CHAPTER

5

Thermal Management

Despite being homeothermic, environmental temperatures can easily overwhelm a newborn's ability to maintain body temperature. Thermal protection of the newborn is a set of continuing measures, which starts at birth, to ensure that the neonate maintains a normal body temperature (Table 5.1).[1]

THERMONEUTRAL ENVIRONMENT

Thermoneutral environment (TNE) refers to a narrow environmental temperature range at which the neonate has a minimum basal metabolic rate (BMR) and maintains normal body temperature. NE varies by gestation and postnatal age (Table 5.2). The infants, therefore, should be kept in TNE so that their energy is utilized

Table 5.1: Temperature ranges

Normal axillary temperature	36.5–37.5°C
Mild hypothermia or cold stress	36–36.4°C
Moderate hypothermia	32–35.9°C
Severe hypothermia	<32°C
Hyperthermia	>37.5°C

Table 5.2: Thermoneutral zone[2]

Weight of the neonate	*Recommended ambient temperature*			
	35°C	*34°C*	*33°C*	*32°C*
<1500 g	1–10 days old	11 days to 3 weeks	3–5 weeks	>5 weeks
1500–1999 g		1–10 days	11 days to 4 weeks	>4 weeks
2000–2499 g		1–2 days old	3 days to 3 weeks	>3 weeks
≥2500 g			1–2 days old	≥3 days old

for growth and other vital functions. As opposed to TNE, thermoregulatory environment (TRE) refers to environmental temperature beyond TNE range, at which the neonate increases its BMR to maintain normal body temperature.

RECORDING TEMPERATURE

The following minimum schedule for taking the temperature of the newborn is recommended:

1. Immediately after completion of initial care of the newborn
2. Arrival in the nursery or postnatal ward.
3. For healthy neonates with their mothers, no further routine measurement is required.

Having identified that an infant is at risk, appropriate nursing measures should be taken immediately. However, it should be explained to the mother that the temperature should be checked if the neonate's feet feel cold. Temperature should be monitored every 1–2 hours for a sick neonate, twice daily for neonates weighing 1500–2499 g, and four times daily for neonates below 1500 g.

Methods of Recording Temperature

Touch Method

Abdominal skin, hands, and feet are touched with the back of the health provider's hand to note the warmth. Abdominal temperature is representative of the core temperature. The interpretation is as follows:

- Neonate's feet and hands are warm: Thermal comfort
- Hands and feet are cold, but the abdomen is warm: Cold stress
- Hands and feet, as well as the abdomen, are cold: Hypothermia

Thermometers

WHO recommends using a low-reading thermometer that can record up to 30°C. The American Academy of Pediatrics (AAP) recommends against using mercury thermometers, given the poisonous nature of mercury.[3] It is best to use a digital thermometer.

Thermister Probe

Skin temperature can be recorded by a thermister probe (available in radiant warmer and incubator). The probe is attached to the skin over the upper abdomen.

Concept of Warm Chain

The warm chain is a set of ten interlinked steps carried out at birth and later, which reduce the chances of hypothermia in newborns:

1. **Thermal care in the delivery room:** After birth, the newborn's temperature can drop at 0.1°C and 0.3°C per minute for core and skin, respectively. The delivery room should be clean, warm (at least 25–28°C), and free from air drafts from open windows, doors, and fans.

   If the room temperature is less than the desired, a room heater should be used to warm the room. The radiant warmer should be switched on in advance (at least 20–30 mins) and put on manual mode with 100% heater output. All the linen (towels, blankets, caps, and neonates' clothes) should be pre-warmed.
2. **Warm resuscitation:** The neonate should be resuscitated using warm supplies, equipment, and drugs. Cold items should be avoided from coming in contact with the neonate.
3. **Immediate drying:** After birth, the neonate should be immediately dried with a dry and warm towel, starting with the head. After drying thoroughly, the neonate should be covered with another dry and warm towel, and the head should be covered with a warm cap.
4. **Skin-to-skin contact:** An otherwise healthy neonate should be kept in skin-to-skin (STS) contact with the mother immediately after delivery.[4] In contrast, the mother is being attended to for placental delivery, episiotomy suturing, and during postnatal ward transfer for a few hours. If the neonate develops cold stress, he should be immediately placed in STS contact with his mother.

   Early Skin-to-skin contact: What is the evidence?

   A Cochrane review has shown that early skin to skin contact started soon after birth until the end of first breastfeeding improved breastfeeding rates and duration. In addition, neonates have better cardiorespiratory stability and higher blood glucose levels.[4]
5. **Breastfeeding:** Breastfeeding should begin as soon as possible after birth, preferably within an hour. This ensures an adequate supply of energy sources.
6. **Postpone bathing /weighing:** Bathing should be postponed in all neonates until stable enough (ideally, it should be given

at home after discharge. For neonates <2 kg, it should be given once the neonate attains a weight of 2 kg). Weighing should be done after covering the neonate adequately and making zero corrections for clothing.

