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Resuscitation of Term Infants in the Delivery Room

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Abstract

The majority of newborn infants make the transition from fetal-to-neonatal live without help. However, around 20% of newborn infants fail to initiate breathing at birth. In these cases, the clinical team has to provide respiratory support, which remains the cornerstone of neonatal resuscitation. This chapter will discuss respiratory support during neonatal resuscitation in both term and preterm infants. The chapter will discuss the respiratory fetal-to-neonatal transition, use of oxygen, mask ventilation and their pitfalls, the application of sustained inflation, positive end expiratory pressure, continuous positive airway pressures, and whether extremely low birth weight infants should be intubated immediately after birth or supported noninvasively.

Keywords: delivery room, resuscitation, newborn, infants

1. Introduction

Before birth, the fetus uses the placenta for gas exchange; however, immediately after birth, the infants has to clear lung liquid fluid and replace it with air, start spontaneous breathing, establish a functional residual capacity (FRC) in order to achieve gas exchange [1–3]. Approximately 85% of babies born at term will initiate spontaneous respirations within 10 to 30 seconds of birth, an additional 10% will respond during drying and stimulation, approximately 3% will initiate respirations after PPV, 2% will be intubated to support respiratory function, and 0.1% will require CC and/or epinephrine to achieve this transition [4–6]. When newborns fail to initiate spontaneous breathing, the International Liaison Committee on Resuscitation (ILCOR) recommend several steps to support the transition of newborn infants [4–6]. The initial steps of stabilization algorithm include providing warmth to maintain a normal body temperature by *drying* the infant, clearing any secretion if needed by using *suction*, and *stimulating* the infant to initiate breathing [4–6]. If these steps are unsuccessful, the clinical

