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Fellow Column: A Review of Neonatal Resuscitation

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Adapted from an educational presentation on 6/23/2020

Objectives:

1. Discuss important physiologic changes vital to a successful transition to extrauterine life
2. Identify infants who qualify for routine care, as well as infants who may need additional resuscitation
3. Review the AHA 2015 NRP guidelines algorithm and related practice cases
4. Discuss the selection of common equipment and settings during neonatal resuscitation

> *" Circulatory changes with the closure of right-to-left shunts (ductus arteriosus and foramen ovale), decreased pulmonary resistance, increased pulmonary perfusion, and increased systemic pressure"*

Transitioning from Intrauterine to Extrauterine Life:

A successful transition is characterized by the following:

- Alveolar clearance - achieved through labor, thoracic squeeze, and initial breath
- Lung expansion - happens when the neonates take an initial breath. Lung expansion also stimulates surfactant release, which reduces alveolar surface tension and increases lung compliance
- Circulatory changes with the closure of right-to-left shunts (ductus arteriosus and foramen ovale), decreased pulmonary resistance, increased pulmonary perfusion, and increased systemic pressure

Case #1:

You are called to attend a cesarean section of a 38 weeks gestation infant due to failure to progress. At delivery, the infant is noted to be crying and breathing spontaneously. HR was greater than 100 bpm. Limbs are flexed, and the hands and feet are blue. What is the APGAR score?

A: 5

B: 6

C: 7

D: 8

E: 9

Apgar Scoring:

- It's important to note that APGAR score should not be used to predict individual outcome as it is not an accurate prognostic tools even though there are data of a population based study that showed lower APGAR scores, especially the 5 minutes score, are associated with higher neonatal mortality and morbidity.
- Approximately 90% of neonates have Apgar scores between 7-10 and generally require no further intervention.

Infants Who Qualify for Routine Care:

- Gestational age: ≥ 35 weeks

Indicator		0 points	1 points	2 points
A	Activity (muscle tone)	Absent	Flexed arms and legs	Active
P	Pulse	Absent	< 100 bpm	> 100 bpm
G	Grimace (reflex irritability)	Floppy	Minimal response to stimulation	Prompt response to stimulation
A	Appearance (skin color)	Blue; pale	Acrocyanosis	Pink
R	Respiration	Absent	Slow and irregular	Vigorous cry

- Spontaneous breathing and crying
- Temperature: 36.5 to 37.5°C (97.7 to 99.5°F)
    - Initial hyperthermia may be reflective of maternal fever. Persistent hyperthermia or hypothermia may be a sign of sepsis.
- Respiratory rate: 40-60
    - Tachypnea may be a sign of pulmonary or cardiac disease. Apnea may be a sign of sepsis, neurological impairment, asphyxia, metabolic disorders, or secondary intrauterine drug exposure.
- Heart rate: 120-160
    - Tachycardia or bradycardia may be a sign of cardiac disease, sepsis, metabolic derangements, or other pathology.
- Color: acrocyanosis or pink
    - Central cyanosis may be a sign of pulmonary or cardiac disease.
- Tone: good muscle tone
    - Hypotonia may be a sign of sepsis, neurological impairment, or underlying pathology such as Down syndrome. It can also be secondary to intrauterine drug exposure.

High-Risk Deliveries (likely to require further resuscitation):

- Maternal conditions – advanced maternal age, maternal diabetes mellitus, hypertension, or eclampsia, maternal drug use, or previous history of stillbirth, fetal loss, or early neonatal death
- Fetal conditions – preterm, postterm, congenital anomalies, or multiple gestation
- Antepartum complications – placental anomalies, oligohydramnios, or polyhydramnios
- Delivery complications – breech presentation, chorioamnionitis, meconium-stained amniotic fluid, antenatal asphyxia with nonreassuring fetal heart rate, or instrumental delivery

Pre-resuscitation Equipment Checklist

Equipment check prior to delivery including but not limited to:

- Preheat radiant warm
- Oxygen blender set to 21%
- Suctioning catheter attached to wall suction, which is set at 80-100 mmHg
- Intubation kit ready
- Right-sized resuscitation bag and mask to provide adequate seal and pressure
- Supplies for placing peripheral IV, UVC, and UAC
- Access to epinephrine and normal saline

The Main Components of Neonatal Resuscitation

- Stabilization
- Ventilation
- Chest Compression
- Administration of inotrope/volume expansion

Case #2:

You are called to repeat C/S delivery of 39 weeks infant. The infant cries spontaneously at birth. You stimulate, dry, and suction the infant, and now you noted moderate respiratory distress with nasal flaring and grunting. You applied pulse ox, which shows SpO2 85%. What should you do next?