7. **Appropriate clothing:** Newborns should be covered with 1–2 layers of clothes, and caps, socks, and mittens are provided.
8. **Mother and neonate together (bedding in):** The mother and the neonate should be nursed on the same bed for thermal protection and breastfeeding.
9. **Warm transportation:** Thermal protection should be ensured in transport-home or another hospital/ward. Stable neonates can be transported in the STS position, including preterm and low birth weight. Sick and small (VLBW) neonates should be transported using an incubator. The temperature should be checked before and after transport. All peripheral hospitals caring for high-risk mothers should undergo in-utero transfer as early as possible.
10. **Training and awareness:** All the healthcare personnel involved in newborn care should be adequately trained and informed about the principles of the warm chain.

THERMAL MANAGEMENT IN PRETERM NEONATES

Apart from the routine measures, extra care is required for preterm neonates:

Polythene occlusive wraps: NRP 2015 recommends using polythene wraps and thermal mattresses for all neonates <32 weeks. This technique involves covering the neonate in a food grade polyethylene bag or wrap just after birth (without drying). The neonate is then placed on a radiant warmer for resuscitation as required. Wrapping reduces evaporative heat loss while allowing radiant heat delivery to the neonate.[5]

Polythene occlusive wraps: What is the evidence?

A Cochrane review has confirmed the efficacy of plastic bags in addition to radiant warming in improving the NICU admission temperature of premature neonates <28 weeks gestation.[6]

All preterm neonates <34 weeks should be nursed in a radiant warmer/incubator. When transferred to an open cot/mother, the preterm neonates provide kangaroo mother care.

Incubators: Incubators are preferred over radiant warmer for the care of preterm neonates <32 weeks.[7] Incubators ensure better thermal protection than radiant warmer in these neonates by decreasing the insensible water loss (IWL) and convective heat losses. Radiant warmers, in contrast, increase the IWL in such infants.

a. **Mechanisms:** The modern incubator incorporates a transparent plastic hood with various access ports. A warming device is positioned below the bed surface, and the air is blown over the heater. The warm air is circulated using a quiet fan to attain a uniform temperature within the hood. A low rate of air circulation, ideally not more than 20–30 L/min, minimizes convective heat losses. The noise level should be kept below 60 dB. Double-wall incubators, which have an additional wall, had the advantage of decreasing the irradiative heat loss from the neonate compared to single-wall incubators.[8]

b. **Practical tips**
   - In air mode, the desired environment temperature around the neonate is set, and the heater output adjusts itself to maintain this. The appropriate set temperature is decided by using the thermoneutral temperature charts
   - In servo mode, the desired skin temperature is 36.5–36.8°C. The feedback system modifies heater output to keep the neonate's temperature constant
   - The temperature probe should be positioned appropriately. Dislodgement of the probe can overheat the neonate. For sick neonates, servo mode is preferred as it minimizes the temperature fluctuations in the neonate.
   - Air mode is preferred for procedures and when the incubator's door is opened. When switching to air mode, set the air temperature equal to the average incubator air temperature in servo mode.

c. **Humidification:** Humidity (80%) can be started in neonates <28 weeks gestation for the initial seven days, followed by weaning by 5% each day for the next seven days.[9] It minimizes insensible water losses and helps in better thermal protection and fluid management. The humidification chamber should be filled with sterile water, cleaned, and dried daily. There is an increased risk of sepsis (particularly *Pseudomonas*) with humidity.[9]

Radiant warmers: Radiant warmer (RW) is a convenient 'open care' system for managing preterm neonates >32 weeks. It allows easy access to neonates for procedures and monitoring but has the

disadvantage of increasing the insensible water losses. Maintenance and cost of RW are low.

a. **Principle:** The radiant warmers produce heat using a quartz crystal heating element. The heat is uniformly reflected onto the surface of the neonate by parabolic reflectors.
b. **Modes:** The Servo mode of control is preferred over the manual mode. Servo control modulates heater output based on skin temperature in real-time. Set the skin temperature at 36.5–36.8°C. The room temperature should be around 25°C for the optimum functioning of RW. A sick neonate can be provided with a cap, socks, and mitten, keeping the chest and abdomen area bare for easy observation. Stable neonates can be covered except the face with appropriate clothing while the neonate is under RW.

