Refresher Course
Neonatal Resuscitation
(for the Pediatric Anesthesia Care Provider)
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SPA Tampa, Fl

Disclosures
No significant financial interests in any commercial products or services mentioned or discussed in this presentation.

Caveat
These slides are for use at a presentation given at the Society for Pediatric Anesthesia. Clinical expertise is assumed by the presenter. These slides are not intended to be a guide for neonatal resuscitation, nor a replacement for participation in a NRP course.

Preparation for Course
No preparation is needed – but it may be helpful to read the AAP & AHA 2010 Guidelines for Neonatal Resuscitation, published jointly in Circulation1 and Pediatrics,2 and available – free as of 1/6/2012 – at http://pediatrics.aappublications.org/content/early/2010/10/18/peds.2010-2972E
Or http://circ.ahajournals.org/content/122/18_suppl_3/S909

Goals
- Review the changes in teaching resuscitation including the AHA/AAP’s NRP — Neonatal Resuscitation Program — and the new emphasis on teamwork skills development
- Understand the scientific basis for changes in the NRP algorithm
- Apply these evolving recommendations to the practice of anesthesia for newborns

What is the NRP?
- The Neonatal Resuscitation Program™ is an educational program, jointly developed by AAP and AHA, that “introduces the concepts and basic skills of neonatal resuscitation”
- “Completion of the program does not imply that an individual has the competence to perform neonatal resuscitation” — it is not a certification
- > 3 million providers have earned participation card
- Great resource: aap.org/nrp

PACPs' Care for Newly Born Babies

- May share responsibility in the delivery room
- called as part of “code” or airway team (see Airway)
- need to integrate as part of NR team
- as an ACPS in attendance for the mother — may be called upon to help with NRP for newly born baby
- newly born proceeds directly to surgical procedure
- fetal cases
- EXIT procedure
- emergent delivery

Neonatal Resuscitation Training and National Standards

- ABA Exam Content¹
- SPA Fellowship Curriculum²
- ASA MOCA Content³
- newborn resuscitation - evaluation and Apgar scoring;... techniques and pharmacology of resuscitation⁴

¹Available at http://www.theaba.org/pdf/ITEContentOutline.pdf
²Available at http://www.theaba.org/pdf/NationalStandardsCoreCurriculum.htm
³Available at http://www.theaba.org/pdf/MinnesotaMOCAContentOutline.pdf
⁴Available at http://www.theaba.org/pdf/MinnesotaMOCAContentOutline.pdf

Brief History of the NRP

- Initial work by Bloom and Cropley at Drew Medical School: Neonatal Education program, funded by an NIH grant
- 1980’s: AAP Resuscitation of the Newborn Taskforce
- Built on NEP, eventually joined forces with the AHA
- 1987: First NRP
- Evolution of recommendations
- ~every 5 years, review of evidence with changes to NRP algorithm and course
- Most recent: 2011 6th Edition of NRP (for details see [1,2])


How is the NRP Program Developed?
1. Definition of Development Questions

- 6 months after guidelines are published, year long process to identify topics for further investigation
- A survey of neonatologists, nurse leadership and NRP instructors
- For NRP 6th Edition, 53 areas were selected for evaluation by the International Liaison Committee on Resuscitation (ILCOR)

(see guided tour of NRP for PACPs, below)

2. ILCOR Systematic Review of Evidence

- > 2 international experts review each question and populate a formal evidence worksheet
- 2010 ILCOR Worksheets’ (and archives) are available online:
  - [http://www2.aap.org/nrp/providers/science/science_2010ILCOR.html](http://www2.aap.org/nrp/providers/science/science_2010ILCOR.html)

3 & 4. ILCOR Meetings Leading to Consensus

- Expert reviews are debated online and then in series of conferences 1/2/2006 – 2/2010
- Outcome of this process is the COSTR: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations

5.6. NRP

- Each resuscitation council then adapts the ILCOR Guidelines to their local needs
- NRP Steering Committee made adaptations of the guidelines to USA practice
- The ILCOR1 and NRP2 Guidelines are published
- The NRP prepares the educational program – including online materials, the Textbook of Neonatal Resuscitation and the Instructor’s Manual.

Physiology Behind the Algorithm

**Fetal Circulation**
- During gestation, the fetus is dependent on the placenta for gas exchange.
- Pulmonary blood flow is not needed other than to meet needs of developing lung.
- Combined cardiac output largely bypasses the high-resistance pulmonary vasculature via two right to left shunts: the ductus arteriosus and the foramen ovale.
- Not a series circulation as in adults (only ~13% of combined CO to pulmonary circulation in 2nd trimester; by 30 weeks 35%).


