for CPR skill maintenance. Int J Nurs Educ Scholarsh. 2012;9. doi: 10.1515/1548-923X.2361.

255. Oermann MH, Kardong-Edgren SE, Odom-Maryon T. Effects of monthly practice on nursing students' CPR psychomotor skill perfor- mance. Resuscitation. 2011;82:447–453. doi: 10.1016/j.resuscitation. 2010.11.022.

256. Stross JK. Maintaining competency in advanced cardiac life support skills. JAMA. 1983;249:3339–3341.

257. Su E, Schmidt TA, Mann NC, Zechnich AD. A randomized con- trolled trial to assess decay in acquired knowledge among paramed- ics completing a pediatric resuscitation course. Acad Emerg Med. 2000;7:779–786.

258. Sutton RM, Niles D, Meaney PA, Aplenc R, French B, Abella BS, Lengetti EL, Berg RA, Helfaer MA, Nadkarni V. "Booster" training: evaluation of instructor-led bedside cardiopulmonary resuscitation skill training and automated corrective feedback to improve cardiopulmonary resuscitation compliance of Pediatric Basic Life Support providers dur- ing simulated cardiac arrest. Pediatr Crit Care Med. 2011;12:e116–e121. doi: 10.1097/PCC.0b013e3181e91271.

259. Turner NM, Scheffer R, Custers E, Cate OT. Use of unan- nounced spaced telephone testing to improve retention of knowl- edge after life-support courses. Med Teach. 2011;33:731–737. doi: 10.3109/0142159X.2010.542521.

260. Lubin J, Carter R. The feasibility of daily mannequin practice to improve intubation success. Air Med J. 2009;28:195–197. doi: 10.1016/j.amj. 2009.03.006.

261. Mosley CM, Shaw BN. A longitudinal cohort study to investigate the retention of knowledge and skills following attendance on the Newborn Life support course. Arch Dis Child. 2013;98:582–586. doi: 10.1136/ archdischild-2012-303263.

262. Nadel FM, Lavelle JM, Fein JA, Giardino AP, Decker JM, Durbin DR. Teaching resuscitation to pediatric residents: the effects of an interven- tion. Arch Pediatr Adolesc Med. 2000;154:1049–1054.

263. Niles D, Sutton RM, Donoghue A, Kalsi MS, Roberts K, Boyle L, Nishisaki A, Arbogast KB, Helfaer M, Nadkarni V. "Rolling Refreshers": a novel approach to maintain CPR psychomotor skill competence. Resuscitation. 2009;80:909–912. doi: 10.1016/j.resuscitation.2009.04.021.

264. Nishisaki A, Donoghue AJ, Colborn S, Watson C, Meyer A, Brown CA 3rd, Helfaer MA, Walls RM, Nadkarni VM. Effect of just-in-time simu- lation training on tracheal intubation procedure safety in the pediatric intensive care unit. Anesthesiology. 2010;113:214–223. doi: 10.1097/ ALN.0b013e3181e19bf2.

265. O'Donnell CM, Skinner AC. An evaluation of a short course in resuscitation training in a district general hospital. Resuscitation. 1993;26:193–201.