MODULE 1

Resuscitation of Full-term and Preterm neonates

IMPORTANT NOTICE: MOTHER'S MILK IS BEST FOR YOUR BABY

At Danone, we support breastfeeding and believe that breast milk is the best food for babies as the sole source of nutrition for the first 6 months of life and is recommended to be continued until 2 years with the introduction of appropriate complementary foods after 6 months of age.

Breastfeeding is the best for babies and a healthy diet/maternal nutrition is important when breastfeeding. A decision not to breastfeed can be difficult to reverse. Infant formula is suitable from birth, when babies are not breastfed. It is recommended that all formula milks can be used on the advice of a healthcare professional or other professional responsible for maternal and childcare. All preparation and feeding instructions should be followed carefully as inappropriate preparation could lead to health hazards.

LEARNING OBJECTIVES

- To have comprehensive knowledge about the difference in neonatal resuscitation in preterm infants and infants born after 37 weeks of gestation.
- To understand the steps involved in the process of resuscitation.

LEARNING OUTCOME

- This program intends to educate Indian nurses on neonatal resuscitation and managing full-term and preterm neonates for improved outcomes.

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PREPARATION FOR THE DELIVERY ROOM

ANTICIPATION AND PREPAREDNESS: KEY TO A SUCCESSFUL NEONATAL RESUSCITATION

The delivery process usually occurs with enough warning that a team of providers has time to prepare for the resuscitation of neonates, if necessary.[1]

Identification of known risk factors before birth may indicate the need for resusciation.[1,2]

Action 3

Prepare team and team briefing

Check equipment and supplies (Ambu bag (self-inflating bag), laryngoscope, endotracheal tubes, suction catheter, and pulse oximeter)

1. Kariuki E, Sutton C, Leone TA. Neonatal resuscitation: current evidence and guidelines. *BJA Educ.* 2021 Dec;21(12):479-485. 2. Aziz K, Lee HC, Escobedo MB, et al. Part 5: Neonatal resuscitation: 2020 American heart association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation*. 2020 Oct 20;142(16_suppl_2):S524-S550. 3. Bharti LK, Prakash A, Jain M, *et al.* Indian Academy of Pediatrics. Neonatal resuscitation program [Internet] [Updated 2022]. Available at: https://iapindia.org/pdf/Ch-104-Neonatal-Resuscitation-Program.pdf. Accessed on Oct 29, 2024.

PREPARATION OF RESUSCITATION TEAM AND EQUIPMENT

Neonatal resuscitation team

- Determine which tasks team members should be ready to perform
- Be informed about all potential risk factors
- Prepare resuscitation equipment

Neonatal resuscitation equipment

- Ensure that the correct sizes of each piece are available
- Check to ensure its function and that it is primed for use

Kariuki E, Sutton C, Leone TA. Neonatal resuscitation: current evidence and guidelines. *BJA Educ*. 2021 Dec;21(12):479-485.

STEPS AFTER DELIVERY

ASSESS FOR CRYING OR BREATHING

Baby is not breathing

- Clamp cord immediately
- Shift to the warmer
- Dry and replace wet linen with a pre-warmed towel
- Place the baby in sniffing position (Figure 1)
- Suction the mouth followed by the nose

Figure 1: Sniffing position

Adapted from: Bharti LK, *et al*. Indian Academy of Pediatrics. Neonatal resuscitation program [Internet] [Updated 2022]. Available at: https://iapindia.org/pdf/Ch-104-Neonatal-Resuscitation-Program.pdf.

Bharti LK, Prakash A, Jain M, *et al*. Indian Academy of Pediatrics. Neonatal resuscitation program [Internet] [Updated 2022]. Available at: https://iapindia.org/pdf/Ch-104-Neonatal-Resuscitation-Program.pdf. Accessed on Oct 29, 2024.

ASSESSMENT OF HEART RATE AND OXYGEN SATURATION

HR can be assessed using ECG, pulse oximetry monitoring, umbilical cord palpation, and cardiac auscultation.

