Current Anesthesiology Reports (2023) 13:67–75
https://doi.org/10.1007/s40140-023-00555-3

OBSTETRIC ANESTHESIA (L LEFFERT, SECTION EDITOR)

# Neonatal Resuscitation in Delivery Room: Current Trends and Guidelines in 2022

**Fatoumata Kromah**[1]

Accepted: 27 January 2023 / Published online: 3 May 2023


## Abstract

**Purpose of Review** This review article summarizes current trends and provides an updated overview of the 2020 guidelines on neonatal resuscitation in the delivery room. Neonatal respiratory depression, which accounts for one-third of all neonatal mortality, results in approximately 1 million newborn deaths each year worldwide due to asphyxia at birth.

**Recent Findings** Around 10% of all newborns will require some intervention, while less than 1% of all newborns necessitate intensive resuscitation at birth. An increase in heart rate during the first few minutes is the key sign of the newborn's smooth transition from intrauterine to extrauterine life. Efficient and timely resuscitation at birth may improve the outcomes of the resuscitated newborn.

**Summary** The neonatal mortality rate due to respiratory depression may be decreased by evidence-based resuscitative efforts that encourage or assist the newborn to initiate and/or sustain breathing. Neonatal resuscitation involves basic interventions such as tactile stimulation, airway clearance, positive pressure ventilation, chest compression, and medication therapy.

**Keywords** Neonatal · Resuscitation · CPR · Newborn · Delivery · Anesthesia

## Introduction

Approximately 1 million newborns worldwide die each year as a result of asphyxia at birth [1] which the WHO defines as the inability to initiate and sustain breathing at birth [2]. A million newborns die the day they are born. The first week of life accounts for almost three-quarters of all neonatal deaths. More than half of all neonatal deaths happen during the first 24 h following birth [2]. The cardiovascular and pulmonary systems are mainly involved in the cessation of maternal–fetal circulation after birth and the rapid physiologic changes that occur in the immediate postpartum period. Neonatal respiratory depression and the necessity for resuscitation are typically due to the failure of cardiorespiratory adaptation. Most newborns effectively and without any intervention transition from intrauterine to extrauterine life. Within 30 s of delivery, 85% of term newborns will begin breathing independently. 10% more of term newborn will respond to drying and tactile stimulation [3]. Only 1% of all newborns will need neonatal resuscitation at birth, which includes chest compressions (CC) and drug administration [4••]. Approximately, 0.1% of term newborns need advanced CPR immediately after birth [4••]. These percentages of advanced CPR with or without administration of epinephrine in neonates are substantially higher in preterm neonates, accounting for 6–7% in neonates < 32 weeks gestational age (GA) and approximately 6–10% in newborns with very low and extremely low birth weight [5•, 6].

Birth asphyxia-related morbidity and mortality can be avoided or treated. Adequate neonatal resuscitation can prevent a significant percentage of these deaths, about 30% [2, 7]. Furthermore, resuscitation may prevent 5–10% of neonatal deaths caused by complications related to preterm delivery [2]. Three in a hundred neonates require positive pressure ventilation (PPV), and about one in ten requires drying and tactile stimulation to initiate spontaneous respirations at delivery. One in one thousand newborns need chest compressions, and five in ten thousand newborns need cardiac medications to

Topical Collection on *Obstetric Anesthesia*

✉ Fatoumata Kromah
Fatoumata.kromah@vcuhealth.org

[1] Department of Anesthesiology, VCUHealth, 1200 E. Broad St., PO Box 980695, Richmond, VA 23298, USA

restore spontaneous circulation [8]. Healthcare systems should ideally be able to identify neonates needing resuscitation before birth and have trained neonatal resuscitation teams readily available. Unfortunately, it is not always possible to foresee the need for resuscitation before birth. Because of that, at any delivery, providers caring for newborns must be ready at any time to perform neonatal resuscitation [8].

## Transition from Intrauterine to Extrauterine Life

Physiological changes at and after birth are necessary to transition from intrauterine to extrauterine life successfully. These adjustments are successfully carried out upon delivery in almost all newborns without medical help. When the umbilical cord is clamped at delivery, the newborn must effectively transition from intrauterine to extrauterine life by undergoing physiologic alterations in cardiopulmonary function. The characteristics of a successful transition include:

- Clearance of alveolar fluid
- Expansion of the lung
- Cardiovascular and pulmonary changes, including the closure of the right-to-left shunts of the fetal circulation and the increase in pulmonary perfusion and systemic arterial pressure [9••]

Lung aeration, believed to include three mechanisms, is the first physiological event that occurs as a newborn transition from fetal to out-of-the-womb life. Sodium reabsorption and changes in fetal position are two mechanisms that happen during labor, followed by the changes in the pressure gradients caused by inspiration after birth. Only one of these mechanisms, the fetal postural switch, contributes to fluid loss from the respiratory system. However, sodium reabsorption and changes in the pressure gradients lead to fluid reabsorption into the lung tissue from the airways. Although it increases pulmonary blood flow (PBF), this alveolar fluid can have a significant negative impact on postnatal respiratory function [10•].