   Manual mode allows the operator to determine the heater output. It is used during resuscitation, for rapid re-warming of a hypothermic neonate, and if the neonate has a fever (to prevent frequent alarms). It is not routinely used because of the risk of overheating or hypothermia.
c. **Practical tips**
   - If on manual mode, the neonate's temperature should be checked frequently (every 15 minutes).
   - There should not be more than one neonate under an RW, as this may allow cross-infection and unequal heat distribution.
   - For small neonates cared in RW, cling wraps mode of polythene sheets can be used for covering the bassinet, which will help in reducing the insensible water loss

Hybrid incubators:[10] Advanced neonatal incubators combine two warming modes: the incubator and the radiant warmer. In the incubator mode, movable plastic walls enclose the infant. In contrast, in the warmer mode, these walls drop down, and the radiant warmer rise overhead on a motorized pylon which maintains the temperature of the neonate during procedures. They provide the benefits of a humidifier system and easy accessibility to the neonate during care procedures.

Kangaroo mother care: KMC is an effective way of keeping neonates warm. KMC is no-cost, accessible, and applicable at home, with multiple advantages (*see* Chapter 52: Kangaroo Mother Care).

Heated water-filled mattress: It is an economical but unsafe device for keeping LBW/sick neonates. Generally, they are of five liters of water capacity. An electric heating plate and control unit fit into

a compartment in the bottom of the mattress, keeping the water temperature at 35–38°C. This is not routinely used because of practical difficulties.

PCM devices: It consists of a sealed pouch containing phase-changing material. These can maintain the neonate's temperature for 4–6 hours. These devices require large-scale validation for their efficacy and practical difficulties.

HYPOTHERMIA

The World Health Organization (WHO) defines neonatal hypothermia as an axillary temperature below 36.5°C (97.7°F) among newborns below 28 days. The prevalence rates of hypothermia range from 32 to 85% in hospital settings of developing countries.[12]

Clinical Presentation of Hypothermia

Signs of hypothermia are usually absent or nonspecific in neonates. It can be discussed under the four different situations

a. Early signs of hypothermia are because of peripheral vasoconstriction, including pallor, acrocyanosis, cool extremities, and decreased peripheral perfusion. There can be irritability.
b. Late signs include features of CNS depression like lethargy, bradycardia, apnea, poor feeding, hypotonia, weak suck or cry, and emesis. There may be respiratory distress because of increased pulmonary artery pressure. Abdominal signs like increased gastric residuals, abdominal distention, or emesis can occur.
c. Prolonged hypothermia leads to increased metabolism leading to hypoglycemia, hypoxia, metabolic acidosis, coagulation failure, and sometimes persistent pulmonary hypertension in newborns. ARF, in extreme cases, carries a high mortality.
d. Chronic periods of cold stress lead to weight loss and poor weight gain.

Important: Hypothermia may be a sign of infection in neonates.

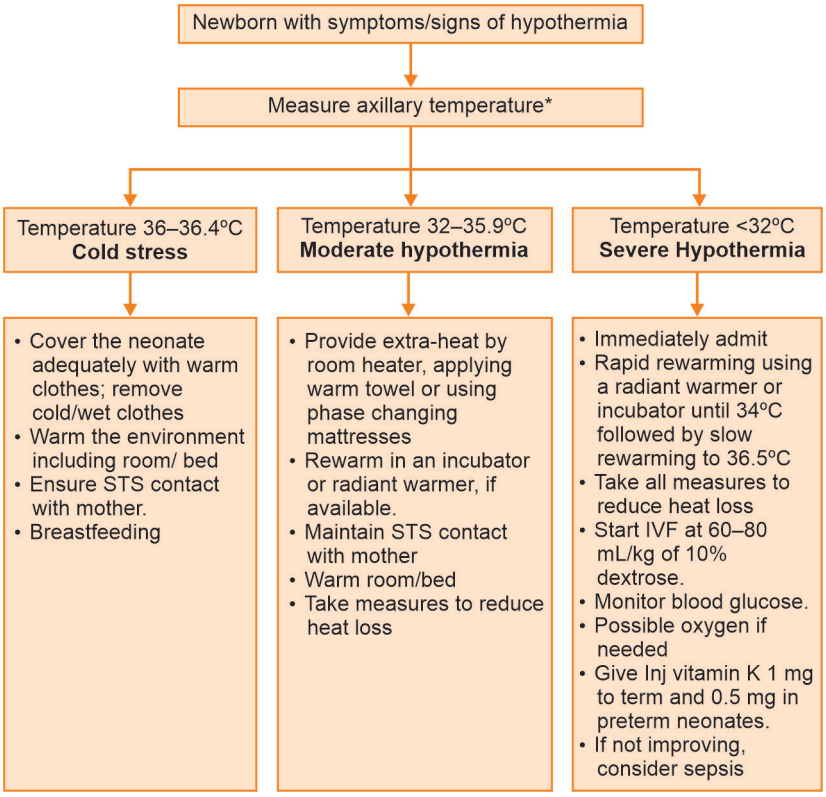
Management

Management of a hypothermic neonate depends on the degree of hypothermia. The management algorithm is elaborated in Flowchart 5.1.

