

THERMAL MANAGEMENT

A newborn baby is homeothermic, but his ability to maintain his body temperature can be easily overwhelmed by environmental temperatures. Thermal protection of the newborn is a set of continuing measures, which starts at birth, to ensure that he maintains a body temperature of 36.5°C to 37.5°C (Table 1).¹ According to NNPD 2002-2003, incidence of hypothermia among extramural babies was 18.4%.²

Table 1: Temperature ranges

Normal axillary temperature	36.5-37.5°C
Mild hypothermia or cold stress	37-36.4°C
Moderate hypothermia	32-35.9
Severe hypothermia	<32°C
Hyperthermia	>37.5°C

Thermoneutral environment (TNE)

TNE refers to a narrow range of environmental temperature at which the basal metabolic rate (BMR) of the baby is at a minimum, oxygen consumption is at least and baby maintains its normal body temperature is called thermoneutral range of temperature.² Range of neutral temperature varies accordingly for the gestation and postnatal age (Table 2).

As opposed to TNE, thermoregulatory environment refers to environmental temperature beyond TNE range, at which baby would be able to maintain its body temperature but by increasing its BMR.

The infants therefore should be kept in TNE so that their energy is utilized for growth and other vital functions.

Table 2: Thermoneutral zone

Weight of the baby	Recommended ambient temperature			
	35°C	34°C	33°C	32°C
Less than 1500 g	1 to 10 days old	11 days to 3 wk old	3 wk to 5 wk old	More than 5 wk old
1500 to 1999 g		1 to 10 days old	11 days to 4 wk old	More than 4 wk old
2000 to 2499 g		1 to 2 days old	3 days to 3 wk old	More than 3 wk old
≥2500 g or more			1 to 2 days old	3 days old or more

Recording temperature

It is not necessary to measure the temperature of healthy newborn babies routinely, particularly when the warm chain is strictly followed.

Temperature should be monitored every 1-2 hour for a baby with serious illness, twice daily for babies weighing between 1500 to 2499 gm, four times daily for babies below 1500 gm and once a day for other babies who are doing well.

Methods of recording temperature

Touch method

Abdomen skin temperature is assessed by touch with dorsum of hand. Abdominal temperature is representative of the core temperature. Baby's temperature can be assessed with reliable accuracy by human touch, which can be easily taught to parents and can be practiced at home as well. The interpretation is as follows:

- Baby's feet and hands are warm: Thermal comfort
- Peripheries are cold, the trunk is warm: Cold stress
- Peripheries and the trunk both are cold: Hypothermia

Thermometers

WHO recommends the use of low reading thermometer which can record up to 30°C. American Academy of Pediatrics (AAP) recommends against using mercury thermometers because the glass can break, and mercury is poisonous.³ The best is to use a digital thermometer.

Thermister probe

Skin temperature can be recorded by a thermister. The probe is attached to skin over upper abdomen. The thermister will sense the skin temperature and display on the panel.

The concept of warm chain

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

1. Thermal care in delivery room

After birth, newborn's temperature can drop at a rate of 0.1°C and 0.3°C per minute for core and skin temperature respectively. Delivery room needs to be prepared much in advance. The room should be clean, warm (at least 25°-28°C) and free from draughts from open windows and doors or from fans.

If the temperature of the room is less than optimal, a heater should be available to warm the room. All the towels, blankets, caps, baby's clothes should be prewarmed. The radiant warmer should be switched on at least 20 to 30 minute in advance and put into manual mode with 100% heater output.

2. Warm resuscitation

3. Immediate drying

After birth, the baby should be immediately dried with a dry towel, starting with the head. After drying thoroughly, the baby should then be covered with a second, dry towel and a cap put on its head.

4. Skin-to-skin contact

Baby can be kept in mother's chest in skin contact while mother is being attended including placental delivery, episiotomy, suturing, transferred and kept in postnatal ward for initial few hours. If a baby is in cold stress, the baby should be immediately put in skin to skin contact with mother.

5. Breast feeding

Breast feeding should begin as soon as possible after birth preferably within an hour. This ensures adequate supply of calories for heat generation.

6. Bathing / weighing postponing

Bathing should be postponed in a term baby at least till next day. Weighing should be done only after covering the baby adequately and making zero correction for clothing.

7. Clothing and bedding

Newborns should be covered with one (or) two layers of clothes and cap, socks and hand gloves. Swaddling, a custom of wrapping bands should be avoided.

8. Rooming in

Babies and mother should be attached together for 24 in the same bed and breast fed on demand.

9. Warm transportation

In case of transport- whether to home, to another hospital / another section, thermal protection should be ensured. Stable babies including preterm and LBW babies should be transported well wrapped and in skin to skin contact with mother.

VLBW, unstable, admitted babies should be transported using an incubator. Temperature should be checked before and after transport. All peripheral hospitals caring for high risk mothers should go for in-utero transfer as early as possible.