Difficulties at birth that could lead to a necessity for resuscitation are [9••]:

- Absence of respiratory effort
- Blockage of the nasopharyngeal airway
- Impaired function of the lung tissue
- Persistently increased pulmonary vascular resistance (persistent fetal circulation)
- Abnormality in cardiovascular structure and function of the heart [9••]

## Circulatory Emergencies in the Delivery Room

An increase in heart rate during the first few minutes is the key sign of the newborn's smooth transition from intrauterine to extrauterine life. A newborn’s heart rate usually rises or remains stable above 100 beats per minute once they start breathing on their own or if positive pressure ventilation is applied. Most newborns who do not have a rising heart rate at birth have insufficient lung expansion as a result of poor ventilation. Persistent bradycardia represents a cardiac emergency. The congenital cardiac condition should be given urgent consideration after an airway has been secured and endotracheal intubation has been performed to provide adequate breathing [11].

## Cardiac Disease

Neonates with severe congenital heart disease or defects may struggle to adjust to life outside the womb. This includes neonates with severe pulmonary edema caused by increased pulmonary arterial blood flow or compromised function of the left ventricle. Neonates with cyanotic heart disease depend on a patent ductus arteriosus to maintain pulmonary and systemic blood flow. Due to a patent ductus arteriosus, most neonates with congenital heart disease do not initially present with severe circulation problems [12, 13]. The delivery team should be ready to set up an IV access quickly after birth and administer prostaglandin for the ductus arteriosus to remain patent. This intervention is mandatory for critical left-sided and right-sided heart lesions when a closed or restrictive patent ductus is detected [12, 13].

## Anticipation for Resuscitation

Randomized studies are challenging to conduct in the delivery room, since it is difficult to gain consent prior to cardiopulmonary resuscitation, it is challenging to blind healthcare professionals to interventions, and it is extremely uncommon to use a poor neonatal outcome to gauge the success of interventions [4••]. Therefore, guidelines are based on substantial clinical experience and limited clinical evidence. Neonatal inability to start and maintain adequate or spontaneous breathing plays a crucial role in early deaths after birth and poor neurodevelopmental outcomes in survivors. Therefore, efficient and timely resuscitation at birth may improve the outcomes of the resuscitated newborn. To optimize the odds of survival, successful newborn resuscitation attempts depend on a series of vital steps as described below that must be taken quickly and in succession [1, 4••]. The facilitation of the transition to proper lung inflation and ventilation as soon as possible after birth is the main objective of neonatal care at birth. As a result, every newborn should be cared for by at least one person who is qualified and prepared to provide PPV. PPV is a method of lung inflation using a resuscitation mask, endotracheal, or tracheostomy tube that results in an increase in alveolar pressure). In recognition that healthy neonates transition naturally, additional essential objectives include establishing and maintaining cardiovascular and temperature stability, and promoting other newborn bonding and breastfeeding [1, 4••].

## Apgar's Score

The Apgar score is a standardized tool utilized to gauge a newborn's status at birth. Usually, resuscitation attempts occur before a full physical assessment of the newborn. The neonatal examination must be quick and accurate because Neonatal Resuscitation Program (NRP) guidelines require for simultaneous assessment and intervention. Five factors are evaluated at 1 and 5 min after birth to determine the Apgar score. If the first results are low, additional scoring may be done at 5- or 10-min intervals. Heart rate, respiratory effort, muscular tone, reflex irritability, and color are the criteria. For each of these five entities, a grade of 0, 1, or 2 is given. An overall score of 8 to 10 is considered normal, 4 to 7 denotes a moderate level of impairment, and 0 to 3 suggests the need for resuscitation [14•].

## High-Risk Delivery

Risk factors listed in Table 1 may be used to identify newborns who are more likely to need resuscitation [15–18].

The necessary equipment to be prepared in anticipation of all delivery and neonatal resuscitation is listed below:

- Warmer—it should be turned on.
- Oxygen source with adequate flow
- Suctioning apparatus with suctioning catheters
- Laryngoscope and endotracheal tubes
- Resuscitation bag and mask that provide a firm seal and can generate adequate pressure

## Umbilical Cord Management

Recent data have demonstrated that umbilical cord clamping severely restricts venous return in the absence of breathing. Therefore, cardiac output drastically decreases and stays low until breathing starts. Once the newborn starts breathing, aeration of the lungs causes a significant rise in pulmonary blood flow, and the left ventricle's source of preload is no longer the umbilical venous return [19, 20]. As a result, cardiac output significantly increases, as evidenced by an increase in heart rate immediately after birth. Therefore, neonates who are born hypoxic and apneic or whose cords are quickly clamped are likely to have both hypoxia and reduced cardiac output. Limiting the rise in cardiac output exposes the newborn to ischemia in addition to hypoxia. Before the umbilical cord is clamped, however, if the newborn initiates breaths, aerates its lungs, and raises pulmonary blood flow, then the pulmonary venous return can take over the supply of left ventricular preload instantly [19, 20]. Based on the most recent American Heart Association (AHA) guideline, it may be appropriate to postpone cord clamping after an uncomplicated term or late preterm delivery until the neonate is breathing, and its movement is evaluated. A higher value of hematocrit after birth and improved iron levels in infancy are linked to delayed cord clamping. Although the effects on development have not been thoroughly studied, iron deficiency is linked to slower motor and cognitive growth. In preterm newborns, delaying the cord clamping (for more than 30 s) makes sense because it minimizes the requirement for blood transfusions and blood pressure support while potentially increasing survival [4••]. Insufficient research has been done on newborns that need PPV before cord clamping to make a recommendation. Early cord clamping should be considered when placental transfusion is unlikely to happen, such as in situations involving maternal hemorrhage or hemodynamic instability, placental abruption, or placenta previa. There is no evidence that postponed cord clamping causes more maternal damage compared to early cord clamping. Although cord milking is being researched as a potential alternative to delayed cord

