Paediatric vs. Neonatal Resuscitation: When to use what?

Vinay Nadkarni MD, MS
Co-Chair, International Liaison Committee on Resuscitation (ILCOR)

Director, Center for Simulation, Advanced Education and Innovation
The Children’s Hospital of Philadelphia
The University of Pennsylvania
Disclosure

NO RELEVANT CONFLICTS

Employment: University of Pennsylvania

- Research Grants:
  - NIH (Cardiac Arrest, Cardiopulmonary bypass, Glucose Control)
  - Canadian Institute of Healthcare Research (CPR)
  - Laerdal Medical and Foundation (Simulation and CPR)

- Science Advisory Board (Volunteer)
  - International Liaison Committee on Resuscitation (ILCOR)
  - Co-chair, Society of Critical Care Medicine 2014 Conference
  - World Federation of Pediatric and ICU Societies (WFPI CCS)
  - Data Safety Monitoring Board (adult CPR device)
  - AHA Get with the Guidelines-Resuscitation/ National Registry
What do a GASP, …a COUGH, …and a HICCUP all have in common?

A: They all MOVE BLOOD!
GASP: negative pressure in chest
COUGH: positive pressure in chest
HICCUP: diaphragm contracts: pump
Did you ever imagine that the ARC would **NOT** recommend:

...A - B - C ?

...Suction Meconium ?

...Give 100% Oxygen ?

...what is next?...epinephrine??
Developing a Culture of High Quality Resuscitation

- Data Collection
- Training / Retraining
- Reporting / Benchmarking
- Feedback (individual & organizational)
Approx 3-6% of babies require basic resuscitation (bag-and-mask ventilation)

.birth to help them breathe (drying and rubbing)

All babies require immediate assessment at birth and simple newborn care

(assess breathing, dry, and put the baby skin-to-skin with mother)

<1 million babies

<1% need advanced resuscitation

0.1% require chest compressions
0.05% require drugs

Approx 6 million babies

136 million babies born

Figure 1 Estimate of annual number of all newborns who require assistance to breathe at birth and varying levels of neonatal resuscitation. Legend: Adapted from [1] using data from [2,3,5,6,20].

Paediatric or Neonatal?
Resuscitation education—Effectiveness of Implementation?

Self-confidence  
(improvement in learner’s self-confidence)

Competence  
(Skill improvement in simulation settings)

Operational Performance  
(Skill improvement in clinical settings)

Effective Care  
(Improvement in patient outcome)
Effectiveness: Translation

<table>
<thead>
<tr>
<th>Medical education interventions</th>
<th>T₁</th>
<th>T₂</th>
<th>T₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved</td>
<td>Knowledge, skill, attitudes and professionalism</td>
<td>Patient care practices</td>
<td>Patient outcomes</td>
</tr>
<tr>
<td>Target</td>
<td>Individuals and teams</td>
<td>Individuals and teams</td>
<td>Individuals and public health</td>
</tr>
<tr>
<td>Setting</td>
<td>Simulation lab (On Manikins)</td>
<td>Clinic and bedside (On patients)</td>
<td>Community (On Systems and Populations)</td>
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</tbody>
</table>

T₁- Simulation Lab --- T₂ -Patient Bedside ---- T₃ -Patient Safety and Population Health

McGaghie 2010; Raemer 2012
One Size may not fit all! ....

But, the principles of:
- assessment
- monitoring
- feedback
- quality
are the same!!
Pre-Arrest

Cardiac Arrest

CPR

Post-Arrest stabilization

No Flow

Low Flow

Low, Normal or High Flow

- PROTECTION
  - Rapid Recognition
  - Call for Help
  - Response Team
  - Oxygen/Ventilation
- PRESERVATION
  - Prompt CC
  - Defibrillate if VF
- RESUSCITATION
  - Push hard, Push Fast
  - Minimize interruption
  - Full recoil
  - Assist ventilation?
    - Vasopressors?
    - Cooling?
- RESUSCITATION /REGENERATION
  - Temperature control
  - Blood pressure
  - Glucose
  - Ventilation (CO2)
  - Goal Directed Care
Neonatal vs. Paediatric: Simple Answer!