10. Training and awareness rising:

All the health care personnel involved in the newborn care should be adequately trained and informed about the principles of warm chain.

Thermal management in preterm babies

Apart from the routine procedures and adhering to warm chain, extra care is required for preterm babies.

Polythene occlusive wraps

NRP 2010 recommends the use of polythene wraps for all babies <28 weeks this technique involves the covering the premature infant in a polyethylene bag or a cover that can be applied on neck, drying of the baby is not done. The baby should be immediately received on to a radiant warm. Wrapping reduces evaporative heat loss, while allowing radiant heat delivery to the baby.⁴

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 babies <28 weeks gestation⁵

All preterm babies <34 weeks should be admitted and nursed either in a radiant warmer / preferable in an incubator. All preterm babies when transferred to open cot / to mother, kangaroo mother care should be started and be ensured minimum 10-14 hrs a day.

Incubators

Incubators should be preferred over radiant women for the care of preterm babies.⁶ Incubators decrease the insensible water loss (IWL), but radiant warmers rather increase the IWL. Infant's temperature is regulated by controlling the air temperature within the hood to provide an optimal TNE or by servo-control of the heating device to the infant's skin temperature.

a) Mechanisms

Convective heat loss dependent on air flow, the incubators reduce the exposure of babies to air currents. Evaporative process of heat loss will be limited by providing maximum possible relative humidity within the incubator. Radiative heat losses are minimized by the hood on the baby or by using double walled incubators.

The modern incubator incorporates a transparent plastic hood with various access ports. A warming device is positioned below the bed surface and air is blown over the warming element. Air or air-oxygen mixture is humidified using a quiet fan; the warm humidified air is then circulated through the hood to attain a uniform temperature within. A low rate of air circulation, ideally not more than 20-30 lit /min minimizes convective heat losses and noise level should be kept below 60 db.

Double wall vs. single wall incubator: what is evidence?

Double wall incubators which has an additional inner wall suspended. The double wall incubators had advantages as far as decreasing heat loss and decreasing heat production.⁷

b) Practical tips

- In air mode, desired temperature of the environment around the baby is set and the heater output adjusts itself to maintain this. The appropriate set temperature is decided by using the thermo neutral temperature charts
- In servo mode, the desired skin temperature is set to 36.5 C. The feedback system modifies heater output to keep the baby temperature constant
- For sick babies, servo mode is preferred. Because, the servo mode, it helps to assess the temperature requirement for the baby. Set the temperature at 36.5°C. The probe should be properly positioned, if it gets dislodged, there is a danger of overheating
- Switch to air mode when the baby is stable. Air mode is preferred for procedures also. When switching over to air mode, set the air temperature to equal the average incubator air temperature during the previous day of skin mode

c) Humidification

Humidity should be started in all infants ≤ 31 weeks gestation at 85% humidity.

- **Infants of 28-30 weeks:** If temperature remains stable for 24 hours, start to decrease humidity by 5% day by day.
- **Infants of <28 weeks:** Maintain humidity of 85% for first 7 days and if stable for 7 days, decrease humidity by 5% daily.

Humidification chamber

One should fill the chamber for humidification with appropriate volume of sterile distilled water. Since this water can be potential source of infection, it must be changed daily completely. The chamber should be washed and dried thoroughly with clean towel clothes.

Weaning from incubator

There is no clear cut recommendation on what is the exact weaning time from open incubator to cot⁸.

The baby can be weaned, when the baby started consistently gaining weight, maintain eutheria when ambient temperature $< 30^{\circ}\text{C}$. After weaning to open cut, the axillary temperature should be checked and then every 4 hourly as of routine.

Radiant warmers

Radiant warmer is an 'open care' convenient system for management of preterm and > 1800 g babies, because maintenance is easy and allows easy access for doing procedures, but the disadvantage is that insensible water is greater increased under radiant warmer.

a) Principle

The radiant warmer produces radiant heat by a heating rod usually made of quartz crystal; this is uniformly reflected onto the surface by parabolic reflectors. They also reduce conductive heat loss by warming the microenvironment.

b) Modes

Skin servo mode of control is preferred over manual mode. Servo control is a mode in which the heater output is determined automatically by the information based on the skin temperature. In servo, set the skin temperature at 36.5°C, cover the infant's head, arms and legs, only stable babies should be clothed. Room temperature should be sufficiently high at least 25°C/77°F.

Manual mode is a mode in which operator himself determines the heater output, not routinely used because of risk of overheating or under heating. Manual mode is used for prewarming the linen, rapid rewarming of hypothermic baby and if the baby has fever.

c) Practical tips

- If on manual mode baby's temperature should be checked at least every 15 minutes
- There should never be more than one baby under a warmer as this may allow cross infection, unequal heat distribution
- In small babies, cling wraps made of polythene sheets can be used for covering the tops of side walls which will help in reducing the insensible water loss
- One of the disadvantages of radiant warmer is that of increased water loss, hence it is advised to give extra fluid and proper daily weighing in small babies.

