East of England Neonatal ODN
(Hosted by Cambridge University Hospitals)

Clinical Guideline: Thermoregulation

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For use in: EoE Neonatal Units
Guidance specific to the care of neonatal patients.

Used by: Healthcare professionals giving direct care to neonatal patients

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Date of meeting	**7th September 2022**

I confirm that the guideline "Thermoregulation" was approved at the COG on the date above and consequently ratified by the ODN Board on the date stated.

Liz Langham Neonatal ODN Director

Audit Standards:

1. Admission temperatures are audited quarterly and actions taken where results are not optimal
2. The well and the sick term/ preterm infant has appropriate early thermal care in delivery according to their gestation / condition
3. Measures are taken to maintain a thermal neutral environment

4. Staff, parents and carers are educated about the important aspects of thermal management

Thermoregulation Guideline
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1. Introduction.

Thermoregulation is the capacity to maintain equilibrium between heat production and heat loss in order to sustain body temperature within a normal range[16]. Hypothermia and hyperthermia may have serious metabolic consequences for all newborns.[24] To minimise these effects, an environmental temperature at which the infant uses minimal rates of oxygen consumption and expends the least energy to maintain its temperature is needed. This is defined as a neutral thermal environment[15].

WHO Classifications of core body temperature for newborns[1]:

- Normal = 36.5-37.5ºC [36,37,38]
- Mild Hypothermia or Cold Stress = 36-36.4ºC – cause for concern
- Moderate Hypothermia = 32-35.9ºC – danger, warm baby
- Severe Hypothermia = <32ºC – outlook grave, skilled care urgently needed.

2. Purpose.

To maintain a neutral thermal environment, individualised to the infant's requirement by:

- Reducing heat loss
- Ensuring an environment suitable to the infant's gestation and current health status.

3. Scope.

Any infant delivered on the Maternity Unit or cared for on a Neonatal Unit.

4. Clinical Symptoms of Temperature Instability.

4.1Signs of Hypothermia[17]

- Shallow breathing, apnoea and bradycardia
- Decreased activity and apparent lethargy
- Hypotonia with diminished reflexes
- Pale mottled skin – cool to touch, cold extremities
- Weak suck, poor feeding, poor gastric emptying, abdominal distension
- Hypoglycaemia

4.2 Signs of hyperthermia due to overheating.[22]

- Tachycardia, tachypnoea, apnoea
- Hypotension

- Warm extremities, flushing, perspiration
- Lethargy, hypotonia, poor feeding
- Central temperature lower that peripheral temperature

4.3 Signs of hyperthermia due to fever.[22]

- Pale, cool extremities
- Core temperature greater than peripheral temperature

5. Methods of Heat Loss.

It is important to understand the mechanisms of heat loss, to minimise their effect on the newborn. Infants lose heat through their skin and respiratory tract to the environment through evaporation, radiation, convection and conduction.

- Evaporation- Heat is lost when water evaporates from skin or breath.
- Convection- Heat is lost to currents of air.
- Radiation – Heat is lost via electro-magnetic waves from skin to surrounding surfaces. e.g. an infant placed near a cold wall will lose heat to that surface.
- Conduction – Heat is lost to surfaces with which the baby is in direct contact.[30,31]

6. Care of the Term Infant in the Delivery Room.[40]

This is aimed at reducing the number of Term infants being admitted into NICU

6.1. Environment.

- The delivery room should be at 23-25ºC but aim ≥25ºC if ≤ 28 weeks [1,29]
- Windows and doors should be shut and fans turned off to limit draughts.
- Air conditioning should be adjusted**.**
- Preparation for skin-to-skin should be made (see local guidelines on skin to skin) and supplementary heating such as an overhead heater should be available in case it is required for clinical care.

6.2. Drying.

- Dry the infant with a pre-warmed, absorbent towel to reduce evaporative heat loss.[1]
- Whilst being dried the infant should be on a warm surface – either the mother's chest or abdomen, on another warmed towel or under a radiant warmer.
- Remove any wet towels.
- The head should be covered with preferably a wool-like hat to prevent heat loss.[6]
- Wrap in a dry prewrmed towel or blanket or prepare for skin to skin.

