Refresher Course
Neonatal Resuscitation
(for the Pediatric Anesthesia Care Provider)

David Robinowitz, MD MHS MS

February 25, 2012
SPA Tampa, Fl

Disclosures

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

1

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.

2

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 *Circulation*[1] 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

1. Kattwinkel, J., J. M. Perlman, et al. (2010). "Part 15: neonatal resuscitation: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care." Circulation **122**(18 Suppl 3): S909-919.
2. 2.Kattwinkel, J., J. M. Perlman, et al. (2010). "Neonatal resuscitation: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care." Pediatrics **126**(5): e1400-1413.

3

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

4

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"[1]
* "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[2]
* Great resource: aap.org/nrp

1. http://www2.aap.org/nrp/providers/about/about_coursedescrp.html
2. Kattwinkel, J. and J. Perlman (2010). "The Neonatal Resuscitation Program: The evidence evaluation process and anticipating edition 6." NeoReviews **11**(12): e673-e680.

5

PACPs§ Care for Newly Born Babies

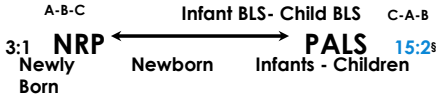
- *May share responsibility in the delivery room*
  - called as part of "code" or airway team (see *Airway*)
    - need to integrate as part of NR team
  - as an ACPs in attendance for the mother — may be called upon to help with NRP for newly born baby
- newly born proceeds directly to surgical procedure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

§ PACPs = Pediatric Anesthesia Care Providers

NRP is Applicable Outside of the Delivery Room

For Perioperative Resuscitations

- Although the primary focus of the NRP is the newly born, NRP also applies to neonates, and young infants
- However, where NRP ends and PALS[1] begins is not clear
  - Differences include A-B-C vs. C-B-A, ratio of compressions to breaths, ETT vs LMA, UVC vs IO, initial fiO2[2]
- Situation, judgment, and experience determine appropriate interventions[1]



1. Berg, M. D., S. M. Schexnayder, et al. (2010). "Pediatric basic life support: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care." Pediatrics **126**(5): e1345-1360.
2. Halamek, L. P. (2008). "Educational Perspectives: The Genesis, Adaptation, and Evolution of the Neonatal Resuscitation Program." NeoReviews.org **9**: e142-e149.

§ For 2 rescuer CPR

Neonatal Resuscitation Training and National Standards

- ABA Exam Content[1]
- SPA Fellowship Curriculum[2]
- ASA MOCA Content[3]

  newborn resuscitation - evaluation and Apgar scoring; … techniques and pharmacology of resuscitation[1]

1. http://www.theaba.org/pdf/ITECcontentOutline.pdf
2. http://www.pedsanesthesia.org/corecurriculum.jphtml
3. ABA MOCA Content Outlines, accessed 1-6-2012 http://www.theaba.org/pdf/MOCAcontentOutline.pdf

Day to Day Anesthesia Experience is also not Sufficient Training

- Perioperative cardiac arrest is relatively rare
  - Mayo 1988-2005[1, §]
    - 0-30 days old, frequency of periop CA: ~0.7%
    - 31 days – 1 year old: ~0.05%
    - 4-9 years old: ~0.04%

⇨ One could practice for years without the need to perform a full resuscitation

1. Flick, R. P., J. Sprung, et al. (2007). "Perioperative cardiac arrests in children between 1988 and 2005 at a tertiary referral center: a study of 92,881 patients." Anesthesiology **106**(2): 226-237; quiz 413-224.
2. § includes cardiac surgery, but not failure to come off pump

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])

1. Halamek, L. P. (2008). "Educational Perspectives: The Genesis, Adaptation, and Evolution of the Neonatal Resuscitation Program." NeoReviews.org **9**: e142-e149.
2. Bloom, R. (1997). "The Early History and Basic Concepts of the Neonatal Resuscitation Program." NRP Instructor Update **6** (available at http://www2.aap.org/nrp/providers/about/about_historyconcepts.html)

How is the NRP Program Developed?

1. Definition of Development Questions

- 6 moths after guidelines are published, year long process to identify topics for further investigation[1]
  - survey of neonatologists, nursing leadership and NR Instructors
- For NRP 6th Edition, 33 areas were selected for evaluation by the International Liaison Committee on Resuscitation (ILCOR)

(see Guided Tour of NRP for PACPs, below)

1. Kattwinkel, J. and J. Perlman (2010). "The Neonatal Resuscitation Program: The evidence evaluation process and anticipating edition 6." NeoReviews **11**(12): e673-e680.

ILCOR

- ILCOR is composed of representatives from
  - American Heart Association (AHA)
  - Eurpean Resuscitation Council (ERC)
  - Heart and Stroke Foundation of Canada (HSFC)
  - Australian and New Zealand Committee on Resuscitation (ANZCOR)
  - Resuscitation Councils of Southern Africa (RCSA)
  - Inter American Heart Foundation (IAHF)
  - Resuscitation Council of Asia (RCA - current members Japan, Korea, Singapore, Taiwan)

1. American Academy of Pediatrics. (2011). "How Neonatal Resuscitation Guidelines and NRP Materials are Developed." Retrieved 01-06-2012, 2011, from http://www2.aap.org/nrp/pdf/ilcorprocess.pdf.
2. http://www.ilcor.org/en/about-ilcor/about-ilcor/

2. ILCOR Systematic Review of Evidence

- >= 2 international experts review each question and populate a formal evidence worksheet
- 2010 ILCOR Worksheets[2] (and archives) are available on line:
  http://www2.aap.org/nrp/providers/science/science_2010ILCOR.html
  Or
  http://www.ilcor.org/en/consensus-2010/worksheets-2010/

1. Kattwinkel, J. and J. Perlman (2010). "The Neonatal Resuscitation Program: The evidence evaluation process and anticipating edition 6." NeoReviews **11**(12): e673-e680.
2. (2010). "Appendix: Evidence-Based Worksheets." Circulation **122**(16 suppl 2): S606-S638.

2. ILCOR Systematic Review of Evidence

- Each study is assigned a level of evidence (LOE) and methodology grade[1]

LOE

1. RCT – or meta analysis of RCT
2. Pseudo-randomized (concurrent controls)
3. Retrospective controls
4. No control group (e.g. case series)
5. Not related to specific population (adult; animal, mathematical models)

Quality of Study[2] (Subjective)
Based on quality criteria depending on type of study

Good
Fair
Poor

1. Kattwinkel, J. and J. Perlman (2010). "The Neonatal Resuscitation Program: The evidence evaluation process and anticipating edition 6." NeoReviews **11**(12): e673-e680.
2. American Heart Association. (2007). "Instructions for completion of the C2010 evidence evaluation worksheet." Retrieved 1-6-2012, 2012, from http://www.heart.org/idc/groups/heart-public/@wcm/@private/@ecc/documents/downloadable/ucm_308196.pdf.

3 & 4. ILCOR Meetings Leading to Consensus

- Expert reviews are debated online and then in series of conferences 12/2006 – 2/2010
- Outcome of this process is the ***COSTR*: 2010 International *Consensus on* *Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations***[1]

1. Perlman, J. M., J. Wyllie, et al. (2010). "Part 11: Neonatal resuscitation: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations." Circulation **122**(16 Suppl 2): S516-538.

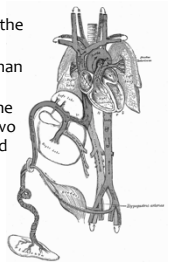
5.6. NRP

- Each resuscitation council then adapts the ILCOR Guidelines to their local needs
- NRP Steering Committee made adaptations of the guidelines to USA practice[1]
- The ILCOR[2] and NRP[3] Guidelines are published
- The NRP prepares the educational program – including online materials, the Textbook of Neonatal Resuscitation and the Instructor's Manual.

1. Kattwinkel, J. and J. Perlman (2010). "The Neonatal Resuscitation Program: The evidence evaluation process and anticipating edition 6." NeoReviews **11**(12): e673-e680.
2. Perlman, J. M., J. Wyllie, et al. (2010). "Part 11: Neonatal resuscitation: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations." Circulation **122**(16 Suppl 2): S516-538.
3. Kattwinkel, J., J. M. Perlman, et al. (2010). "Neonatal resuscitation: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care." Pediatrics **126**(5): e1400-1413.