Neonatal Resuscitation Algorithm—2015 Update

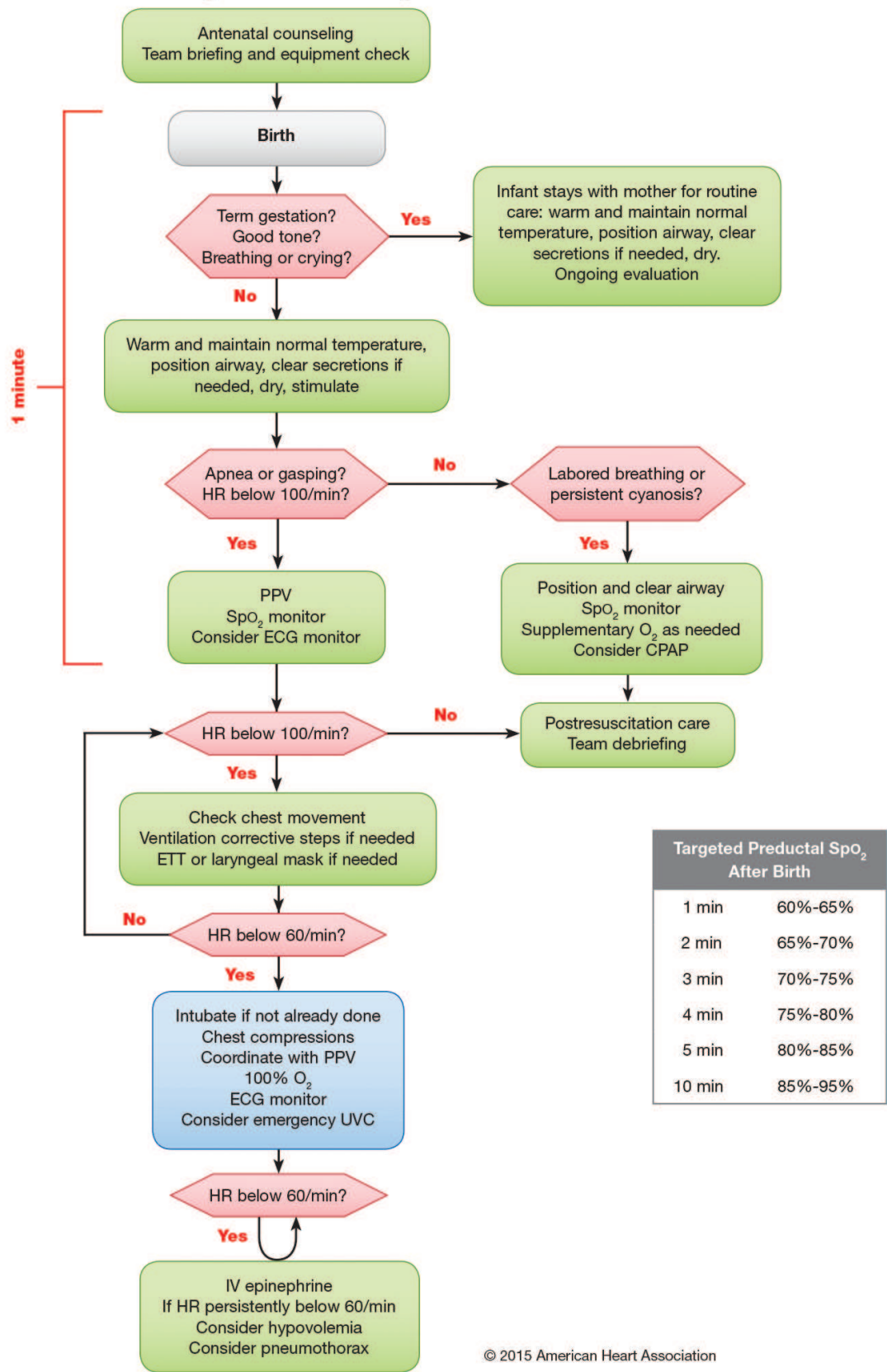


Figure 1. NRP algorithm.

team must initiate *mask positive pressure ventilation* (PPV) using a face mask and a ventilation device [4–6]. Adequate ventilation is the cornerstone of successful neonatal resuscitation; therefore, it is mandatory that anybody involved in neonatal resuscitation is trained in mask ventilation techniques [4–6]. In the rare cases (0.1% in term infants) where mask PPV is unsuccessful, more extensive resuscitation measures (*chest compression* (CC) and *epinephrine*) are needed (**Figure 1**) [4–6]. This chapter will discuss these various steps during stabilization/resuscitation of term infants in the delivery room (DR).

2. Initial steps of stabilization (drying, suction, and stimulation)

The initial steps of newborn stabilization/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, and stimulate the infant [4–6]. Most newborn infants are breathing or crying and have good tone immediately after birth [7, 8]. However, they must be dried and kept warm to avoid hypothermia, which can happen while the baby is lying on the mother’s chest to avoid separation of mother and baby [4–6]. Maintaining normal temperature after birth is crucial due to a dose-dependent increase in mortality for temperatures $<36.5^{\circ}\text{C}$ [9]. Simple interventions (e.g., skin-to-skin contact or kangaroo mother care, plastic wrap, radiant warmer, thermal mattress, or warmed humidified resuscitation gases) to prevent hypothermia during transition (birth until 1 to 2 hours of life) can reduce mortality [4–6, 10, 11]. Maternal hyperthermia in labor is associated with adverse neonatal effects including increased mortality, neonatal seizures, and adverse neurologic states like encephalopathy [4–6]. Similarly, neonatal hyperthermia $>38.0^{\circ}\text{C}$ should be avoided due to the potential associated risks [4–6].

Suctioning immediately after birth, whether with a bulb syringe or suction catheter, should only be done if the airway appears obstructed or if PPV is required [4–6]. Avoiding unnecessary suctioning helps prevent the risk of induced bradycardia due to suctioning of the nasopharynx [4–6]. The presence of meconium-stained amniotic fluid may indicate fetal distress and increases the risk that the infant will require resuscitation after birth; therefore, a team that includes an individual skilled in tracheal intubation should be present at the time of birth [4–6]. Any infant who is vigorous with good respiratory effort and muscle tone may stay with their mother to receive the initial steps of newborn care [4–6]. Any infant presenting with poor muscle tone and inadequate breathing efforts after being born through meconium-stained amniotic fluid should receive the initial steps of resuscitation under a radiant warmer [4–6]. 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 [4–6]. Routine intubation for tracheal suction in this setting is not suggested, because there is insufficient evidence to continue recommending this practice [4–6].

Tactile stimulation including warming, drying, and rubbing the back or the soles of the feet is recommended in the current ILCOR guidelines [4–6]. Tactile stimulation is the first step to stimulate spontaneous breathing in newborn infants [4–6]. Retrospective studies reported a large variability in the use of tactile stimulation during the stabilization of infants at birth [12].

Furthermore, a recent randomized trial reported an increase in respiratory effort during repetitive stimulation compared to standard tactile stimulation with less oxygen requirements during transport to the NICU [13]. However, it did not reach significance, and further studies are needed.