- If not to be nursed skin-to-skin (through parental choice or clinical condition of the mother) but is to remain with their mother, the infant should be dressed in pre-warmed clothes and hat then wrapped in blankets.

6.3. Skin to Skin [2, 3, 4, 5]

Please refer to local skin to skin guidelines for more detailed guidance

- Ensure mother is aware of the advantages of skin to skin for thermoregulation.
- After drying and covering head with a hat, place on the mother's chest and cover baby and mother with pre-warmed blankets – this will help reduce conductive heat loss.
- During skin to skin, regularly monitor head position (airway), breathing colour, tone.[9,43]
- If mother is unable to undertake skin to skin safely (due to pain, invasive procedures or drowsiness) skin to skin may be undertaken by the other parent or support person if this is agreed. The above steps and checks should still be performed.

6.4 Handling and Weighing.

- Term infants should be weighed in clean scales which are lined with a warmed towel.
- Weighing should be completed after skin to skin.[9,43]
- Always warm hands before touching the infant.
- If an examination is made ensure that the stethoscope is warmed by your hands before applying it to the infant's chest.[30.31]

6.5. Measuring the temperature

An axilla temperature should be taken within or soon after the first hour of birth
Consider taking a temperature earlier if:

- there is a suspicion that the infant is becoming hypothermic,
- the infant was resuscitated at birth.

6.6 Hypothermia

- If the infant becomes cold and this is not resolved through appropriate skin-to-skin, they should be placed naked under a pre-heated radiant heat source with the plastic side panels up to create a warm environment and minimize heat loss.
- The hat and nappy should remain in-situ.
- Alternatively, they should be placed on a warming mattress or hot cot with only one sheet between the infant and the mattress. More warmed bedding should be placed over the infant.[30,]

7. Care of the the Preterm Infant or Sick Newborn in the Delivery Room or theatre.[38]

7.1 Environment.

- Ensure that the delivery room/theatre or where the baby is to be resuscitated is warm (23-25ºC but aim ≥25ºC if ≤ 28 weeks). [23,24,38]
- Windows and doors should be shut and fans switched off to limit draughts.
- Radiant heaters should be turned on to maximum.
- Towels and hats should be warming on the radiant warmer.
- More towels and blankets should be warming in the room ready for use.
- An axilla temperature should be taken on delivery unit prior to transfer for **all infants** who require admission to the neonatal unit or transitional care ward.[38]

7.2. Very Preterm Infant (≤32weeks gestation).

- Place feet first, into a pre-warmed polyethylene bag or jacket on the radiant warmer platform.
- The infant should be placed in the polyethylene bag or jacket so that it covers the back of the head but leaves the face free.[9,10,11,12,38]
- Keep the bag closed and covering the baby (leaving the face free) at all times. When siting a saturation probe, ensure the arm is placed back into the bag as soon as possible. Auscultate the heart rate through the plastic back to minimize evaporative heat loss.
- Put a wool likehat on the infant to minimise heat loss.[7]
- Do not cover the polyethylene bag with any towels as this will prevent the heat from reaching the infant.
- If the resuscitation is prolonged the output from the radiant heater should be adjusted as required to maintain a normo-thermic temperature.
- Commence continuous temperature monitoring and continue throughout stabilization and transfer to NICU.[45]When stable, with the infant still in the polyethylene bag, transfer to the unit. Maintain body temperature by providing a heat source for safe transfer, e.g. portable incubator, trans-warmer mattress.[13, 30]

7.3. Preterm Infant (>32 -36 weeks gestation).

- Place infant on radiant warmer and dry with warm towels.
- Remove wet towels and wrap the infant in a dry towel.
- Place a woolly hat on the infants' head to limit heat loss.
- Any baby who required resuscitation measures post-delivery; should be assessed and either transferred immediately to the unit maintaining a neutral thermal environment or, if not requiring any respiratory support, may stay with the mother for skin to skin as appropriate for gestational age.
- Infants of 35+ weeks who did not require resuscitation, but demonstrate hypothermia despite appropriate skin to skin, can be placed in a cot with a heated mattress.

- Infants of 35+ weeks gestation who have not required resuscitation and have a normal temperature can remain with mother for skin to skin.