Physiology Behind the Algorithm Fetal Circulation

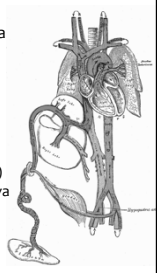
* Fetal Circulation
  * During gestation, the fetus is dependent on the placenta for gas exchange
  →Pulmonary blood flow is not needed other than to meet needs of developing lung
  • Combined cardiac output largely bypasses the high-resistance pulmonary vasculature via two right to left shunts: the ductus arteriosus and the foamen ovale
  • Not a series circulation as in adults
  (only ~13% of combined CO to pulmonary circulation in 2nd trimester; by 30 weeks 25%)[1]



1. Rasanen, J. and et al (1996). "Role of the pulmonary circulation in the distribution of human fetal cardiac output during the second half of pregnancy." Circulation **94**(5): 1068-1073.

Physiology Behind the Algorithm Fetal Circulation

* Fetal Circulation
  * Deoxygenated blood →low resistance placenta via paired umbilical arteries
  * Oxygenated blood → body via single umbilical vein
  (analogous to the pulmonary arteries and veins)
  * Umbilical vein → hilum of liver
    * Left lobar vessels; arcuate branch (w/portal vein) to right lobe; ductus venosus → inferior vena cava



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
  * recognize failure and assist getting the transition back on track
  * Initial treatment of complicating concomitant disease

The Normal *Transition*

* Hormonal changes towards the end of gestation and with spontaneous labor activate rapid elimination of fetal lung fluid
  * Active reabsorption of [Na+] across the alveolar epithelium
  * Small role for mechanical forces (e.g. delivery)[1]
  * (potential for increased pulmonary morbidity for C-section without labor)
* The uterine arteries constrict, and with placement of an umbilical clamp, the uterine vessels are no longer patent → increased SVR and increased systemic BP

1. Jain, L. and D. C. Eaton (2006). "Physiology of Fetal Lung Fluid Clearance and the Effect of Labor." Seminars in Perinatology **30**(1): 34-43.

The Normal *Transition*

* Pulmonary vascular resistance drops rapidly with the onset of ventilation
  – due to expansion of lungs *with gas* and increased alveolar oxygen tension[1]
* Coupled with increased SVR the right to left shunt across the foramen ovale is ablated.
  * Within 24-48 hours, the PDA has functionally closed
    * Muscular contraction associated with decreasing prostaglandin concentration and increased O_2 tension
  * Anatomic closure may take weeks

1. Rudolph, A. M. (2009). Prenatal and postnatal pulmonary circulation. Congenital diseases of the heart: Clinical-physiological considerations. A. M. Rudolph. West Sussux, UK, Wiley-Blackwell.

Persistent Pulmonary Hypertension of the Newborn

PPHN

* Newly born pulmonary vasculature pressures remain high for several weeks after birth
* Significant vasoconstriction in response to hypoxia, especially in setting of acidosis[1]
* Therefore, pulmonary failure, or simple failure to transition to adult circulation can lead to ↑ PVR, & continuation/resumption of R → L shunt via the foramen ovale & PDA (leading to hypoxia, acidosis)

1. Rudolph, A. M. and S. Yuan (1966). "Response of the pulmonary vasculature to hypoxia and H+ ion concentration changes." J Clin Invest **45**(3): 399-411.

Most Often the Newlyborn Transition without Significant Intervention

The Inverted Pyramid of NRP[1]

- Always Needed
  - Assessment of Baby
  - Warmth, positioning, airway clearance if needed, Dry, Stimulate
- Needed Less Frequently
  - Supplemental Oxygen§
  - Ventilation with PP
  - Intubation
- Rarely Needed by Newborns
  - Chest compressions
  - Medications

1. (Redrawn from) American Academy of Pediatrics (2011). Textbook of Neonatal Resuscitation, American Academy of Pediatrics & American Heart Association.

§ Based on new recommendations, perhaps Ventilation with PP should go above supplemental oxygen.

24

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[1]

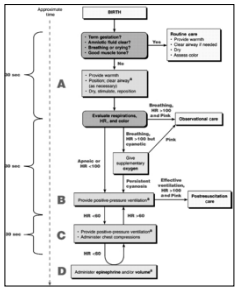
1. Perlman, J. M. and R. Risser (1995). "Cardiopulmonary resuscitation in the delivery room. Associated clinical events." Arch Pediatr Adolesc Med **149**(1): 20-25.

25

An Anesthesiologist's Tour of the NRP Algorithm

26

The 2005 NRP Algorithm



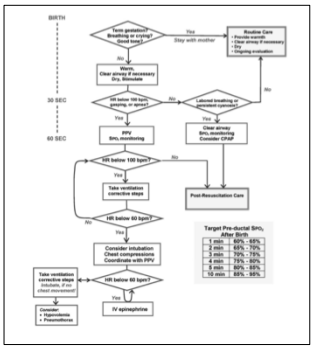
Same overall goals:

- **Control environment**
- **Ensure Ventilation**
- **Circulation**
- **Volume expansion/ionotropic/ pressor support**

© American Heart Association, American Academy of Pediatrics, Pediatrics 2006;117:e1029-e1038 (reprinted with permission)

27

The 2010-2011 Algorithm

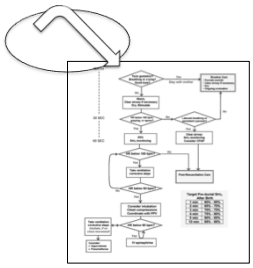


© American Academy of Pediatrics (2011). Textbook of Neonatal Resusscitation, American Academy of Pediatrics & American Heart Association. (reprinted with permission)

28

Preparation for Resuscitation

- Before the algorithm begins
  - Equipment
  - Personnel
  - Assessment of Risks
  - Sign-out



29

Equipment

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*

Adapted from American Academy of Pediatrics (2011). Textbook of Neonatal Resuscitation. American Academy of Pediatrics & American Heart Association. (used with permission)

30

Equipment

* 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**

31

Equipment

* Airway Equipment
  * Laryngoscope w/ Miller **00**, 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**

Anesthesia providers obviously can bring airway equipment appropriate to the clinical situation, their expertise and preference

32

Equipment

* 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

33

Equipment

* 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

34

Equipment

* 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
  * Oropharygeal airways (0, 00, and 000 sizes or 30, 40, and 50 mm lengths)

35

Equipment

* For very preterm babies
  * 00 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[1]

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.

1. American Society of Anesthesiology (2010). Guidelines for Neuraxial Anesthesia in Obstetrics, ASA.

Personnel

ASA: Attendance at Deliveries:[1]

Personnel, other than the surgical team, should be immediately available to assume responsibility for resuscitation of the depressed newborn. The surgeon and anesthesiologist are responsible for the mother and may not be able to leave her to care for the newborn, *even when a neuraxial anesthetic is functioning adequately.*

Individuals qualified to perform neonatal resuscitation should demonstrate:

3.1 Proficiency in rapid and accurate evaluation of the newborn condition, including Apgar scoring.

3.2 Knowledge of the pathogenesis of a depressed newborn (acidosis, drugs, hypovolemia, trauma, anomalies, and infection), as well as specific indications for resuscitation

3.3 Proficiency in newborn airway management, laryngoscopy, endotracheal intubations, suctioning of airways, artificial ventilation, cardiac massage, and maintenance of thermal stability.

1. ASA House of Delegates. (2010). Optimal Goals for Anesthesia Care in Obstetrics, American Society of Anesthesiologists.

Personnel

* Attendance at Deliveries (AAP/ACOG Guidelines)[1]
  * *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 … medications.*

1. American Academy of Pediatrics and American College of Obstetricians and Gynecologists (2002). Guidelines for Perinatal Care. Elk Grove Village, IL; Washington, DC, AAP/ACOG.

Some Anesthesiologists Are Performing NR in the DR

* 2001 Survey of 156 or 212 graduates from University of Pennsylvania[1]
  * 65% involved in NR as anesthesiologists
    * 35% once per year; 24% 6x per year; 14.5% monthly; 3.5% weekly
  * 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
* 1991 Survey: 31% of anesthesia personnel at Midwestern community hospitals routinely were involved in NR.[2]
* For discussion of legal implications of NR-by-anesthesiologist, see [3]

1. Gaiser, R., S. B. Lewin, et al. (2001). "Anesthesiologists' interest in neonatal resuscitation certification." J Clin Anesth **13**(5): 374-376.Heyman, H. J., N. J. Joseph, et al. (1991).
2. "Anesthesia Personnel, Neonatal Resuscitation, and the Courts." Anesthesiology **75**(3): A1074.
3. Liang, B. A. and R. R. Gaiser (1999). "Newborn resuscitation and anesthesia responsibility post-cesarean section." J Clin Anesth **11**(1): 69-72.