2.1. Oxygen delivery during stabilization/resuscitation

The fetal oxygen saturation before birth is between 40 and 60% [14], which increases in uncompromised term infants within the first 10 minutes following birth to levels between 90 and 100% [15], thus resulting in the appearance of cyanosis during that time [16]. In addition, clinical assessment of skin color or the lack of cyanosis is a very poor indicator of oxygen saturation during that period [16–19]. The 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 term infant with hypoxia and ischemia are known to result in injury to multiple organs and hyperoxia causing increased mortality [16, 20, 21]. Therefore, infants >35 weeks' gestation should be resuscitated in 21% oxygen and oxygen should be increased only if heart rate does not increase despite adequate ventilation.

3. Mask ventilation

Approximately, 10% of newborns require respiratory support at birth [22]. ILCOR and various national guidelines recommend techniques and equipment for neonatal resuscitation [4–6]. They all agree that mask ventilation is the cornerstone of respiratory support immediately after birth [4–6]. The purpose of PPV is to establish FRC, deliver an adequate V_T to facilitate gas exchange, and stimulate breathing while minimizing lung injury [2]. Several factors can reduce the effectiveness of mask ventilation, including poor face mask technique resulting in leak or airway obstruction, spontaneous movements of the baby, movements by or distraction of the resuscitator, and procedures such as changing the wraps or fitting a hat [23, 24]. Delivery room studies have shown that mask PPV is difficult, and mask leak and airway obstruction are common [23–29]. Both leak and obstruction are usually unrecognized unless expired CO_2 detectors or respiratory function monitors (RFM) are used [23–29]. In addition, airway maneuvers (e.g., jaw thrust or chin lift) to maintain airway patency is a crucial step during mask PPV [30].

4. Ventilation devices during respiratory support in the delivery room

There is currently limited evidence to guide clinicians' choice of the device to be used to provide PPV in the DR [31]. Self-inflating bags, flow-inflating bags, or T-piece devices may all be used for mask PPV [4–6]. A self-inflating bag, however, does not provide PEEP or continuous positive airway pressure (CPAP) [32, 33]. An attached PEEP-valve provides inconsistent

PEEP and cannot deliver CPAP [32–37]. A flow-inflating bag provides variable and operator dependent PEEP [16, 38]. With a T-piece device more consistent, predetermined levels of PEEP and PIP can be delivered [34, 35]. In addition, a T-piece device has been shown to be the most accurate device for delivering a sustained inflation [35, 39–41].

5. Interfaces

5.1. Face mask and nasal prongs

Effective and consistent PPV is important to facilitate lung aeration, establishment of a functional residual capacity, and gas exchange, which should occur in a predictable manner so that the clinician can avoid under- or over-inflating the lungs [2, 42–44]. However, PPV is often complicated by mask leak or airway obstruction [23–29]. Currently, clinicians can either use a face mask or a nasal prong during mask PPV [4–6]; however, face mask ventilation remains the primary mode of resuscitation. There are a variety of face masks available to provide PPV [25, 45, 46]. The Fisher & Paykel (F&P) (Fisher & Paykel Healthcare, Auckland, New Zealand) and the Laerdal round masks are the most commonly used commercially available products [47–52]. Although, face masks for preterm infants <33 weeks' do not adequately fit their face [53], the only study comparing F&P vs. Laerdal masks reported no difference in mask leak during PPV in the DR in preterm infants <33 weeks' [25]. Similarly, two studies compared face masks to nasal prongs in the DR and reported no difference in intubation in the delivery room [45, 46]. These data suggest that either face mask or nasal prong could be used for PPV in the DR and the focus should rather be on delivery of an adequate tidal volume to achieve lung aeration.

5.2. Laryngeal mask

Archie Brain, a British anesthetist, described the laryngeal mask airway (LMA) as an alternative to endotracheal intubation in 1981 [54]. A LMA consists of an airway tube connected distally to a soft elliptical mask with an inflatable rim to fit over the laryngeal inlet, whereas the proximal end connects to the ventilation device [54]. LMAs are routinely used in emergency and operating rooms for adult and pediatric anesthesia and ambulance services [55, 56]. In newborn infants, there is increasing evidence from randomized trials [57, 58], suggesting that a LMA can provide an effective rescue airway during resuscitation if both mask ventilation and endotracheal intubation have been unsuccessful. Current neonatal resuscitation guidelines recommend the use of LMA in infants >34 weeks' gestation or >2000 g birth weight. Furthermore, LMA have been described during neonatal transport [59–61], provision of prolonged mechanical ventilation in particular for infants with upper airway abnormalities [62–64], and surfactant and epinephrine administration [65–69]. Although LMAs are recommended by various neonatal resuscitation guidelines, they are not routinely used during neonatal resuscitation [4–6].

