Neonatal Resuscitation

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Newborns go through a complex set of physiologic changes to successfully transition to extrauterine life. These changes quickly shift responsibility for gas exchange from the placenta to the newborn's lungs. The infant's initial breaths and respiratory effort are the catalyst; they drive up intrapulmonary pressures and help clear fetal lung fluid. Increased blood oxygen content decreases pulmonary vascular resistance, increases pulmonary blood flow, and facilitates closure of the foramen ovale and patent ductus arteriosus, which previously shunted blood away from fetal lung circulation. Just as a newborn's efforts at ventilation are key to a successful transition after birth, the most important part of newborn resuscitation is effective ventilation.

In 2015, the Neonatal Resuscitation Program (NRP) published updated guidelines for neonatal resuscitation. Key additions to the 2015 NRP algorithm include consideration of using 3-lead electrocardiography (ECG) to monitor heart rate (HR) and initiating intubation before chest compressions. The guidelines now recommend that providers 1) do not routinely intubate for tracheal suctioning in the setting of meconium aspiration, 2) ensure thermoregulation of all newborn infants between 97.7°F and 99°F (36.5°C and 37.5°C), and 3) delay cord clamping for all vigorous newborns.

The updated NRP algorithm (Figure) begins with a basic risk assessment by the clinician, asking if the baby is term, is crying or breathing, and has good muscle tone. If the answer to all of these questions is yes, the baby should be placed skin to skin with the mother with continued observation. If the answer to any of the questions is no, providers should move the infant to a radiant warmer and warm, dry, and stimulate the infant. If needed, secretions can be cleared, but term infants should not be routinely suctioned without evidence of meconium or obstruction because suctioning can lead to bradycardia. After 30 seconds, if the newborn has apnea, gasping, or an HR of less than 100 beats/min, providers should initiate positive pressure ventilation (PPV) (at 21% for newborns ≥35 weeks' gestation and 21%–30% for newborns <35 weeks' gestation) (see below for more details), begin monitoring oxygen saturation, and consider using an ECG monitor. These initial steps of evaluation should occur within 60 seconds (the "Golden Minute") to prevent a delay in initiating ventilation. If despite securing an airway and ensuring ventilation the HR remains below 60 beats/min, the provider should intubate the newborn, begin chest compressions in coordination with PPV, and increase delivery of oxygen to 100%. If the HR still does not respond, guidelines recommend intravenous epinephrine and consideration of fluid resuscitation.

An increase in the newborn's HR is the most sensitive indicator of positive response to each resuscitative step. Being able to quickly, accurately, and reliably determine the HR is vital to a successful resuscitation. Although the NRP previously recommended clinical assessment of HR through auscultation of