**The Normal Transition**
- In a matter of seconds, the fetus is separated from placental circulation and becomes the newborn – dependent on pulmonary perfusion & ventilation for survival.
- The major goals in the delivery room are:
  - to support the transition when going well
  - to recognize failure and assist getting the transition back on track
  - Initial treatment of complicating concomitant disease

**Persistent Pulmonary Hypertension of the Newborn**
- Newly born pulmonary vasculature pressures remain high for several weeks after birth.
- Significant vasoconstriction in response to hypoxia, especially in setting of acidosis.
- Therefore, pulmonary failure, or simple failure to transition to adult circulation can lead to increased PVR, & continuation/resumption of R to L shunt via the foramen ovale & PDA (leading to hypoxia, acidosis).
Most Often the Newlyborn Transition without Significant Intervention

The Inverted Pyramid of NRP

- **Always Needed**
  - Assessment of Baby
  - Warmth, positioning, airway clearance if needed, etc.
  - Gag reflex

- **Needed Less Frequently**
  - Supplemental Oxygen
  - Ventilation with IPPV
  - Intubation
  - Stay/Needed by Newborns
  - Supplemental Oxygen
  - Medications

- **Rarely Needed**
  - Supplemental Oxygen

Based on new recommendations, perhaps ventilation with IPPV should go above supplemental oxygen.

Significant Interventions in Delivery Room are Rare

- ~ 10% of newly born infants require some assistance in neonatal transition
- ~ 1% need "extensive resuscitation measures"
- Positive pressure ventilation
  - 0.4% at term
  - 70% at 23-26 weeks EGA
  - 0.12% need CPR and/or medications

An Anesthesiologist’s Tour of the NRP Algorithm

The 2005 NRP Algorithm

- Same overall goals:
  - Control environment
  - Ensure Ventilation
  - Circulation
  - Volume expansion/dopamine/pressor support

Preparation for Resuscitation

- Before the algorithm begins
  - Equipment
  - Personnel
  - Assessment of Risks
  - Sign-out
Similar to preparation for anesthesia case – additions are in italics; changes to support new recommendations are in bold

- Suction
- Bulb syringe
- Mechanical suction and tubing
- Suction catheters (5F or 6F, 8F, 10F, 12F or 14F)
- 8F feeding tube and 20ml syringe
- Meconium aspirator

Suction

Bulb syringe

Mechanical suction and tubing

Suction catheters (5F or 6F, 8F, 10F, 12F or 14F)

8F feeding tube and 20ml syringe

Meconium aspirator

Bag and mask ventilation equipment
- Device to deliver PPV with fIO2 of 0.9 – 1
- Face masks (preemie to newborn sized; cushioned rims)
- Oxygen source
- Compressed air (medical air) source
- Oxygen blender; flowmeter up to 10L/min and tubing
- Pulse Oximeter and Pulse Oximeter Probe

Airway Equipment
- Laryngoscope w/ Miller 0, 0, and 1
- Extra bulbs* and batteries for laryngoscope
- Endotracheal tubes 2.5, 3.0, 3.5, and 4.0 mmID
- Stylet (optional)
- Scissors
- Tape or securing device
- Alcohol
- CO2 detector or capnograph
- LMA #1

Medications
- Epinephrine (standard code box) 1:10,000 (0.1mg/ml)
- 3ml or 10ml ampules
- Isotonic crystalloid (100ml or 250ml) NS or LR
- Dextrose 10%, 250 mL
- Normal saline flushes

Umbilical Venous Catheterization Supplies
- Sterile gloves
- Scalpel or scissors
- Antiseptic prep solution
- Umbilical tape
- Umbilical catheters 3.5F, 5F
- 3 way stopcock
- Syringes, various sizes 1ml – 50ml
- Needles, various sizes, or needle free access devices

Miscellaneous
- Personal protection devices (gloves, gowns)
- Radiant warmer or other heat source
- Firm, padded resuscitation surface
- Clock with second hand (timer optional)
- Warmed linens
- Stethoscope (with neonatal head)
- Tape, ½ or ¾ inch
- Cardiac monitor and electrodes
- Oropharyngeal airways (0, 00, and 000 sizes or 30, 40, and 50 mm lengths)
Equipment

- For very preterm babies
  - oo laryngoscope blade (optional)
- Re-closable, food-grade plastic bag (1 gallon size) or plastic wrap
- Chemical warming pad
- Transport incubator – to maintain thermal environment
  - for transport to nursery

Personnel

ASA: Attendance at Deliveries

QUALIFIED PERSONNEL, OTHER THAN THE ANESTHESIOLOGIST ATTENDING THE MOTHER, SHOULD BE IMMEDIATELY AVAILABLE TO ASSUME RESPONSIBILITY FOR RESUSCITATION OF THE NEWBORN.

The primary responsibility of the anesthesiologist is to provide care to the mother. If the anesthesiologist is also requested to provide brief assistance in the care of the newborn, the benefit to the child must be compared to the risk to the mother.

Personnel

- Attendance at Deliveries (AAP/ACOG Guidelines)
  - At every delivery there should be at least one person whose primary responsibility is the neonate and who is capable of initiating resuscitation. Either that person or someone else who is immediately available should have the skills required to perform a complete resuscitation, including ventilation,... intubation... chest compressions, and ...