Pediatricians Attendance and Skills

* Univ of Texas Study of Pediatric Resident Intubation Skills[1]
  * 1998-1999 and 2000-2001
    * 449 intubation procedures observed
      * 35% never successful by housestaff
    * PGY1: successful on 1st or 2nd attempt: 50%
    * PGY2: 55%
    * PGY3: 62%

1. Falck, A. J., M. B. Escobedo, et al. (2003). "Proficiency of pediatric residents in performing neonatal endotracheal intubation." Pediatrics **112**(6 Pt 1): 1242-1247.

Pediatricians Attendance and Skills

- 2004 Video study of Pediatric Residents in the Delivery Room attempting intubation[1]
  - PL-1: 31% attempts successful; 31.9 sec for successful attempts
  - PL2/3: 39% attempts successful; 27.5 sec
  - Fellows: 53% successful; 23.6 sec
  - Mean time to completion of successful intubation: 27.3 sec
- Successful intubations
  - 15 1st try; 15 2nd try; 10 third try; 10 required > 3 tries
- 2006 Australian video study 37/60 intubations successful[2]
  - Residents: 24% (49 sec); Fellows 78% (32 sec); consultants 86% (25 sec)

Role for anesthesiologist or other a/w team?

1. Lane, B., N. Finer, et al. (2004). "Duration of intubation attempts during neonatal resuscitation." J Pediatr **145**(1): 67-70.
2. O'Donnell, C. P., C. O. Kamlin, et al. (2006). "Endotracheal intubation attempts during neonatal resuscitation: success rates, duration, and adverse effects." Pediatrics **117**(1): e16-21.

Pediatricians Attendance and Skills

- Several factors are decreasing level of experience of pediatric NRP providers[1]
  - Changes in ACGME requirements – increased focus on primary care and other rotations, decreased ICN
  - Increased presence of neonatologists
  - Residents often trained by other – now less experienced -- residents
  - Change in resuscitation practice – less experience
    - Meconium intubation for aspiration now rare

1. Hermansen, M. C. and M. G. Hermansen (2005). "Pitfalls in neonatal resuscitation." Clin Perinatol **32**(1): 77-95, vi.

Predicting Need for Resuscitation Antepartum Factors[1]

- Majority of cases in which resuscitation is needed can be pre-identified.
- Prematurity is a major risk factor for resuscitation, and necessitates special equipment and personnel
  - Preemies have
    - Immature lungs, possibility of decreased pulmonary compliance
    - smaller airways! Decreased apneic oxygenation time
    - Lung injury risk
    - Immature brain – more risk of hemorrhage
    - Increased risk of infection
    - High surface area to volume ration & immature skin → increased risk of hypothermia
    - Small blood volume → risk of hypovolemia

1. American Academy of Pediatrics (2011). Textbook of Neonatal Resusscitation, American Academy of Pediatrics & American Heart Association.

Predicting Need for Resuscitation Antepartum Factors[1]

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

PROM
Fetal hydrops
Post-term gestation
Multiple gestation
Size-dates discrepancy
Drug therapy, such as Mg++
Adrenergic agonists
Maternal substance abuse
Fetal malformation or anomalies
Diminished fetal activity
No prenatal care
Mother older than 35 years old

1. American Academy of Pediatrics (2011). Textbook of Neonatal Resusscitation, American Academy of Pediatrics & American Heart Association.

Predicting Need for Resuscitation Intrapartum Factors[1]

Emergency C-section
Forceps or vacuum-assisted delivery
Breech or abnormal presentation
Premature labor
Precipitous labor
Chorioamnionitis
Prolonged rupture of membranes (> 18 hours before delivery)
Prolonged labor (> 24 hours)
Macrosomia

Category 2 or 3 fetal heart rate patterns
Use of general anesthesia
Uterine tachysystole with fetal heart rate changes
Narcotics administer to mother < 4 hours prior to delivery
Meconium-stained amniotic fluid
Prolapsed cord
Abruptio Placentae
Placenta previa
Significant intrapartum bleeding

1. American Academy of Pediatrics (2011). Textbook of Neonatal Resusscitation, American Academy of Pediatrics & American Heart Association.

Predicting Need for Resuscitation Intrapartum Factors[1]

- Elective C-section alone, with neuraxial anesthesia at term, does NOT increase risk of significant[§] resuscitation need vs. vaginal delivery[1-4]

§ Slight increase in need for bag mask ventilation, but not intubation

1. Annibale, D. J., T. C. Hulsey, et al. (1995). "Comparative neonatal morbidity of abdominal and vaginal deliveries after uncomplicated pregnancies." Arch Pediatr Adolesc Med **149**(8): 862-867.
2. Parsons, S. J., S. Sonneveld, et al. (1998). "Is a paediatrician needed at all Caesarean sections?" J Paediatr Child Health **34**(3): 241-244.
3. Gordon, A., E. J. McKechnie, et al. (2005). "Pediatric presence at cesarean section: justified or not?" Am J Obstet Gynecol **193**(3 Pt 1): 599-605.
4. Atherton, N., S. J. Parsons, et al. (2006). "Attendance of paediatricians at elective Caesarean sections performed under regional anaesthesia: is it warranted?" J Paediatr Child Health **42**(6): 332-336.

Predicting Need for Resuscitation: FHR Monitoring[1]

- 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 System[2]
    - **Category I: normal;** baseline (110-160 bpm); variability: moderate; accelerations: +/-; absent decelerations
    - **Category II: indeterminate**; abnormal baseline; minimal variability; absent accelerations; or decelerations of moderately concerning character and duration (see ref)
    - **Category III: abnormal** → evaluation, possible delivery; absent variability; any of the following: recurrent late decelerations, recurrent variable decels; bradycardia; sinusoidal pattern (see ref for details and definitions)

1. ACOG Committee on Practice Bulletins (2009). "Intrapartum fetal heart rate monitoring, nomenclature, interpretation, and general management principles." Obstet Gynecol **114**(1): 192-202.
2. Macones, G. A., G. D. Hankins, et al. (2008). "The 2008 National Institute of Child Health and Human Development workshop report on electronic fetal monitoring: update on definitions, interpretation, and research guidelines." Obstet Gynecol **112**(3): 661-666.

Predicting Need for Resuscitation: FHR Monitoring[1]

- No RCT of Electronic Fetal Heart Rate Monitoring (EFHM)[2]
- False positive rate for predicting cerebral palsy is high (> 99%)
- Recurrent variable decelerations, consider cord compression (Ob may consider amnioinfusion)
- High interobserver and intraobserver (!!) variability
- But, important for predicting need for resuscitation[4]

1. ACOG Committee on Practice Bulletins (2009). "Intrapartum fetal heart rate monitoring, nomenclature, interpretation, and general management principles." Obstet Gynecol **114**(1): 192-202.
2. Freeman, R. K. (2002). "Problems with intrapartum fetal heart rate monitoring interpretation and patient management." Obstet Gynecol **100**(4): 813-826.
3. Alfirevic, Z., D. Devane, et al. (2006). "Continuous cardiotocography (CTG) as a form of electronic fetal monitoring (EFM) for fetal assessment during labour." Cochrane Database Syst Rev **3**: CD006066.
4. Posen, R., P. Friedlich, et al. (2000). "Relationship between fetal monitoring and resuscitative needs: fetal distress versus routine cesarean deliveries." J Perinatol **20**(2): 101-104.