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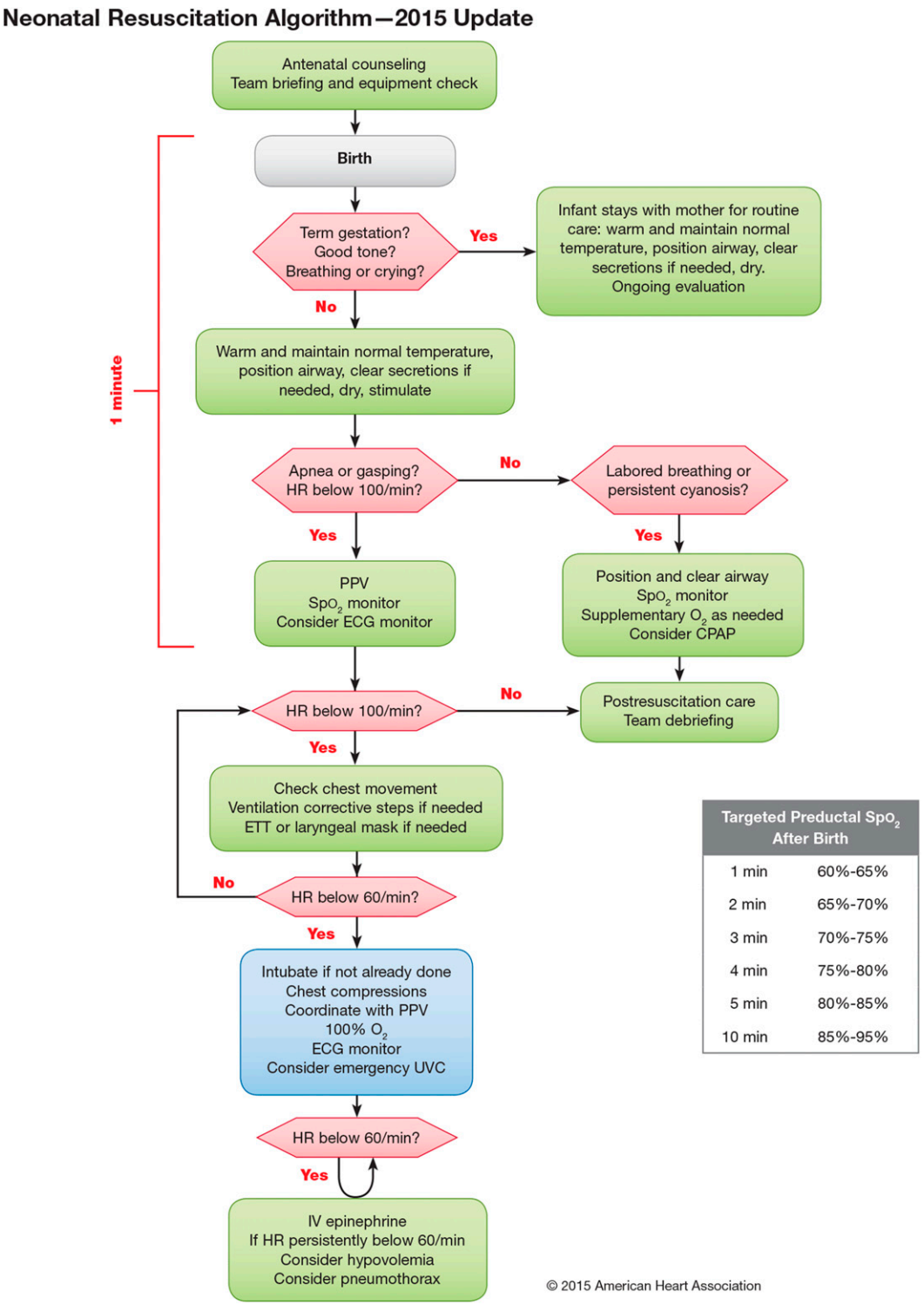

Figure. Neonatal resuscitation algorithm—2015 update. Reprinted with permission from Weiner GM, Zaichkin J, eds. *Textbook of Neonatal Resuscitation*. 7th ed. Itasca, IL: American Academy of Pediatrics; 2016. CPAP=continuous positive airway pressure; ECG=electrocardiography; ETT=endotracheal tube; HR=heart rate; IV=intravenous; O_2=oxygen; PPV=positive pressure ventilation; Spo_2=pulse oxygen saturation.

the precordium in conjunction with use of pulse oximetry, neither is a reliable or accurate measure of infant HR. Recent studies demonstrate that the 3-lead ECG is superior to pulse oximetry for HR detection. The ECG reports HR more quickly and reliably than pulse oximetry, which can underestimate the actual HR and lead to unnecessary interventions.

Pulse oximetry remains the essential tool in determining a newborn's oxygenation and guiding titration of oxygen delivery during resuscitation. For newborns at least 35 weeks' gestation, PPV should be started at 21% oxygen. For newborns less than 35 weeks' gestation, PPV should be initiated with 21% to 30% oxygen. Oxygen concentration should be titrated upward to achieve adequate oxygenation. Most infants respond to oxygen at 30% or less, and even brief exposure to 100% oxygen can be toxic to an infant. If PPV is required, it is recommended to use a device that allows for 5 cm H20 to be delivered. However, if chest compressions are necessary, oxygen should be increased to 100%. For infants with persistent cyanosis or labored breathing who require supplemental oxygen but not PPV, free-flow oxygen begins at 30%.

Continuous positive airway pressure is an alternative to intubation in the neonate who continues to display respiratory distress or is unable to maintain saturations despite 100% free-flow oxygen. If adequate ventilation is established but the HR remains less than 60 beats/min, it may be necessary to insert an alternative airway such as an endotracheal (ET) tube or a laryngeal mask. An ET tube insertion depth table that uses both infant weight and gestational age can provide an estimation of correct ET tube insertion depth. Using gestational age in addition to weight has been associated with a significant decrease in malpositioned ET tubes. Alternatively, the nasal-tragus length may be used to determine tip-to-lip distance. After the airway is secured, chest compressions should be initiated and oxygen should be increased to 100%.