**Table 1** Risk factors for the newborn who are more likely to need resuscitation

| | |
|---|---|
| Maternal conditions | Very young or advanced maternal age, hypertension, and history of stillbirth, fetal loss or early neonatal death, diabetes mellitus, substance use disorder |
| Fetal conditions | Prematurity and post maturity, congenital anomalies, intrauterine growth restriction |
| Antepartum complications | Anomalies of the placenta (placenta previa, placental abruption), oligohydramnios, polyhydramnios |
| Delivery complications | Abnormal (transverse or breech) presentation, abnormal (malodorous or meconium-stained) amniotic fluid, antenatal asphyxia, instrumentation (forceps or vacuum) delivery, cesarean delivery |

clamping, it should be avoided in newborns born before 28 weeks of gestation because it has been linked to brain injury [4••].

## Newborn Temperature Management

The World Health Organization (WHO) and the Neonatal Resuscitation Program (NRP) have repeatedly stressed the significance of preventing neonatal hypothermia and advise maintaining newborn body temperatures between 36.5 and 37.5 °C. "Warm and maintain normal temperature" is the first step in the neonatal resuscitation. Despite these efforts, hypothermia still affects many newborns worldwide. According to studies conducted in developed countries, up to 56% of neonates with very low birthweights (VLBW, less than 1500 g) and up to 40% of neonates under the gestational age of 26 weeks have admission temperatures less than 36 and 35 °C, respectively. These figures for both preterm and term neonates may be substantially higher in developing nations [4••, 21]. Heat loss begins at delivery. Newborns are exposed to a cold, dry environment after leaving the warm, humid, intrauterine environment. All newborns have some degree of evaporative heat loss. However, those born at earlier gestational ages are more severely impacted. Preterm neonates have an immature epidermal barrier, lack of a functional stratum corneum, decreased subcutaneous fat, higher surface area to body weight ratio, and poor vasomotor control in the first few days after birth. Preterm neonates born at less than 28 weeks gestation are especially at risk. Accordingly, research has shown that evaporative heat loss increases proportionately with decreasing gestational age [21]. Maintaining normal body temperature and avoiding hypothermia are important factors that determine neonatal morbidity and mortality. Neonatal intensive care units (NICUs) have long used skin temperature probes (STPs) for noninvasive skin temperature monitoring. The heat output needed to maintain normothermia is calculated by feedback mechanisms from STP readings in incubators and radiant heaters. For the temperature to be optimally controlled by the servo system, the STP must be placed on the newborn's body at the ideal location. Suggestions for STP placement differ according to guidelines. Most investigations compare the temperatures from the axilla and the abdomen. Even though a Cochrane review deemed abdominal skin the preferred location, other researchers reported no distinction between axilla and abdominal skin temperature measurements [22]. After delivery, a healthy newborn should undergo skin-to-skin care. Warming adjuncts (increased ambient temperature [greater than 23 °C], skin-to-skin care, radiant warmers, plastic wraps or bags, hats, blankets, exothermic mattresses, and warmed humidified inspired gases) individually or in combination may lessen the risk of hypothermia in preterm-and-low-birth-weight-newborns as well as in newborns needing resuscitation. Exothermic mattresses have been known to produce hyperthermia and localized heat damage [4••].

## Airway, Suctioning, and Tactile Stimulation

An initial evaluation of gestation, breathing, and tone is part of the immediate management of newborns.

### Positioning

The neonate should be placed in a sniffing position to allow ease of access and opening of the airway in the event that assistance is needed. The ideal position is achieved by laying the neonate flat on the back, on top of a radiant warmer bed with the neck in a neutral to a slightly extended position; the neck should not be hyperextended or flexed. Air entry is improved when the posterior pharynx, larynx, and trachea are in alignment. If necessary, a towel or blanket wrapped up and tucked under the newborn's shoulder will help keep the newborn's airway open [23].

### Suctioning

Only newborns with apparent blockage from secretions and those who require PPV should be suctioned right after birth. After placing the newborn in a sniffing position, the mouth and nose should be suctioned using a bulb syringe or suction catheter. To reduce the possibility of aspiration, it is recommended to suction the mouth first, followed by the nares. If not necessary, avoid suctioning since this can trigger a vagal response and cause apnea and/or bradycardia [4••, 15, 24].

### Meconium-Stained Amniotic Fluid

Vigorous (breathing normally and/or crying) newborns who do not require interventions such as tactile stimulation or suctioning may receive skin-to-skin care. Tactile stimulation may encourage breathing when there are ineffective breathing attempts or apnea after birth. Drying the newborn and massaging the sole of their feet and backs should be the extent of tactile stimulation. Repeated tactile stimulation during or after PPV may benefit preterm neonates in some ways, but further research is needed to confirm this. The mouth and nose may be suctioned if, at first assessment, there is obvious fluid obstructing the airway or there is a worry about blocked airways. If there is an indication of an obstruction of the airway during PPV, intubation in addition to endotracheal suctioning should also be taken into account [4••].