Outcome

Neonatal hypothermia is an independent predictor of neonatal mortality across all gestational ages. In addition, hypothermia in

Flowchart 5.1: Management of hypothermic neonate



*In all cases, monitor the axillary temperature every 0.5–1 hours till it reaches 36.5°C, then hourly for the next 4 hours, two hourly for 12 hours after that.

very low birth weight neonates has been associated with an increased risk of intraventricular hemorrhage, bronchopulmonary dysplasia, neonatal sepsis, and retinopathy of prematurity.[11]

HYPERTHERMIA

Hyperthermia is also a common problem with neonates. It is common in dry and warm areas. A temperature of more than 37.5°C is defined as hyperthermia in newborns.

Causes

- Too hot environment
- The neonate has too much of clothes
- Dehydration
- Sepsis—especially in term neonates

Symptoms

Early: Irritable, tachycardia, tachypnea, flushed face, hot and dry kin
Late: Apathy, lethargy, and coma
Severe hyperthermia can lead to shock, convulsions, and even death.

Management

Place the neonate in a normal environment (25–28°C) away from the heat source. Undress the neonate partially/fully. Give frequent breastfeeding or expressed breast milk by *katori* spoon. The neonate can be sponged with tap water if the temperature is >39. Measure the temperature hourly till it becomes normal. Evaluate for underlying cause if there is no response.

REFERENCES

1. World Health Organization. Maternal and Newborn Health/Safe Motherhood. (1997). Thermal protection of the newborn: a practical guide.
2. Hey E. Thermal neutrality. Br Med Bull. 1975 Jan;31(1):69–74.
3. American Academy of Pediatrics, Altmann TR, Hill DL. Caring for Your Baby and Young Child: Birth to Age 5. American Academy of Pediatrics; 2019.
4. Moore ER, Bergman N, Anderson GC, Medley N. Early skin-to-skin contact for mothers and their healthy newborn infants. Cochrane Database Syst Rev. 2016 Nov 25;11(11):CD003519.
5. Weiner GM, Zaichkin J, Kattwinkel J, American Academy of Pediatrics, American Heart Association, editors. Textbook of neonatal resuscitation. 7th edition. Elk Grove Village, IL: American Academy of Pediatrics; 2016.
6. McCall EM, Alderdice F, Halliday HL, Jenkins JG, Vohra S. Interventions to prevent hypothermia at birth in preterm and/or low birth weight infants. Cochrane Database Syst Rev. 2010 Mar 17;(3):CD004210.
7. Flenady V, Woodgate PG. Radiant warmers versus incubators for regulating body temperature in newborn infants. Cochrane Database of Systematic Reviews 2003, Issue 4. Art. No.:CD000435.
8. Laroia N, Phelps D, Roy J. Double wall versus single wall incubator for reducing heat loss in low birth weight infants in incubators. Cochrane Database of Systematic Reviews 2007, Issue 2. Art. No.:CD004215.
9. Harpin VA, Rutter N. Humidification of incubators. Arch Dis Child. 1985 Mar;60(3):219–24.
10. Gleason CA, Juul SE, editors. Avery's diseases of the newborn. Tenth edition. Philadelphia, PA: Elsevier; 2018. 1627 p.
11. Lunze K, Bloom DE, Jamison DT, Hamer DH. The global burden of neonatal hypothermia: a systematic review of a major challenge for newborn survival. BMC Med. 2013 Jan 31;11:24.

CHAPTER

6

Golden-hour Management of High-risk Newborn

'Golden-hour' (first 60 minutes of life) management refers to implementing evidence-based practices focused resuscitation, and stabilization at birth and within the first hour of life. Specific interventions include thermal protection, gentle ventilation, avoidance of hyperoxia, timely administration of surfactant, and early initiation of nutrition. Team performance and communication form the backbone of golden-hour care.

BEFORE DELIVERY

Organizing a team: Preterm neonates, particularly those born before 32 weeks' gestation, may need resuscitation at birth. A team of 3–4 members, including a neonatologist or senior neonatal fellow, one or two pediatric residents, and a nurse, should always be ready for resuscitation and management during golden hour. The roles and responsibilities of team members should be assigned, and equipment should be pre-arranged using a checklist.