Intubation is strongly recommended before initiating chest compressions. Ventilation is the most effective action in resuscitation, and compressions may compete with the ability to effectively ventilate. Once initiated, compressions should be administered at the head of the bed with the 2-thumb technique and should continue for 60 seconds at a 3:1 ratio with ventilation before checking the HR. Repeated assessments of the HR should continue throughout the resuscitation to measure progress and guide further intervention.

Recommendations regarding the management of infants born with meconium-stained fluid were updated in the 2015 guidelines. The recommendation that vigorous infants with meconium-stained fluid stay with their mother and receive the routine initial steps of newborn care is unchanged. However, infants born with meconium-stained fluids who are not vigorous at birth with poor tone and respiratory effort should no longer receive routine intubation for tracheal suctioning. Recent studies have found no difference in the frequency of meconium aspiration syndrome, pulmonary hypertension, asphyxia, or mortality in nonvigorous neonates who are not intubated for tracheal suction. Initial steps in the resuscitation of nonvigorous infants with meconium-stained fluids should be performed under the radiant warmer and include starting PPV if the HR is less than 100 beats/min or the infant is not breathing. All infants born with meconium-stained fluids require the presence of 1 team member with full resuscitation skills because of the risk of needing intubation and intensive care.

Thermoregulation remains a key element of the NRP. Multiple studies have demonstrated that hypothermia at the time of NICU admission is associated with a higher mortality rate and increased risk of respiratory distress syndrome, hypoglycemia, and late-onset sepsis. Simple interventions can decrease these risks. All neonates without a concern for asphyxia should be maintained at a temperature between 97.7°F and 99.5°F (36.5°C and 37.5°C). The room temperature should be increased to 74°F to 77°F (23°C –25°C). Newborns less than 32 weeks' gestation should be covered with plastic wrap or a bag and covered with a hat. If available, a thermal mattress should be used.

For term and preterm infants who are vigorous at birth and do not require resuscitation, there is evidence to recommend delayed cord clamping for more than 30 seconds. Delayed cord clamping is associated with less need for transfusion for anemia after birth as well as decreased intraventricular hemorrhage and necrotizing enterocolitis. In term infants, delayed cord clamping is linked to higher birthweight, higher hemoglobin concentrations at 24 to 48 hours after birth, and improved iron stores at 3 to 6 months of age. Although delayed cord clamping is associated with increased bilirubin levels and risk of jaundice requiring phototherapy, both the American College of Obstetricians and Gynecologists and the American Academy of Pediatrics endorse delayed cord clamping. For infants who do require resuscitation, there is insufficient evidence to recommend an approach.

COMMENT: This *In Brief* reminds me of the importance of lifelong learning in our field of pediatrics and the need to question dogma to deliver the highest quality of care. Several decades ago I still remember being in the delivery room and intubating all infants with meconium staining, perhaps leading in some cases to unnecessary interventions in the newborns and high levels of anxiety in all involved: parents, staff, and health-care providers. How refreshing to have an algorithm that has increased precision and individualizes care to the specific parameters of the patient! The updated neonatal resuscitation algorithm is a great example of the marvels of scientific discovery to continually question and improve what we do, to minimize unnecessary interventions that may have unintended consequences while focusing on what has been found to be effective care. Other concepts that the algorithm reinforces include the importance of teamwork, of having competent staff accessible, of ensuring that you have the correct equipment working and readily available, and of debriefing after the resuscitation of neonates to review not only the clinical decision making but also the emotional impact of the experiences.

– Janet R. Serwint, MD
Associate Editor, *In Brief*

ANSWER KEY FOR MARCH 2020 PEDIATRICS IN REVIEW

The Male Genital System: 1. B; 2. D; 3. D; 4. D; 5. D.
Social Media: Anticipatory Guidance: 1. D; 2. A; 3. E; 4. D; 5. C.
Acute Hematogenous Bacterial Osteoarticular Infections in Children: 1. C; 2. D; 3. E; 4. D; 5. B.

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