Be Prepared

- ~ 20% of newborns who require resuscitative efforts will have no identifiable risk factor[1]

Quick Checklist[1]

Warm	Preheat warmer Towels or blankets
Clear airway	Bulb syringe 10F or 12F suction catheter attached to wall suction set at 80-100 mm Hg Meconium aspirator
Auscultate	Stethoscope
Oxygenate	Method to give free-flow oxygen (mask, tubing, flow-inflating bag, or T-piece) Gases flowing just prior to birth, 5-10 L/min Blender set per protocol Pulse oximeter probe (detached from oximeter until needed) Pulse oximeter
Ventilate	Positive-pressure ventilation (PPV) device(s) present with term and preterm masks PPV device(s) functioning Connected to air/oxygen source (blender) 8F feeding tube and 20-mL syringe
Intubate	Laryngoscope Size 0 and Size 1 (and size 00, optional) blades with bright light Endotracheal tubes, sizes 2.5, 3.0, 3.5, 4.0 Stylets End tidal CO_2 detector Laryngeal mask airway (size 1) and 5-mL syringe
Medicate	Access to 1:10,000 epinephrine and normal saline Supplies for administering meds and placing emergency umbilical venous catheter Documentation supplies
Thermoregulate	Plastic bag or plastic wrap Chemically activated warming pad Transport incubator ready
Other	

1. American Academy of Pediatrics (2011). Textbook of Neonatal Resuscitation, American Academy of Pediatrics & American Heart Association. (reprinted with permission)

Sign-out from Obstetric Providers

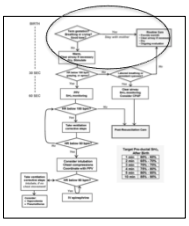
- What is the gestational age?
- Is the fluid clear?
- How many babies are expected?
- Are there any additional risk factors?

Initial Assessment

- Is baby term?
- Breathing or crying?
  (But NOT gasping)
- Good tone?
  (normal is flexed extremities)

  Color is no longer emphasized as a guide 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



1. American Academy of Pediatrics (2011). Textbook of Neonatal Resuscitation, American Academy of Pediatrics & American Heart Association. (reprinted with permission)

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)

54

The APGAR Score

* Fiver 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

1. Apgar, ANESTH ANALG, 1953
2. Butterfield, JAMA 1962

55

The Apgar Score Continued

	Apgar Score		
Sign	0	1	2
(A) color	Blue or Pale	Body Pink, Extremities Blue	Completely Pink
(P) Heart rate	Absent	< 100 bpm	> 100 bpm
(G) Reflex irritability	No response	Grimace	Cry or Active Withdrawal
(A) Tone	Limp/flaccid	Some flexion	Active motion
(R) Respirations	Absent	Weak cry; hypoventilation	Strong cry

56

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!)

§ A vague term, recommended terms "fetal acidosis" or hypercarbia more descriptive.
1. (2006). "The Apgar score." Pediatrics **117**(4): 1444-1447.

57

Use of Apgar Score[1]

* Other limitations
  * Subjective components
  * Not adjusted for prematurity
  * Not adjusted for medical interventions
  * Poor marker for "asphyxia"[§]
  * Affected by maternal drugs, trauma, infection, congenital anomalies
  * 5 minute Apgar score not a good predictor for long term neurologic outcome[2]

(score < 3 at 10 minutes and beyond may predict poor neurologic outcome)

§ A vague term, recommended terms "fetal acidosis" or hypercarbia more descriptive.
1. (2006). "The Apgar score." Pediatrics **117**(4): 1444-1447.
2. Freeman, J. M. and K. B. Nelson (1988). "Intrapartum asphyxia and cerebral palsy." Pediatrics **82**(2): 240-249.

58

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

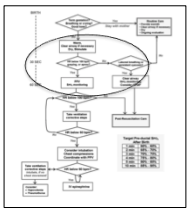
1. (2006). "The Apgar score." Pediatrics **117**(4): 1444-1447.

59

Initial Steps[1] Airway Block

- Initial steps of resuscitation should take less than 30seconds, but are ongoing
  - Warmth
  - Clear airway if necessary
    - Positioning
    - If meconium & **non vigorous**, intubate and suction

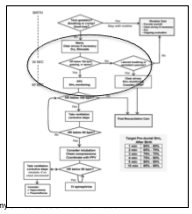
    (no routine suctioning)
  - Dry
  - Stimulate



1. 1. American Academy of Pediatrics (2011). Textbook of Neonatal Resusscitation, American Academy of Pediatrics & American Heart Association. (reprinted with permission)

Evaluation of Resuscitation Effectiveness[1]

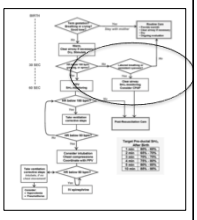
- Simultaneous evaluation of
  - Heart Rate
  - Respirations
- Since 1968, heart rate described as best measure of effectiveness of resuscitation[2]
  - NRP recommends auscultation (umbilical artery palpation 2nd)[3]
  - Use of pulse oximeter



1. American Academy of Pediatrics (2011). Textbook of Neonatal Resusscitation, American Academy of Pediatrics & American Heart Association. (reprinted with permission)
2. Dawes, G. S. (1968). Foetal and Neonatal Physiology. Chicago, IL, Year Book Medical Publishers.
3. Owen, C. J. and J. P. Wyllie (2004). "Determination of heart rate in the baby at birth." Resuscitation **60**(2): 213-217.
4. See worksheets NRP-001A,NRP-001B,NRP-014A,NRP-014B

Pulse Oximetry

- Pulse oximetry is viable in DR – use whenever concern for low HR, poor respiratory result
  - Good signal usually obtained by 90 seconds[2]
  - 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[3]



1. See worksheets NRP-001A,NRP-001B,NRP-014A,NRP-014B
2. O'Donnell, C. P., C. O. Kamlin, et al. (2005). "Feasibility of and delay in obtaining pulse oximetry during neonatal resuscitation." J Pediatr **147**(5): 698-699.
3. O'Donnell, C. P., C. O. Kamlin, et al. (2005). "Obtaining pulse oximetry data in neonates: a randomised crossover study of sensor application techniques." Arch Dis Child Fetal Neonatal Ed **90**(1): F84-85.

Labored Breathing or Cyanosis

- For newborns with HR > 100, but with labored breathing
  - Clear Airway
  - Consider CPAP[1]
    - For term, no conclusive evidence for or against
    - For preemie – may reduce need for intubation, but may increase rate of pneumothorax[2]

1. See worksheets NRP-002A,NRP-002B
2. Morley, C. J., P. G. Davis, et al. (2008). "Nasal CPAP or intubation at birth for very preterm infants." N Engl J Med **358**(7): 700-708.

Bradycardia or Apnea

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

Primary and Secondary Apnea[1]

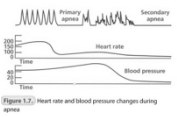


Figure 1.7. Heart rate and blood pressure changes during apnea

Primary Apnea –

- Characterized by
  - Decreasing heart rate
  - Adequate arterial BP
  - pH (if measured) > 7
  - Intact physiologic reflexes (including Head's)
  - Good Apgar scores
- responds to initial steps, including stimulation

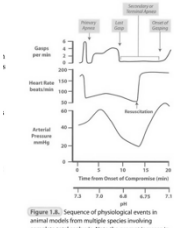


Figure 1.8. Sequence of physiological events in animal models from multiple species involving complete total asphyxia. Note the prompt increase in heart rate as soon as resuscitation is begun.

1. American Academy of Pediatrics (2011). Textbook of Neonatal Resusscitation, American Academy of Pediatrics & American Heart Association. (reprinted with permission)

Primary and Secondary Apnea[1]

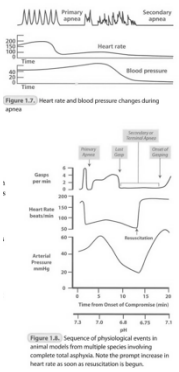


Figure 1.7. Heart rate and blood pressure changes during apnea

Secondary Apnea –
- Characterized by
  - Low heart rate
  - Decreased arterial BP
  - pH (if measured) < 7
  - Impaired physiologic reflexes (including Head's)
  - Low Apgar scores (0-3)
- Does not respond to initial steps, including NO response to stimulation
- TREATMENT IS VENTILATION

Figure 1.8. Sequence of physiological events in animal models from multiple species involving complete total asphyxia. Note the prompt increase in heart rate as soon as resuscitation is begun.