## Heart Rate Assessment During Neonatal Resuscitation

Heart rate, which is the strongest indicator of a successful resuscitation, is measured immediately after delivery to evaluate the neonate's health. Published studies do not clearly define the thresholds for intervention during neonatal resuscitation. Essentially pragmatic, the heart rates of 100 and 60 beats per minute (bpm) are the recommended rates for which interventions are triggered. The heart rate is typically greater than 100 bpm in term newborns with uncomplicated breathing and delayed umbilical cord clamping. Initial heart rates at birth were distributed in a bimodal peak between 60 and 165 min in an observational study of 1237 term/near-term newborns who were resuscitated in a rural context. Most cases, bradycardic neonates' heart rate increased during ventilation, reaching a final median of 161 bpm [4••, 15].

## Ventilation: Positive Pressure Ventilation

Most neonates begin to breathe on their own within 30 to 60 s after delivery, occasionally after drying and tactile stimulation. Neonates who are consistently bradycardic (heart rate less than 100 bpm) or who do not breathe within the first 60 s of life should be provided with PPV at a rate of 40 to 60 breaths per minute [4••, 15]. Compared to pediatric and adult resuscitation algorithms, the sequence of resuscitative measures is different in neonates. According to animal studies, the cessation of respiratory activity occurs before the beginning of heart failure when primary apnea in neonate progresses to secondary apnea. Adults who have been asphyxiated go through a different cycle of events because they simultaneously experience respiratory and cardiac collapse [4••, 15]. When newborns have inadequate breathing, are apneic, or continue to be consistently bradycardic despite proper initial steps, it is reasonable to start PPV at a rate of 40 to 60/min (in addition to tactile stimulation). The inspiratory time when delivering PPV should be 1 s or shorter to mimic the natural breathing pattern of both term and preterm neonates. While there have been studies to examine the potential efficacy of longer, prolonged inflations, it is possible that longer sustained inflations than 10 s for premature neonates could be harmful. It is unclear if prolonged inflations lasting between one and 10 s will be beneficial or harmful [4••, 15]. An increase in heart rate and, less consistently, chest expansion is used to gauge ventilation effectiveness. The lungs can typically be inflated at peak inflation pressures of up to 30 cm H2O in term neonates and 20 to 25 cm H2O in preterm neonates. However, under other circumstances, larger inflation pressures are necessary. Peak inflation pressures or tidal volumes higher than what is necessary to raise heart rate and cause chest expansion should be avoided. Neonates with illnesses (such as bronchopulmonary dysplasia and respiratory distress syndrome) or who are preterm have a propensity for atelectasis due to immaturity and surfactant deficiencies. During expiration, PEEP inflates the lungs at low pressure. In animal studies, PEEP has been demonstrated to sustain lung capacity during PPV, enhancing lung function and oxygenation [4••, 15].

## Ventilation: Continuous Positive Pressure

Neonates who spontaneously breathe at birth must develop a functional residual capacity after birth. Some newborns endure respiratory distress, which manifests as prolonged cyanosis or difficulty breathing [15]. CPAP aids in keeping the newborn's lungs inflated. When compared to endotracheal ventilation, CPAP is beneficial for preterm neonates who have trouble breathing after birth or after resuscitation. CPAP may lower the risk of bronchopulmonary dysplasia in early preterm neonates. In addition, CPAP is a less invasive method of respiratory assistance than PPV and intubation [4••]. A crucial phase in establishing the lungs' functional residual capacity (FRC) is the transition between normal breathing and physiologic stability. Finding the optimal FRC in the neonate lung's transitioning from the fluid-filled state can be complex, as it rests between atelectasis and overdistention. In newborns who are breathing on their own, CPAP increases intra-alveolar pressure and helps establish FRC and ventilation-perfusion matching [25]. CPAP, however, may raise the incidence of pneumothorax in late preterm and term newborns (GA > 35 weeks) [26–28]. Newborns who received CPAP in the delivery room had a higher risk of pneumothorax compared to children who did not (16.9% versus 3.7% [26].

## Oxygen Therapy

The newborn adapts from the low oxygen environment of the womb to room air (21% oxygen) with an uneventful birth, and blood oxygen levels rise over several minutes [4••, 29]. Relatively low oxygen levels during the fetal stage stimulate lung growth. "Normoxia" or hyperoxia after a preterm delivery may lead to HIF (hypoxia-inducible factor) which may cause degradation, inadequate alveolarization, and vascular pruning [29]. Supplemental oxygen may be given during resuscitation to prevent damage from insufficient oxygen delivery to tissues (hypoxemia). Hyperoxia, on the other hand, overexposure to oxygen, may be harmful. When respiratory support during resuscitation is initiated with 21% oxygen (air) instead of 100% oxygen, term and late-preterm neonates had lower short-term mortality. The neurodevelopmental outcomes of survivors showed no differences. Pulse oximetry may be used during resuscitation to check the oxygen saturation levels of healthy term newborns delivered vaginally at sea level [4••, 15].