Heated water filled mattress:

It is an economical device for keeping LBW/sick babies. 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 and it keeps the temperature of water at 35-38°C. This is not routinely used, because of practical difficulties.

Portable infant warmer-PCM devices

1. It consists of a precision heat source used to melt wax within 30 minutes. Models exist that work both with and without electricity.
2. It consists of a sealed pouch containing PCM. Maintains 37°C for 4 hours without electricity pouch can be reheated repeatedly.

Some in vitro studies have proven the efficacy of phase changing materials which constantly maintain the temperature of the LBW over a defined time period. Trials are needed to assess the efficacy of PCM as a modality for effective thermal management in newborns.

Kangaroo mother care:

For LBW babies, who are stable, KMC is perhaps the most effective way of keeping babies warm. KMC is a no cost, easy, applicable at home, which has multiple added advantages. Regular breast feedings and skin-skin contact are encouraged for all LBW babies who are prone for hypothermia.

Hypothermia:

Clinical features of hypothermia can be discussed under the four different situations

- a) Initial signs of hypothermia are generally those which appear because of peripheral vasoconstriction like pallor, acrocyanosis, cool extremities, decreased peripheral perfusion, there can be early signs of CNS manifestations like irritability.
- b) Later signs include features of CNS depression like lethargy, bradycardia, apnea, poor feeding, hypotonia, weak suck or cry, emesis. Because of increase in pulmonary artery pressure, there can be symptoms of respiratory distress mainly tachypnea. 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, sometimes, PPHN like situation, ARF in extreme case high likelihood of mortality.
- d) Chronic periods of cold stress lead to weight loss and poor weight gain.

Management:

a) Cold stress

- Cover the baby adequately- remove cold/wet clothes, cover the baby adequately with warm clothes
- Warm the environments including room / bed
- Ensure skin to skin contact with mother, if not possible, kept next to mother after fully covering the baby
- Immediately breastfeed the baby
- Monitor axillary temperature every ½ hr till it reaches 36.5°, then hourly for next 4 hours, 2 hourly for 12 hours thereafter

b) Moderate hypothermia:

In this situation, one should provide the baby with additional source of heat.

- Maintain skin to skin contact
- Warm room / bed
- Take measures to reduce heat loss
- Provide extra heat by room heater, radiant warmer, incubator, applying warm towel or using phase changing mattresses

c) Severe hypothermia

- All babies with severe hypothermia (<32°C) should be immediately admitted to the hospital
- Rapid rewarming should be done immediately which can be done using a radiant warmer or air heated incubator
- Rapid rewarming is done up to 34°C, then slow rewarming to 36.5°C
- Take all measures to reduce heat loss
- Start IVF at 60-80 ml/kg of 10% dextrose
- Possible oxygen if needed
- Check whether the baby received Inj vit K or not. Give Inj vitamin K 1mg in term and 0.5mg in preterm babies
- If not improving immediately, think of causes like sepsis

Hyperthermia

Hyperthermia is also a common problem with neonates. Very common in dry warm climate areas. Temperature of more than 37.5°C is defined as hyperthermia in newborns.

a) Causes

- Too hot environment – high room temperature
- The baby has many layers of covers / clothes
- Dehydration fever – the baby may be in a dehydration state
- Sepsis

b) Dehydration fever

Dehydration results in excess weight loss for the baby and hence one of the important clue for dehydration fever is excess weight loss. Fever generally subsides with correction of breastfeeding issues or when extra feeds given properly.

c) Symptoms

Early: Irritable, tachycardia, tachypnea, flushed face, hot and dry skin

Late: Apathetic, lethargic and then comatose

Severe forms of hyperthermia can lead to shock, convulsions, even death in neglected cases

d) Management

Place the baby in a normal environment (25-28°C) away from heat source

- Undress the baby partial / fully
- Give frequent breast feeds give breast milk or by katori spoon if needed
- If temperature >39°, sponge can be done with tap water

 **Practice tip:** Don't use cold / ice water for sponge. Tap water is good enough

Research issues: Research issues relevant to Indian context are outlined here

SN	Research question	Subjects	Study design	Intervention	Outcomes to be measured
1	What is the Outcome of neonates who have suffered prolonged severe hypothermia?	Documented severe hypothermia	Cohort study		Mortality and neurodevelopmental Outcome at 2 years
2	What is the incidence and seasonality of hyperthermia Among newborns in tropical climates?	All neonates eligible	Observational studies		Incidence of hyperthermia, dehydration in relation to seasonality and different climate zones in a tropical country like India
3	Evaluation of new methods of thermometry in neonates	All neonates eligible	Comparative studies 1. Mercury vs Infrared thermometry 2. Mercury vs Phase change thermometers		Individual difference in the accuracy of body temperatures and correlation with core temperatures
4	What is the efficacy of phase changing materials in thermal maintenance?	LBW neonates	Comparative studies		Average axillary and core temperatures, incidence of cold stress and hypothermia

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