1. American Academy of Pediatrics (2011). Textbook of Neonatal Resusscitation, American Academy of Pediatrics & American Heart Association. (reprinted with permission)

Primary and Secondary Apnea Implications

Most important 3 steps of neonatal resuscitation for ACP

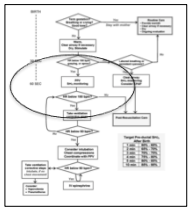
(my opinion)

1. Ventilation
2. Ventilation
3. Ventilation

Especially if ACP was called to resuscitation as part of code or emergency A/W 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[1]

* 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 cmH20
  * 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[3]

1. See worksheets NRP-028A,NRP-028B
2. § Use of manometer recommended
3. American Academy of Pediatrics (2011). Neonatal Resuscitation: Instructor's Manual. Elk Grove, IL.

PPV Strategies: Advanced Ventilation Devices[1,2]

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

1. See NRP-015A,NRP-015B,NRP-015C,NRP-017A,NRP-017B
2. Perlman, J. M., J. Wyllie, et al. (2010). "Part 11: Neonatal resuscitation: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations." Circulation **122**(16 Suppl 2): S516-538.

PPV Strategies: Advanced Ventilation Devices[1]

* Pressure limited T-piece resuscitator
  * More consistent peak pressures, PEEP, and sustained pressures than other devices[2,3]

[Video]

1. NRP-015A,NRP-015B,NRP-015C,NRP-017A,NRP-017B
2. Hussey, S. G., C. A. Ryan, et al. (2004). "Comparison of three manual ventilation devices using an intubated mannequin." Arch Dis Child Fetal Neonatal Ed **89**(6): F490-493.
3. Bennett, S., N. N. Finer, et al. (2005). "A comparison of three neonatal resuscitation devices." Resuscitation **67**(1): 113-118.

PPV Strategies: LMAs

- LMA #1 now recommended when
  - Mask ventilation and intubation are not successful
    - E.g. Pierre-Robin[3]
  - Can substitute for face mask for newborns > 2000 g or GA >= 34 weeks
    - Insufficient evidence for use in smaller newly born
  - Possible alternative to tracheal 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

1. NRP-017A,NRP-017B
2. Perlman, J. M., J. Wyllie, et al. (2010). "Part 11: Neonatal resuscitation: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations." Circulation **122**(16 Suppl 2): S516-538.
3. Baraka, A. (1995). "Laryngeal mask airway for resuscitation of a newborn with Pierre-Robin syndrome." Anesthesiology **83**(3): 645-646.

Oxygen Toxicity

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

http://www.pedsanesthesia.org/meetings/2011winter/syllabus/submissions/lectures/fri/Niezgoda-Oxygen%20Toxicity%20Spa%202011.pdf

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

Semenza GL 2007 Life with oxygen. Science 318:62-64; Lane N 2002 Oxygen: The molecule that made the World. Oxyford University Press, Oxford, 2002; Maltepe E & Didrik S Oxygen in Healthy and Disease: Regulation of Oxygen Homeostasis – Clinical Implications. Pediatric Research 2009 (65) No 3: 261- 268.

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.

Semenza GL 2007 Life with oxygen. Science 318:62-64; Lane N 2002 Oxygen: The molecule that made the World. Oxyford University Press, Oxford, 2002; Maltepe E & Didrik S Oxygen in Healthy and Disease: Regulation of Oxygen Homeostasis – Clinical Implications. Pediatric Research 2009 (65) No 3: 261- 268.

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

- Discovered in 1773.
- First given to babies in 1780.
- 1870'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.
- Modern times
  - oxygen analyzers, blenders, transcutaneous PaO2, SpO2, paucity of data.
  - Routine use of oxygen
  - recognition of potentially toxic effects of 100% oxygen: "a long standing, but unjustified practice."
  - Evolution of resuscitation guidelines.

Semenza GL 2007 Life with oxygen. Science 318:62-64; Lane N 2002 Oxygen: The molecule that made the World. Oxyford University Press, Oxford, 2002; Maltepe E & Didrik S Oxygen in Healthy and Disease: Regulation of Oxygen Homeostasis – Clinical Implications. Pediatric Research 2009 (65) No 3: 261- 268.

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

Sola A, Rogido M, Deulofeut R. Oxygen as a neonatal health hazard. Acta Paediatrica 2007(96): 801-812
Didrik S Oxygen in Healthy and Disease: Regulation of Oxygen Homeostasis – Clinical Implications. Pediatric Research 2009 (65) No 3: 261- 268.
Maltepe E & Didrick, 2009

78

Hypoxia

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

Maltepe E & Didrick, 2009; Saugstad OD 1975; Blomgren & Hagberg 2006

79

Hyperoxia

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

Maltepe E & Didrick, 2009; Saugstad OD 1975; Blomgren & Hagberg 2006

80

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

Saugstad OD, Oxidative stress in the newborn -- a 30 year perspective. Biol Neonate 2005; 88;228-236. Sola, 2007; Maltepe 2009.

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.

Saugstad OD, Oxidative stress in the newborn -- a 30 year perspective. Biol Neonate 2005; 88;228-236. Sola, 2007; Maltepe 2009.

Hypoxia Induced Factor

* Found to specifically bind to erythropoietin gene in oxygen-dependent fashion.

Wang GL 1995, Park, Sanders, Maltepe, 2010;

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

    Temesvari P, Karg E, Bodi I, et al. Impaired early neurologic outcome in newborn piglets re-oxygenated with 100% oxygen compared with room air after pneumothorax-induced asphyxia. Pediatr Res. 2001; 49:812-819.

    Handley S, Wang XP, Sola A, Wen TC, Genetta T, Moore JE, et al. Hyperoxia causes oxidative stress and increases neural stem cells proliferation in the murine developing brain. Pediatr Res E-PAS 2006; 59: 5168.6.
  - Induces inflammatory changes in lung, heart, and brain

    Munkeby BH, Borke WB, Bjomland K, et al. Resuscitation of hypoxic piglets with 100% O2, increases pulmonary metallo-proeinases and IL-8. Pediatr Res 2005; 58:542-548.

    Munkeby BH, Borke WB, Bjomland K, et al. Increased myocardial matrix metalloproteinases in hypoxic newborn pigs during resuscitation: effects of oxygen and carbon dioxide. Eur J Clin Invest. 2004; 32:459-466.

    Haase E, Bigam DL, Majonechny QB, Rayner D, Korbutt G, Cheung PY. Cardiac function, myocardial glutathione, and matrix metalloproteinase-2 levels in hypoxic newborn pigs re-oxygenated by 21%, 50%, or 100% oxygen. Shock. 2005; 23: 383-389.
  - Increases pulmonary resistance and reactivity

    Lakshminrusimha S, Russell JA, Steinhorn RH, et al. Pulmonary arterial contractility in neonatal lambs increases with 100% oxygen resuscitation. Pediatr Res. 2006; 59:137-141.

Animal Studies

- 100% oxygen vs. Room Air
  - Increases oxidative stress, and
    - Kondo M, Itoh S, Isobe K, et al. Chemiluminescence because of the production of reactive oxygen species in the lungs of new-born piglets during resuscitation periods after asphyxiation load. Pediatr Res. 2000;47:524-527.
    - Kutzche S, Ilves P, Kirkeby OJ, Saugstad OD. Hydrogen peroxide production in leukocytes during cerebral hypoxia and re-oxygenation with 100% or 21% oxygen in newborn piglets. Pediatr Res. 2001; 49:834-842.
    - Stevens J, Churchill T, Fkkelman K, et al. Oxidative stress and matrix metalloproteinase-9 activity in the liver after hypoxia and re-oxygenation with 21% or 100% oxygen in newborn piglets. European Journal of Pharmacology 2008; 580:385-393.
    - Haase E, Bigam DL, Nakonechny QB, Jewell LD,Korbutt G, Cheung PY. Resuscitation with 100% oxygen causes intestinal glutathione oxidation and re-oxygenation injury in asphyxiated newborn piglets Ann Surg 2004; 240:364-373.
  - Activates neuronal transcription factors
    - Dohlen G, Carlse H, Blomhoff R, Thaulow E, Saugstad OD. Re-oxygenation of hypoxic mice with 100% oxygen induced brain nuclear factor-kappa B. Pedatr Res 2005; 58:941-945.

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 neonatal mortality

Cochrane: RR: 0.71 (0.54-0.94) n=1,302 s = 5 NNT: 20 (12-100)
Saugstad: OR: 0.57 (0.42-0.78) n=1,737 s = 5
Rabi: OR: 0.63 (0.43-0.92) n=2,011 s = 7

Saugstad OD, Ramji S, Vento M. Resuscitation of newborn infants with 100% oxygen or air: a systematic review and meta-analysis. Lancet. 2004; 364:1329-1333.