7.4. Sick Term Infant.

- Dry unless contraindicated – for example, because there is a need to assess their airway first because of concerns such as or diaphragmatic hernia
- Remove wet towels, cover with a warm dry towel and put on a hat.
- If the infant has an abnormality that involves a large surface area of skin (such as gastroschisis or myelomenigocele) the area should be covered with cling-film or plastic wrap to limit evaporative loss.[25]
- If the infant is neurologically suppressed their ability to produce heat may be affected. The infant's temperature should be continuously monitored to ensure they remain warm until the decision to cool has been made. See East of England guideline for therapeutic Cooling[24].
- A sick infant may have decreased muscle activity and therefore be unable to retain or produce heat by activity/flexion.
- If the resuscitation is prolonged the output from the radiant heater should be adjusted as necessary.
- Once stabilised, the infant should be wrapped in warm, dry towels and a have an axilla temperature taken prior to transfer.
- The baby should be transferred to NICU with a suitable heat source (eg.transport incubator) in-situ to maintain normothermia.

8. Therapeutic Cooling.[14, 24]

Infants with suspected Hypoxic Ischaemic Encephalopathy (HIE) who meet the criteria may be considered for treatment with cooling. The decision to cool should **ideally be made within 4-6 hours of delivery and after a full neurological examination has been undertaken.**

Adhere to therapeutic guidelines for therapeutic Cooling.[24]

9. Ongoing assessment of temperature following admission to NICU

- The temperature of any sick newborn or preterm infant should be measured continuously and recorded hourly using a skin probe.
- This should be checked 6-8 hourly against an axilla temperature measurement.
- The frequency of checks should be increased if temperature is outside the normal range. (30-60 minute intervals until temperature stable within normal range) [32]

9.1. Axilla temperature on Admission.[29,]

Axillary temperature approximates to the core temperature

- The thermometer used should read down to 25^0C.
- Use an electronic thermometer.
- Infra-red devices should not be used in incubator/radiant warmers as they are influenced by the ambient temperature.

9.2. Placement of the skin temperature probe [15]

- The skin temp probe should be placed on the lower abdomen if nursed supine or back if nursed prone.[44]
- If probe is secured a hydrogel based probe cover should be used
- Do not place probe over broken skin.
- If the infant's position is changed the probe position should be changed to reduce the risk of pressure wounds. The infant should not be laying on the probe.
- Check the position of the probe to prevent over or under-heating.

9.3. Measurement of toe-core gap (c-pT)

Using one temperature will offer a guide as to how warm or cold the infant is but will give not further information. Measuring the gap between the core and peripheries will give an early indication of cold stress, hypovolaemia, infection and iatrogenic over-heating - c-pT >2-3^{o}C is abnormal.[28,]

- The core temp probe should be placed over the abdomen or the back if nursed prone.
- The peripheral temp probe should be placed on the sole of the foot.

9.4. Method of temperature control.[32]

- Incubators provide heat using either Air control or Servo control mode. Both methods require careful monitoring and appropriate setting of alarm limits.
- Air control mode may result in greater variance in the infant's temperature but a more stable incubator temperature.
- In Servo control mode there is a greater variance in incubator temperature but a more stable infant temperature may be seen.[42] Servo control should be the preferred method for small or sick infants.
- The position of temperature probe is important in both modes. A poorly placed or fixed probe may result in under or over heating.
- In air mode, confirm axilla temp and skin temp position/fixing prior to making incubator air temp adjustments.
- Incubator temperature should be documented hourly in order to identify trends and shifts in environmental temperature.
- If the incubator temperature is fluctuating or rapidly increasing, check the axilla temperature and temperature probe position. If temperature probe is well positioned and fixed, consider escalate for medical review.[32]

10. Incubator Care guideline.

10.1. Equipment.

- Intensive care incubator, checked and assembled correctly
- Temperature probes and hydrogel covers if required
- Warm bedding and positioning aids in place Hat
- Sterile water for incubator humidity (if required <30weeks gestation)

10.2. Admission procedure.

1. Doors and windows closed to prevent draughts.

2. Pre-warm incubator to 35^{0}C (all probes to be attached should also be warming in the incubator). Increase incubator temperature to 37^{0}c if gestational age is below 28weeks.