Pulse oximetry

- Simultaneously provides both HR and saturation of peripheral oxygen (SpO_2).
- Should be applied to the right wrist or hand of a newborn to obtain pre-ductal SpO_2 (oxygenation of cerebral blood flow).

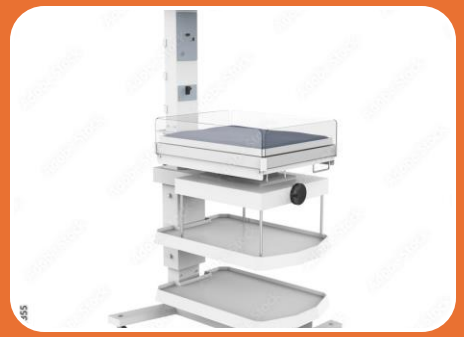
ECG, electrocardiogram; HR, heart rate; SpO_2, saturation of peripheral oxygen

Kariuki E, Sutton C, Leone TA. Neonatal resuscitation: current evidence and guidelines. *BJA Educ*. 2021 Dec;21(12):479-485.

ASSESSMENT OF HEART RATE AND OXYGEN SATURATION (CONT.)

ECG

- Allows the HR to be displayed continuously on a monitor during the resuscitation.
- Difficulties may arise if the leads do not adhere well to the newborn's chest because of amniotic fluid, meconium, or vernix.



Temperature management

- An essential part of neonatal resuscitation, especially in preterm neonates.
- Maintain normothermia by setting a temperature target on the radiant warmer and using a skin temperature probe.

ECG, electrocardiogram; HR, heart rate

Kariuki E, Sutton C, Leone TA. Neonatal resuscitation: current evidence and guidelines. *BJA Educ.* 2021 Dec;21(12):479-485.

RESUSCITATION STEPS TO IMPROVE BREATHING AND HEART RATE

- **Breathing and HR > 100 beats per minute but appears cyanosed**
  - Provide free-flow oxygen if saturation is below target oxygen
- **Labored breathing**
  - Consider nasal continuous positive airway pressure (CPAP)
- **Not breathing or breathing but HR < 100 beats per minute**
  - Provide positive pressure ventilation (PPV)

Target oxygen saturation in the first 10 minutes

1 min	60-65%
2 min	65-70%
3 min	70-75%
4 min	75-80%
5 min	80-85%
10 min	> 85%

CPAP, continuous positive airway pressure; HR, heart rate; PPV, positive pressure ventilation

Bharti LK, Prakash A, Jain M, et al. Indian Academy of Pediatrics. Neonatal resuscitation program [Internet] [Updated 2022]. Available at: https://iapindia.org/pdf/Ch-104-Neonatal-Resuscitation-Program.pdf. Accessed on Oct 29, 2024.

PPV – AN ESSENTIAL STEP IN RESUSCITATION

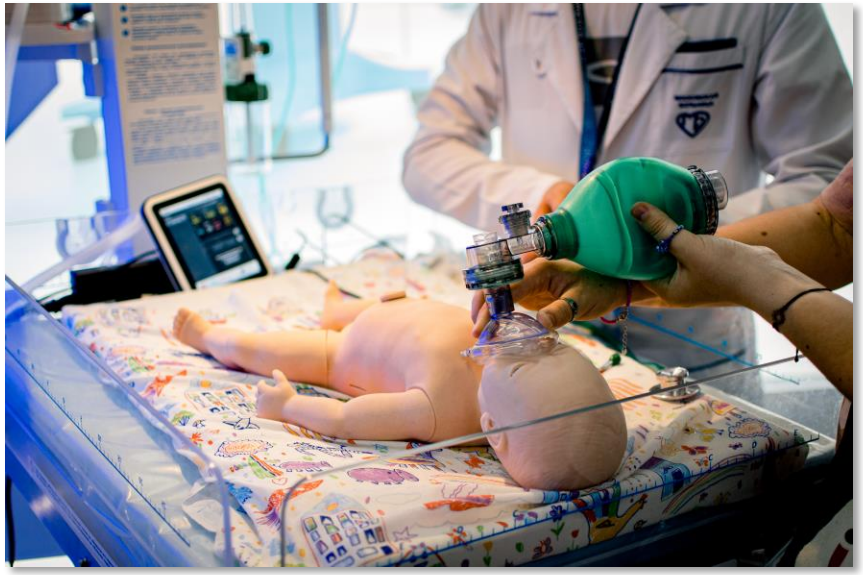


Figure 2: PPV for neonatal resuscitation

PPV

Should be initiated if the newborn is apneic, gasping, or has HR < 100 beats per minute.[1]