Parental counseling: Parents confronted with delivering a preterm neonate experience anxiety and fear. Antenatal counseling is best done by a team comprising both neonatologists and obstetricians. The physician should provide information on survival and anticipated morbidity relevant to the gestational age in simple terms. The use of a written template and decision aids for counseling is recommended. The morbidity statistics of extremely low birth weight (ELBW) infants from a birth cohort of 2013–2018 delivered at AIIMS are given in Table 6.1.[1]

Decision-making at limits of viability: Gestational age of the fetus is an essential determinant of viability and influences major interventions at birth. Hence, every effort should be made to confirm the exact gestational age based on LMP (last menstrual period) and

Table 6.1: Morbidity statistics for extremely low-birth-weight neonates delivered in AIIMS, New Delhi, between 2013 and 2018

Morbidity	*Risk*
Respiratory distress syndrome	80%
Bronchopulmonary dysplasia (any severity)	40%
Severe intraventricular hemorrhage	20%
Patent ductus arteriosus requiring treatment	30%
Major neurodevelopmental impairment (cerebral palsy, motor or mental developmental quotient <70 on DASII, visual or hearing impairment, or epilepsy) at 18 months corrected age	<28 weeks; 40% <1000 g; 30%

first-trimester ultrasound. Other factors that positively influence the neonatal outcome at peri-viable gestation include; female sex, singleton gestation, not being SGA, exposure to antenatal steroids, absence of perinatal complications like chorioamnionitis, and being born in a tertiary care center.[2]

India has no national guidelines regarding resuscitation at limits of viability. The survival of neonates 25 weeks' gestation is uniformly good across various developed countries[3,4] and therefore full resuscitation is recommended. If the gestation is between 24^{+0} and 24^{+6} weeks (gray zone), resuscitation depends on shared decision-making with parents.[5] Our center offers comfort care for neonates with gestation 23 weeks. Although survival of neonates less than 500 grams is less, decision-making should not solely rely on birth weight alone as viable neonates with intrauterine growth restriction can have birth weights less than 500 grams.

One should never forget the inaccuracies associated with gestational age and birth weight estimations, with first-trimester dating ultrasound variation of ±7 days and estimates of fetal weight variation of ±15%. Thus, in many situations, the clinician should continually reassess the neonate's response to resuscitative efforts. For example, if a neonate born at 24 weeks' gestation is severely compromised at birth, redirection to comfort care after provisional NICU admission can be made. If the neonate is vigorous at birth or responds well to initial resuscitation, active management with ongoing evaluation after admission to NICU is advised.

Antenatal steroids: A single course of corticosteroids (betamethasone 12 mg, two doses given 24 hours apart, or dexamethasone 6 mg, four doses given 12 hours apart IM) is recommended for pregnant women between 24 and 34 weeks of gestation.[6] Even in periviable

gestations (23–26 weeks), antenatal corticosteroids[7] do have a role in decreasing neonatal mortality and IVH and should be used where applicable. A single repeat course of steroids can be given to pregnant women <34 weeks' gestation with an impending preterm delivery within the next seven days and who received an earlier course more than 14 days ago.[8] As even a single dose of antenatal steroid significantly reduces neonatal morbidity and mortality, the first dose should be administered even if the chances of completing an entire course appear unlikely.

Antenatal magnesium sulfate ($MgSO_4$) for neuro-protection: The prevalence of cerebral palsy (CP) in very-low-birth-weight infants is 60 per 1000 infants, and about a third of new CP cases are associated with prematurity before 32 weeks' gestation.[13] Six randomized trials involving 6000 women have shown the neuroprotective benefits of $MgSO_4$ in reducing the risk of CP in preterm infants when provided for pregnant women <32 weeks gestation with imminent preterm birth (preterm birth likely within the next 24 hours) irrespective of the cause of preterm birth or the number of fetuses in-utero.[9] The drug is administered as a 4 g IV loading dose over 30 minutes, followed by a 1 g/hour maintenance infusion until birth. Therapy should be discontinued if delivery does not occur or a maximum infusion period of 24 hours is reached. The treatment is safe for neonates without increased risk of resuscitation at birth. Mothers receiving $MgSO_4$ require monitoring for adverse effects like respiratory depression.

Evidence for antenatal magnesium sulfate[9]

Magnesium sulfate administered to pregnant women at risk of imminent preterm birth reduces the risk of cerebral palsy (RR 0.68; 95% CI 0.54–0.87). It also decreases substantial gross motor dysfunction (inability to walk without assistance) (RR 0.61; 95% CI 0.44–0.85) at two years of age.[10] The benefits were noted regardless of gestational age, cause of birth, or total dose administered.

DURING DELIVERY

Resuscitation and initial stabilization of a preterm neonate during the "golden hour" should follow the Neonatal Resuscitation Program guidelines and requires adequate preparation and teamwork. Preterm neonates are at high risk of hypothermia, and each degree drop in admission temperature is associated with increased odds of mortality by 28% and late-onset sepsis by 11%. Preterm neonates have surfactant deficiency, poor respiratory drive,

weak and compliant chest wall, fragile brain capillary network, and higher sensitivity to oxygen-induced free radical damage. Hence specific interventions at birth should focus on (Table 6.2).