3. The incubator lid should be lowered as soon as possible after admission and procedures performed through the portholes. If the incubator lid needs to be lifted it is important to ensure that the radiant heat source is on a high setting. Frequent checks on the monitored temperature are required as there may be rapid heating. As soon as the procedures are finished the roof should be closed.

4. The polyethylene bag or jacket should be left in situ until lines are in place, unless contaminated with body fluids.

5. On admission the infant should be weighed (preferably on in-bed scales). If standard scales are used, a pre-warmed towel should line the scales and the baby should be wrapped (the weight of the towel/sheet can be deducted from the weight).[1]

6. An axilla temperature should be taken and recorded within 10 minutes of admission.[36] If the temperature is less than 36.5ºC check the position of probe and ensure the bedding is dry. With sick neonates, consider commencing toe and core temperature monitoring as outlined in *section 9.2*. A drop in the peripheral temperature should be escalated to the medical team.

7. The infant should have a hat on to reduce heat loss and a nappy if appropriate. Any covering for comfort during procedures should be removed at the end of the procedure.

8. If the incubator has a warm air curtain boost this should be used during any procedures to limit heat loss

9. The incubator should be set to maintain the infants' temperature between 36.7ºC and 37.2ºC (this allows action to be taken prior to the temperature moving out of accepted range 36.5ºC-37.5ºC).

10. If using air control mode, alter the incubator temperature 0.5ºC-1ºC approximately every 30 minutes, depending on the extent of temperature instability.[32]

11. If using servo mode closely monitor incubator temperature and skin probe placement.

12. Axilla temperature checks should be made every 30-60 mins after adjustments until the temperature has stabilised.

13. As soon as all lines are in situ and x-rays have been completed the humidity should be set to 80% if required. Once the humidity is at this level the plastic bag can be removed.

14. If using humidity (refer to network humidity guidelines[40)] nurse baby only in a nappy as clothes will become damp. Bedding should be checked regularly for dampness and changed.

15. If the infant becomes hyperthermic – check probe sites, check that the air ducts in the incubator are not blocked. If in air control mode, reduce the incubator

temperature. For babies in humidity, consider reducing humidity level if due for reduction. Consider an infection screen if not thought to be iatrogenic.

11. Weaning from an Incubator to a cot.[33]

Indicators for weaning are:

- At least 32 weeks corrected gestational age
- Medically stable enough to be dressed and covered in blankets.
- Consecutive weight gain appropriate to age and gestation

- Research relating to the optimum weight for a baby to maintain their temperature in a cot without affecting weight gain is 1600gm, although gestational age and maturity of the infant and incubator settings should be taken into consideration[34]
- Monitor location of cot for draughts from windows or vents that may impact on the infant maintaining a normo-thermic temperature.

11.1. Weaning from an incubator to hot cot/ warming mattress.

Indicators for using a hot cot: See above

- Start the hot cot at 37ºC (or as recommended by manufacturer's guidelines), cover the mattress in a sheet only; do not use a nest to avoid too many layers between the mattress and baby, reducing its effectiveness.
- If boundaries are required, use a folded towel or sheet.
- A variety of hot cots are in use within the network and the use of clothes and dress should be in accordance with manufacturer's recommendation for the type of mattress in use. This should be reviewed each shift.
- Ensure an axilla temperature is taken 30 minutes post transfer or if the mattress temperature has been adjusted and then at least 4-6hourly.
- Adjust the mattress temperature accordingly.
- If the axilla temperature is below 36.5ºC the mattress can be increased to a maximum of 37.5ºC. If the infant is still unable to maintain a normo-thermic temperature, return them to an incubator.

11.2. Weaning from a hot cot to a cot.

- Follow manufacturer's guidelines for weaning hot cots in use in your area
- Wean gradually ensuring the infant remains normo-thermic.
- Discontinue once the infant is normo-thermic in an open cot in clothing appropriate for a home setting. Recommendations for parents by the Lullaby Trust suggest a vest and sleepsuit when inside.[41]

- A waterbed must be removed once the infant does not require it. An unheated waterbed is a cold surface and will cause temperature instability.