If provided within the first golden minute and in a correct manner, can revive **99%** of the apneic babies.[2]

HR, heart rate; PPV, positive pressure ventilation

1. Kariuki E, Sutton C, Leone TA. Neonatal resuscitation: current evidence and guidelines.*BJA Educ*. 2021 Dec;21(12):479-485. 2. Bharti LK, Prakash A, Jain M, et al. Indian Academy of Pediatrics. Neonatal resuscitation program [Internet] [Updated 2022]. Available at: https://iapindia.org/pdf/Ch-104-Neonatal-Resuscitation-Program.pdf. Accessed on Oct 29, 2024.

STEPS FOR AN EFFECTIVE PPV

Initiating PPV [1,2]

- With a self-inflating bag, flow-inflating bag, or a neonatal T-piece resuscitator.
- Place the mask covering the chin to the bridge of the nose to minimize leaks (avoid eyes).
- Duration: 30 seconds in room air for babies ≥ 35 weeks of gestational age and 21-30% for preterm babies < 35 weeks.

Role of an assistant [1]

- The assistant connects the pulse oximeter to the right hand.
- After 15 seconds, look for the effectiveness of PPV by primarily assessing the increasing HR by auscultation, and if it is not increasing, then look for chest movement with PPV.

HR, heart rate; PPV, positive pressure ventilation

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STEPS FOR AN EFFECTIVE PPV (CONT.)

Ineffective PPV*

- Mask readjustment.
- Reposition the head.
- Suction the mouth and nose and open the mouth.
- Increase the delivered pressure by squeezing the bag harder.
- Alternate airway-like intubation.

After PPV

- HR > 100 beats per minute but not breathing well: Continue PPV and add oxygen if saturation below target; if prolonged, consider intubation.
- HR < 100 beats per minute: Continue PPV, ensure effective ventilation by intubation, and add oxygen if saturation is below target.

Aftercare

- Effective PPV for 30 seconds: Monitor vitals, feeding, and activity every 15 minutes in the first hour and every 30 minutes in the 2nd hour.

*HR not increasing and chest not moving
HR, heart rate; PPV, positive pressure ventilation
Bharti LK, Prakash A, Jain M, *et al.* Indian Academy of Pediatrics. Neonatal resuscitation program [Internet] [Updated 2022]. Available at: https://iapindia.org/pdf/Ch-104-Neonatal-Resuscitation-Program.pdf. Accessed on Oct 29, 2024.

INDICATIONS FOR ENDOTRACHEAL INTUBATION

- **Prolonged PPV with bag and mask ventilation**
- **HR < 100 beats per minute even if PPV moves the chest to ensure ventilation**
- **Before chest compression (CC)**

CC, chest compression; HR, heart rate; PPV, positive pressure ventilation

Bharti LK, Prakash A, Jain M, *et al.* Indian Academy of Pediatrics. Neonatal resuscitation program [Internet] [Updated 2022]. Available at: https://iapindia.org/pdf/Ch-104-Neonatal-Resuscitation-Program.pdf. Accessed on Oct 29, 2024.

STEPS FOR ET INTUBATION

ET tube insertion

- ET tube is inserted and checked for its endotracheal position by witnessing increasing HR or chest rise with PPV.
- The procedure should be done within 30 seconds; if not, then provide PPV with a bag and mask before the next attempt.

Duration

- PPV for 30 seconds

Assessment and action

- HR > 100 beats per minute and breathing well: post-resuscitation care
- HR between 60-100 beats per minute: Continue PPV
- HR < 60 beats per minute: Start CC

CC, chest compression; ET, endotracheal; HR, heart rate; PPV, positive pressure ventilation

Bharti LK, Prakash A, Jain M, *et al.* Indian Academy of Pediatrics. Neonatal resuscitation program [Internet] [Updated 2022]. Available at: https://iapindia.org/pdf/Ch-104-Neonatal-Resuscitation-Program.pdf. Accessed on Oct 29, 2024.