When the Umbilical Cord Falls off… switch from Neo to Paeds!

Yes
Umbilical Cord
Neonatal ALS

No
Umbilical Cord
Paediatric ALS
Adult vs. Paediatric: Simple Answer!

When there is pubic hair ....switch from Paeds to Adult!

Yes
Pubic Hair
Adult

No
Pubic Hair
Paediatric
Neo focuses on the first breath of life
...and Paeds on preventing the last gasp of death
Worldwide, most infants and children who die, do so in the first 5 years of life...

- Stillborn: 4 million
- Day 1: 2 million
- Day 2-28: 2 million
- 1 month - 5 years: 6 million

4 million in neonatal period
What do they die from?

**Paediatric ALS** focuses outside the delivery room... respiratory failure, shock, arrhythmia, and cardiac arrest

Neonatal training programs focus on the delivery room... respiratory failure and hemorrhagic shock
Chest and Lung Growth
Chest/lung volume and Vital Capacity

1947

- Relationship between chest and lung growth
- Animal model of hypoplastic chest resulted in hypoplastic lungs

Lang, F. The Child’s Lung, London

Fig. 187.—Diagram for the comparison of I, volume of the lung; II, circumference of the chest (after Belot-Seammon); III, vital capacity (after Stewart). Note the parallelism of I and III and the parallelism of the early portions of I and II.
TERMINAL CARDIAC RHYTHM
In Children

Bradycardia → Asystole
Ventilation alone restores perfusion, but slowly, in asphyxiated newborn animals (No CC given). 


Time to Desaturation < 90%

- Normal Adult: 8 min
- Ill Adult: 5 min
- Normal 1 year old: 4 min
- Obese adult / Pregnant: 3 – 4 min
- Critically ill infant: 1 min
- Newly Born: 0 min

Benumof: Textbook of Anesthesia 1997
The “Bow Tie” Concept

Pre-Arrest Recognition and Intervention

Cardiac Arrest

Post Resuscitation Outcomes

Neo: Delivery Room

Hypoxia, HIE and Hypothermia, Goal Directed Therapies

Paeds: Emergency room and ICU

Goal Directed Therapies: T, BP, fluid, Glu
Approach

Neo vs Paeds

- Delivery Room
- Newly Born, Premature
- Hemorrhage/shock
- Reversal of anesthetic/sedative
- Prevention oriented

- Out of Hospital, Ward, Emergency Room and ICU
- Diverse ages
- 10-25% Shockable rhythms
- Shock / Cardiac Arrest oriented: Vascular Access, Fluid Bolus, Antibiotics, Rhythm / Shocks
Challenges: Etiology based approach

- Trauma
- Overdose
- Submersion
- Airway Obstruction
- Newly born
- Sudden VF
- Prolonged VF
- Acute Coronary Syndromes
TERMINAL CARDIAC RHYTHM
In Adults

Ventricular Fibrillation
Pulseless Arrest

**VF/VT**
- Single Shock
- Epinephrine
- Single Shock
- Anti-arrhythmic?

**Not VF/VT**
- CPR
- Push Hard
- Push Fast
- Minimize Interruptions
- Complete Release
- Breathe Slow
- Seek reversible causes*
- Epinephrine
- CPR
Airway positioning for infants
Normal larynx in a 3 day old
Resistance of airflow through ET tubes is **NOT** like breathing through a straw. Usual flow rate = 0.5 L/Kg/min

*(Newth PCCM 2009, Manczur CCM 2000)*
Interesting Number Facts

• A 3kg infant accepts a 3.0mm ID and a 30kg 8 year child accepts a 6.0mm ID (a 20 X increase in body size, but only 2X increase in ET size)

• The subglottic area of the infant is 20 X greater in proportion to body size vs 30 kg child
  (Eckenhoff J. Anesthesiology 1951)
Pulse check: Where to feel for a pulse?
Where to place Vascular Access?