12. Care guideline for infants' 32–40+ weeks gestation.

12.1 Equipment.

- Basinet cot / hot cot
- Scales
- Axilla thermometer
- Heated mattress
- Bedding
- Clothing and hat

12.2 Admission procedure

1. Doors and windows closed to prevent draughts.
2. Weigh the infant on the scales on pre-warmed towels.
3. A baseline axilla temperature should be recorded. If the temperature is less than 36.5ºC and additional heat source will be required (e.g. heated mattress, transwarmer mattress).
4. The infant should be dressed in at least two thin layers of clothing (vest and babygro) with a hat.[41]
5. If using a heated mattress the infant should be placed on a single sheet and covered with a sheet and blanket (not wrapped in them). The cot should be set at 37ºC (or as per manufacturer's guidelines) and titrated as required.
6. The infant's temperature should be monitored frequently or continuously and adjustments made to the temperature of the heated mattress a necessary.
7. Once a term infant is maintaining a normothermic temperature the heated mattress should be removed. **(see 11.2 for guidance on weaning)**
8. The preterm infant may require longer term care on the heated mattress.
9. If an overhead radiant source is used the temperature should be monitored continuously. If the temperature does not stabilise within 30-60mins an alternate heat source should be used.

13 Bathing[23,27]

- Bathing should be delayed until 24 hours after birth. If this is not possible due to cultural reasons, bathing should be delayed for at least six hours.[23]
- The infant's temperature should have stabilised before bathing[7] (3 readings of T36.5ºC-37.5ºC at least one hour apart)
- The bathwater should be maintained at approximately 37°C for all babies.

Appendix 1: Definition of terms

Heat production

The newborn infant has limited abilities to produce heat by changing position to preserve heat or shivering. The primary source of heat production in the newborn is non-shivering thermogenesis which uses brown adipose tissue[17].

Non-shivering thermogenesis

In very preterm infants brown adipose tissue (BAT) is utilised from 26 weeks gestational age to generate new heat in response to cold stress[18]. BAT has a high concentration of stored triglycerides, has a close network of sympathetic nerve endings and each cell has numerous mitochondria with an uncoupling protein which is concerned with heat production. This protein enables fat to be utilised as heat in the presence of noradrenaline rather than energy[19]. Non-shivering thermogenesis occurs as a response to rapid heat loss at removal from the warm intrauterine environment to the relatively cold external environment[20].

Mechanisms of non-shivering thermogenesis

Thermogenesis is initiated by skin cooling, oxygenation and separation form the placenta. Skin receptors stimulate the release of noradrenaline which act on the brown adipocyte receptors, release thyroxine and initiate the metabolism of brown fat. This process is reliant on adequate glucose, fatty acids and oxygen.

Hypothermia

Cold stress is defined as a core temperature <36.5°C which has been shown to affect many systems[1]:

- ↑ metabolic rate leading to ↑ oxygen consumption = hypoxia
- ↑ calorie consumption and ↓ glycogen stores = hypoglycaemia + acidosis
- Peripheral vasoconstriction ↑ diuresis leading to ↓cardiac output = acidosis
- Pulmonary vasoconstriction, ↓ surfactant production
- Loss of weight or failure to gain weight
- Thermal shock leading to disseminated intravascular coagulopathy

Hyperthermia

Hyperthermia (>37.5°C)[35,36,37,] is rare and is usually iatrogenic. It is important to identify that the condition is not caused by a fever. Hyperthermia can lead to:

- Peripheral vasodilatation
- ↑ Metabolic rate ↑ oxygen consumption
- ↑ insensible water loss = dehydration

Neutral thermal environment (NTE)

This is the environmental temperature at which oxygen consumption at minimum and the metabolic rate is at minimum and thermoregulation is achieved by basal non-evaporative physical processes alone[15]. This means that no additional calories are used for heat production or heat loss. The ambient air temperature required to maintain NTE is dependent upon weight, gestational age, and postnatal age and each infant has his or her own individualized neutral thermal environmental temperature.