CIRCULATION – CHEST COMPRESSIONS

Indicated when a newborn has HR < 60 beats per minute despite effective PPV for 30 seconds.[1,2]

Ideal method of providing CCs[1]:

- **Two thumb technique:** Provides consistent compressions of the appropriate depth (Figure 3)

Figure 3: Two thumb technique

Once an advanced airway is established

- Count out loud to coordinate CCs and ventilation

HR

- Sensitive indicator of a newborn's clinical status
- Improves with effective resuscitation
- Assess HR after 60 seconds of CCs
- Stop CCs while assessing HR

CC, chest compression; HR, heart rate

1. Kariuki E, Sutton C, Leone TA. Neonatal resuscitation: current evidence and guidelines. *BJA Educ.* 2021 Dec;21(12):479-485. 2. Bharti LK, Prakash A, Jain M, et al. Indian Academy of Pediatrics. Neonatal resuscitation program [Internet] [Updated 2022]. Available at: https://iapindia.org/pdf/Ch-104-Neonatal-Resuscitation-Program.pdf. Accessed on Oct 29, 2024.

STEPS TO PERFORM CC

- Position: CC from the head end and PPV from the side of the baby
- Ratio of PPV to CC: 1:3 in 2 seconds (30 PPV and 90 CC in 1 minute)
- Depth: 1/3rd of anterior-posterior distance
- Location: Lower 1/3rd of sternum above xiphisterna

↓

Coordinated PPV and CC provided for 1 minute

↓ After 1 minute

HR > 60 beats per minute

Yes →
- Continue PPV
- Follow PPV chart

No →

Checked "CARDIO"
- Chest movement with PPV
- Airway intubated
- Rate of coordinated EtPPV, PPV *via* ET tube (EtPPV) and CC
- Depth of CC
- FiO_2 us 100%

↓ **Yes**

Indications for vascular access and medications

CC, chest compression; ET, endotracheal; EtPPV, positive pressure ventilation via endotracheal tube; FiO_2, fraction of inspired oxygen; HR, heart rate; PPV, positive pressure ventilation

Bharti LK, Prakash A, Jain M, *et al.* Indian Academy of Pediatrics. Neonatal resuscitation program [Internet] [Updated 2022]. Available at: https://iapindia.org/pdf/Ch-104-Neonatal-Resuscitation-Program.pdf. Accessed on Oct 29, 2024.

MEDICATIONS USED IN ACUTE RESUSCITATION

Medications are rarely required during newborn resuscitation; they may be considered when there is an inadequate response despite adequate control of the airway, effective ventilation, and CCs.

Adrenaline

When to consider?

Ventilation or CCs failed to increase HR > 60 beats per minute

Route of administration and dosage

Intravenous (IV) or intraosseous (IO): 10-30 micrograms kg^{-1} (0.1-0.3 mL kg^{-1} of 1:10,000 adrenaline [1000 micrograms in 10 mL])

Intratracheal (if intubated and no other access available): 50-100 micrograms kg^{-1}

Subsequent doses every 3-5 min if HR remains < 60 beats per minute

CC, chest compression; HR, heart rate

Madar J, Roehr CC, Ainsworth S, *et al.* European resuscitation council guidelines 2021: Newborn resuscitation and support of transition of infants at birth. *Resuscitation*. 2021 Apr;161:291-326.

