NEONATAL RESUSCITATION

INTRODUCTION (DANA SUOZZO, M.D., 11/2015)
Every 5 years the American Heart Association reviews the resuscitation literature and updates their recommendations. This PEM Guide reviews the updated guidelines for neonatal resuscitation. This PEM Guide includes the recommendations from 2010 that have not changed as well as those from the 2015 update.

MAJOR 2015 RECOMMENDATIONS
ECG is more accurate than auscultation in assessing heart rate immediately after delivery
Delayed cord clamping is suggested for preterm neonates NOT requiring resuscitation at delivery
There is insufficient data to support tracheal suctioning in a non-vigorous baby born with meconium as it delays ventilation
Laryngeal mask airways can be used for > 34 week neonates if the clinician is unsuccessful with ventilating via a face mask and/or tracheal intubation
There is not sufficient evidence for any delivery room prognostic score to help make decisions about < 25 week neonates. Presumed gestational age is the best guide
In late preterm and term neonates, an APGAR of 0 and an undetectable heart rate after 10 minutes of effective resuscitation should prompt consideration of stopping resuscitation. Each case must be considered individually.

Approximately 10% of newborns require some assistance to begin breathing at birth. Less than 1% requires extensive resuscitative measures. Those neonates who do not require resuscitation can generally be identified by a rapid assessment using 3 questions.

1. Is this a term gestation?
2. Does the neonate have good muscle tone?
3. Is the neonate crying or breathing?

If the answer to all 3 of these questions is “yes,” the neonate does not need resuscitation and can stay with the mother for routine care.

ROUTINE CARE
Remain with mother
Warm, dry and maintain normal temperature
Position the airway in the sniffing position
Clear secretions if needed
Stimulate the infant to breath
Ongoing evaluation

If the answer to any of the three questions is “no,” the neonate should receive one or more of the following categories of interventions.

INTERVENTION SEQUENCE AND TIMING		
1	Warm, dry, stimulate. Clear and position airway if necessary	0-30 seconds
2	Oxygenation and ventilation	30-60 seconds
3	Chest compressions	60-90 seconds
4	Administration of epinephrine and volume expansion	> 90 seconds
5	Post-resuscitation care	> 90 seconds

Approximately 60 seconds ("the Golden Minute") are allotted for completing the initial steps, reevaluating, and beginning ventilation if required. The decision to begin resuscitation is based on the assessment of both respirations (apnea, gasping, or labored/unlabored breathing) and heart rate (greater than or less than 100 bpm). In general, the best guide to a successful resuscitation is an improvement in heart rate.

EQUIPMENT
Infant warmer, towels
Suction equipment: bulb syringe, mechanical suction catheters
Bag-and-mask, O_2 source w/ flow meter (up to 10L/min)
Intubation equipment: Laryngoscope w/ Miller blades, ETT, capnograph, LMA
Umbilical vein catheter

UMBILICAL CORD MANAGEMENT (2015):
Until recently, it was common practice to clamp the umbilical cord immediately after birth to facilitate rapid transfer of the neonate to the pediatric provider for stabilization. There is evidence, primarily in neonates who do not require resuscitation, that delayed cord clamping is associated with less intraventricular hemorrhage, higher blood pressure and blood volume, less need for transfusion after birth, and less necrotizing enterocolitis. Delayed cord clamping conferred no benefit on mortality or severe intraventricular hemorrhage. The only negative consequence seems to be a slightly increased level of bilirubin, associated with more need for phototherapy.

Delayed cord clamping for longer than 30 seconds is reasonable for both term and preterm neonates (> 29 weeks) who do not require resuscitation at birth. There is insufficient evidence to recommend delayed cord clamping or cord "milking" for neonates who require resuscitation.