Appendix 2 : Neonatal responses to thermal stress

Characteristic	Preterm	Full term
Skin	Thin	Thick
Blood Vessels	Uninsulated, poorly reactive	Insulated, vasoactive
Adipose	Poorly developed	Well developed

Posture	Unable to flex	Well flexed
Body Water Content	High	Lower than preterm
Glucose Store	Poorly developed	Well developed
Physical Condition	Usually compromised	Usually hardy

Ability to cope with thermal stress[21]

Responses to cold stress are going to be more exaggerated in the preterm infant who has less brown fat, poor vasomotor response, less insulation and their ability to mount a biochemical response to cold is immature. However all neonates are at risk in the first 8-12 hours of life especially if there are additional problems[10]:

- Gastroschisis or exomphalos, neural tube defects
- Poor skin integrity
- Receiving paralytic medication
- Hypoglycaemia (who cannot generate BAT oxidation)
- Sepsis
- Prolonged resuscitation or birth suppression
- Persistent pulmonary hypertension and hypoxia
- Infants who are small for gestational age

Appendix 3: Methods of Providing Thermal Stability

Radiant Warmers

Advantages:

Provide energy to heat the infant's skin and allow direct access, decrease radiant heat loss and provide a suitable environment for initial stabilisation procedures

Disadvantages:

Radiant warmers increase insensible water loss and convective heat loss which can in turn increase the metabolic rate and oxygen consumption, therefore need if used for any length of time it is important to create a micro-climate for preterm infants.
Use:

- The infant must be naked or the heat will not be effective
- Efforts made to limit draughts around the warmer
- The warmer should be pre-warmed before use
- The heater should be at the recommended distance from the infant
- A temperature probe should be positioned 'skin-to-mattress'[44]
- If infant <30 weeks create a humid micro-environment if a closed incubator is not available
- Assess and adjust the fluid intake to compensate for insensible water loss

Incubators

Advantages:
Double walled incubators provide heat by circulating warmed air and limit radiant heat loss
Disadvantages:
Access is limited where stabilisation required and there are temperature fluctuations when the doors and portholes are open. If the incubator is single walled there is more radiant heat loss to the cooler surfaces.

- Pre-warm the incubator according to the infant's gestation between 36-38°C
- Use in air control mode
- A temperature probe should be positioned 'skin-to-mattress'[44]
- Add humidity to address evaporative heat loss and insensible water loss
- Do not obstruct the airflow with bedding
- Remove non-essential items if humidity is in use

Hot cots

Advantages:
The hot cot is a simple device that is effective at preventing and treating hypothermia in the delivery suite or special/transitional care unit. It is as effective as an incubator for nursing the well preterm infant and enhances bonding with the parents as a physical wall is not interposed between them.

Disadvantages:
If used to warm near term infants, the hot cot should be removed once the temperature has stabilised as the infant may become too warm and start to sweat, inducing further hypothermia.

- re-warm the mattress 37°C
- Do not use nesting devices

- Monitor the infants' temperature regularly

Transport incubators

Advantages:
Transport incubators provide a warm environment when infants require moving either between hospitals or intra-hospital.
Disadvantages:
The gas used on the transport incubator is rarely warmed and can lead to increases in insensible water loss.