5.3. Oropharyngeal airway

In 1907, Sir Fredrick Hewitt presented the first known artificial oral “air-way” to alleviate upper airway obstruction, a common problem during general anesthesia [31]. In 1933, Arthur Guedel presented “the Guedel oropharyngeal airway” [37], designed to hold the tongue away from the back of the pharynx, thus providing a clear channel for respired gases [70]. An oropharyngeal airways may be used to open the airway in floppy newborn infants, or if mask ventilation is ineffective [71–74]. In addition, various surveys evaluating neonatal resuscitation practice reported that Guedel airways are part of the neonatal resuscitation equipment [50, 75]. Guedel airways for newborn infants come in traditional sizes of 000, 00, and 0. However, oropharyngeal airways during neonatal resuscitation have not been systematically studied, and only one trial is currently ongoing comparing an oropharyngeal airway for prevention of airway obstruction during PPV in preterm infants <34 weeks’ gestation in the DR [49]. Until further evidence is available, oropharyngeal airway should be used with caution.

6. Ventilation modes

When infants fail to initiate spontaneous breathing, the current neonatal resuscitation guidelines recommend mask PPV using any above described ventilation devices coupled with a face mask or a nasal prong [4–6]. The purpose of PPV is to establish FRC, deliver an adequate V_T to facilitate gas exchange, and stimulate breathing while minimizing lung injury [2]. The current neonatal resuscitation guidelines further recommend to use a peak inflation pressure of around 30 cm H_2O , a positive end expiratory pressure of 5 cm H_2O when using a T-Piece or a flow-inflating bag, and a gas flow rate of 10 L/min and 21% oxygen [4–6]. Oxygen should only be increased if the infant requires chest compression (see the paragraph below), the heart rate does not increase despite adequate ventilation, or if SpO_2 is below the recommend target range [4–6]. If infants have adequate spontaneous respiration, but remain cyanotic (e.g., SpO_2 is below the recommend target range [4–6]) during the initial stabilization, CPAP using pressures between 5 and 8 cm H_2O should be provided using a T-Piece or a flow-inflating bag (see the paragraph about ventilation devices).

There is no need for any other ventilation modalities (e.g., high frequency ventilation or mechanical ventilation) in the delivery room, which should be done in the NICU.

7. Surfactant administration

During fetal development, surfactant production starts at around 24–26 weeks’ gestation with a continuous increase in production up to 36 weeks’ gestation. At that time, the surfactant production is similar to that of adults. Term infants rarely require surfactant in the delivery room and surfactant should be given only after the infants have been admitted to the NICU. Using this approach will allow for a more gentle intubation with reduced stress for the resuscitation team. Potential indications for surfactant administration include transient tachypnea of

the newborn, meconium aspiration syndrome, respiratory distress syndrome, pulmonary hemorrhage, or presumed sepsis with secondary surfactant consumption.

8. Chest compressions

About 0.1% of term infants and up to 15% of preterm infants [76, 77] receive chest compression (CC) or epinephrine in the DR, which results in ~1 million newborn deaths annually worldwide. Infants who received epinephrine in the DR had a high incidence of mortality (41%) and short-term neurologic morbidity (57% hypoxic-ischemic encephalopathy and seizures) [78]. Furthermore, newborns receiving prolonged CC and epinephrine with no signs of life at 10 minutes following birth have up to 83% mortality, with 93% of survivors suffering moderate-to-severe disability [79]. Asphyxia could result from either failure of placental gas exchange before delivery (e.g., abruption and chorioamnionitis) or deficient pulmonary gas exchange immediately after birth (e.g., pulmonary hypertension) [80]. This condition of impaired gas exchange with simultaneous hypoxia and hypercapnia is leading to a mixed metabolic and respiratory acidosis [80]. Newborn infants are typically born with severe bradycardic or asystole. Current resuscitation guidelines recommend CC if the heart rate remains <60/min despite adequate PPV with 100% oxygen for 30 seconds; CC should be then performed at a rate of 90/min with 30 ventilations 3:1 C:V (compression:ventilation) ratio [4–6]. Rationales for using a 3:1 C:V ratio include (i) higher physiological heart rate (120–160/min) and breathing rates (40–60/min) in newborns compared to adults; (ii) profound bradycardia or cardiac arrest caused by hypoxia rather than primary cardiac compromise; therefore, providing ventilation is more likely to be beneficial in neonatal CPR compared to adult CPR [4–6].