ASSESSMENT OF HEART RATE (2015):
Assessment of the newborn's heart rate is used to evaluate the effectiveness of spontaneous respiratory effort and determine the need for subsequent interventions. An increase in the newborn's heart rate is the most sensitive indicator of a successful response to resuscitation. Clinical assessment of heart rate has been found to be both unreliable and inaccurate. ECG (3-lead) displays a reliable heart rate faster than pulse oximetry. Pulse oximetry tended to underestimate the newborn's heart rate. During resuscitation of term and preterm neonates, the use of 3-lead ECG for the rapid and accurate measurement of the newborn's heart rate may be reasonable.

1. INITIAL STEPS: 0 – 30 SECONDS

During the first 30 seconds: provide warmth by placing infant under a radiant heat source, position the head in the “sniffing” position, clear the airway as necessary (bulb syringe, suction catheter), dry the infant, and stimulate breathing.

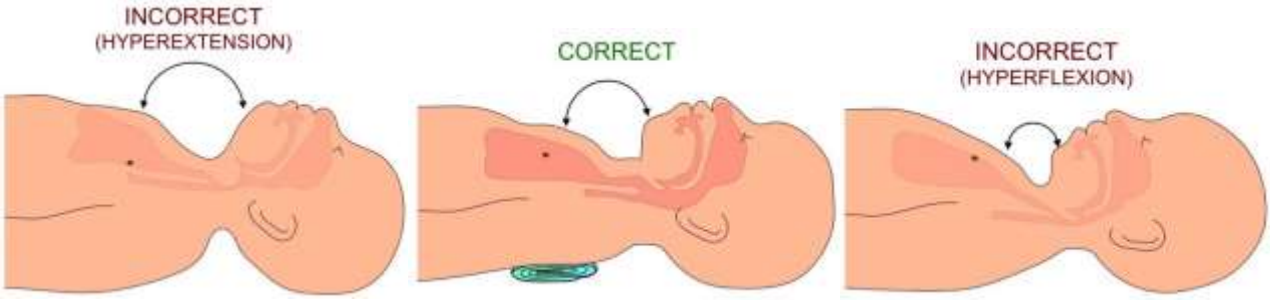
INITIAL STEPS: AHA 2015
Warm (avoid hypothermia)
Dry
Position the airway in sniffing position
Stimulate breathing
Clear (suction) the airway PRN

MAINTAINING NORMAL TEMPERATURE (2015):

It is recommended that the temperature of newly born non-asphyxiated neonates be maintained between 36.5°C and 37.5°C after birth through admission and stabilization. Temperature must be monitored to avoid hyperthermia as well.

There is new evidence supporting a variety of interventions that may be used alone or in combination to reduce hypothermia. At a gestational age of less than 32 weeks, use a combination of environmental temperature of 23-25 C, warm blankets, plastic wrapping without drying, hat, and thermal mattresses.

AIRWAY POSITIONING



RECOMMEDATIONS: CLEARING (SUCTION) THE AIRWAY: AHA 2015	
Clear amniotic fluid	Suctioning in the presence of secretions can decrease respiratory resistance but may also decreases heart rate
	Suctioning the airway should be reserved for neonates who have obvious obstruction to spontaneous breathing
	Those requiring positive pressure ventilation (PPV).
Meconium stained amniotic fluid	There is insufficient evidence to recommend routine suctioning of the trachea in vigorous or non-vigorous neonates. In the vigorous infant gentle suctioning of the mouth and nares with a bulb syringe may be considered In the non-vigorous infant, positive pressure ventilation should be initiated.

2. OXYGENATION AND VENTILATION: 30 – 60 SECONDS

If newborn is not breathing adequately (apneic or gasping), or has a HR < 100 bpm initiate supplemental oxygen with positive pressure ventilation (PPV) with a bag-valve-mask (BVM) and place on a pulse oximeter and 3 lead EKG.