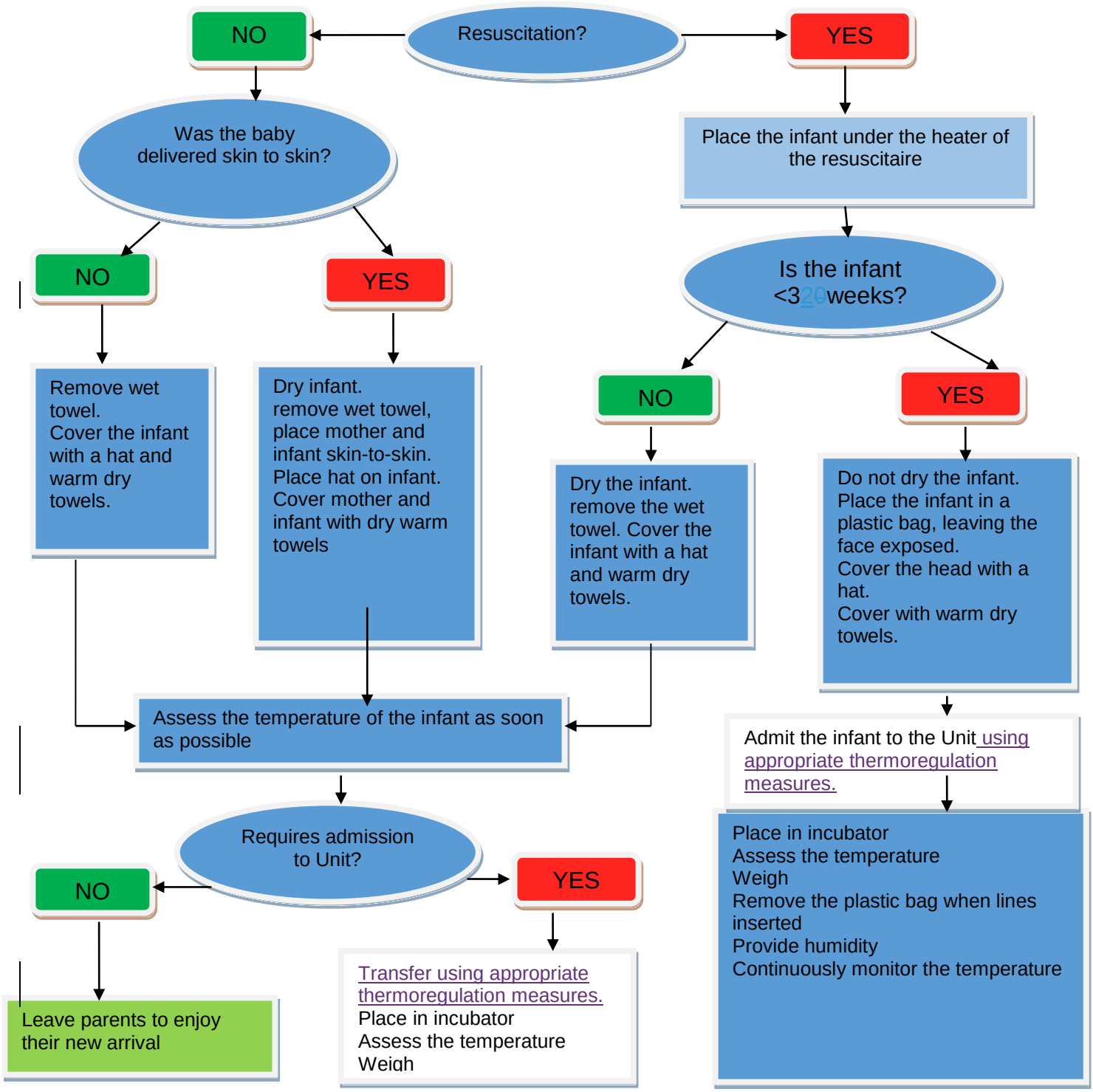
- Pre-warm the incubator 35-38^{o}C
- Ensure that supplementary heating is available for the very preterm infant (chemically heated warming mattress, plastic bag)
- If humidity is availability for the gases this should be applied

Transwarmer mattress.[34]