However, the optimal C:V ratio that should be used during neonatal resuscitation to optimize coronary and cerebral perfusion while providing adequate ventilation of an asphyxiated newborn remains unknown [81]. Studies using newborn piglets with asphyxia-induced cardiac arrest demonstrated that combining CC with ventilations improves the return of spontaneous circulation (ROSC) and neurological outcome at 24 hours compared to ventilations or CC alone [16, 21]. Animal studies comparing various C:V ratios including 2:1 C:V, 4:1 C:V, 9:3 C:V, and 15:2 C:V to 3:1 C:V reported no difference in ROSC, survival or any other outcomes [82–84]. These studies suggest that during neonatal CPR, higher C:V ratios do not improve outcomes, and potentially a higher ventilation rate is needed. Similarly, *Schmölzer et al.* compared 3:1 C:V CPR with continuous CC with asynchronous ventilations (CCaV) using 90 CC and 30 non-synchronized inflations. The study reported similar time to ROSC (143 and 114 sec for 3:1 and CCaV, respectively), and survival (3/8 and 6/8, respectively) [85] suggesting no advantages of using CCaV compared to 3:1 C:V.

Most recently, a new technique providing CC during a sustained inflation (SI) (CC + SI) has been proposed, which significantly improved hemodynamics, minute ventilation, and time to ROSC compared to the 3:1 C:V ratio during resuscitation of asphyxiated newborn piglets [86]. While this first study used a CC rate of 120/min (in the CC + SI group) instead of the recommended 90/min, further studies using CC rates of 90/min in the same animal model

have confirmed the initial findings [87–90]. Also a recent pilot trial in preterm infants <32 weeks' gestation showed similar results to the animal studies with a reduction in the mean (SD) time to ROSC with 31 (9) sec vs. 138 (72) sec in the CC + SI group and 3:1 C:V group ($p = 0.011$), respectively [91]. These data suggest that CC + SI has the potential to improve neonatal CPR, and a large randomized trial is currently ongoing to compare CC + SI with 3:1 C:V. Until these data are available, the 3:1 C:V ratio should be used during neonatal CPR.

9. Presence of parents during delivery room stabilization

There are no general rules about the presences of parents in delivery room during stabilization of their newborn. The approach chosen at any given facility will depend on (i) the local policy, (ii) geographical situation (e.g., separate stabilization room away from where the baby was delivered), and (iii) comfort of attending staff having parents in the room and observing the team. In addition, the increased use of smartphones and the urge of parents to photo document or video record, the resuscitation can add additional stress to the resuscitation team. In our institution, there is a geographical separation of the delivery suite and the stabilization room for high-risk deliveries. While the mother is unable to observe the resuscitation/stabilization, the father/partner would join the resuscitation team to be with their baby (father/partner is allowed to take photos, but not to video record) and would go back and forth between the stabilization room and the delivery suite to communicate with the mother. However, every hospital has to develop their own policy according to their needs to allow parents attendance during delivery and resuscitation.

10. Summary

Among the 15% of term babies who do not initiate spontaneous respirations after birth, 10% will require initial steps of stabilization: maintain normal temperature of the infant due to a dose-dependent increase in mortality for decreases of body temperature, position the infant in a “sniffing” position to open the airway, clear secretions with a bulb syringe or suction catheter if needed (if the airway appears obstructed or if PPV is required within 10–30 seconds of birth), dry the infant, and stimulate the infant (rubbing the back or the soles of the feet). Approximately 3% of term babies who do not initiate spontaneous respirations after birth will require PPV. Self-inflating bags, flow-inflating bags or T-piece devices may all be used for mask PPV, with currently limited evidence on the best device to be used to provide PPV in the DR. Among the interfaces, either face masks or nasal prongs could be used for PPV. Other interfaces that can be used are laryngeal mask and Guedel oropharyngeal airway. Lastly, approximately 2% of term babies who do not initiate spontaneous respirations after birth will be intubated and 0.1% will require CC and/or epinephrine to achieve this transition: current resuscitation guidelines recommend CC if the heart rate remains <60/min despite adequate PPV with 100% oxygen for 30 seconds; CC should be then performed at a rate of 90/min with a 3:1 C:V ratio. However, the optimal C:V ratio that should be used during neonatal resuscitation

of an asphyxiated newborn remains unknown, with several ongoing studies assessing other techniques.

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