Pulse oximetry should be utilized carefully in neonatal resuscitation. During labor, HbF saturation is approximately 50%. In the complicated physiological process of birth, fluid is absorbed from the alveoli and replaced with air, which lowers the pulmonary vascular resistance. Systemic blood pressure also rises at delivery. Both result in a considerable improvement in oxygenation and pulmonary blood flow. SpO2 levels of 90% are reached in spontaneously breathing late-preterm newborns in about 10 m. Preterm newborns are more likely to experience an inadequate increase in pulmonary blood flow and an inadequate pulmonary transition due to their immature lungs and surfactant insufficiency [30]. The foundation of facilitating pulmonary transition relies on ensuring a proper inspired oxygenation fraction of the lungs during effective ventilation. In a recent study by Chandrasekharan et al., preterm lambs ventilated with 100% oxygen at delivery led to a considerable decrease in pulmonary arterial pressure, an increase in pulmonary blood flow, but also a large amount of hyperoxemia [30]. A reduced increase in PBF was observed after ventilation with 21% oxygen, but there was no discernible decrease in pulmonary arterial pressure. A slight reduction in pulmonary arterial pressure and an inadequate increase in pulmonary blood flow were the results of starting with 21% oxygen and titrating to reach the NRP's suggested SpO2. NRP recommendations state that chest compressions should be initiated if the infant's heart rate is below 60 beats per minute despite sufficient ventilation. FiO2 should be raised to 1.0 at this time. It is believed that by the time a newborn requires chest compressions, sufficient ventilatory efforts should have taken place with room air to achieve return of spontaneous circulation (ROSC). There are no human studies available currently that either support or refute this recommendation. Furthermore, research on animals has not revealed any benefits to consuming 100% oxygen for ROSC or survival and findings regarding the neurologic outcome and oxidative injury are not conclusive. The recommendation to utilize 100% oxygen during neonatal cardiopulmonary resuscitation is supported by best clinical practice and professional judgment. To avoid using excessive amounts of supplemental oxygen, a pulse oximeter should be utilized to measure the neonate SpO2 and oxygen should be withdrawn once ROSC is attained and the infant's heart rate is within the recommended range [9••].

## Chest Compression Technique and Compression-to-Ventilation Ratio

Most newborns who are apneic or do not have effective breathing at delivery will respond to the first steps of neonate resuscitation (positioning to open the airway, clearing secretions, drying, and tactile stimulation) or to an effective PPV by increasing heart rate and breathing. Chest compressions may deliver oxygenated blood to the brain until the heart rate increases if the heart rate remains less than 60 bpm despite appropriate interventions. Before beginning chest compressions, ventilation should be maximized, ideally with endotracheal intubation. Chest compressions should be initiated if the heart rate is still less than 60 bpm after at least 30 s of sufficient PPV. Although oxygen is necessary for organ function, too much oxygen inspired during resuscitation could be damaging [4••]. About 0.1% of full-term newborns receive chest compressions, but preterm newborns receive them more frequently. Regardless of an advanced airway availability, chest compression and ventilation during neonatal resuscitation should always be timed at a 3:1 ratio. With a rhythm of "one-and-two-and-three-and-breath," the target chest compression rate is 90 compressions per minute, synchronized with 30 breaths per minute [4••, 15, 31]. The chest wall should relax between compressions because the sternum is compressed to a depth of approximately one-third of the neonate's anterior–posterior chest diameter [15, 31].

## Intravascular Access

It is necessary to gain vascular access to administer epinephrine and volume expanders to neonates who have not responded to PPV and chest compressions. Umbilical venous catheterization (UVC) is the primary vascular access technique in the delivery room. The intraosseous route may be a viable alternative outside the delivery room or if intravenous access is not possible, depending on the local equipment, training, and experience availability [3, 4••, 9••, 15, 32]. At our institution, we generally have trained neonatologists as part of the neonatal resuscitation team. These neonatal intensivists frequently place UVC lines in the delivery room or NICU [33•].

## Epinephrine in Neonatal Resuscitation

Since bradycardia typically arises from either inadequate ventilation after birth or critically low oxygen saturation, medications are rarely used in the resuscitation of the newborn. The pivotal step in treating bradycardia is to establish ventilation. The administration of epinephrine is necessary if the heart rate remains less than 60 bpm despite adequate lung inflation with 100% oxygen (ideally through an endotracheal tube) and chest compressions. The fastest and most dependable method of administering epinephrine is through a UVC line. 0.02 mg/kg of epinephrine 1:10,000 concentration is administered intravenously, followed by a saline flush [4••, 15, 31]. In the absence of umbilical venous access, epinephrine 1:10,000 concentration may be administered endotracheally at a dose of 0.1 mg/kg. If the heart rate remains below 60 bpm, epinephrine dosing intervals are every 3 to 5 m; however, if endotracheal epinephrine response has been insufficient, an intravenous dose may be administered as soon as umbilical access is gained [3, 4••, 15, 34•]. When preparing epinephrine for newborn resuscitation, dosage mistakes are frequent. The authors advise preparing 0.1 mg/kg or 1 ml/kg of 1 mg/10 ml epinephrine in a 5 ml syringe for ETT administration based on animal findings. They also advise preparing an initial dose of 0.02 mg/kg or 0.2 ml/kg of 1 mg/10 ml epinephrine in a 1 ml syringe for IV epinephrine. A 1 ml syringe can be used for a wide range of birth weights, from 500 g to 5 kg, at a dose of 0.02 mg/kg. Using a color-coded syringe may reduce dosage preparation mistakes [34•].