Some Anesthesiologists Are Performing NR in the DR

- 2001 Survey of 156 or 212 graduates from University of Pennsylvania
  - 65% involved in NR as anesthesiologists
  - More prevalent in private practice
  - Anesthesiologist practicing at hospitals with fewer than 1,000 deliveries/year had rate of participation 11 times greater than those at higher volume obstetric hospitals
  - 1995 Survey: 31% of anesthesia personnel at Midwestern community hospitals routinely involved in NR.
  - For discussion of legal implications of NR-by-anesthesiologist, see [3]

Pediatricians Attendance and Skills

- Univ of Texas Study of Pediatric Resident Intubation Skills
  - 49% intubation procedures observed
  - 31% never successful by housestaff
  - PGY1: successful on 1st or 2nd attempt: 50%
  - PGY2: 55%
  - PGY3: 62%

### Pediatrics Attendance and Skills

- 2004 Video study of Pediatric Residents in the Delivery Room attempting intubation:
  - Physicians: 315 attempts successful, 31.9 sec for successful attempts
  - Fellows: 301 attempts successful, 25.5 sec
  - Mean time to completion of successful intubation: 27.3 sec
- Successful intubations
  - 1st try: 19; 2nd try: 10; 3rd try: 10 required > 3 tries
- 2006 Australian video study (1260 intubations successful):
  - Residents: 241 (49 sec); Fellows: 291 (32 sec); consultants: 861 (26 sec)

### Predicting Need for Resuscitation Antepartum Factors

- Majority of cases in which resuscitation is needed can be pre-identified.
- Preemies have a major risk factor for resuscitation, and necessitates special equipment and personnel.
- Premies have immature lungs, probability of decreased pulmonary compliance.
- Slight increase in need for bag mask ventilation, but not intubation.
- Slight increase in need for ventilation, but not intubation.
- Increased risk of hypothermia.
- High surface area to volume ratio & immature skin increase risk of hypothermia.
- Increased risk of hypovolemia.

### Predicting Need for Resuscitation Intrapartum Factors

- Emergency C-section
  - Forceps or vacuum-assisted delivery
  - Breach or abnormal presentation
  - Premature labor
  - Chorioamnionitis
  - Prolonged rupture of membranes (>10 hours before delivery)
  - Prolonged labor (>24 hours)
  - Macrosomia

### Predicting Need for Resuscitation Antepartum Factors

- Maternal DM
- Gestational Hypertension or pre-eclampsia
- Chronic Hypertension
- Fetal anemia or isoimmunization
- Previous fetal or neonatal death
- Bleeding in 2nd or 3rd trimester
- Maternal infection
- Maternal cardiac, renal, pulmonary, thyroid, or neurologic disease
- Polyhydramnios
- Oligohydramnios

### Predicting Need for Resuscitation Intrapartum Factors

- Maternal DM
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Predicting Need for Resuscitation: FHR Monitoring¹

- Fetal heart rate is controlled by brain regulation of the ANS, and therefore reflects oxygenation and perfusion, acid-base status of fetus.
- 2009 ACOG published guidelines for FHR interpretation based on 2008 conference
- Three Tiered Fetal Heart Rate System¹
  - Category I: normal; baseline (110-160 bpm); variability: moderate; acclerations; +; abrupt decelerations
  - Category II: indeterminate; abnormal baseline; minimal variability; absent accelerations; or decelerations of moderately concerning character and duration (see ref)
  - Category III: abnormal or evaluation, possible delivery; absent variability; any of the following: recurrent late decelerations, recurrent variable decelerations, bradycardia, sinusoidal pattern (see ref for details and definitions)


Be Prepared

- ~ 20% of newborns who require resuscitative efforts will have no identifiable risk factor²

Quick Checklist³

- Is baby term³?
  - Breathing or crying³ (but NOT gasping³)
  - Good tone³ (normal is flexed extremities)
  - Color is no longer emphasized as a guide to intervention at this point
  - These questions determine whether routine care is given and baby stays with mother or if baby should go to radiant warmer for initial steps

Sign-out from Obstetric Providers

- What is the gestational age?
- Is the fluid clear?
- How many babies are expected?
- Are there any additional risk factors?

Initial Assessment

- Is baby term³?
  - Breathing or crying³ (but NOT gasping³)
  - Good tone³ (normal is flexed extremities)
  - Color is no longer emphasized as a guide to intervention at this point
  - These questions determine whether routine care is given and baby stays with mother or if baby should go to radiant warmer for initial steps
Who is this woman?

* Virginia Apgar
* Bonus Points: What was her specialty?
* Pediatric anesthesiologist (also expert in neonatology, violinist, violin maker; advocate for immunizations, March of Dimes)

The APGAR Score

* Five parameters, scores of 0-2:
  * Color, heart rate, reflex irritability, tone, respiratory effort
* Practical epigram of the Apgar Score 1,2
  * A: Appearance (color)
  * P: Pulse (heart rate)
  * G: Grimace (reflex irritability)
  * A: Activity (tone)
  * R: Respiratory effort