A: Start PPV

B: Start CPAP

C: Start blowby O2

D: Intubate

E: Do nothing

Targeted Pre-ductal SpO2 After Birth

- 1 minute 60 to 65%
- 2 minutes 65 to 70%
- 3 minutes 70 to 75%
- 4 minutes 75 to 80%
- 5 minutes 80 to 85%
- 10 minutes 85 to 95%
- Remember that immediately post-delivery, the neonate is in active transition from intrauterine to extrauterine circulation, so saturations won't be at 100% right away.
- The pulse oximeter should be placed on the neonate's right hand to detect pre-ductal saturation because the right arm receives blood from the aorta prior to the ductus arteriosus.

Supplemental Oxygen Use:

- Supplemental oxygen is used when neonates have lower oxygen saturations than the targeted preductal saturation
- Recommended starting FiO_2:
  - ≥ 35 weeks gestations: 21%
  - < 35 weeks gestations: 21-30%
- Consider starting CPAP if have labored breathing or if on 100% oxygen yet SpO_2 not at goal

Case #3:

You are called to a delivery of 30 weeks gestation infant secondary to premature rupture of membrane. Amniotic fluid is meconium stained. At birth, the infant did not cry spontaneously and is noted to be limp and apneic. Suctioning and vigorous stimulation were performed, and the infant remained apneic. Pulse ox was applied, and PPV was started at 1 minute of life. At 2 minutes of life, the infant remained apneic, and pulse ox reads 60%. What should you do next?

A: Intubate

B: Start chest compression

C: MR SOPA

D: Give epinephrine

E: Call for fellow/attending

Steps to Correct Mask Ventilation:

- MR SOPA are maneuvers trialed after PPV has failed to improve the neonate's heart rate or apnea. Effective PPV can be assessed by evaluating for good chest rise and bilateral breath sounds.
- M – Mask adjustment
- R – Reposition head to open up the airway
- S – Suction mouth, then the nose. Avoid deeper and vigorous suction, which can cause vagal response and bradycardia
- O – Open mouth to open up the airway
- P – Increase pressure every few breaths until good chest rise is observed. Initial PIP usually starts around 20-25 cm H_2O, and PEEP usually starts around 5-6 cm H_2O. Max PIP for preterm is 30 cm H_2O and for full term is 40 cm H2O.
- A – Alternative airway, such as intubation

Case #4:

You have been called to the delivery of a 36 weeks gestation infant via emergency C-section for placental abruption and nonreassuring fetal heart rate tracing. On delivery, the infant is cyanotic, apneic, and with poor tone. He undergoes vigorous stimulation, warming, suctioning of secretions, and positioning of the airway. He remains apneic, cyanotic, and poorly responsive, and palpation of the umbilical pulse reveals a heart rate of 84. What is the best next step in resuscitation?

A: Reposition and clear airway, apply SpO_2 monitor, start CPAP

B: Apply SpO_2 monitor, start PPV, consider ECG monitor

C: Insert a nasopharyngeal airway

D: Intubate

E: Start blowby O_2

A Review of the Early Portion of the NRP Algorithm:

- If the infant is term, tone, and breathing or crying, then you are cleaning the child off and returning him or her to the mother to obtain the myriad benefits of early skin-to-skin contact.
- If preterm, hypotonic, apneic, or breathing irregularly without a cry, essentially, we are starting with the classic initial resus-

citation maneuvers: warm, dry, suction, position (airway), and stimulate. A mnemonic to help remember these maneuvers is Dry PaWSS (Dry, Position airway, Warm, Suction, Stimulate).

- If, after your initial efforts, the infant is not improving, then check the pulse; if it is under 100, or if the infant is gasping or apneic, you want to quickly place a pulse oximeter and simultaneously start PPV, or bag-mask ventilation, as well as consider placing EKG leads, especially in situations such as known or suspected congenital heart disease. Per the AHA, if the heart rate is not rising after 15sec or if chest rise is not being accomplished on PPV, you are to run through your MR SOPA corrective measures.

- If, after initial resuscitation, the infant's HR is >100, but breathing is labored, or he or she continues to appear cyanotic, then you are headed off to the right side of the algorithm, where you'll also place a pulse ox but here instead of starting PPV can try repositioning and clearing the airway first, and if those do not work then start CPAP and titrate the FiO2 as needed.

Case #5:

You are urgently called to the delivery of a 37 weeks gestation infant with no prenatal care. He is apneic, floppy, and cyanotic at birth with HR72. PPV is started; however, adequate chest rise is not noted. Despite attempts at airway repositioning, suctioning, mask adjustment, ventilatory pressure increases, and insertion of a nasopharyngeal airway, chest rise does not improve, and HR falls to 54. What is the best next step?