RECOMMENDATIONS: SUPPLEMENTAL OXYGEN: AHA 2010
In babies requiring resuscitation, supplemental oxygen can be supplied to maintain oxygen saturation in the interquartile range of pre-ductal saturation (right arm)
Initiate with air or blended oxygen
If the baby is bradycardic (HR < 60 BPM) then supplemental oxygen can be provided with 100% oxygen until recovery of a normal heart rate

OXYGEN FOR PRETERM NEONATES (2015):

Meta-analysis of the randomized trials that compared initiating resuscitation of preterm neonates (less than 35 weeks of gestation) with high oxygen (65% or greater) versus low oxygen (21%–30%) showed no improvement in survival or morbidity to hospital discharge with the use of high oxygen.

Resuscitation of preterm newborns of less than 35 weeks of gestation should be initiated with low oxygen (21% to 30%), and the oxygen concentration titrated to achieve preductal oxygen saturation approximating the interquartile range measured in healthy term neonates. Initiating resuscitation of preterm neonates with high oxygen (> 65%) is not recommended.

Pulse oximeter should be attached to a pre-ductal location (right upper extremity), usually the wrist or the medial surface of the palm. Blood oxygen levels in uncompromised neonates do not reach extrauterine values until approximately 10 minutes following birth. Oxyhemoglobin saturation may remain 70 – 80% for several minutes after birth, resulting in an acrocyanotic appearance.

TARGETED PREDUCTAL SpO_2	
1 min	60-65%
2 min	65-70%
3 min	70-75%
4 min	75-80%
5 min	80-85%
10 min	85-95%

RECOMMENDATIONS: PULSE OXIMETRY: AHA 2010
When resuscitation can be anticipated
When positive pressure ventilation is administered for more than a few breaths
When cyanosis is persistent beyond the first 5 -10 minutes
When supplementary oxygen is administered

RESPIRATORY SUPPORT (2015):
For premature neonates without spontaneous respirations at birth sustained positive-pressure inflation may reduce the need for intubation at 72 hours. The optimal method and duration to administer sustained inflations and long-term effects is unknown. Routine use of initial sustained breaths of greater than 5 seconds is not routinely recommended but may be considered on an individual basis. Positive end expiratory pressure (PEEP) should be used for premature neonates as it helps to establish functional residual capacity (FRC).

Assisted ventilation should be delivered at 40-60 breaths per minute with a PEEP of 5 cm H_20. Initial peak inflating pressures are variable and unpredictable and should be individualized to achieve an increase in heart rate and chest expansion with each ventilation. Over-ventilation can result in gastric distension. Gastric distension is a vagal stimulus, can limit diaphragmatic expansion and increase the risk of aspiration.

If a newborn has labored breathing or persistent cyanosis, but HR >100 clear the away again, place pulse oximeter, provide supplemental oxygen and consider continuous positive airway pressure (CPAP) as it can reduce the need for mechanical ventilation.

RECOMMENDATION: POSITIVE PRESSURE VENTILATION: AHA 2015
The neonate remains apneic or gasping after initial steps completed
Heart rate < 100 BPM
Ventilate at a rate of 40-60 breaths/minute
Minimal inflation pressure to achieve chest rise and HR > 100 BMP
A laryngeal mask airway can be considered in neonates > 34 weeks if facemask ventilation or endotracheal intubation is not successful

ENDOTRACHEAL INTUBATION
Endotracheal intubation may be performed at various points during resuscitation. Intubation is required for extreme prematurity, surfactant administration, and suspected diaphragmatic hernia with respiratory distress. A laryngeal mask airway may be used during resuscitation for neonates greater than 34 weeks if bag-valve-mask ventilation or endotracheal intubation is unsuccessful. There is insufficient evidence to recommend capnography to detect return of spontaneous circulation (ROSC).