The Apgar Score Continued

<table>
<thead>
<tr>
<th>Sign</th>
<th>Score 0</th>
<th>Score 1</th>
<th>Score 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>(N) color</td>
<td>Normal or Pale</td>
<td>Blue</td>
<td>Complete Pale</td>
</tr>
<tr>
<td>(P) heart rate</td>
<td>Normal</td>
<td>&lt; 100 bpm</td>
<td>&gt; 100 bpm</td>
</tr>
<tr>
<td>(G) Reflex irritability</td>
<td>None</td>
<td>Grimace</td>
<td>Cry or Active Withdrawal</td>
</tr>
<tr>
<td>(A) Tone</td>
<td>Limp/flushed</td>
<td>Some reaction</td>
<td>Active motion</td>
</tr>
<tr>
<td>(R) Respiration</td>
<td>Absent</td>
<td>Weak or labile</td>
<td>Strong or labile</td>
</tr>
</tbody>
</table>

Use of Apgar Score 1

* A "convenient shorthand" to describe the condition of the newly born shortly after delivery
* Can be used to summarize fetal-neonatal transition and response to resuscitation
* But... NOT A GUIDE TO RESUSCITATION (do not wait to begin interventions until 1 minute!)

Use of Apgar Score 1

* Other limitations
  * Subjective components
  * Not adjusted for prematurity
  * Not adjusted for medical interventions
  * Poor marker for "asphyxia" 1
  * Affected by maternal drugs, trauma, infection, congenital anomalies
  * 5 minute Apgar score not a good predictor for long term neurologic outcome 2
  * (Scores < 3 at 10 minutes and beyond may predict poor neurologic outcome)

Expanded of Apgar Score

* Change in score from one time frame to another (especially 1 min --> 5 min) is frequently used as a marker of response to resuscitative efforts.
* AAP/ACOG added information about resuscitation and interventions to score
**Initial Steps**

- Initial steps of resuscitation should take less than 30 seconds, but are ongoing.
- Warm
- Clear airway if necessary
- Positioning
  - Non vigorous: intubate and suction (no routine suctioning)
- Dry
- Stimulate

**Evaluation of Resuscitation Effectiveness**

- Simultaneous evaluation of
  - Heart Rate
  - Respirations
- Since 1968, heart rate described as best measure of effectiveness of resuscitation
- NRP recommends auscultation (umbilical artery palpation)
- Use of pulse oximeter

**Pulse Oximetry**

- Pulse oximetry is viable in DR – use whenever concern for low HR, poor respiratory result
- Good signal usually obtained by 90 seconds
- More accurate than "eyeball" test for cyanosis
- Display of HR, and also used for titration of oxygen (see below)
- Suggest placing probe first then connecting to monitor

**Labored Breathing or Cyanosis**

- For newborns with HR > 100, but with labored breathing
  - Clear Airway
  - Consider CPAP
  - For term, no conclusive evidence for or against
  - For preemie – may reduce need for intubation, but may increase rate of pneumothorax

**Bradycardia or Apnea**

- For newborns with HR < 100, apnea or gasping
  - Positive Pressure Ventilation
  - SpO2 monitoring

**Primary and Secondary Apnea**

Primary Apnea –
- Characterized by
  - Decreasing heart rate
  - Adequate arterial BP
  - pH (if measured) > 7.1
  - Intact physiologic reflexes (including Head’s)
- Good Apgar scores
  - respond to initial steps, including stimulation
Primary and Secondary Apnea

Secondary Apnea –

• Characterized by
  • Low heart rate
  • Decreased arterial BP
  • pH (if measured) < 7
  • Impaired physiologic reflexes (including Head’s)
  • Low Apgar scores (< 3)
  • Does not respond to initial steps, including NO response to stimulation

TREATMENT IS VENTILATION

Primary and Secondary Apnea Implications

Most important 3 steps of neonatal resuscitation for ACP (my opinion)

1. Ventilation
2. Ventilation
3. Ventilation

Especially if ACP was called to resuscitation as part of code or emergency A/E team – patient likely has been compromised for sufficient period of time to be in period of secondary apnea

Labored Breathing or Cyanosis

• For newborns with HR < 100, apnea or gasping
• Positive Pressure Ventilation
• SpO2 monitoring

Positive Pressure Ventilation Strategies: Initial Lung Inflation

• ILCOR review failed to draw conclusions on long vs. short inspiratory times
• Required PIPs are variable
• Premature baby – Initial peak inspiratory pressures generally less than 20 cmH2O
• Term baby – may need 30-40 cmH2O pressure (If no manometer, use minimal pressure needed to obtain increase in heart rate)
• Caution with excessive pressure, especially in preemies

40-60 breathes per minute

PPV Strategies: Advanced Ventilation Devices

• No recommendation for any specific device over another
• flow-inflating bag
• a self-inflating bag
• or a pressure limited T-piece resuscitator

PPV Strategies: Advanced Ventilation Devices

• Pressure limited T-piece resuscitator
• More consistent peak pressures, PEEP, and sustained pressures than other devices

[Video]
PPV Strategies: LMAs

- LMA #1 now recommended when
  - Mask ventilation and intubation are not successful
  - E.g. Pierre-Robin
- Can substitute for face mask for newborns > 1000 g or GA >= 34 weeks
- Insufficient evidence for use in smaller newly born
- Possible alternative to trach intubation as a secondary airway for resuscitation for larger newly born
- No studies with respect to LMA and
  - Meconium-stained amniotic fluid
  - Use while administering chest compressions
- Or as a route for intratracheal medications