Neo = Umbilical  
Paeds = Intraosseous
Pulse checks and Vascular Access: Neo vs Paeds

- **Pulse Check:**
  - Auscultation (or umbilical artery)
  - Fluid bolus 10 mL/kg
  - Cord milking, blood, crystalloid or colloid
  - Via Umbilical a or v

- **Pulse Check:**
  - Brachial or Femoral
  - Fluid bolus 20 mL/kg
  - Crystalloid > colloid
  - Via IV or IntraOsseous
Pediatric CPR:
Direct Compression > Thoracic Pump

- Push Hard: Depth?
- Push Fast: Rate?
- Complete release: How?
- Avoid Interruptions
- Look for VF and special circumstances
- Don’t over-ventilate
Mathematical Modeling
Compression : Ventilation Ratios

Children

- “Optimal CPR” (best systemic oxygen delivery)
- Children need more O2 delivery
- Assumed no ventilation with compressions
- Optimal C-V ratio for: lay rescuers profesional

<table>
<thead>
<tr>
<th>Weight (kg)</th>
<th>Lay Rescuers</th>
<th>Professional</th>
</tr>
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<tbody>
<tr>
<td>10</td>
<td>~6:1</td>
<td>~6:1</td>
</tr>
<tr>
<td>20</td>
<td>~12:1</td>
<td>~8:1</td>
</tr>
<tr>
<td>40</td>
<td>~15:1</td>
<td>~10:1</td>
</tr>
</tbody>
</table>

Babbs C, Nadkarni V Resuscitation 2004
Simulations using a 7-compartment model and Measurements from CT scans of neonates

Babbs D, Meyer A, Nadkarni V. Resuscitation 2009
Chest Compressions: Neo vs Paeds

- Emphasis on effective Ventilation
  - 3:1 ratio
  - Depth 1/3 AP chest depth
  - 90 compressions and 30 ventilations (120 events/min)

- Emphasis on continuous CC
  - 15:2 ratio
  - Depth > 1/3 AP chest depth
  - >100 compressions/minute
“Crash Cart”
1969
Adrenaline  Methoxamine  Phenylephrine  Norepinephrine  Dopamine  Isoproterenol  Orciprenaline  Dobutamine

Angiotensin II  Endothelin-1

Lidocaine  Amiodarone

Theophylline  Atropine

Vasopressin?, Thrombolysis??, Less Epinephrine???
Thoughtful Evaluation and Intervention based upon pattern recognition

1. Pre-load?
2. Contractility?
3. Afterload?
4. Heart rate and rhythm?

Any limitations????
Brain

- Cerebral perfusion
- Sedation
- Control of seizures
- Temperature control
- Glucose control
Infant undergoing Selective Hypothermia with a cooling cap

Courtesy: Dr. David Durand, Children’s Hospital Oakland
Infant undergoing Total Body Cooling with a Cooling Blanket
Ethical and Legal Considerations

• Decision Making
  – Consent/assent
  – Minors
  – Advanced Directives

• Limiting Life Sustaining Medical Treatment

• DNAR orders
• irreversible cessation of neurological function
• organ recovery
Ethics:

**Neo vs aeds**

- Emphasis on gestational age
- Emphasis on duration of chest compressions

- Emphasis on prior QOL assessment, witnessed status and bystander CPR
- Decreased emphasis on duration of chest compressions
Formula One: Training and practice
Resuscitation Process and Outcomes

