Neonatal Resuscitation Program (NRP)
American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Approximately 10% of newborns require some assistance to begin breathing at birth. Less than 1% require extensive resuscitative measures. Although the vast majority of newly born infants do not require intervention to make the transition from intrauterine to extrauterine life, because of the large total number of births, a sizable number will require some degree of resuscitation.

Those newly born infants who do not require resuscitation can generally be identified by a rapid assessment of the following 3 characteristics:

- Term gestation?
- Crying or breathing?
- Good muscle tone?

If the answer to all 3 of these questions is “yes,” the baby does not need resuscitation and should not be separated from the mother. The baby should be dried, placed skin-to-skin with the mother, and covered with dry linen to maintain temperature. Observation of breathing, activity, and color should be ongoing.

If the answer to any of these assessment questions is “no,” the infant should receive one or more of the following 4 categories of action in sequence:

A. Initial steps in stabilization (provide warmth, clear airway if necessary, dry, stimulate)
B. Ventilation
C. Chest compressions
D. Administration of epinephrine and/or volume expansion

Approximately 60 seconds (“the Golden Minute”) are allotted for completing the initial steps, reevaluating, and beginning ventilation if required.

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 (whether greater than or less than 100 beats per minute).

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.
A pulse oximeter can provide a continuous assessment of the pulse without interruption of other resuscitation measures. Once positive pressure ventilation or supplementary oxygen administration is begun, assessment should consist of simultaneous evaluation of 3 vital characteristics: heart rate, respirations, and the state of oxygenation, the latter optimally determined by a pulse oximeter. The most sensitive indicator of a successful response to each step is an increase in heart rate.

**Anticipation of Resuscitation Need**

Anticipation, adequate preparation, accurate evaluation, and prompt initiation of support are critical for successful neonatal resuscitation. At every delivery there should be at least 1 person whose primary responsibility is the newly born. This person must be capable of initiating resuscitation, including administration of positive-pressure ventilation and chest compressions. Either that person or someone else who is promptly available should have the skills required to perform a complete resuscitation, including endotracheal intubation and administration of medications. With careful consideration of risk factors, the majority of newborns who will need resuscitation can be identified before birth.

If a preterm delivery (≤37 weeks of gestation) is expected, special preparations will be required. Preterm babies have immature lungs that may be more difficult to ventilate and are also more vulnerable to injury by positive-pressure ventilation. Preterm babies also have immature blood vessels in the brain that are prone to hemorrhage; thin skin and a large surface area, which contribute to rapid heat loss; increased susceptibility to infection; increased risk of hypovolemic shock related to small blood volume.

**Initial Steps**

The initial steps of resuscitation are to provide warmth by placing the baby under a radiant heat source, positioning the head in a “sniffing” position to open the airway, clearing the airway if necessary with a bulb syringe or suction catheter, drying the baby, and stimulating breathing.

**Temperature Control**

Very low-birth-weight (<1500 g) preterm babies are likely to become hypothermic despite the use of traditional techniques for decreasing heat loss. Additional warming techniques are recommended (eg, prewarming the delivery room to 26°C, covering the baby in plastic wrapping, placing the baby on an exothermic mattress, and placing the baby under radiant heat). The infant’s temperature must be monitored closely.
Other techniques for maintaining temperature during stabilization of the baby in the delivery room have been used (eg, prewarming the linen, drying and swaddling, placing the baby skin-to-skin with the mother and covering both with a blanket) and are recommended.

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

Infants born to febrile mothers have been reported to have a higher incidence of perinatal respiratory depression, neonatal seizures, and cerebral palsy and an increased risk of mortality. Hyperthermia should be avoided.

The goal is to achieve normothermia and avoid iatrogenic hyperthermia.

**Clearing the Airway When Amniotic Fluid Is Clear**

There is evidence that suctioning of the nasopharynx can create bradycardia during resuscitation and that suctioning of the trachea in intubated babies receiving mechanical ventilation in the neonatal intensive care unit (NICU) can be associated with deterioration of pulmonary compliance and oxygenation and reduction in cerebral blood flow velocity when performed routinely (ie, in the absence of obvious nasal or oral secretions).

However, there is also evidence that suctioning in the presence of secretions can decrease respiratory resistance.

Therefore it is recommended that suctioning immediately following birth should be reserved for babies who have obvious obstruction to spontaneous breathing or who require positive-pressure ventilation (PPV).

**When Meconium is Present**

Aspiration of meconium before delivery, during birth, or during resuscitation can cause severe meconium aspiration syndrome (MAS). In the absence of randomized, controlled trials, there is insufficient evidence to recommend a change in the current practice of performing endotracheal suctioning of nonvigorous babies with meconium-stained amniotic fluid.

However, if attempted intubation is prolonged and unsuccessful, bag-mask ventilation should be considered, particularly if there is persistent bradycardia.

**Assessment of Oxygen Need and Administration of Oxygen**

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.

**Pulse Oximetry**
It is recommended that oximetry be used when resuscitation can be anticipated, when positive pressure is administered for more than a few breaths, when cyanosis is persistent, or when supplementary oxygen is administered.

**Administration of Supplementary Oxygen**

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 measured in healthy term babies following vaginal birth at sea level.

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.

If blended oxygen is not available, resuscitation should be initiated with air.