## Role of the Anesthesiologist

Anesthesiologists have specialized training in airway management and critical care to participate in neonatal resuscitation. However, as reported by W. Gao et al. in 2019, due to a lack of comfort with NRP and a lack of NRP training, anesthesiologists who work in the labor and delivery department have poor neonatal resuscitation knowledge [35••]. Only 16% of anesthesiologists working in the L&D had current NRP certification, while 68% of the anesthesiologists were taking an active part in neonatal resuscitation [36]. It also has been reported that NRP training may decrease the risk of unintentional injuries by an anesthesiologist who performs neonatal resuscitation [36]. Although national professional organizations such as the ASA and ACOG state that surgeons or anesthesiologists who are caring for the patient (mother) should not switch the main focus of their work to neonatal resuscitation [15], there are a number of clinical practices, where one anesthesiologist is responsible for taking care of the patient (mother) and neonate [37, 38]. Based on our experience, if only one anesthesiologist is responsible for taking care of the mother and providing resuscitation to the newborn, the anesthesiologist should consider having the newborn and warming devices placed in alignment with the mother's head if neonatal resuscitation is needed. In that way, an anesthesiologist could provide neonatal resuscitation without leaving the mother, which provides continuous observation of both a mother and a newborn [39]. Therefore, regardless of whether the anesthesiologist is a member of neonatal resuscitation team or not, knowledge of neonatal resuscitation is necessary for those anesthesia providers who are routinely involved in the care of pregnant patients in a delivery area [35••]. For the past decade, NRP training has become a mandatory education for obstetric anesthesiology fellows.

## Updated 2020 Neonatal Resuscitation Guidelines

Comparing the AHA guidelines from 2020 to 2015, AHA guideline 2020 affirms everything previously stated in the older version. The primary intervention in newborn resuscitation continues to be positive-pressure ventilation (PPV). The improvement of PPV skills and practice has been emphasized, even as monitoring and other components of newborn resuscitation continue to be studied and practiced. Pulse oximetry should be utilized carefully when increasing oxygen concentration. Neonatal resuscitation continues to place a high priority on preventing hypothermia. To encourage early bonding, breastfeeding, and skin-to-skin contact are recommended for healthy neonates. In 2015, delayed cord clamping was advised for both term and preterm newborns. This was reconfirmed in the 2020 AHA guideline with more strength of evidence.

## NRP 8$^{th}$ Edition: What Changed?

Comparing NRP 8$^{th}$ edition to NRP 7$^{th}$ edition, one significant change is when absent heart rate is confirmed, the timeframe before the cessation of resuscitative efforts increased from 10 to 20 min. Additional minor changes are listed in Table 2.

## Conclusion

Even though a small number (0.1%) of newborns require neonatal resuscitation, understanding, obtaining clinical skills, and maintenance of NRP training are important parts for the anesthesiologist who provides care in the delivery room. Although the most updated neonatal resuscitation protocols do not significantly differ from the previous versions, research data suggest that anesthesiologists who encounter neonatal resuscitation in the delivery room lack the comfort, knowledge, and, to a certain extent, skills when managing this specific group of a highly vulnerable patient. The neonatal resuscitation program has become a mandatory part of the Obstetric Anesthesiology fellowship curriculum.

**Table 2** Summary of changes of NRP guideline 7th and 8th edition

| Change | NRP 7th edition | NRP 8th edition |
|---|---|---|
| 4 pre-birth questions:<br>1. "Umbilical cord management plan?" (included)<br>2. "How many babies?" (removed) | The 4 pre-birth questions: (1) gestational age? (2) Amniotic fluid clear? (3) How many babies? (4) Additional risk factors? | The 4 pre-birth questions: (1) gestational age? (2) Amniotic fluid clear? (3) Additional risk factors? (4) Umbilical cord management plan? |
| Initial steps: rearranged | Warm and maintain normal temperature, position airway, clear secretions if needed, dry, and stimulate | Warm, dry, stimulate, position airway, and suction if needed |
| Algorithm: electrical cardiac monitoring recommended earlier in the algorithm | An electronic cardiac monitor is the preferred method for assessing heart rate during cardiac compressions | When an alternative airway becomes necessary, a cardiac monitor is recommended for the most accurate assessment of the baby's heart rate |
| Medication therapy<br>1. Intravenous/intraosseous (IV/IO) epinephrine flush volume increased<br>2. IV/IO and endotracheal epinephrine doses simplified | Flush IV/IO epinephrine with 0.5 to 1 mL normal saline<br>IV or IO dose = 0.01–0.03 mg/kg<br>(Equal to 0.1–0.3 mL/kg)<br>Endotracheal dose = 0.05–0.1 mg/kg<br>(Equal to 0.5–1 mL/kg) | Flush IV/IO epinephrine with 3 mL normal saline regardless of birth weight and gestational age<br>IV or IO dose = 0.02 mg/kg<br>(Equal to 0.2 mL/kg)<br>Endotracheal dose = 0.1 mg/kg<br>(Equal to 1 mL/kg) |
| Cessation of resuscitation: time before cessation of resuscitative effort increased to 20 min | Reasonable to stop resuscitative efforts if the med absence of neonatal HR confirmed after 10 min of resuscitation<br>(Decision should be individualized) | Consider cessation of resuscitative efforts around 20 min after birth if absence of neonatal HR confirmed after all appropriate steps performed<br>(Decision should be individualized) |