RECOMMENDATION: ENDOTRACHEAL INTUBATION: AHA 2015
When bag-valve mask ventilation is ineffective or prolonged
If chest compression are necessary (intubating may facilitate coordination of chest compression and ventilation and maximize efficacy of ventilation)
If epinephrine is required, administration of epinephrine directly into the endotracheal tube while venous access is established.
Bag-valve-mask ventilation can result in gastric distension further limiting lung expansion in a neonate with a diaphragmatic hernia. If an infant with diaphragmatic hernia requires positive pressure ventilation they should be endotracheally intubated
A laryngeal mask airway can be considered if facemask ventilation or endotracheal intubation is not successful

ENDOTRACHEAL TUBE & SUCTION CATHETER SIZES			
GESTATIONAL AGE (WKS)	WEIGHT (GM)	ETT SIZE	CATHETER SIZE
< 28	< 1000	2.5	5F or 6F
28 - 34	1,000 - 2,000	3.0	6F or 8F
34 - 38	2,000 - 3,000	3.5	8F
> 38	> 3,000	3.5 – 4.0	8F or 10F

THE MECONIUM STAINED INFANT (2015):
Vigorous neonates born through meconium stained amniotic fluid have been treated no differently than if they had been born through clear fluid. The 2010 guidelines recommended intubation and suctioning of neonates with meconium stained amniotic fluid that have poor muscle tone and inadequate breathing efforts at birth. In 2015, routine intubation for tracheal suctioning in this setting is no longer suggested because there is insufficient evidence and it may delay the onset of ventilation.

3. CHEST COMPRESSIONS: 60 – 90 SECONDS

If the heart rate remains < 100 but > 60 BPM, take ventilation corrective steps: Reposition airway into the "sniffing" position, clear the airway with suction, and visualize adequate chest rise. Continue positive pressure ventilation for 30 seconds, then check the heart rate. If the HR is < 60 bmp, support circulation by starting chest compressions while continuing positive pressure ventilations for 30 seconds and consider intubation.

The 2 thumb-encircling technique generates a higher blood pressure and less rescuer fatigue. Once compressions started use 100% oxygen. Wean oxygen as soon as return of spontaneous circulation (ROSC) is obtained. The compression and ventilations should be coordinated to avoid simultaneous delivery. The chest should be permitted to reexpand fully during relaxation. The rescuers thumbs should not leave the chest wall.

RECOMMENDATION: CHEST COMPRESSIONS: AHA 2015
Indicated if the heart rate < 60 BPM despite adequate ventilation with supplemental oxygen for 30 seconds
The two thumb technique is preferred
Chest compressions should be delivered on the lower 3rd of the sternum, with a depth of 1/3 the anterior-posterior diameter of the chest
A ratio of compression (90/min) to ventilation (30/min) of 3:1 should be used in patients with a non-cardiac etiology (the vast majority of neonates)
A higher compression to ventilation ratio of 15:2 if the arrest is cardiac in origin

OXYGEN DURING CARDIAC COMPRESSIONS (2015):
The available animal evidence demonstrated no obvious advantage of 100% oxygen over air. However, by the time resuscitation of a newborn includes cardiac compressions, the steps of trying to improve the heart rate via effective ventilation with low concentrations of oxygen should have already been tried. It is reasonable to increase the oxygen concentration during compressions and then wean the oxygen as the heart rate recovers.

4. EPINEPHRINE AND VOLUME EXPANSION: > 90 SECONDS

Medications are rarely indicated in neonatal resuscitation. Bradycardia is typically respiratory in origin and resolves with adequate oxygenation and/or ventilation

RECOMMENDATION: EPINEPHRINE: AHA 2010
If despite previous 30 seconds of adequate chest compressions and ventilation, the heart rate remains < 60 BPM, administer epinephrine intravenously. Intubate if no chest rise.

EPINEPHRINE 1:10,000 (0.1 MG/ML)		
ROUTE	DOSE	SAFETYCONSIDERATIONS
Intravenous (preferred route)	0.01 – 0.03 mg/kg	Higher IV doses (0.1 mg/kg) cause high BP, myocardial and neurologic dysfunction
Endotracheal (while access being obtained)	0.05 – 0.1 mg/kg*	This dose may be considered, but safety & efficacy have not been evaluated

VOLUME EXPANSION

Volume expansion should be considered when blood loss is known or suspected (poor perfusion, weak pulse, pale skin). In premature neonates, rapid infusions of large volumes have been associated with intra-ventricular hemorrhage. (See PEM Guide: Procedures: Umbilical Venous Catheterization)