FLUID THERAPY USED IN ACUTE RESUSCITATION

	Glucose	Volume replacement	Sodium bicarbonate
When to consider?	Prolonged resuscitation to reduce the likelihood of hypoglycemia	Suspected blood loss or shock unresponsive to other resuscitative measures	Prolonged unresponsive resuscitation with adequate ventilation to reverse intracardiac acidosis
Route of administration and dosage	**IV or IO:** 250 mg kg^{-1} bolus (2.5 mL kg^{-1} of 10% glucose solution)	**IV or IO:** 10 mL kg^{-1} of O-ve blood or isotonic crystalloid	**IV or IO route:** 1-2 mmol kg^{-1} (2-4 mL kg^{-1} of 4.2% solution) by slow IV injection

IO, intraosseous; IV, intravenous

Madar J, Roehr CC, Ainsworth S, *et al.* European resuscitation council guidelines 2021: Newborn resuscitation and support of transition of infants at birth. *Resuscitation*. 2021 Apr;161:291-326.

WITHHOLDING RESUSCITATION

HR undetectable for > 10 minutes, review

- Clinical factors (e.g., gestation age of the infant)
- Effectiveness of resuscitation

HR undetectable for > 20 minutes, despite all recommended steps of resuscitation and exclusion of reversible causes

- Consider stopping resuscitation

Partial or incomplete HR improvement despite apparently adequate resuscitative efforts

- Taking the infant to the ICU
- Consider withdrawing life-sustaining treatment if no improvement is observed

Provide appropriate palliative care to infants where life-sustaining treatment is withheld or withdrawn

ICU, intensive care unit; HR, heart rate

Madar J, Roehr CC, Ainsworth S, *et al*. European resuscitation council guidelines 2021: Newborn resuscitation and support of transition of infants at birth. *Resuscitation*. 2021 Apr;161:291-326.

DISCONTINUING RESUSCITATION

Resuscitation is always indicated in

- > 50% survival rate
- Acceptable morbidity, that includes most infants with
  - •Gestational age ≥ 24 weeks
  - •Congenital malformation

Support parental decisions in

- < 50% rate of survival
- High rate of morbidity
- High anticipated burden of medical treatment for the child

Madar J, Roehr CC, Ainsworth S, *et al.* European resuscitation council guidelines 2021: Newborn resuscitation and support of transition of infants at birth. *Resuscitation*. 2021 Apr;161:291-326.

HISTORY RELEVANT TO PRETERM DELIVERY

RISK FACTORS THAT MAY INCREASE THE LIKELIHOOD OF NEONATAL RESUSCITATION

Preterm birth < 36 weeks [1,2]

Multiple pregnancies at < 35 weeks gestation [1,2]

Polyhydramnios or oligohydramnios [1,2]

Major fetal anomalies or malformations [1,2]

No prenatal care [1]

Lack of antenatal steroids [2]

Emergency caesarean section or C-section before 39 weeks [1,2]

Placental abruption [1]

Intrauterine growth restriction [2]

1. Kariuki E, Sutton C, Leone TA. Neonatal resuscitation: current evidence and guidelines. BJA Educ. 2021 Dec;21(12):479-485. 2. Madar J, Roehr CC, Ainsworth S, et al. European resuscitation council guidelines 2021: Newborn resuscitation and support of transition of infants at birth. Resuscitation. 2021 Apr;161:291-326.

RESPIRATORY MANAGEMENT OF PRETERM NEONATE

Preterm neonates are

- Born at an early stage of lung development
- More susceptible to lung injury due to mechanical ventilation

Respiratory failure in preterm neonates

- Associated with increased neonatal morbidity and mortality.

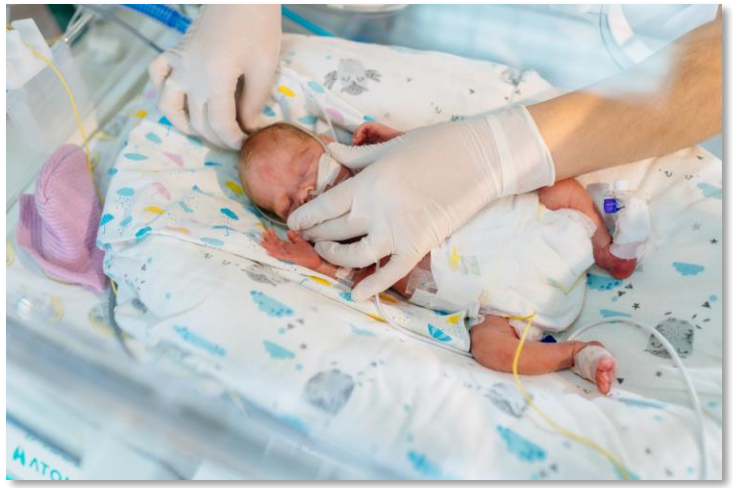
Respiratory management

- Must begin from the delivery room
- Carry on throughout the entire stay in the NICU