Oxygen Toxicity

For a review of oxygen toxicity – see Julie Niezgoda’s syllabus from her SPA 2011 presentation:


Supplemental Oxygen: A Brief History of Oxygen & Neonatology & the World

[Photos to follow]

Supplemental Oxygen: A Brief History of Oxygen & Neonatology & the World

- 4.6 billion years ago, no oxygen on earth
- First life ~ 3.5 billion: atmosphere ~ 1 ppm oxygen
- Photosynthesis 2.5 billion years ago → 1% O2 in atmosphere
- Eukaryotes ~ 1.5 billion years ago, then mitochondria

Supplemental Oxygen: A Brief History of Oxygen & Neonatology & the World

- Oxygen content over time
  (Lane, 2002)
  - 2 billion years ago: 5-18%, from near zero.
  - Cambrian period ~ 500 million years ago; modern concentrations of oxygen;
  - Carboniferous and early Permian period: as high as 35% oxygen in atmosphere.

Supplemental Oxygen: A Brief History of Oxygen & Neonatology & the World

- Discovered in 1773.
- First given to babies in 1780.
- 1970’s oxygen toxicity discovered
- 1917-1950’s intra-gastric administration.
- 1928: neonatal resuscitation with oxygen and carbon dioxide.
- 1950’s association with ROP and CLD.

Supplemental Oxygen: A Brief History of Oxygen & Neonatology & the World

- Modern times
  - Oxygen analyzers, blowers, transcutaneous PaO2, SpO2, pulse oximeter.
  - Routine use of oxygen
  - Recognition of potentially toxic effects of 100% oxygen → "a lot standing, but unjustified practice."
  - Evolution of resuscitation guidelines.
Supplemental Oxygen: A Brief History of Oxygen & Neonatology & the World

- Aerobic metabolism: advantageous for energy-related stoichiometry.
- Consequence is formation of reactive oxygen species (ROS).
- Absence of oxygen: electron transport chain (ETC) inhibited – glucose metabolized by glycolytic pathways → depression of cellular metabolism.

Hypoxia

- Absence of oxygen
  - Compensated/Physiologic
    - Bioenergetic status maintained
    - May be developmental signal
  - Uncompensated/Pathologic
    - Numerous changes

Hyperoxia

- Excess of oxygen
  - Production of ROS
    - Oxygen → superoxide → hydrogen peroxide → hydroxyl radical → water
  - Inhibition of physiologic-hypoxia-driven processes
    - E.g. development

Oxidative Stress and the newborn

- Transient Mechanisms
  - maintain redox homostasis in normal circumstances
  - First line of defense in infants
    - Enzymatic inactivation of superoxide (superoxide dismutase)
    - Inactivation of hydrogen peroxide (catalase)
    - Up-regulation of antioxidant enzymes
  - Infant’s red-ox systems less robust
  - Role of hypoxemia in normal development

Development occurs in physiologic hypoxic conditions

- Optimal oxygen concentration 3-5% for mammalian embryonic development.
- Exposure of embryo to 21% impairs development.
- Oviducts and uterine horn remain hypoxic until after ~12 weeks of pregnancy until significant maternal blood flow influence on fetus (when pulsatile flow to placental bed).
- Fetal circulation maintains relative hypoxemic
  - PaO2 rarely greater than 30 mm Hg.

Hypoxia Induced Factor

- Found to specifically bind to erythropoietin gene in oxygen-dependent fashion.
Hypoxia Induced Factor

- Coordinates & regulates expression of hundreds of genes with developmentally critical functions (vegf)
- Important in angiogenesis, branching morphologies, alveolar development
- Knockout animals – deficiencies in organogenesis including neurologic; pulmonary disease like RDS
- Oxygen is a lynchpin for many aspects of development

Oxygen Exposure and Outcomes

- Clinical Outcomes
  - Long term morbidity/mortality
  - Especially neurologic, pulmonary, ophthalmologic

Animal & In Vitro Studies

- 100% oxygen vs. Room Air
  - Increases neurologic injury and brain injury
  - Increases oxidative stress, and
  - Activates neuronal transcription factors

Animal Studies

- 100% oxygen vs. Room Air
  - Increases oxidative stress, and
  - Induces inflammatory changes in lung, heart, and brain
  - Increases pulmonary resistance and reactivity
  - Increases pulmonary resistance and reactivity
  - Enhances nitric oxide production in in-vitro cultures

Human Studies

- Premature Infants
  - Retinopathy of Prematurity
  - Chronic lung disease
  - (both significantly reduced if SaO2 < 93%)

Human Studies

- 100% oxygen compared with room air resuscitation
  - Increases oxidative stress at least 4 weeks after birth
Photos for Oxidation Analogy Here

Human Studies

100% oxygen compared with room air resuscitation

* Increases myocardial and kidney injury
  Vento M, Sastre J, Asensi MA, Vina J. Room air resuscitation causes less damage to heart and kidney than 100% oxygen. AM J Respir Crit Care Med. 2001; 172:1265-1268.
  Delays recovery (significantly lower 5 minute Apgar score and heart rate, prolonged time to first cry and breath)
  Increases time in need of resuscitation and oxygen
  Vento et al, 2005

Human Epidemiologic Studies (but data subject to multiple biases)

100% oxygen compared with room air resuscitation

* May even be associated with higher risk for childhood leukemia and cancer
  Swedish case control study: 500 cases; compared resuscitation with 100% face mask/bag vs room air: odds ratio 2.6; if oxygen used more than 3 minutes: OR: 3.5.