Table 6.2: Delivery room management of very preterm neonates

Situation		*Recommendations*
Anticipatory preparation		• Use pre-resuscitation checklist. • Check equipment and organize a team. • Prepare a resuscitation kit. • Call for additional help if necessary.
Delivery room management	Delayed cord clamping	• In uncomplicated preterm birth, delayed cord clamping should be attempted for a minimum time of 30 seconds after delivery.
	Thermoregulation	• Maintain DR temperature of at least 26°C for all deliveries <32 weeks. Switch off the air conditioner in the DR. • Pre-warm the radiant warmer to 100% heater output for at least 10 minutes before delivery. • Use polythene bags/wraps for all neonates <32 weeks' gestation. Do not dry the neonate. Do not remove the bag until the neonate is transferred to the NICU axnd normal temperature is recorded. • Cover the head with a plastic bag. Use of hat is recommended. • Use a transport incubator to transfer neonates from DR to NICU. Pre-warm the baby boundaries and the transport incubator before use. • Measure axillary temperature within 10 minutes of NICU admission.
	Respiratory management and oxygen targeting	• Neonates are resuscitated as per NRP guidelines. • Spontaneously breathing preterm infants <32 weeks' gestation at high risk of RDS should be supported with CPAP of 5 cm H_2O using T-Piece as soon as respiratory distress is noted. • Infants needing positive pressure ventilation are provided with PIP and PEEP using a T-Piece device. Initial settings on the device are 15/5. If rapid heart rate or chest movement improvement is not obtained, higher pressures to achieve effective ventilation may be used.

(*Contd.*)

Table 6.2: Delivery room management of very preterm neonates (*Contd.*)

Situation		*Recommendations*
		• Avoid the use of self-inflating bags for delivering PPV in preterm infants <32 weeks to prevent uncontrolled delivery of tidal volume. • Use a pulse oximeter and blended oxygen to target oxygen saturation. • Begin resuscitation with FiO_2 between 21–30% and titrate every minute to target the NRP saturation targets.
	Supportive care	• Maintain a normal body temperature of 36.5–37.5°C. • Start early parenteral nutrition after inserting the central line in ELBW neonates. • Early initiation of enteral feeding with mother's milk. • Titrate oxygen administration by monitoring oxygen saturation using pulse oximetry. Target oxygen saturation should be between 90 and 95%. • Monitor blood pressure and perfusion. • Protocols for pain management and developmentally supportive care.

Evidence

1. Delayed cord clamping in preterm neonates is associated with a 30% reduction in in-hospital mortality, decreased need for transfusions for anemia (RR 0.61, 95% CI 0.46–0.81) and less intraventricular hemorrhage of all grades (RR 0.59, 95% CI 0.41–0.85). Other physiological benefits include better circulatory stability, better lung fluid clearance, increased cardiac output, and better tissue oxygen delivery.[11]
2. Thermoregulation: Plastic wraps applied within 10 minutes of birth to preterm or low-birth-weight neonates improve core body temperature on NICU admission and up to two hours after birth (body temperatures were 0.58°C higher compared to usual thermal care). The incidence of hypothermia was 23% lower (95% CI 0.62–0.72) with the use of plastic bags. The risk of pulmonary hemorrhage was less, but there is insufficient evidence to suggest a reduction in in-hospital mortality or other significant morbidities.[12]
3. Delivery room CPAP: Early CPAP among very preterm neonates (especially those <28 weeks' gestation) as compared to intubation and surfactant administration is associated with a reduction in the incidence of BPD at 36 weeks, (RR 0.89, 95% CI 0.79–0.99), need for mechanical ventilation (RR 0.50, 95% CI 0.42–0.59) and surfactant in the CPAP group (typical RR 0.54, 95% CI 0.40–0.73).[13]

1. Delayed cord clamping
2. Thermoregulation
3. Gentle respiratory support, and
4. Hyperoxia avoidance

Delayed cord clamping: NRP recommends delayed umbilical cord clamping for at least 30 seconds for preterm infants not requiring immediate resuscitation after birth.[16] There are no recommendations regarding delayed cord clamping in a non-vigorous infant, where resuscitative efforts take priority. Performing delayed cord clamping in preterm neonates who require immediate resuscitation at birth is a challenge and future studies are required to investigate the feasibility and safety of resuscitating neonates with an intact cord. Umbilical cord milking in preterm infants is not recommended, as a higher rate of severe intraventricular hemorrhage was noted in the umbilical cord milking group in a large RCT.

Thermoregulation: Prevention of heat loss requires multiple strategies, including increasing the temperature of the delivery room, preheating the radiant warmer, and using food-grade plastic bags or wraps. The neonate should be covered or placed inside the plastic bag without drying, and the head should be covered with a hat to prevent evaporative heat loss. The plastic wrap should be removed only after ensuring a normal axillary temperature in the NICU.