A. Insert an oropharyngeal airway

B. Give epinephrine

C. Start CPR

D. Intubate and give PPV

E. Increase PIP

Assuming that, instead of the persistence of poor chest rise, that attempts at airway management yielded adequate chest rise for 30sec, yet HR still dropped to 54. In this case, what would the best next step be?

A. Insert an oropharyngeal airway

B. Give epinephrine

C. Start CPR

D. Intubate and give PPV

E. Increase PIP

A Review of the Later Portion of the NRP Algorithm

- As shown in the early portion of this half of the NRP algorithm, you are performing PPV and MR SOPA for a heart rate between 60 and 100. In our scenario, PPV and MR SOPA have not corrected your heart rate, which has dropped below 60, indicating impending cardiopulmonary collapse if something is not done immediately. It is important to note that, at this point, the algorithm alone does not provide all of the information needed.

- First, as highlighted by the case we just reviewed, you must ask yourself whether adequate chest rise and, therefore, adequate ventilation have been achieved. If not, the next step is to intubate as quickly as possible and, once accomplished, apply PPV for 30 seconds via your ETT; this is essentially the most that you can do in neonatal resuscitation to ensure adequate ventilation. If this does not correct your heart rate (bring it above 60), then you are starting CPR.

- If you had adequate chest rise on PPV for 30 seconds without having to intubate (such as in the 2nd situation we discussed in Case #5) and your heart rate did not improve above 60, then you are also going to intubate and start CPR rapidly, the only difference being that you are not trialing PPV for 30 seconds before starting CPR, as we already know that adequate ventilation has not fixed the issue. By the time you are intubating or starting chest compressions, your EKG leads should be on, and FiO_2 should be 100%.

- CPR is performed by giving three chest compressions followed by one breath in every 2 seconds. Ideal compression depth is ⅓ the AP chest diameter and the preferred technique, according to the AHA, is the two thumbs-encircling hands technique, as some evidence shows that it may offer some advantages in generating peak systolic pressure and coronary perfusion pressure; the two-finger technique, however, is also acceptable.

- If the heart rate remains below 60 after 60 seconds of chest compressions, then you give epinephrine. The dose is 0.1-0.3mL/kg of 1:10,000 epi IV, or 0.5-1mL/kg endotracheally (which, notably, is less desirable, as it takes ~1min to take effect); you are repeating your epi every 3-5min if HR remains <60. If you are resorting to epinephrine, then you should be wondering why; the AHA states to make sure to consider hypovolemia, in which case you'd give a 10mL/kg NS bolus or pneumothorax, in which case you'd perform a needle thoracostomy. Once HR>60, chest compressions can be stopped, and once HR>100 and the infant is breathing spontaneously and adequately, then PPV can be stopped, as well. Make sure to continue supplemental O_2 until saturations are at goal, too.

Case #6:

You are attending the delivery of an infant with no prenatal care and of unknown gestational age. On delivery, her weight is estimated to be 1200g. She is apneic at birth and remains so despite your resuscitation efforts. What size ETT and laryngoscope blade will you use for the intubation, and at what depth (at the lip) will you secure the ETT?

A: 2.5 ETT, 00 blade, inserted to 7.2cm

B: 3.0 ETT, 00 blade, inserted to 7.5cm

C: 3.0 ETT, 1 blade, inserted to 7.5cm

D: 3.0 ETT, 0 blade, inserted to 7.2cm

E: 2.5 ETT, 0 blade, inserted to 7.2cm

NRP "By the Numbers:"

- This is a list of the common settings and equipment as relates to neonatal resuscitation:

- ETT size:

    - By age: divide gestational age by 10 and round to nearest 0.5 (ex: 27wk = 2.5, 28wk = 3.0)

    - By size: <1 kg = 2.5, 1-2 kg = 3.0, 2-3 kg = 3.5, and >3 kg = 3.5 or 4.0

- ETT insertion depth: weight (kg) + 6
- Laryngoscope blade size: 00 for ELBW (<1kg), 0 for preterm >1kg, 1 for term
- Suction: 8-10Fr catheter set to 80-100mmHg
- Blowby flow: start at 10L/min
- PPV settings: start at PIP: 20-22 / PEEP: 5-6 and titrate by 5/1; RR40-60
- FiO_2 settings (CPAP, PPV): start at 21% for ≥35wks and 28 (21-30)% for <35wks
- Epinephrine dosing: IV 0.1-0.3 mL/kg, endotracheal 0.5-1mL/kg; start at 60sec of CPR, repeat every 3-5min for HR<60
- NS bolus: 10mL/kg
- HR: <60 = CPR, 60-100 = PPV
- SpO_2 goals: >60% at 1min, then at 5% per minute until 5min; after 5min should be >85-90%

Answer Key:

1. **D**
2. **B**
3. **C**
4. **B**
5. **D, C**
6. **D**

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Disclosure: The authors identify no conflict of interest

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