NICU, neonatal intensive care unit

Tana M, Tirone C, Aurilia C, *et al.* Respiratory management of the preterm infant: supporting evidence-based practice at the bedside. *Children (Basel).* 2023 Mar 10;10(3):535.

RESUSCITATION TECHNIQUE IN PRETERM NEWBORNS



- Cover with a plastic sheet without drying (except the face) to maintain appropriate temperature [1,2]
- Thermal mattresses can help maintain normothermia [2]
- Initial oxygen concentration during PPV – between 21-30% [1]

PPV, positive pressure ventilation

1. Bharti LK, Prakash A, Jain M, *et al.* Indian Academy of Pediatrics. Neonatal resuscitation program [Internet] [Updated 2022]. Available at: https://iapindia.org/pdf/Ch-104-Neonatal-Resuscitation-Program.pdf. Accessed on Oct 29, 2024. 2. Kariuki E, Sutton C, Leone TA. Neonatal resuscitation: current evidence and guidelines. *BJA Educ.* 2021 Dec;21(12):479-485.

MEDICATIONS AND FLUID THERAPY IN ACUTE RESUSCITATION OF THE PRETERM INFANT

Resuscitation of preterm infants	• Volume is rarely needed • Rapid infusion of large volumes of fluid is associated with intraventricular and pulmonary hemorrhages
Prolonged resuscitation of extremely preterm infants	• Low survival rates • High morbidity • Decision should be individualized

Madar J, Roehr CC, Ainsworth S, *et al.* European resuscitation council guidelines 2021: Newborn resuscitation and support of transition of infants at birth. *Resuscitation*. 2021 Apr;161:291-326.

INFANTS BORN AT THE THRESHOLD OF VIABILITY

INFANTS BORN AT THE THRESHOLD OF VIABILITY

Birth of neonates at the threshold of viability (22-23 weeks of gestation) frequently results in

- Infant mortality
- Neurodevelopmental impairment

Neonatal interventions include

- Resuscitation
- NICU admission
- Medications administration
- Assisted ventilation

NICU, neonatal intensive care unit

Hajdu SA, Rossi RM, DeFranco EA. Factors associated with maternal and neonatal interventions at the threshold of viability. *Obstet Gynecol*. 2020 Jun;135(6):1398-1408.

RESUSCITATION OF INFANTS BORN AT THE THRESHOLD OF VIABILITY

Neonatal resuscitation can include different interventions and intensities depending on specific medical conditions.

- Ventilation and oxygenation
- CCs
- Medications and fluid therapy

The decision to resuscitate extremely preterm infants (EPIs) can be difficult. Compared to term infants, EPIs are at an increased risk of

- Severe disability (e.g., neurosensory, motor, cognitive, and behavioral impairments)

CC, chest compression; EPI, extremely preterm infant

Cavolo A, de Casterlé BD, Naulaers G, *et al.* Neonatologists' decision-making for resuscitation and non-resuscitation of extremely preterm infants: ethical principles, challenges, and strategies-a qualitative study. *BMC Med Ethics.* 2021 Sep 25;22(1):129.

COMPLICATIONS ASSOCIATED WITH RESUSCITATION

COMPLICATIONS ASSOCIATED WITH RESUSCITATION

Difficult airway situation

- More common in premature neonates
- Highly linked to adverse events and severe oxygen desaturations

Repeated instrumentation of the airway can cause

- Bleeding
- Airway edema
- Tissue trauma
- A “can’t ventilate, can’t intubate” situation

An increased risk of air leak with the widespread use of T-piece resuscitators and mask CPAP can cause

- Brain injuries
- Lung injuries

CPAP, continuous positive airway pressure; ET, endotracheal

Berisha G, Boldingh AM, Blakstad EW, *et al.* Management of the unexpected difficult airway in neonatal resuscitation. *Front Pediatr*. 2021 Oct 28;9:699159.