Tan A, Schulze A, O' Donnell CP, Davis PG, Cochrane Database Syst Rev. 2005 Apr 18; (2): CD002273.

Rabi Y, Rabi D, Yee W. Room air resuscitation of the depressed newborn: a systematic review and meta-analysis. Resuscitation 2007; 72:353-363.

- Increases oxidative stress at least 4 weeks after birth

Vento M, Asensi M, Sastre J, Lloret A, Garcia-Sala F, Vina J. Oxidative stress in asphyxiated term infants resuscitated with 100% oxygen. J Pediatr. 2003; 142: 240-246.

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. 2005; 172:1393-1398.

* Delays recovery (significantly lower 5 minute Apgar score and heart rate, prolonged time to first cry and breath)

Saugstad OD, Ramji S, Vento M. Resuscitation of depressed newborn infants with ambient air or pure oxygen: a meta-analysis. Biol Neonate. 2005; 87:27-34.

* 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 resus with 100% face mask/bag vs room air: odds ratio 2.6; if oxygen used more than 3 mins: OR: 3.5.

Naumburg E, Bellocco R, Cnattingius S, Jonzon A, Ekbom A. Supplementary oxygen and risk of childhood lymphatic leukaemia. Acta Paediatr. 2002; 91: 1328-1333.

Retrospective analysis of participants in USA Collaborative Perinatal Project -- 1959-1966 -- hazard ratio 1.77; 2.87 for oxygen > 3 minutes; authors: "weak and ambiguous." Risk not seen for more prolonged postnatal oxygen therapy.

Spector LG, Klebanoff MA, Feusner JH, Georgieff MK, Ross, JA. Childhood cancer following neonatal oxygen supplementation. J Pediatr. 2005; 147:27-31.

Human Studies

100% oxygen compared with room air resuscitation

* 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…

Saugstad OD, Ramji S, Irani SF, et al. Resuscitation of newborn infants with 21% or 100% oxygen: follow-up at 18-24 months. Pediatrics. 2003; 112:296-300.

Rozycki, Henry. The need to assess benefits and not just risks of 100% oxygen for newborn resuscitation. Pediatrics 2007; 119(1): 217.

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."

Guidelines for cardiopulmonary resuscitation and emergency cardiac care. Emergency Cardiac Care Committee and Subcommittees, American Heart Association. Part V. Pediatric basic life support. JAMA. 1992; 268: 2252-2261.

Evolution of Guidelines

* AHA guidelines 2000: at delivery ask five questions: "Is amniotic fluid clear of **meconium**? Is the infant **breathing** or crying? Is there good muscle **tone**? Is the color **pink**? Was the infant born at **term**?
* "If assisted ventilation is required, 100% oxygen should be delivered by positive pressure ventilation" and "if supplemental oxygen is not available, resuscitation of the newly born infant should be initiated with positive pressure ventilation and room air."

Kattwinkel J, editor. Textbook of neonatal resuscitation. 4th Edition. American Academy of Pediatrics, American Heart Association 2000.

Evolution of Guidelines

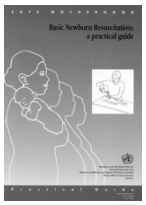
- 2005 update to NRP
  - "Current evidence is insufficient to resolved all questions regarding supplemental oxygen use during neonatal resuscitation."
  - For babies at term, the guidelines recommend 100% supplemental oxygen when a baby is cyanotic or when positive-pressure ventilation is required during neonatal resuscitation.

American Heart Association. Neonatal resuscitation guidelines. Circulation. 2005;112(suppl): IV-188-IV-195.

Evolution of Guidelines

- 2005 update to NRP
  - "However, research suggests that resuscitation with something less than 100% may be just as successful."
  - 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.

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



WHO 1998

"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."

World Health Organization. Basic newborn resuscitation: A practical guide. Geneva: Maternal and Newborn Health/Safe Motherhood Unit, WHO; 1998.

Evolution of Guidelines

- ILCOR 1999
  - "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 PaO_2) 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 inflation of the fluid-filled lungs, followed by attention to the desired concentration of inspired oxygen.

Kattwinkel J, Niermeyer S, Nadkarni V, et al. ILCOR advisory statement: resuscitation of the newly born infant. An Advisory statement from the pediatric working group of the International Liason Committee on Resuscitation. Circulation. 1999; 99(14): 1927-38.

Evolution of Guidelines

- ILCOR 2005
  - "There is currently insufficient evidence to specify the concentration of oxygen to be used at initiation of resuscitation…."
  - "Once adequate ventilation is established, if the heart rate remains low, there is no evidence to support or refute a change in the oxygen concentrated that was initiated…."
  - "However, the first priority should be to ensure adequate inflation of the fluid-filled lungs, followed by attention to the desired concentration of inspired oxygen."

International Liason Committee on Resuscitation. 2005 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. Part 7: Neonatal resuscitation. Resuscitation. 2005:; 67:293-303.

Evolution of Guidelines

- Australian national guidelines

"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." Journal of Paediatrics and Child Health **43** (2007) 6–8

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)


Update on Oxygen Versus Room Air

Evolution of Guidelines

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

What is the optimal initial FiO_2 in newly born resuscitation?

* Observed SpO_2 in normal newborns:

Saugstad O, Oxygen saturations immediately after birth. Journal of Pediatrics. 2006; 148:569-70. Gonzalo Mariani, Pablo Brener Dik, Analia Ezquer, Adolfo Aguirre, Mirta Lucia Esteban, Cecilia Perez, Silvia Fernandez Jonusas, Carlos Fustinana, Pre-ductal and Post-ductal O2 Saturation in Healthy Term Neonates after Birth, The Journal of Pediatrics; 150(4): 418-421, 4/2007.

Oxygen Delivery, Hemoglobin-O2 Dissociation

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

Castillo A, Deulofeut R, Sola A. Clinical practice and SpO2 technology in the prevention of ROP in ELBW infants. E-PAS Annual Meetings 2007, electronic.


The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 MAY 27, 2010 VOL. 362 NO. 21

Target Ranges of Oxygen Saturation in Extremely Preterm Infants

SUPPORT Study Group of the Eunice Kennedy Shriver NICHD Neonatal Research Network*

(multicenter, randomized, blinded clinical trial)

* SpO2: 85-89% vs 91-95% in 1316 extremely preterm infants (24-27 wks GA)
* Severe ROP OR death before discharge
  28.3% vs 32.1% (P = 0.21)
* Death before discharge:
  19.9% vs 16.2%
  RR = 1.27 (1.01 – 1.60 95% CIs)
* Severe ROP: 8.6% vs 17.9%

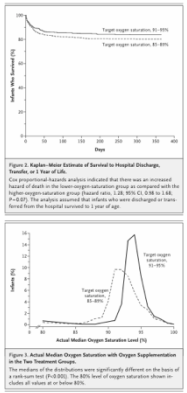


Figure 2. Kaplan–Meier Estimate of Survival to Hospital Discharge, Transfer, or 1 Year of Life.

Figure 3. Actual Median Oxygen Saturation with Oxygen Supplementation in the Two Treatment Groups.

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)

1. American Academy of Pediatrics (2011). Textbook of Neonatal Resuscitation. American Academy of Pediatrics & American Heart Association.

107

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

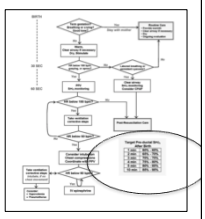
Maltepe E & Didrick, 2009; Saugstad OD 1975; Blomgren & Hagberg 2006

2011 NRP Oxygen Recommendations

- Goal for supplemental oxygen concentration is SpO_2 in interquartile range of preductal SpO_2 via use of blender
- If blender not available, should start with $fiO_2 = 0.21$
- For bradycardia after 90secs of resuscitation, should increase fiO_2 to 1.0 until HR recovers

(preterm infants may require fiO_2 of ~0.3 – unclear at what fiO_2 to start for preemies)

- Some dissent?[2]

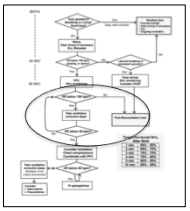


1. American Academy of Pediatrics (2011). Textbook of Neonatal Resusscitation, American Academy of Pediatrics & American Heart Association.
2. Kattwinkel, J. and J. Perlman (2010). "The Neonatal Resuscitation Program: The evidence evaluation process and anticipating edition 6." NeoReviews **11**(12): e673-e680.

