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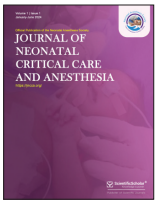
Journal of Neonatal Critical Care and Anesthesia



Narrative Review

Neonatal and Pediatric Resuscitation – How Similar and How Different

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ABSTRACT

The neonatal period in human life is accompanied by the most dramatic physiological changes, and any resuscitative measures should be in accordance with these changes. Resuscitation protocols for infants and children cannot be applied here. If a neonate requires resuscitation in the perioperative period, one has to use both the neonatal and pediatric resuscitation protocol, as there is no separate protocol available for these situations. With this background, this article focuses on the important and significant differences between pediatric and neonatal resuscitation.

Keywords: Resuscitation, Differences, Pediatric, Neonatal

INTRODUCTION

The physiological transition from fetal to neonatal life at birth demands a different resuscitation protocol as compared to all other forms of resuscitation.[1] The science of neonatal resuscitation applies to newborns transitioning from the warm fluid-filled environment of the womb to the air-filled environment of the labor room and in the days after birth.[2] These guidelines can be applied to newborns and neonates (up to 28 days).[2] The currently available literature does not give clear recommendations on whether to follow pediatric or neonatal resuscitation guidelines in the neonatal perioperative period, and thus, a combination of these two is often used. This article will highlight the similarities and differences between the neonatal and pediatric resuscitation guidelines so that the attending anesthesiologist can make an expedite decision during perioperative resuscitation in neonates.

NEONATAL VERSUS PEDIATRIC RESUSCITATION

Neonatal period is a very crucial period, as the neonate undergoes many physiological changes. The presence of prematurity or congenital syndromes adds to the criticality.[3] The underlying pathophysiology is significantly different in a neonate needing surgical intervention. The causes and events leading to the need of resuscitation might be challenging depending on the surgical pathology and thus demand a separate resuscitation protocol in the surgical neonate.[4]

The American Heart Association (AHA) and American Academy of Pediatrics (AAP) provide algorithms and guidelines on neonatal[2] and pediatric resuscitation.[5] European Resuscitation Council (ERC),[6] Singapore Resuscitation and First Aid Council,[7] and the Indian Academy of Pediatrics[8] also provide guidelines for neonatal resuscitation. Every five years, these guidelines are updated by International Liaison Committee on Resuscitation, and the recommendation is to follow the latest.

The AHA/AAP guidelines are applicable only during the first hospitalization of the newborn following birth while pediatric basic and pediatric-advanced life support (PALS) guidelines apply to neonates (under 30 days of life, after discharge).[5] The PALS considers infants, children, and adolescents up to 18 years of age in the pediatric age (excluding newborns). The AAP recommends use of neonatal resuscitation protocol for resuscitation at birth.[2,9]

Pediatric basic life support guidelines are as follows:

i. Infant guidelines for patients younger than approximately 1 year of age
ii. Child guidelines for children approximately 1 year of age until puberty.

The ERC recommends to use pediatric life support guidelines for all children aged 0–18 years except for newborns at births (transition at birth) for which separate guidelines are given.[10]

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Received: 26 December 2023 **Accepted:** 06 February 2024 **Published:** 15 March 2024 **DOI** 10.25259/JNCCA_8_2023

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The first and most important step in resuscitation is early identification of risk factors or recognition of early warning signs and prevention of impending cardiorespiratory arrest. The most important and effective intervention in neonatal resuscitation is to initiate positive pressure ventilation (PPV) whereas initiation of chest compression (CC) is priority in adults.[9]

Initial assessment

Initial assessment is similar for both pediatric and neonatal groups:

i. Scene safety before initiation of resuscitation
ii. Check response – in neonates by tapping the sole of the foot and in children by tapping on the shoulder.
a. In case of witnessed and sudden arrest – first call for help and then initiate resuscitation
b. In case of unwitnessed arrest – first give one cycle of CPR and then call for help.
iii. Pulse check – Brachial pulse is the preferred pulse for checking in neonates and infants while in children carotid pulse is preferred. In neonates, cardiac monitoring is recommended for assessing heart rate (HR).[9]
iv. Airway and breathing is a priority in the pediatric population including neonates. Hence, neonatal resuscitation should begin with PPV at the earliest rather than with CC s.[2]

There are a few differences in PPV recommendations by AAP and ERC, as mentioned in Table 1.

While giving PPV, adequacy of ventilation is confirmed by[6]

i) Improvement in HR or a stable HR
ii) Visible chest rise, failure of which indicates insufficient inflation pressure or delivered volume or obstruction of the airway.

The recommended ventilation corrective steps (MRSOPA)[9] in neonates are Mask adjustment, Re-position of head and neck, Suction of the mouth and nose, Open the mouth, Pressure increase, and Alternative airway.