In this way, the anesthesiologist will gain more knowledge, skills, and comfort in managing this highly stressful situation. In ideal healthcare settings, the neonatal team should be able to recognize the potential newborns who will need resuscitation after birth. Unfortunately, it is not always possible to anticipate adverse situation. Because of that, during each delivery, an anesthesiologist and other medical team members who are involved in newborn delivery should be prepared to provide neonatal resuscitation at any time.

**Abbreviations** *WHO*: World Health Organization; *CC*: Chest compression; *CPR*: Cardiopulmonary resuscitation; *GA*: Gestational age; *PPV*: Positive pressure ventilation; *PBF*: Pulmonary blood flow; *IV*: Intravenous; *NRP*: Neonatal resuscitation program; *AHA*: American Heart Association; *VLBW*: Very low birth weight; *NICU*: Neonatal intensive care unit; *STP*: Skin temperature probe; *BPM*: Beats per minute; *CPAP*: Continuous positive pressure ventilation; *FRC*: Functional residual capacity; *HIF*: Hypoxia inducible factor; *ROSC*: Return of spontaneous circulation; *UVC*: Umbilical venous catheterization; *ETT*: Endotracheal tube; *L&D*: Labor and delivery; *ASA*: American Society of Anesthesiologist; *ACOG*: Obstetric analgesia and anesthesia

## Declarations

**Conflict of Interest** The author does not have any potential conflicts of interest to disclose.

**Human and Animal Rights and Informed Consent** This article does not contain any studies with human or animal subjects performed by the author.

## References

Papers of particular interest, published recently, have been highlighted as:
• Of importance
•• Of major importance


1. Moshiro R, Mdoe P, Perlman JM. A global view of neonatal asphyxia and resuscitation. Front Pediatr. 2019;26:7.
2. Shikuku DN, Milimo B, Ayebare E, Gisore P, Nalwadda G. Practice and outcomes of neonatal resuscitation for newborns with birth asphyxia at Kakamega County General Hospital, Kenya: a direct observation study. BMC Pediatr. 2018;18(1):167.
3. Soraisham AS, Srivastava A. Recent update on neonatal resuscitation. Indian J Pediatr. 2022;89(3):279–87.
4. •• Aziz K, Lee HC, Escobedo MB, Hoover AV, Kamath-Rayne BD, Kapadia VS, et al. Part 5: Neonatal resuscitation: 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2020;142(16_suppl_2):S524-65. **This article reflects the most up to date 2020 guidelines for neonatal resuscitation.**
5. • Fischer N, Soraisham A, Shah PS, Synnes A, Rabi Y, Singhal N, et al. Extensive cardiopulmonary resuscitation of preterm neonates at birth and mortality and developmental outcomes. Resuscitation. 2019;135:57–65. **This paper summarizes essential and comprehensive resuscitative management of preterm newborns.**