Failure of PPV

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

MR. SOPA[1]	
M	Adjust **M**ask
R	**R**eposition airway to *sniffing* position
S	**S**uction oral & nasal secretions if present
O	**O**pen mouth slightly & move jaw forward
P	Increase **P**ressure until chest rise
A	Consider **A**irway **Al**ternative (ETT, LMA)



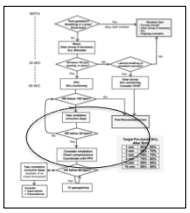
1. Kattwinkel, J. and J. Perlman (2010). "The Neonatal Resuscitation Program: The evidence evaluation process and anticipating edition 6." NeoReviews **11**(12): e673-e680.

Failure of PPV: Intubation

- If ventilation is optimized – and HR is < 60 then
  - Consider intubation & chest compressions
- ETT placement confirmation
  - Use of exhaled CO_2 detectors to confirm tracheal tube placement[1]
    - Faster & more accurate than clinical signs alone
    - Possible false negatives during cardiac arrest
    - Can have false positives when contaminated with epinephrine, surfactant, and atropine[3]
    - No conclusive evidence for continuous CO_2 monitoring vs colorimetric

COLORIMETRIC: Should change from Purple => Yellow in presence of CO_2. If yellow when opened, do not use

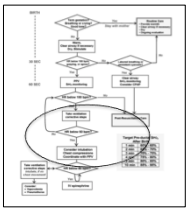
Purple => **P**roblem (no CO_2) **Y**ellow => **Y**es!



1. Perlman, J. M., J. Wyllie, et al. (2010). "Part 11: Neonatal resuscitation: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations." Circulation **122**(16 Suppl 2): S516-538.
2. NRP-01A
3. Hughes, S. M., B. L. Blake, et al. (2007). "False-positive results on colorimetric carbon dioxide analysis in neonatal resuscitation: potential for serious patient harm." J Perinatol **27**(12): 800-801.

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*



1. American Academy of Pediatrics (2011). Neonatal Resuscitation: Instructor's Manual. Elk Grove, IL.

Chest Compression Technique

- Ratio of compressions : ventilation **3:1**
  - NRP has **NOT** adopted strategy of C-A-B or increased compression to ventilation ratio
    - Key to reversing vast majority of newly born extremis events is ventilation – and avoidance of interruption of ventilation is important as is continuous chest compressions
    - If arrest is know to be of cardiac cause, then higher compression-ventilation can be considered, such as 15:2
  - Go to 100% oxygen
  - Two-thumb-encircling hands is recommended
  - Thumbs should be centered over the lower third of sternum
  - Compression depth = 1/3rd AP diameter of chest
  - Coordinated chest compressions and ventilation:

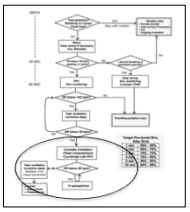
1 and 2 and 3 and *breathe* … 1 and 2 and 3 and *breathe*

120 events in 1 minute *(90 compressions, 30 breaths)*

1. NRP-00&A,NRP-00&B,NRP-007A,NRP-007B
2. Perlman, J. M., J. Wyllie, et al. (2010). "Part 11: Neonatal resuscitation: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations." Circulation **122**(16 Suppl 2): S516-538.
3. American Academy of Pediatrics (2011). Textbook of Neonatal Resusscitation, American Academy of Pediatrics & American Heart Association.

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



1. American Academy of Pediatrics (2011). Neonatal Resuscitation: Instructor's Manual. Elk Grove, IL.

114

Epinephrine

* Route of administration
  * Umbilical venous (UVC) administration preferred
  * Intraosseous route (IO) acceptable[3]
  * Administration via ETT is problematic
    * Variable absorption
    * Not likely to be effective
    * May be used while establishing venous access

1. NRP-008A,NRP-008B,NRP-009A,NRP-009B
2. Perlman, J. M., J. Wyllie, et al. (2010). "Part 11: Neonatal resuscitation: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations." Circulation **122**(16 Suppl 2): S516-538.
3. NRP-020A

115

Epinephrine

* Dosing
  * Concentration to be used – always 1:10,000 (100mcg/ml)
    * Concentration in boxed epinephrine
  * IV dose 10-30mcg/kg (0.1-0.3ml/kg)
    * Typical term baby should receive total dose of ~0.3 – 1 ml
      * E.g. for 3.5 kg infant = 35 – 105 mcg total dose = 0.35 – 1.05ml of 1:10,000 epinephrine
  * ETT dosing – uncertain –
    * 5-10x increase in dose

    (50 mcg/kg – 100 mcg/kg may reach equivalent plasma concentrations as 10 mcg/kg IV – for 3.5 KG baby, this would be ~ 1ml of 1:10,000 epinephrine)[4]

1. NRP-008A,NRP-008B,NRP-009A,NRP-009B
2. Perlman, J. M., J. Wyllie, et al. (2010). "Part 11: Neonatal resuscitation: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations." Circulation **122**(16 Suppl 2): S516-538.
3. NRP-020A
4. Barber, C. A. and M. H. Wyckoff (2006). "Use and efficacy of endotracheal versus intravenous epinephrine during neonatal cardiopulmonary resuscitation in the delivery room." Pediatrics **118**(3): 1028-1034.

116

Umbilical Venous Access

Umbilical vein is *single* large, thin walled structure, often at 11-12 o'clock position

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

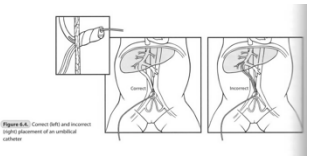


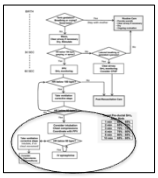
Figure 6.4 Correct (left) and incorrect (right) placement of an umbilical catheter

1. American Academy of Pediatrics (2011). Textbook of Neonatal Resusscitation. American Academy of Pediatrics & American Heart Association. (reprinted with permission)

117

Epinephrine

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



1. NRP-008A,NRP-008B,NRP-009A,NRP-009B
2. Perlman, J. M., J. Wyllie, et al. (2010). "Part 11: Neonatal resuscitation: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations." Circulation **122**(16 Suppl 2): S516-538.

118

Nalaxone

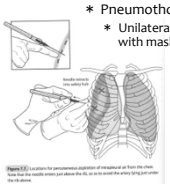
* Not part of initial resuscitation for respiratory depression
  * Treatment of opioid exposure is
    Ventilate, ventilate, ventilate
* Contraindicated in cases of chronically opioid exposed infants (risk of seizures)
* Dose 0.1mg/kg IV (not well studied)
* Monitor after use (for continuation of opioid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

1. NRP-022A, NRP-022B

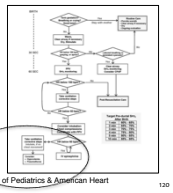
119

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



4th intercostal space at anterior axillary line OR 2nd intercostal space at mid clavicular line



1. American Academy of Pediatrics (2011). Textbook of Neonatal Resuscitation, American Academy of Pediatrics & American Heart Association. (reprinted with permission)

Volume Expansion

* Indicated when
  * Baby is unresponsive to resuscitation

  AND
  * Appears "in shock"

  OR
  * 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

IVF Administration[3]
NS, LR, O-negative RBC
10ml/kg over 5-10 minutes
Via umbilical vein
(avoid rapid expansion due to association with ICH)

1. Perlman, J. M., J. Wyllie, et al. (2010). "Part 11: Neonatal resuscitation: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations." Circulation **122**(16 Suppl 2): S516-538.
2. NRP-019A,NRP-019B,NRP-019C
3. American Academy of Pediatrics (2011). Textbook of Neonatal Resuscitation, American Academy of Pediatrics & American Heart Association.

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

1. American Academy of Pediatrics (2011). Textbook of Neonatal Resuscitation, American Academy of Pediatrics & American Heart Association.

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

1. American Academy of Pediatrics (2011). Textbook of Neonatal Resuscitation, American Academy of Pediatrics & American Heart Association.

Special Circumstances

* 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

1. American Academy of Pediatrics (2011). Textbook of Neonatal Resuscitation, American Academy of Pediatrics & American Heart Association.