PREVENTIVE MEASURES TO AVOID COMPLICATIONS OF NEONATAL RESUSCITATION

- Sustained inflation to initiate resuscitation
- 100% oxygen in infants receiving respiratory support
- Potentially harmful and should be avoided in preterm infants
- Should be avoided as it increases the risk of mortality

Soraisham AS, Srivastava A. recent update on neonatal resuscitation. *Indian J Pediatr*. 2022 Mar;89(3):279-287.

POST-RESUSCITATION CARE

POST-RESUSCITATION CARE

The condition of an infant who received resuscitation may deteriorate. Hence, it is essential that adequate ventilation and circulation are received, and the infant is cared for and transferred to an environment where close monitoring or anticipatory care can be provided.

Glucose

- Monitory carefully after resuscitation
- Void large shifts in glucose concentration

Thermal care

- Aim for a temperature between 36.5-37.5°C
- Rewarm if the temperature falls below the recommended value

Madar J, Roehr CC, Ainsworth S, *et al*. European resuscitation council guidelines 2021: Newborn resuscitation and support of transition of infants at birth. *Resuscitation*. 2021 Apr;161:291-326.

POST-RESUSCITATION CARE (CONT.)

Maintain clinical records to accurately evaluate

- Clinical state of the infant at birth
- Any interventions and the response during the resuscitation

Madar J, Roehr CC, Ainsworth S, *et al.* European resuscitation council guidelines 2021: Newborn resuscitation and support of transition of infants at birth. *Resuscitation.* 2021 Apr;161:291-326.

SUMMARY

- The neonatal resuscitation team needs to have a plan for managing varying resuscitation requirements levels, determine team members' roles and responsibilities, and prepare resuscitation equipment.
- During resuscitation, HR can be assessed using pulse oximetry, ECG, cardiac auscultation, and umbilical cord palpation, of which pulse oximetry simultaneously provides both HR and SpO_2, and ECG allows continuous HR monitoring during resuscitation.
- Since temperature management is essential, especially in preterm neonates, it is important to maintain normothermia by setting a target temperature on a radiant warmer and using a skin temperature probe.
- PPV should be initiated if the newborn is apneic, gasping, or has HR < 100 beats per minute. ET intubation is indicated in case of prolonged PPV with bag and mask ventilation, HR < 100 beats per minute before CC, and congenital malformations.
- CCs are indicated in case of severe bradycardia despite effective PPV for 30 seconds.
- Medications and fluid therapy may be considered for neonates with inadequate response despite adequate control of the airway, effective ventilation, and CC.
- The decision to withhold resuscitation can be made when the HR is undetectable for > 20 minutes or when there is partial or incomplete improvement in HR despite all recommended steps of resuscitation.
- Resuscitation of infants born at the threshold of viability can include different interventions and intensities based on specific medical conditions.
- Newborns must receive adequate ventilation and circulation post-resuscitation and must properly document all events.

IMPORTANT NOTICE: MOTHER'S MILK IS BEST FOR YOUR BABY

At Danone, we support breastfeeding and believe that breast milk is the best food for babies as the sole source of nutrition for the first 6 months of life and is recommended to be continued until 2 years with the introduction of appropriate complementary foods after 6 months of age.

Breastfeeding is the best for babies and a healthy diet/maternal nutrition is important when breastfeeding. A decision not to breastfeed can be difficult to reverse. Infant formula is suitable from birth, when babies are not breastfed. It is recommended that all formula milks can be used on the advice of a healthcare professional or other professional responsible for maternal and childcare. All preparation and feeding instructions should be followed carefully as inappropriate preparation could lead to health hazards.

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Published By - Nutricia International Private Limited, Building A, unit no. 304, 3rd Floor, Agastya Corporate Park, Kamani Junction, L.B.S. Marg, Opp. Fire Brigade, Kurla (West), Mumbai 400070

Date of Publishing 21ST April **CVM code –**1745237545536

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