While using oropharyngeal airway, it should be used with caution in babies <34 weeks gestation, as it may increase airway obstruction.[6]

Appropriate mask size selection

The correct size face mask should make an airtight seal between the face mask and face so as to achieve adequate pressure to cause lung inflation. The mask should rest on the chin and cover the mouth and nose, but not the eyes. The different sizes of neonatal masks are size 0, 00 with external diameters of 35, 42, or 50 mm. For infants, size 01 and for older children size 01/02 is commonly used.

Table 1: PPV recommendations for neonates.

AAP[9]	ERC[6]

• Respiratory rate 40–60 breaths/min
• PIP 20–25 cm H_2O
• PEEP 5 cm H_2O
• Pop off pressure 40 cm H_2O (self-inflating bag)
• FiO_2 recommendations-
  • For term infants (>35 weeks GA)- 0.21
  • For preterm infants (<35 weeks GA) – 0.21–0.30.
	• Give five "inflations" maintaining inflation pressure for up to 2–3 s
	• Start with inflation pressure of 30 cm H_2O using air for term infants
	• Start with inflation pressure of 25 cm H_2O, FiO_2 0.21–0.30 for preterm infants (≤32 weeks).

GA – Gestational age (or menstrual age) as defined by AAP is the time elapsed between the 1st day of the last menstrual period and the day of delivery. ERC: European resuscitation council, AAP: American academy of pediatrics, PIP: Peak inspiratory pressure, GA: Gestational age, PEEP: Positive end expiratory pressure, PPV: Positive pressure ventilation, FiO_2: Fraction of inspired oxygen, H_2O: Water

Definitive airway indications

Definitive airway (i.e., endotracheal intubation) is considered when there is no HR response or HR response is accompanied by persistent apnea.

A differing range of endotracheal tube sizes should be available [Table 2] to permit placement of most appropriate size of tube to ensure adequate ventilation and minimal leak.[6]

For estimation of endotracheal tube size in older children various formulae are available, of which Coles formula is often used.[11] For length of insertion, various recommendations are given as per the gestational age and birth weight.[6,9]

Most commonly nasal tragus length (NTL) is measured, and the estimated insertion depth is NTL +1 centimeter at lips.[9]

The correct placement is confirmed by detecting exhaled CO_2 ($EtCO_2$) and rapidly improving HR.

Role of supraglottic devices in neonatal resuscitation

The laryngeal mask airway (LMA) is an effective alternative airway when attempts at face-mask ventilation or intubation are unsuccessful. It can be considered as a primary interface to administer PPV.[12] The LMA can effectively transfer positive pressure even during CCs. However, its use in neonatal resuscitation is restricted due to limited experience, lack of awareness, non-availability of appropriate LMA size for the baby, and preference for definitive airway, that is, endotracheal intubation.

The variations of LMA available are as follows: (i) devices with an inflatable mask, (ii) a soft-gel mask that does not

require inflation, (iii) device with pre-curved airway tube, and (iv) device with a port for gastric drainage.[9]

The PPV equipment that should be kept ready for resuscitation is listed in Table 2.

If the baby is put on a mechanical ventilator, and there is deterioration, consider in terms of displaced/obstructed/pneumothorax/equipment failure[9] and manage accordingly.

Chest compressions

- The CC is indicated when HR is <60/min or not improving in spite of effective ventilation
- Thumb encircling technique in neonates,[2] and two finger technique for more than 6 months age
- The CC rate is same in all ages 100–120/min
- Depth of CC 1/2–1/3 of anteroposterior chest diameter
- Location for CC – lower one-third of sternum (similar for all groups).

Compression ventilation ratio (CV ratio)

Neonates

3:1 (3 CC and 1 PPV breath, that is, 90 compressions and 30 inflations/min).[2]

Older children

Recommended CV ratio – One rescuer 30:2; Two rescuer 15:2.

Circulation

If HR is <60/min after 60 s of CC and coordinated ventilation, epinephrine and volume expansion are suggested. Cardiac monitor (electrocardiogram [ECG]) is the preferred method for assessing HR during resuscitation in neonates.

Drugs

The drug dosage is calculated as per the body weight of the child (same in neonates and pediatric). Epinephrine is indicated if there is no increase in HR even after PPV and CCs, in a dose of 0.02 (0.01–0.03) mg/kg IV, every 3–5 min. Three mL normal saline (NS) is used as flush following drug administration.

For volume resuscitation, 0.9% NS is used at 10 mL/kg, given slowly over 30–45 min, to prevent periventricular hemorrhage. In older children, either NS or Lactated Ringers or a balanced salt solution can be used as a bolus.

An IV dose of 250 mg/kg (2.5 mL/kg of 10% glucose) dextrose should be used in case of prolonged resuscitation to reduce the likelihood of hypoglycemia in neonates.[9] Flush volume

Table 2: PPV equipment.