Using an exothermic heat mattress also improves temperature stabilization, but caution is needed when both plastic bags and exothermic mattresses are used simultaneously due to the risk of hyperthermia. Although studies show that plastic bags improve admission temperatures of preterm neonates, there is insufficient evidence that it improves important clinical outcomes like mortality or neurodevelopment.

Monitoring the neonate's temperature in the delivery room and using a pre-warmed transport incubator further reduce heat loss at birth. NRP recommends that the temperature of a neonate be maintained between 36.5°C and 37.5°C from birth till initial stabilization and admission temperature be recorded as a predictor of outcomes and a quality indicator of good resuscitation.

Respiratory support in the delivery room: Respiratory support aims to help establish functional residual capacity (FRC) in the lung to ensure adequate gas exchange. This is facilitated by assisting

ventilation in the least invasive manner and providing just the right amount of oxygen.

Devices for respiratory support in the delivery room: The T-piece device delivers peak inspiratory and positive end-expiratory pressure (PEEP) more consistently than a resuscitation bag[21]. Many countries report usage rates of 45–50% in the delivery room. Advantages of the T-piece device include its ease of use and ability to deliver continuous positive airway pressure or PEEP. Its limitations are the need for a pressurized gas source to drive the device, the need to turn the pressure knob to increase the PIP repeatedly, and the possibility of inadvertently delivering higher levels of PEEP.

Setting up the T-piece device: While setting the machine for preterm deliveries <32 weeks, we prefer flow rates of (5–8) lpm and PIP and PEEP of 15 and 5 cm H_2O, respectively. The FiO_2 is set between 21 and 30%. The preferred level of delivery room CPAP is 5 cm H_2O. CPAP level of 8 cm H_2O or above is associated with a high risk of pneumothorax and should be avoided.

After completing the initial steps, a spontaneously breathing neonate with respiratory distress should be offered CPAP than intubation and positive pressure breaths. Early CPAP rather than intubation in the delivery room among neonates <28 weeks' gestation has been shown in meta-analyses to produce a small but clinically significant reduction in the incidence of BPD at 36 weeks' postmenstrual age, the need for mechanical ventilation as well as surfactant.[13] However, positive pressure breaths (PPV) should be delivered *if the neonate is apneic or gasping or if the heart rate is less than 100 bpm*. A trial of PPV should also be considered if oxygen saturation is below the target range despite free flow oxygen and or CPAP in a spontaneously breathing neonate with a heart rate 100 bpm.

Role of sustained inflation (SI): Sustained Inflation refers to the delivery of PIP for a longer duration, typically from 5 to 15 seconds, with pressures varying from 20 to 30 cm H_2O for 1–3 breaths for preterm neonates exhibiting signs of respiratory distress (rescue) at birth. While studies showed short-term benefits with SI, like the reduced need for mechanical ventilation in the first 72 hours of life, there was no effect on the incidence of significant outcomes like BPD or overall mortality. Of note, pressure, time duration, and frequency of SI breaths used differed significantly in various studies, and the interface as well (endotracheal tube, face mask, or nasopharyngeal

tube). NRP does not recommend using SI for resuscitation except in individual clinical circumstances or research settings.

Avoidance of hyperoxia: Oxygen blenders capable of delivering titrated oxygen and a pulse oximeter must be available for all high-risk deliveries. The pulse oximeter sensor should first be placed on the right hand or wrist and then connected to the monitor to rapidly acquire the pleth signal. The blender should be set between 21 and 30% and subsequent oxygen administration should be based on the inter-quartile range of saturations targets as described for healthy term neonates.

Initial stabilization in the NICU: Continuing care in the NICU should focus on thermoregulation, respiratory support, and early initiation of nutrition. Spontaneously breathing preterm neonates with respiratory distress are most effectively treated with CPAP until the criteria for surfactant therapy are met. Early (<2 hours) selective surfactant therapy that is given by the "INSURE" approach (INtubation, SURfactant, Extubation) or less invasive surfactant administration (LISA) is preferred. Neonates <32 weeks' gestation are administered caffeine therapy for the treatment of apnea of prematurity or before extubation from mechanical ventilation. Caffeine therapy has been shown in RCT to reduce the risks of both short-term morbidities such as bronchopulmonary dysplasia (BPD) and severe retinopathy of prematurity and long-term neurodevelopmental impairment at 18 months and improve gross motor function at five years.[14] We initiate early caffeine therapy for neonates <28 weeks' gestation, irrespective of their respiratory support. Observational studies have shown that early caffeine initiation (0–3 days of life) is associated with less incidence of BPD, patent ductus arteriosus, and a shorter duration of mechanical ventilation.[15]

Central line insertion and early nutrition: Umbilical venous cannulation is established at birth to initiate intravenous fluids or early parenteral nutrition in neonates <1000 grams (as per unit policy) to get the lines in by 30 minutes of age. The first blood sugar is checked with line insertion and other blood work.