If the baby is bradycardic (HR <60 per minute) after 90 seconds of resuscitation with a lower concentration of oxygen, oxygen concentration should be increased to 100% until recovery of a normal heart rate.

**Positive-Pressure Ventilation (PPV)**

If the infant remains apneic or gasping, or if the heart rate remains <100 per minute after administering the initial steps, start PPV.

**Initial Breaths and Assisted Ventilation**

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.

**End-Expiratory Pressure**

Many experts recommend administration of continuous positive airway pressure (CPAP) to infants who are breathing spontaneously, but with difficulty, following birth.

Starting infants on CPAP reduced the rates of intubation and mechanical ventilation, surfactant use, and duration of ventilation, but increased the rate of pneumothorax.

Spontaneously breathing preterm infants who have respiratory distress may be supported with CPAP or with intubation and mechanical ventilation. Nevertheless, PEEP is likely to be beneficial and should be used if suitable equipment is available. PEEP can easily be given with a flow-inflating bag or T-piece resuscitator.

**Assisted-Ventilation Devices**

Effective ventilation can be achieved with either a flow inflating or self-inflating bag or with a T-piece mechanical device designed to regulate pressure.

**Laryngeal Mask Airways**
Laryngeal mask airways that fit over the laryngeal inlet have been shown to be effective for ventilating newborns weighing more than 2000 g or delivered >34 weeks gestation. There are limited data on the use of these devices in small preterm infants, ie, <2000 g or <34 weeks. A laryngeal mask should be considered during resuscitation if facemask ventilation is unsuccessful and tracheal intubation is unsuccessful or not feasible.

**Endotracheal Tube Placement**

Endotracheal intubation may be indicated at several points during neonatal resuscitation:
- Initial endotracheal suctioning of nonvigorous meconium stained newborns
- If bag-mask ventilation is ineffective or prolonged
- When chest compressions are performed
- For special resuscitation circumstances, such as congenital diaphragmatic hernia or extremely low birth weight The timing of endotracheal intubation may also depend on the skill and experience of the available providers.

After endotracheal intubation and administration of intermittent positive pressure, a prompt increase in heart rate is the best indicator that the tube is in the tracheobronchial tree and providing effective ventilation.

Exhaled CO2 detection is effective for confirmation of endotracheal tube placement in infants, including very low-birth-weight infants.

Other clinical indicators of correct endotracheal tube placement are condensation in the endotracheal tube, chest movement, and presence of equal breath sounds bilaterally.

**Chest Compressions**

Chest compressions are indicated for a heart rate that is <60 per minute despite adequate ventilation with supplementary oxygen for 30 seconds.

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.

Compressions should be delivered on the lower third of the sternum to a depth of approximately one third of the anterior-posterior diameter of the chest.

Two techniques have been described: compression with 2 thumbs with fingers encircling the chest and supporting the back (the 2 thumb–encircling hands technique) or compression with 2 fingers with a second hand supporting the back. the 2 thumb–encircling hands technique is recommended for performing chest compressions in newly born infants.
Compressions and ventilations should be coordinated to avoid simultaneous delivery. The chest should be permitted to reexpand fully during relaxation, but the rescuer’s thumbs should not leave the chest. There should be a 3:1 ratio of compressions to ventilations with 90 compressions and 30 breaths to achieve approximately 120 events per minute to maximize ventilation at an achievable rate.

It is recommended that a 3:1 compression to ventilation ratio be used for neonatal resuscitation where compromise of ventilation is nearly always the primary cause, but rescuers should consider using higher ratios (e.g., 15:2) if the arrest is believed to be of cardiac origin. 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.

**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 toward correcting it.

However, if the heart rate remains <60 per minute despite adequate ventilation (usually with endotracheal intubation) with 100% oxygen and chest compressions, administration of epinephrine or volume expansion, or both, may be indicated. Rarely, buffers, a narcotic antagonist, or vasopressors may be useful after resuscitation, but these are not recommended in the delivery room.

**Rate and Dose of Epinephrine Administration**

Epinephrine is recommended to be administered intravenously. The IV route should be used as soon as venous access is established. The recommended IV dose is 0.01 to 0.03 mg/kg per dose. 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. The concentration of epinephrine for either route should be 1:10,000 (0.1 mg/mL).

**Volume Expansion**

Volume expansion should be considered when blood loss is known or suspected (pale skin, poor perfusion, weak pulse) and the baby’s heart rate has not responded adequately to other resuscitative measures. An isotonic crystalloid solution or blood is recommended for volume expansion in the delivery room. 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 intraventricular hemorrhage.

**Postresuscitation Care**

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

**Naloxone**

Administration of naloxone is not recommended as part of initial resuscitative efforts in the delivery room for newborns with respiratory depression. Heart rate and oxygenation should be restored by supporting ventilation.

**Glucose**

Newborns with lower blood glucose levels are at increased risk for brain injury and adverse outcomes after a hypoxic ischemic insult, although no specific glucose level associated with worse outcome has been identified.

Intravenous glucose infusion should be considered as soon as practical after resuscitation, with the goal of avoiding hypoglycemia.

**Induced Therapeutic Hypothermia**

It is recommended that infants born at>36 weeks gestation with evolving moderate to severe hypoxic-ischemic encephalopathy should be offered therapeutic hypothermia.

The treatment should be implemented according to the studied protocols, which currently include commencement within 6 hours following birth, continuation for 72 hours, and slow rewarming over at least 4 hours.