* No good long term neurologic outcome data.
  Only existent study had only ~40% of original cohort -- 213 subjects -- and was underpowered to detect any benefit of 100% oxygen; but many animal/in vitro studies... 

Evolution of Guidelines

* AHA 1992: "hypoxia is nearly always present in the newborn requiring resuscitation at birth. Therefore, if cyanosis, bradycardia, or other signs of neonatal distress are noted in a breathing newborn during stabilization, early administration of 100% oxygen is important."
  "The hazards of administering too much oxygen during the brief period required for resuscitation should not be a concern."

For babies at term, the guidelines recommend inspired oxygen.

By attention to the desired concentration of adequate inflation of the fluid-filled lungs, followed concentrated that was initiated...

If resuscitation is started with less than 100% oxygen, supplemental oxygen should be administered if there is no appreciable improvement within 90 seconds following birth.

If supplemental oxygen is unavailable, use room air to deliver positive pressure ventilation.

Additional oxygen is not necessary for basic resuscitation although it has been considered so by some practitioners. Oxygen is not available at all places and at all times. It is also expensive. Moreover, new evidence from a controlled trial shows that most newborns can be successfully resuscitated without additional oxygen. Research also suggests that high oxygen concentration may not be beneficial in most circumstances. However, when the newborn's colour does not improve despite effective ventilation, oxygen should be given if available. An increased concentration of oxygen is needed for severe lung problems such as meconium aspiration and immature lung, or when the baby does not become pink despite adequate ventilation.

There is some evidence that infants born high altitude (i.e., low ambient PaO₂) have more difficulty establishing normal oxygenation and pulmonary blood flow than infants born at sea level.

However, the first priority should be to ensure adequate inhalation of the fluid-filled lungs, followed by attention to the desired concentration of inspired oxygen.

Although there is some in vitro evidence, a valid biochemical rationale, and preliminary clinical evidence to support resuscitation with lower oxygen concentrations, current clinical data are insufficient to justify adopting this as a routine practice.

Conversely, in settings where availability of oxygen is limited (e.g., the developing world), it is reasonable to consider resuscitation with room air.

There is some evidence that infants born at high altitude (i.e., low ambient PaO₂) have more difficulty establishing normal oxygenation and pulmonary blood flow than infants born at sea level.

However, the first priority should be to ensure adequate inhalation of the fluid-filled lungs, followed by attention to the desired concentration of inspired oxygen.

There are some methodological concerns about these studies and the results should be interpreted with caution. However, at present, the best available evidence suggests air should be used initially with supplemental oxygen reserved for infants whose condition does not improve after effective ventilatory support. If a flow inflating bag or T-piece device is used and supply of medical air is not available oxygen should be used.

Several studies have raised concerns about the potential adverse effects of 100% oxygen during resuscitation of newly born infants. Meta-analysis of randomised controlled trials of resuscitation showed a significant reduction in mortality and no evidence of harm in infants resuscitated with air compared with 100% oxygen. There are some methodological concerns about these studies and the results should be interpreted with caution. However, at present, the best available evidence suggests air should be used initially with supplemental oxygen reserved for infants whose condition does not improve after effective ventilatory support. If a flow inflating bag or T-piece device is used and supply of medical air is not available oxygen should be used.


WHO 1998


2005 AAP/AHA Guidelines for Neonatal Resuscitation; Summary of Major Changes; Vol 15(2) Fall/Winter 2005
Evolution of Guidelines

* NRP 2008
  * Endorses starting resuscitation with FiO2 0.21 - 0.5 (can achieve 0.4 with self-inflating bag with no reservoir).
  * Blenders for neonatal resuscitation (blenders and SpO2 monitoring for preemies)
  * "The fact is we’re so motivated by the Apgar score to make babies pink that we probably overuse oxygen, which is in reality a drug with significant side effects." (Dr. Jay P. Goldsmith, Co chair of the NRP steering committee)

Evolution of Guidelines

* 2010 update (pending October, 2010)
  * Evidenced base review worksheet for ILCOR-NRP working group

What is the optimal initial FiO2 in newly born resuscitation?

* Observed SpO2 in normal newborns:


Oxygen Delivery, Hemoglobin-O2 Dissociation

* Pulse oximetry designed to detect hypoxemia, not hyperoxemia.
* SpO2: one monitor is not the same as another monitor.