6. Savani M, Upadhyay K, Talati AJ. Characteristics and outcomes of very low birth weight infants receiving epinephrine during delivery room resuscitation. Resuscitation. 2017;115:1–4.
7. World Health Organization. Guidelines on basic newborn resuscitation. Geneva: World Health Organization; 2012.
8. Sawyer T, Lee HC, Aziz K. Anticipation and preparation for every delivery room resuscitation. Semin Fetal Neonatal Med. 2018;23(5):312–20.
9.•• Weiner G, ed. *Textbook of neonatal resuscitation*. 8th ed. Itasca: the American Academy of Pediatrics. 2021. **This textbook provides the necessary training material and clinical skills needed for NRP certification.**
10.• Hooper SB, Roberts C, Dekker J, te Pas AB. Issues in cardiopulmonary transition at birth. Semin Fetal Neonatal Med. 2019;24(6):101033. **The author highlights challenges that may occur with fetal to neonatal cardiopulmonary transition.**
11. Hooper SB, Polglase GR, Roehr CC. Cardiopulmonary changes with aeration of the newborn lung. Paediatr Respir Rev. 2015;16(3):147–50.
12. Katheria AC, Rich WD, Lakshminrusimha S. Circulatory emergencies in the delivery room. Semin Fetal Neonatal Med. 2019;24(6):101030.
13. Khalil M, Jux C, Rueblinger L, Behrje J, Esmaeili A, Schranz D. Acute therapy of newborns with critical congenital heart disease. Transl Pediatr. 2019;8(2):114–26.
14.• Aucott, SW MD, Murphy JD MD. Neonatal assessment and resuscitation. Chestnut's Obstetric Anesthesia. 2020. Sixth Edition. p. 171–98. **This book chapter describes an in-depth overview of neonatal assessment and resuscitation.**
15. Madar J, Roehr CC, Ainsworth S, Ersdal H, Morley C, Rüdiger M, et al. European Resuscitation Council Guidelines 2021: newborn resuscitation and support of transition of infants at birth. Resuscitation. 2021;161:291–326.
16. de Almeida MFB, Guinsburg R, da Costa JO, Anchieta LM, Freire LMS, Campos JD. Resuscitative procedures at birth in late preterm infants. J Perinatol. 2007;27(12):761–5.
17. Spain JE, Tuuli MG, Macones GA, Roehl KA, Odibo AO, Cahill AG. Risk factors for serious morbidity in term nonanomalous neonates. Am J Obstet Gynecol. 2015;212(6):799.e1-799.e7.
18. Berazategui JP, Aguilar A, Escobedo M, Dannaway D, Guinsburg R, de Almeida MFB, et al. Risk factors for advanced resuscitation in term and near-term infants: a case–control study. Arch Dis Child Fetal Neonatal Ed. 2017;102(1):F44-50.
19. Hooper SB, Binder-Heschl C, Polglase GR, Gill AW, Kluckow M, Wallace EM, et al. The timing of umbilical cord clamping at birth: physiological considerations. Matern Health Neonatol Perinatol. 2016;2(1):4.
20. Hooper SB, Polglase GR, te Pas AB. A physiological approach to the timing of umbilical cord clamping at birth. Arch Dis Child Fetal Neonatal Ed. 2015;100(4):F355–60.
21. Lapcharoensap W, Lee HC. Temperature management in the delivery room and during neonatal resuscitation. NeoReviews. 2016;17(8):e454–62.
22 Joseph RA, Derstine S, Killian M. Ideal site for skin temperature probe placement on infants in the NICU. Adv Neonatal Care. 2017;17(2):114–22.
23. Haase B, Badinska A, Poets CF, Koos B, Springer L. An approach to define newborns´ sniffing position using an angle based on reproducible facial landmarks. Pediatr Anesth. 2021;31(4):404–9.
24. Kelleher J, Bhat R, Salas AA, Addis D, Mills EC, Mallick H, et al. Oronasopharyngeal suction versus wiping of the mouth and nose at birth: a randomised equivalency trial. The Lancet. 2013;382(9889):326–30.
25. Claassen CC, Strand ML. Understanding the risks and benefits of delivery room CPAP for term infants. Pediatrics. 2019;144(3):e20191720.
26. Smithhart W, Wyckoff MH, Kapadia V, et al. Delivery room continuous positive airway pressure and pneumothorax. Pediatrics. 2019;144(3):e20190756.
27. Hishikawa K, Goishi K, Fujiwara T, Kaneshige M, Ito Y, Sago H. Pulmonary air leak associated with CPAP at term birth resuscitation. Arch Dis Child Fetal Neonatal Ed. 2015;100(5):F382–7.
28. Duong HH, Mirea L, Shah PS, Yang J, Lee SK, Sankaran K. Pneumothorax in neonates: trends, predictors and outcomes. J Neonatal Perinatal Med. 2014;7(1):29–38.
29. Saugstad OD, Oei JL, Lakshminrusimha S, Vento M. Oxygen therapy of the newborn from molecular understanding to clinical practice. Pediatr Res. 2019;85(1):20–9.
30 Kapadia V, Oei JL. Optimizing oxygen therapy for preterm infants at birth: are we there yet? Semin Fetal Neonatal Med [Internet]. 2020;25(2):101081. https://doi.org/10.1016/j.siny.2020.101081.
31. Sawyer T, Umoren RA, Gray MM. Neonatal resuscitation: advances in training and practice. Adv Med Educ Pract. 2017;8:11–9.
32. Wagner M, Olischar M, O'Reilly M, Goeral K, Berger A, Cheung PY, et al. Review of routes to administer medication during prolonged neonatal resuscitation. Pediatr Crit Care Med. 2018;19(4):332–8.
33.• Kromah F, Bhatt D, Chahin N, Yitayew M, Khoury J. Neonatal assessment and resuscitation. Obstet Anesth Pract. 2021;280–94. **This book chapter highlights neonatal assessment and resuscitation as it pertains to the Obstetric Anesthesia clinical practice.**
34.• Vali P, Weiner GM, Sankaran D, Lakshminrusimha S. What is the optimal initial dose of epinephrine during neonatal resuscitation in the delivery room? J Perinatol. 2021;41(7):1769–73. **This paper summarizes the dosing strategies for epinephrine use during cardiopulmonary resuscitation of neonates.**
35.•• Gao W, Moss D, Schumann R, Drzymalski DM. Knowledge and comfort with neonatal resuscitation among practising anesthesiologists. Int J Obstet Anesth. 2019;39:148–9. **This article discusses issues with knowledge and maintenance of NRP training amongst practicing Anesthesiologists.**
36. Davies JM, Posner KL, Lee LA, Cheney FW, Domino KB. Liability associated with obstetric anesthesia. Anesthesiology. 2009;110(1):131–9.
37. Bucklin BA, Hawkins JL, Anderson JR, Ullrich FA. Obstetric anesthesia workforce survey. Anesthesiology. 2005;103(3):645–53.
38. Heyman HJ. Neonatal resuscitation and anesthesiologist liability. Anesthesiology. 1994;81(3):783–783.
39. Gordon A, Mckechnie EJ, Jeffery H. Pediatric presence at cesarean section: justified or not? Am J Obstet Gynecol. 2005;193(3):599–605.