Patient → Interventions → Outcomes

Data

System/Quality

Patient Factors
System Factors
Event Factors

Technique
Drug
Devices
Education

ROSC
Favorable Neurologic Survival
Quality of Life

Short term Survival
Discharge Survival
Gap between Training and Implementation

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<tr>
<th>CHALLENGES NOTED DURING SIMULATIONS</th>
<th>% of Centers</th>
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<tbody>
<tr>
<td>Child Weight Estimates</td>
<td>34%</td>
</tr>
<tr>
<td>IO preparation</td>
<td>69%</td>
</tr>
<tr>
<td>IV Fluid Bolus</td>
<td>89%</td>
</tr>
<tr>
<td>Order Glucose bolus</td>
<td>97%</td>
</tr>
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Difficulty with 25/44 (57%) C-Spine Stabilization Tasks

Simulation of C-Spine Stabilization in 35 North Carolina Emergency Departments

Team Training…building competence to Excellence!
Education Tools Tailored to the Learner and Environment
Universal Links in Chain of Survival:
Education - Care Delivery - Quality Improvement


**Pre-arrest**

**Identification**
- High Risk
- Clinical Indicators
  - Parshuram 2009
  - Bonafide 2011

**“Rolling Refreshers”**
- Hands-on practice with defibrillator, chest compressions and ventilations

**Intra-arrest**

**Real-time CPR Feedback**
- MRx/Q-CPR
- Audio + visual feedback
- ETCO2
- Arterial BP

**CSI: Code Scene Investigation**
- Code scene forensics
- Mattress Reconstruction
  - Maltese 2008
  - Nishisaki 2009

**CSD: Code Scene Debriefing**
- Quality of CPR
- Clinical issues
- Latent and obvious hazards
- Examples of excellence
  - Edelson 2008
  - Dine 2008

**Post-Resuscitation Care**

**Temperature control, Blood pressure/Hemodynamics, Oxygen, CO₂, PCA, ECMO, Glucose, pH, electrolytes, Fluid management**

**Post-Resuscitation “Dress Rehearsals”**
- Anticipate Challenges,
- Rehearse Interventions,
- Review Protocols,
- Clarify Communication,
- Document Competence

**Case Debriefing**
- Quality of Care
- Clinical issues
- Latent and obvious hazards
- Barriers to process
- Examples of excellence

**Primary Outcome:**
- Return of Spontaneous Circulation

**Primary Outcome:**
- Survival to discharge
- Secondary Outcome: Survival to One Year
Primary Outcome:  
Time to Spontaneous Breathing

Secondary Outcomes:  
Baby:  Time to 1) effective ventilation; 2) HR>100  
HCP:  Performance; retention of skills, confidence

“INSPIRE-DR Bundle”

Pre-Delivery

Pre-ID  
High Risk Checklist  
Always be prepared to resuscitate!  
* NRP 2011

Team Huddle  
Anticipate challenges, review protocols. clarify team roles and communication

“Rolling Refreshers”  
Frequent, brief psychomotor skill practice with PPV on Newborn Lung Simulator

Intra-Delivery

Assessment at Time of Birth  
~50% of babies who need resuscitation are not recognized prior to delivery

Born at term, breathing/crying, good tone?

For babies born unresponsive, Follow NRP, HBB Guidelines

Record time from birth to:  
- Effective ventilations  
- HR >100

Metrics need to be carefully defined (i.e. birth with no impairment, partial impairment, fully impaired, etc.)

Evaluate (<15 sec)  
Respirations, Heart Rate, Assessment of Oxygenation

Post-Delivery

Review and Debriefings  
Immediate and Scheduled:  
Provide feedback for multidisciplinary delivery and resuscitation teams

Brief Team Reflection  
Quick discussion:  
Latent and obvious errors, clinical issues, barriers to process and examples of excellence

INSPIRED Debriefings  
(Audio/Video)  
Extended team discussion of selected events: Resuscitation process, provider skills, system process, etc.

The Golden Minute®

is the most important time of a newborn’s life
Newborns are not just little infants....

...But the basic approach and management are very similar!
Neonatal vs. Paediatric: Simple Answer!

When the Umbilical Cord Falls off….switch from Neo to Paeds!

Yes
Umbilical Cord
Neonatal ALS

No
Umbilical Cord
Paediatric ALS
It takes a Village!