2011 NRP Oxygen Recommendations

* For first 10 minutes of life, normal newly born SpO2 may remain in 70-80% for several minutes
* Both hypoxia and even brief exposures to oxygen may be harmful
* Increased survival of neonates resuscitated with room air vs 100% in large meta-analysis studies (no significant data on starting resuscitation with FiO2 other than 0.21 or 1.0)
Hypoxia – Re-oxygenation Injury

- Excess of oxygen
- Production of ROS
  Oxygen → superoxide → hydrogen peroxide → hydroxyl radical → water
- Inhibition of physiologic-hypoxia-driven processes
  E.g. development
- Analogous to reperfusion injury

2011 NRP Oxygen Recommendations

- Goal for supplemental oxygen concentration is SpO2 in chest inspire range of predueal SpO2 via use of blender
- If blender not available, should start with FiO2 = 0.3
- For bradycardia after 90s of resuscitation, should increase SpO2 to 1.0 until HR recovers
- Premature infants may require SpO2 of >0.5 – unclear at what SpO2 to start for preemies
- Some dissent

Failure of PPV

- If, after 30 seconds of ventilation, HR is not above 100
- Take ventilation corrective steps

Indications for ET Intubation

- Tracheal suctioning for meconium
- Non-vigorous baby only
- PPV does not improve clinical condition, and ventilation with mask is not effective (inadequate chest rise; breath sounds)
- Prolonged PPV (to improve quality and consistency of PPV)
- When performing chest compressions
- Special circumstances: surfactant administration, CDH

Chest Compression Technique

- Ratio of compressions : ventilation = 3:1
  - NRP has not adopted guidelines as C:V or increased compression to ventilation ratio
  - Key to resuming chest compressions is respiratory function and the end of the respiratory event
  - Parameters of chest compressions is important as is continuous chest compressions
  - In absence of known cardiac cause, higher compression ventilation can be considered, such as 3:2
  - Go to red oxygen
  - Two thumb & index fingers is recommended
  - Collimated chest compressions and ventilation
  - Coordinated chest compressions and ventilation

Failure of PPV: Intubation

- If ventilation is optimized – and HR is < 60 then
- Consider intubation & chest compressions
- ETT placement confirmation
- Use of esohedral CO2 detectors to confirm tracheal tube placement
  Faster & more accurate than clinical signs alone
- Possible false negatives during cardiac arrest
- Can have false positives when contaminated with epi/nephrine, and atropine
- No conclusive evidence for continuous CO2 monitoring vs colorimetry
  COLORIMETRIC: Should change from Purple >> Yellow in presence of CO2. If yellow when opened, do not use Purple >> Problem (no CO2) Yellow >> Yes

References:
Failure of Chest Compressions

- To avoid interruption of perfusion to coronary circulation, continue coordinated chest compressions for 45-60 seconds before checking pulse
- If HR still remains below 60, ensure adequate ventilation, chest compression technique
- If still below 60, epinephrine is indicated

Epinephrine

- Route of administration
  - Umbilical venous (UVC) administration preferred
  - Intravenous route (IV) acceptable
  - Administration via ETT is problematic
  - Variable absorption
  - Not likely to be effective
  - May be used while establishing venous access

Epinephrine

- Dosing
  - Concentration to be used – always 1:10,000 (100mcg/ml)
  - IV dose: 0.01-0.045mg/kg (0.1-0.45ml/kg)
  - Typical term baby should receive total dose of 0.05 - 1 ml
  - E.g., for 3 kg infant: 0.05 - 0.3mg total dose: 0.35 - 1.25 ml/kg 1:10,000 epinephrine
  - ETT dosing – uncertain
  - 5-10x increase in dose
  - (0.5-10mcg/kg – 1-3 mcg/kg may reach equivalent plasma concentrations as 1 mcg/kg IV – for 3 kg baby, this would be ~0.5ml 1:10,000 epinephrine)

Umbilical Venous Access

- Preferred route for epinephrine is umbilical vein using 1ml syringe
  - 3.5 - 5F catheter (non fenestrated)
  - As sterile as you can be
  - Considering replacing catheter in sterile conditions after resuscitation
  - Stop cock & syringe
  - Aspirate until blood flow and stop there – do not want catheter to be in liver

Epinephrine

- Reassess 1 minute after epinephrine administration
- May repeat epinephrine every 3-5 minutes

Nalaxone

- Not part of initial resuscitation for respiratory depression
- Treatment of opioid exposure is
  - Ventilate, ventilate, ventilate
- Contraindicated in cases of chronically opioid exposed infants (risk of seizures)
- Dose 0.1mg/kg IV (not well studied)
- Monitor after use (for continuation of opioid effect after naloxone has worn off)
Failure of Resuscitation

- Consider other causes –
  - Re-evaluate adequacy of ventilation and chest compression
  - Consider
  - Hypovolemia
  - Pneumothorax
  - Unilateral chest rise or breath sounds with mask or proper position of ETT

Volume Expansion

- Indicated when
  - Baby is unresponsive to resuscitation
  - Appears “in shock”
  - There is a history consistent with blood loss
  - Limited data to support volume expansion without a history of blood loss, but blood loss may not be readily apparent
  - Consider a trial of IV fluid/blood