RECOMMENDATION: VOLUME EXPANSION: AHA 2010
Consider when blood loss is suspected (pale skin, poor perfusion, weak pulse) and the heart rate has not responded adequately to other resuscitative efforts
Isotonic crystalloid solution or blood, at 10 ml/kg should be infused slowly

5. POST RESUSCITATION CARE

Patients should be transferred after resuscitation to an environment where close monitoring and expertise is the management of neonates is available. Naloxone is not recommended. Heart rate and oxygenation should be managed by supporting ventilations.

HYPOGLYCEMIA: Newborns with hypoglycemia are at risk of brain injury after a hypoxic ischemic event. Blood glucose concentrations as low as 30 mg/dl are common in healthy neonates within 1-2 hours of birth. Almost all neonates with symptomatic hypoglycemia have levels lower than 20-25 mg/dl. An American Academy of Pediatrics practice guideline (2011) recommends treatment for symptomatic neonates with a glucose level of ≤ 40 mg/dl. However, it is not possible to recommend a specific protective target glucose range.

Symptoms of hypoglycemia are nonspecific. In general, they can be divided into central nervous system manifestations (e.g. lethargy, irritability) and signs of sympathetic excess (e.g. sweating, tachycardia, tachypnea, jitteriness, seizure).

THERAPEUTIC HYPOTHERMIA
There is substantial, high quality evidence that therapeutic hypothermia is beneficial in neonates greater than 36 weeks with moderate-severe hypoxic ischemic encephalopathy and should be offered using clearly defined protocols. This is true of resource.

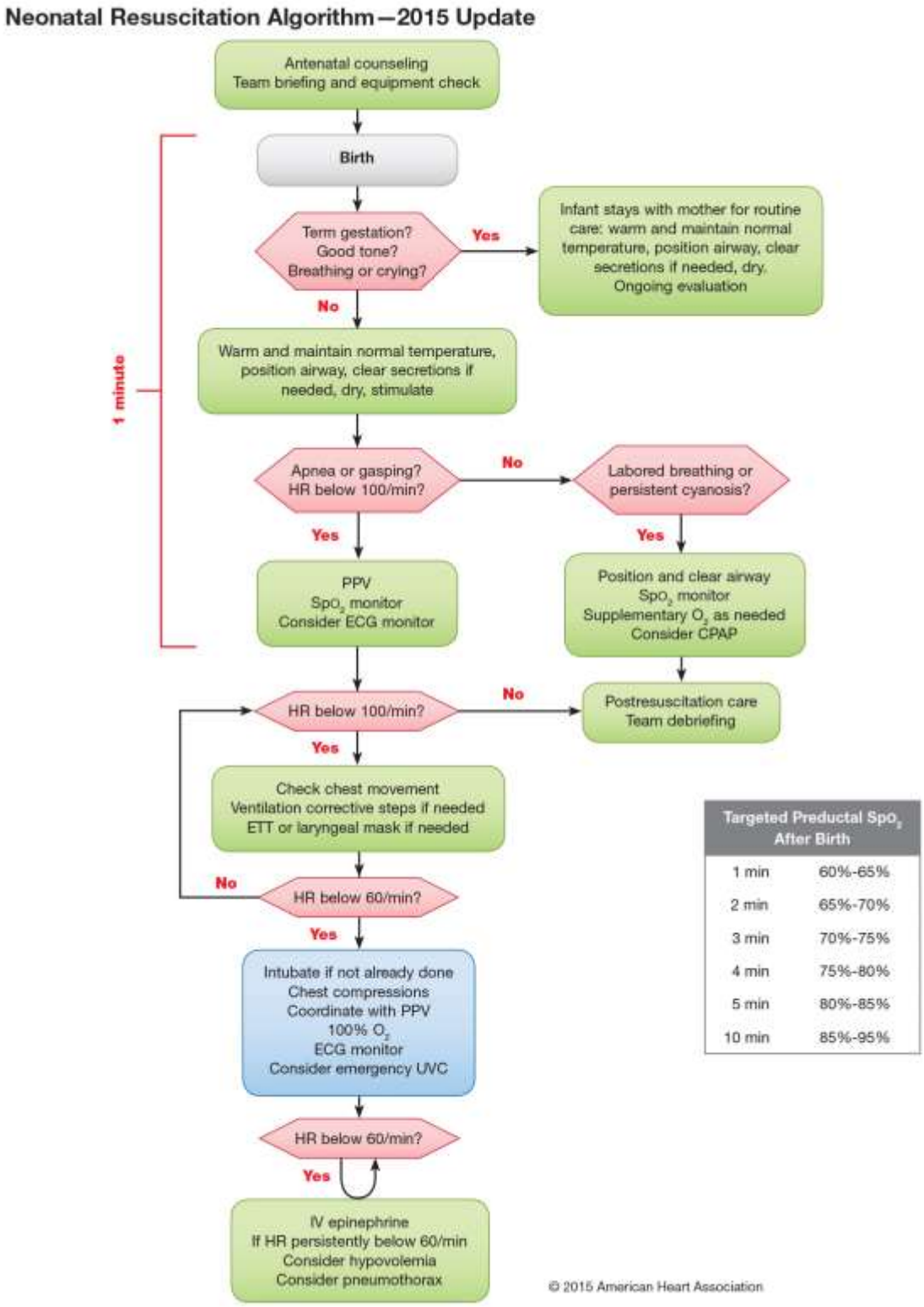
PROGNOSTICATION (2015):
For delivery room assessment at less the 25 weeks there is insufficient evidence to support any delivery room prognostic score over estimated gestational age alone. Care may be individualized based on: the perceived accuracy of gestational age, presence of chorioamnionitis and the level of care available at the delivery facility. The decision to continue or initiate resuscitation for those less than 25 weeks will be influenced by regional guidelines.