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

1. American Academy of Pediatrics (2011). Textbook of Neonatal Resuscitation, American Academy of Pediatrics & American Heart Association.

Post-Resuscitation Care

- Hypoglycemia[1]
  - no specific glucose concentration target confirmed by current science
    - Hypoglycemia post resuscitation may be harmful
    - Hyperglycemia not confirmed to be harmful
  - Goal: Avoid Hypoglyemia
    - All infants at some risk
    - Increased in
      - Premature infants
      - Infants of diabetic mothers, mothers on IV solutions with dextrose
  - If hypoglycemia, rapid initiation of treatment with IV D10%W

1. NRP-019A,NRP-019B

Post-Resuscitation Care

- Therapeutic Hypothermia[1]
  - Three large RCTs[2,3,4]
  - Either selective head or whole body cooling induced using cooling blankets to target (33.5–34.5°C)
  - Initiation within 6h of birth
  - Outcomes:
    - significantly fewer deaths
    - less neurodevelopmental disability at 18-month follow-up.
    - Death or severe disability NNT = 9 (5-25)[5]
- No head to head comparison of cooling methods

1. NRP-024A,NRP-024B
2 Azzopardi, D. V., B. Strohm, et al. (2009). "Moderate hypothermia to treat perinatal asphyxial encephalopathy." N Engl J Med **361**(14): 1349-1358.
3. Gluckman, P. D., J. S. Wyatt, et al. (2005). "Selective head cooling with mild systemic hypothermia after neonatal encephalopathy: multicentre randomised trial." Lancet **365**(9460): 663-670.
4. Shankaran, S., A. R. Laptook, et al. (2005). "Whole-body hypothermia for neonates with hypoxic-ischemic encephalopathy." N Engl J Med **353**(15): 1574-1584.
5. Edwards, A. D., P. Brocklehurst, et al. (2010). "Neurological outcomes at 18 months of age after moderate hypothermia for perinatal hypoxic ischaemic encephalopathy: synthesis and meta-analysis of trial data." BMJ **340**: c363.

Post-Resuscitation Care

- Guidelines[2]
  - Eligibility
    - Near-term or Term
    - Moderate to severe HIE
  - Procedure
    - Either whole body cooling and selective head cooling
    - Done in NICU/ICN with protocol
    - Initiate within 6 hours of birth
    - for 72 hours
    - rewarm slowly – over >= 4 hours
- Complications include thrombocytopenia and hypotension
- Patients require long term follow up

1. NRP-024A,NRP-024B
2. Kattwinkel, J., J. M. Perlman, et al. (2010). "Neonatal resuscitation: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care." Pediatrics **126**(5): e1400-1413.

Discontinuance of Resuscitation

- Consider discontinuance[§] of resuscitative efforts after 10 minutes without a heart rate for newlyborn[1]
- 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 [4])

1. American Academy of Pediatrics (2011). Textbook of Neonatal Resusscitation, American Academy of Pediatrics & American Heart Association.
2. NRP-025A,NRP-025B,NRP-025C,NRP-026A,NRP-026B,NRP-026C,RP-027A, NRP-027B
3. § Non-initiation and discontinuance are considered ethically equivalent
4. Paris, J. J. (2005). "What standards apply to resuscitation at the borderline of gestational age?" J Perinatol **25**(11): 683-684.

Training

Sentinel Event Report

- 2004-2005 The Joint Commission Sentinel Events[1]
  - 109 cases of death (93) or permanent disability
    - unrelated to a congenital condition
    - BW > 2,500 grams
    - Mother's age 13-41 years old (median 27)
    - > ½: first child
    - Average GA: 39 weeks
    - Lack of prenatal care: only~ 4%

  So what were the identified root causes?

1. The Joint Commission (2004). Preventing infant death and injury during delivery. JCAHO Sentinel Event Alert. Oakbrook Terrace, IL, JCAHO.

Root Cause Analysis of Infant Death and Disability§

- **Communication issues (72%)**
  - 55% of reports cited organization culture as a barrier to effective communication and teamwork
    - hierarchy and intimidation
    - failure to function as a team
    - failure to follow the chain-of-communication
- staff competency (47 %)
- orientation and training process (40 %),
- inadequate fetal monitoring (34 %)
- unavailable monitoring equipment and/or drugs (30 %)
- credentialing/privileging/supervision issues for physicians &nurse midwives (30%)
- staffing issues (25 %)
- physician unavailable or delayed (19 %)
- unavailability of prenatal information (11 %)

1. The Joint Commission (2004). Preventing infant death and injury during delivery. JCAHO Sentinel Event Alert. Oakbrook Terrace, IL., JCAHO.
§ Of 47 cases studied, as of 2004.

132

The Joint Commission Recommendations[1]

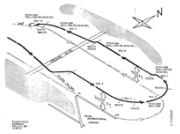
- **Team training in perinatal areas**
- **Clinical drills for high-risk events**
  - **Debriefings to evaluate team performance and identify areas for improvement**
- **Apply national practice guidelines**
  - **Fetal heart tracing monitoring; standard terminology**
  - **Policy for availability of personnel for emergencies**
  - **Stocking of NR areas**
  - **Policies for transfer to higher level of care**

1. The Joint Commission (2004). Preventing infant death and injury during delivery. JCAHO Sentinel Event Alert. Oakbrook Terrace, IL., JCAHO.

133

Training in Other High Risk Occupations

- Cockpit/Crew/Crisis Resource Management
  - History: series of aviation crashes in 1970s involving human error
  - NASA developed curriculum
  - Adopted by commercial aviation and other high risk industries
  - In anesthesia, David Gaba and others developed ACRM[3]



1. From http://en.wikipedia.org/wiki/File:n750ea_EasternAirlines_L1011.jpg (Author: Versgeek, GNU free documentation license)
2. From http://en.wikipedia.org/wiki/File:NytstEA.png (NTSB Graphic)
3. Gaba, D. M., K. J. Fish, et al. (1994). Crisis management in anesthesiology. New York, Churchill Livingstone.

134

CRM

- Anesthesiology led the way with Anesthesia CRM[1]
- Application of aviation training and procedures such as
  - Team training
  - Simulation
  - Accident/near miss analysis
  - Reporting
- For 2011, NRP adopts many of these practices
  - Influenced by work of CAPE (Stanford)

1. Gaba, D. M., K. J. Fish, et al. (1994). Crisis management in anesthesiology. New York, Churchill Livingstone.

135

NRP Training, 2011

- learning theory informed new program[1]
  - New approach is via varied curriculum and evaluation for 3 components[2]
    - Knowledge (e.g. algorithm, dose of epinephrine)
    - Skills (skills stations)
    - Teamwork and communication (simulation & debriefing)
  - Knowledge
    - learners used to "arrive at course with Textbook … still in its plastic wrapper"[2]
    - Self-directed learning via textbook and pre-course online test
      - Allows instructors to focus more on team/behavioral training via simulation, rather than "'spoon-feeding' didactic material"

1. Halamek, L. P. (2008). "Educational Perspectives: The Genesis, Adaptation, and Evolution of the Neonatal Resuscitation Program." NeoReviews.org 9: e142-e149.
2. American Academy of Pediatrics (2011). Neonatal Resuscitation: Instructor's Manual. Elk Grove, IL.

136

NRP Training, 2011

Key behavioral skills in NRP[1]

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. Call for help when needed
10. Maintain professional behavior

Simulator and Debriefing Sessions

- Learners are own evaluators
- Use *failure* to learn
- Mini-course in debriefing facilitation found in NRP Instructor's Manual and companion DVD

1. American Academy of Pediatrics (2011). Neonatal Resuscitation: Instructor's Manual. Elk Grove, IL. (reprinted with permission)

137

Neonatal Resuscitation in Resource Limited Settings

* See *Helping Babies Breathe* (AAP Program

Helping Babies Breathe
THE GOLDEN MINUTE

http://www.helpingbabiesbreathe.org/

138

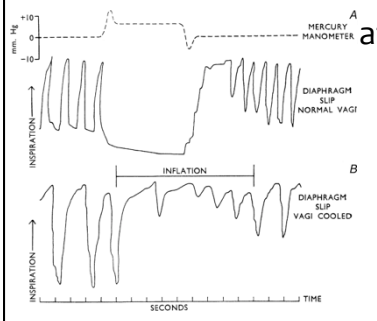
My Recommendations

* 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!

139

ations



140