Special Circumstances

- Choanal Atresia
  - Poor ventilation despite good technique
  - Catheter does not pass through nares
  - Oral airway
  - Pierre Robin
  - Turn prone
  - Nasal airway (can make one with 2.5 ETT)
  - Other airway lesions

- Pulmonary Hypoplasia
  - Suspect in cases of oligohydramnios
  - May have poor compliance and require increased PIP
  - Extreme immaturity
    - May have “stiff” lungs – but caution with prolonged high pressure
    - Surfactant administration timing varies by institution, but should occur after initial resuscitation complete

Special Circumstances

- Congenital diaphragmatic hernia (CDH)
  - May have prenatal diagnosis via ultrasound study
  - At birth, classic presentation is scaphoid abdomen
  - Avoid prolonged PPV by mask as intrathoracic abdominal contents may become distended with gas, further inhibiting ventilation
  - Consider placement of OG sump (e.g., 10F Repogle)
  - Pulmonary hypertension common
  - Often require urgent intubation

Special Circumstances

- Congenital Pneumonia and Meconium Aspiration Syndrome
  - Pneumonia often associated with maternal group B Streptococcal infection
  - Can present in delivery room
  - May require intubation in DR, ECMO

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Post-Resuscitation Care

- Hypoglycemia
  - no specific glucose concentration target confirmed by current science
  - Hypoglycemia post resuscitation may be harmful
  - Hypoglycemia not confirmed to be harmful
- Goal: Avoid Hypoglycemia
  - All infants at some risk
  - Premature infants
  - Infants of diabetic mothers, mothers on IV solutions with dextrose
  - If hypoglycemia, rapid initiation of treatment with IV Dextrose

Post-Resuscitation Care

- Therapeutic Hypothermia
  - Three large RCTs
  - Either selective head or whole body cooling induced using cooling blankets to target (33.5–34.5°C)
  - Initiate within 6h of birth
- Outcomes:
  - significantly fewer deaths
  - less neurodevelopmental disability at 18-month follow-up.
- No head to head comparison of cooling methods

Discontinuance of Resuscitation

- Consider discontinuance of resuscitative efforts after 10 minutes without a heart rate for newborns
- Factors to consider in continue or stop decision
  - Cause of arrest
  - Gestational age
  - Concomitant medical issues (e.g., potentially lethal genetic conditions)
  - Availability and utility of therapeutic hypothermia
  - Parents’ (or guardian’s) wishes with respect to risks (of severe morbidity, long-term disability) and benefits
  - Community and social standards
  - For a review of ethical and legal issues around initiating resuscitation for "borderline" viable newborns, see 1

Sentinel Event Report

- 2004-2005 The Joint Commission Sentinel Events
  - 109 cases of death (95) or permanent disability
  - unrelated to a congenital condition
  - BW > 2,500 grams
  - Mother’s age 15-41 years old (median 27)
  - > ½ first child
  - Average GA: 39 weeks
  - Lack of prenatal care: only ~4%

So what were the identified root causes?

Training
Root Cause Analysis of Infant Death and Disability

- Communication issues (215)
- Failure to follow the chain of communication
- Staff competency (47)
- Inadequate fetal monitoring (34)
- Unavailable monitoring equipment and/or drugs (30)
- Credentialing/privileging/supervision issues for physicians & nurse midwives (25)
- Staffing issues (19)
- Unavailability of personnel (11)
- Unavailability of prenatal information (11)
- Communication issues (72%)

The Joint Commission Recommendations

- Team training in perinatal areas
- Clinical drills for high-risk events
- Debriefings to evaluate team performance and identify areas for improvement
- Apply national practice guidelines
- Policies for transfer to higher level of care

Training in Other High Risk Occupations

- Cockpit/Crew/Crisis Resource Management
- History: series of aviation crashes in 1970s involving human error
- NASA developed curriculum
- Accepted by commercial aviation
- Adopted in other high-risk industries

CRM

- Anesthesiology led the way with Anesthesia CRM

NRP Training, 2011

- New approach is via varied curriculum and evaluation for 3 components
  - Knowledge (e.g., algorithm, dose of epinephrine)
  - Skills (skills stations)
  - Teamwork and communication (simulation & debriefing)
- New learning theory informed new program
- Simulator and Debriefing Sessions
- Key behavioral skills in NRP
  1. Know your environment
  2. Anticipate and plan
  3. Assume the leadership role
  4. Communicate effectively
  5. Delegate workload optimally
  6. Allocate attention wisely
  7. Use all available information
  8. Use all available resources
  9. Offer help when needed
  10. Maintain professional behavior

Neonatal Resuscitation in Resource Limited Settings

- See Helping Babies Breathe (AAP Program)

http://www.helpingbabiesbreathe.org/

My Recommendations

- Anesthesia Providers have a special role in neonatal resuscitation in the DR
- Airway management, advanced monitoring
- "Code team"
- Training of NRP providers
- Application of anesthesia CRM to other medical domains

Reach out to other pediatric providers – practice resuscitation together – learn from them, and share your expertise!