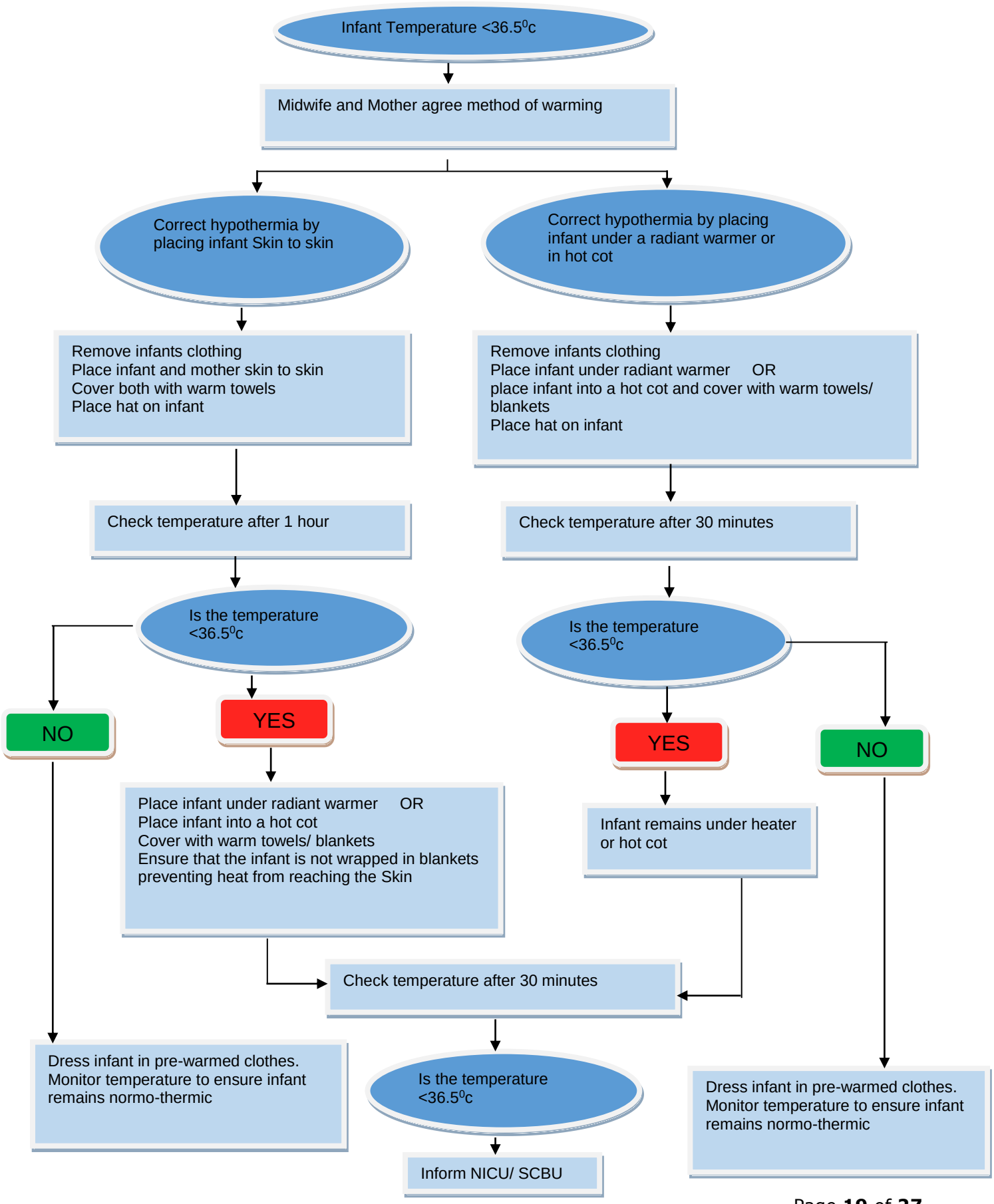
Advantages:
Heats up quickly and provides continuous heat for up to 2 hours without an external power source.
Disadvantages:
Only lasts for 2 hours, short term solution.
Heats up to a set temperature of 38^{o}C with ambient temperature of 22^{o}C, if used with other warming devices can cause hyperthermia. (As ambient temperatures are artificially higher this can lead to the mattress reaching temperatures greater than 38^{0}C).

- Not to be used with other warming devices.
- Do not use nesting devices

Appendix 4: Thermoregulation at Delivery



Appendix 5: Correcting Hypothermia on Delivery or Postnatal Ward



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East of England Neonatal ODN
(Hosted by Cambridge University Hospitals)

Exceptional Circumstances Form

Form to be completed in the **exceptional** circumstances that the Trust is not able to follow ODN approved guidelines.

Details of person completing the form:	
Title:	Organisation:
First name:	Email contact address:
Surname:	Telephone contact number:
Title of document to be excepted from:	
Rationale why Trust is unable to adhere to the document:	
Signature of speciality Clinical Lead: Date:	Signature of Trust Nursing / Medical Director: Date:
Hard Copy Received by ODN (date and sign):	Date acknowledgement receipt sent out:

Please email form to: add-tr.eoeneonatalodn@nhs.net requesting receipt.
Send hard signed copy to:

EOE ODN Administrator
Box 402
The Rosie Hospital

Cambridge University Hospital NHS Foundation Trust,
Robinson Way, Cambridge.
CB2 0SW

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