An APGAR score of 0 after 10 minutes of resuscitation is a strong predictor of mortality and morbidity in both late preterm and term neonates. In a cohort of neonates greater than 35 weeks an APGAR score of 0 at 10 minutes was associated with 50% death and 24% survival without moderate or major disability at 18-24 months. If the APGAR score is 0 after 10 minutes of resuscitation and the heart rate remain undetectable it may be reasonable to stop resuscitation. However the decision to continue should be individualized. Variables to consider include: if the resuscitation is optimal, availability of NICU treatments (e.g. cooling), circumstances pre-delivery (e.g. if timing of insult is known) and family wishes.

RECOMMENDATION: WITHHOLDING RESUSCITATION: AHA 2010
When gestation, birth weight, or congenital anomalies are associated with almost certain early death and when unacceptably high morbidity is likely among the rare survivors, resuscitation is not indicated. Examples include extreme prematurity (gestational age < 23 weeks or birth weight < 400 grams), anencephaly, and some major chromosomal abnormalities, such as trisomy 13
In conditions associated with a high rate of survival and acceptable morbidity, resuscitation is nearly always indicated. This will generally include babies with gestational age ≥ 25 weeks and those with most congenital malformations
In conditions associated with uncertain prognosis in which survival is borderline, the morbidity rate is relatively high, and the anticipated burden to the child is high, parental desires concerning initiation of resuscitation should be supported

RECOMMENDATION: DISCONTINUING RESUSCITATION: AHA 2010
In a newly born baby with no detectable heart rate, it is appropriate to consider stopping resuscitation if the heart rate remains undetectable after 10 minutes.
The decision to continue resuscitation efforts beyond 10 minutes with no heart rate should take into consideration factors such as the presumed etiology of the arrest, the gestation of the baby, the presence or absence of complications, the potential role of therapeutic hypothermia, and the parents' previously expressed feelings about acceptable risk of morbidity.

APPENDIX: NEWBORN RESUSCITATION ALGORITHM: AHA 2015



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