Interventions to minimize stress: At every opportunity, efforts should focus on reducing pain and stress by providing developmentally supportive care. These include noise reduction, gentle handling, coupling procedures, attention to skin care, and early parental participation.

Implementation of quality initiatives to improve outcomes: Several institutions that have implemented a protocolized approach to management in the "golden hour" have demonstrated improved outcomes among preterm neonates like better admission temperature and blood glucose level, a marked decrease in intraventricular hemorrhage, and faster time for umbilical catheter insertion and surfactant administration. QI studies have also demonstrated improved clinical outcomes, such as a reduction in late-onset sepsis and bronchopulmonary dysplasia and a trend toward reduction in early blood transfusion and ventilation duration.[16]

REFERENCES

1. Sahoo T, Anand P, Verma A, et al. The outcome of extremely low birth weight (ELBW) infants from a birth cohort (2013–2018) in a tertiary care unit in North India. J Perinatol. 2020: 40, 743–9.
2. Salihu HM, Salinas-Miranda AA, Hill L, Chandler K. Survival of pre-viable preterm infants in the United States: a systematic review and meta-analysis. Semin Perinatol. 2013;37(6):389–400.
3. Stoll BJ, Hansen NI, Bell EF, et al. Neonatal outcomes of extremely preterm infants from the NICHD Neonatal Research Network. Pediatrics. 2010;126(3):443–56.
4. Fischer N, Steurer MA, Adams M, Berger TM, Swiss Neonatal N. Survival rates of extremely preterm infants (gestational age <26 weeks) in Switzerland: impact of the Swiss guidelines for the care of infants born at the limit of viability. Arch Dis Child Fetal Neonatal Ed. 2009;94(6):F407–13.
5. Berger TM, Bernet V, El Alama S, et al. Perinatal care at the limit of viability between 22 and 26 completed weeks of gestation in Switzerland. 2011 revision of the Swiss recommendations. Swiss Med Wkly. 2011;141:w13280.
6. McGoldrick E, Stewart F, Parker R, Dalziel SR. Antenatal corticosteroids for accelerating fetal lung maturation for women at risk of preterm birth. Cochrane Database Syst Rev. 2020 Dec 25;12(12):CD004454.
7. Wapner RJ. Antenatal corticosteroids for periviable birth. Semin Perinatol. 2013;37(6):410–3.
8. American College of O, Gynecologists' Committee on Obstetric P, Society for Maternal- Fetal M. Committee Opinion No.677: Antenatal Corticosteroid Therapy for Fetal Maturation. Obstet Gynecol. 2016;128(4):e187–94.
9. Wolf HT, Huusom LD, Henriksen TB, Hegaard HK, Brok J, Pinborg A. Magnesium sulphate for fetal neuroprotection at imminent risk for preterm delivery: a systematic review with meta-analysis and trial sequential analysis. BJOG. 2020 Sep;127(10):1180–8.
10. Doyle LW, Crowther CA, Middleton P, Marret S, Rouse D. Magnesium sulphate for women at risk of preterm birth for neuroprotection of the fetus. Cochrane Database Syst Rev. 2009(1):CD004661.

11. Rabe H, Gyte GM, Díaz-Rossello JL, Duley L. Effect of timing of umbilical cord clamping and other strategies to influence placental transfusion at preterm birth on maternal and infant outcomes. Cochrane Database Syst Rev. 2019 Sep 17;9(9):CD003248.10.
12. Jani P, Mishra U, Buchmayer J, Walker K, Gözen D, Maheshwari R, D'Çruz D, Lowe K, Wright A, Marceau J, Culcer M, Priyadarshi A, Kirby A, Moore JE, Oei JL, Shah V, Vaidya U, Khashana A, Godambe S, Cheah FC, Zhou W, Xiaojing H, Satardien M. Thermoregulation and golden hour practices in extremely preterm infants: an international survey. Pediatr Res. 2022 Sep 8:1–9.
13. Subramaniam P, Ho JJ, Davis PG. Prophylactic nasal continuous positive airway pressure for preventing morbidity and mortality in very preterm infants. Cochrane Database Syst Rev. 2016(6):CD001243.
14. Schmidt B, Roberts RS, Davis P, et al. Caffeine therapy for apnea of prematurity. N Engl J Med. 2006;354(20):2112–21.
15. Patel RM, Leong T, Carlton DP, Vyas-Read S. Early caffeine therapy and clinical outcomes in extremely preterm infants. J Perinatol. 2013;33(2):134–40.
16. Croop SEW, Thoyre SM, Aliaga S, McCaffrey MJ, Peter-Wohl S. The Golden Hour: a quality improvement initiative for extremely premature infants in the neonatal intensive care unit. J Perinatol. 2020 Mar;40(3):530–9.