Equipment	Neonates	Children
Ventilation mask	Round transparent masks neonatal size 00, size 0	Round, triangular, anatomical age-appropriate size
ETT size[5]	2, 2.5, 3, 3.5	Calculated by coles formula[11] (ID [mm]=[age/4]+4.0)
	GA <30 weeks 2.5 mm Weight <1000g	
	GA 30–34 weeks 3 mm Weight 1000–2000g	
	GA >34 weeks 3.5 mm Weight >2000g	
Length at angle of mouth	<1 kg 5.5–6.5 cm	
	1 kg 7 cm	
	2 kg 8 cm	
	3 kg 9 cm	
Laryngoscope blade	Millers 1 (term newborn) Millers 0 (preterm newborn) Millers 00 (optional for extremely preterm newborn) Pencil handle laryngoscope	Millers/Macintosh (age appropriate)
LMA	0.5/1	As per body weight
Reservoir bag	240 mL	500 mL
Vascular access	26G/24G IV cannula Umbilical catheters size[13] 5 Fr for >3.5 kg and 3.5 Fr for <3.5 kg Umbilical vein can be used up to 7 days of life	24G IV cannula or higher

GA: Gestational age, PPV: Positive pressure ventilation, LMA: Laryngeal mask airway, ETT: Endotracheal tube

and volume of other injectables should always be considered when calculating the total volume used for fluid resuscitation.

Defibrillation

For pediatric defibrillation or cardioversion, biphasic attenuated defibrillators are preferred over adult defibrillators, which are non-attenuated. Since smallest paddle size available is 4.5 cm, it is used for all age pediatric groups. The dose of defibrillation is 2J/kg, which can be increased to 4J/kg (same for all age groups). The pad placement can be anteroposterior (anterior over mid chest left to the sternum and posterior in between the two scapulae) or anterolateral (one below right clavicle and the other one below left axilla).[13] While placing pads make sure to avoid contact between pads, as this can create charge arcing.[13]

Temperature

For effective resuscitation, maintaining normothermia is essential. Temperature should be maintained in the range of 36.5–37.5°C. Resuscitation should take place in a warm, well-illuminated, draught-free area with a flat resuscitation surface and a radiant heater (if available).[6]

Monitoring

To assess the effectiveness of resuscitation, baby should be attached to a monitor as soon as it is made available. Basic monitoring includes ECG, oxygen saturation (SpO_2), $EtCO_2$, and temperature. Preductal SpO_2 monitoring should be done in neonates to know the saturation of blood flowing to the brain. Re-assessment is done every 60 s using the brachial artery for pulse check or ECG monitor.

Post-resuscitation care

Abnormalities in multiple systems may occur following neonatal or pediatric resuscitation.[9] The management should be according to the individual circumstances. The underlying principle of post-resuscitation care is the same for the neonatal and pediatric age groups.

i) Maintain adequate oxygenation and ventilation and monitor for signs of pulmonary hypertension.[9] Avoid hypo/hypercarbia and target SpO_2 94–98%
ii) Monitor blood pressure and HR, volume replacement or inotrope as required (maintain mean arterial pressure >5th percentile for age)[10]
iii) Avoid wide swings in glucose level (avoid hypo/hyperglycemia).[9] Consider the use of glucose infusions and replacement of electrolytes as indicated
iv) Monitor urine output and other biochemical and hematological parameters
v) For thermal care aim to keep the temperature between 36.5°C and 37.5°C.[6] If there is clinical/biochemical evidence of moderate or severe hypoxemic ischemic encephalopathy, therapeutic hypothermia 33–34°C can be considered. The reason should be clearly documented (cord blood gases, neurological examination)
vi) Evaluate the precipitating cause and manage accordingly.

CONCLUSION

The key to successful resuscitation is knowledge, anticipation, and preparedness. This article compares the neonatal and pediatric resuscitation guidelines in a step-wise manner to understand minor; yet, salient differences and to be more adept at using them for the best resuscitation outcome. With limited literature and growing enthusiasm, there is a need for specific guidelines for the resuscitation of neonates in the perioperative period.

Key points to remember-

- Ventilation is priority in neonates, early initiation of positive pressure ventilation should be done
- Sign of effective ventilation – Visible chest rise, improvement in heart rate
- Rate of ventilation – 1 breath/2–3 s, fraction of inspired oxygen not more than 0.30
- Early use of monitors
- Chest compressions – Only when no response in heart rate (or less than 60/min); chest compression to ventilation ratio CV- 3:1
- Drugs – Epinephrine and fluids when heart rate is less than 60/min after 60 secs of PPV and chest compression
- Definitive airway – When no heart rate response or response is accompanied with apnea
- Gestational age is always considered for deciding treatment plan
- Get intravenous access early
- Keep track of all fluids given intravenously (flush volume, dextrose, Normal Saline for volume expansion)
- Documentation – All interventions and events, record of iv fluids (including flush volume), drugs, cord blood gases, other laboratory investigations, neurological assessment, and clinical parameters
- Coordinated team work result in better outcomes

Ethical approval

The Institutional Review Board approval is not required.

Declaration of patient consent

Patient's consent was not required as there are no patients in this study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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How to cite this article: Motghare A, Raval A. Neonatal and Pediatric Resuscitation – How Similar and How Different. J Neonatal Crit Care Anesth. 2024;1:6-10. doi: 10.25259/JNCCA_8_2023