Champlain Maternal Newborn Regional Program
Programme régional des soins à la mère
et au nouveau-né de Champlain

Newborn Thermoregulation

Self – Learning Module

Developed by the
Interprofessional Education and Research Committee
of the
Champlain Maternal Newborn Regional Program (CMNRP)

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Objectives

1. Understand the physiology of thermoregulation
2. Identify mechanisms of thermoregulation
3. Understand the consequences of inadequate thermoregulation in neonates
4. Identify strategies to support thermoregulation
5. Review best practices in neonatal thermoregulation

Disclaimer: This self-learning module is intended for health care providers caring for term, low-risk newborns. Please refer to institutional policies and procedures.

THERMOREGULATION IN THE NEWBORN

Maintaining a neutral thermal environment is one of the key physiologic challenges that a newborn must face after delivery. Thermal care is central to reducing morbidity and mortality in newborns. Thermoregulation is the ability to balance heat production and heat loss in order to maintain body temperature within a certain normal range.

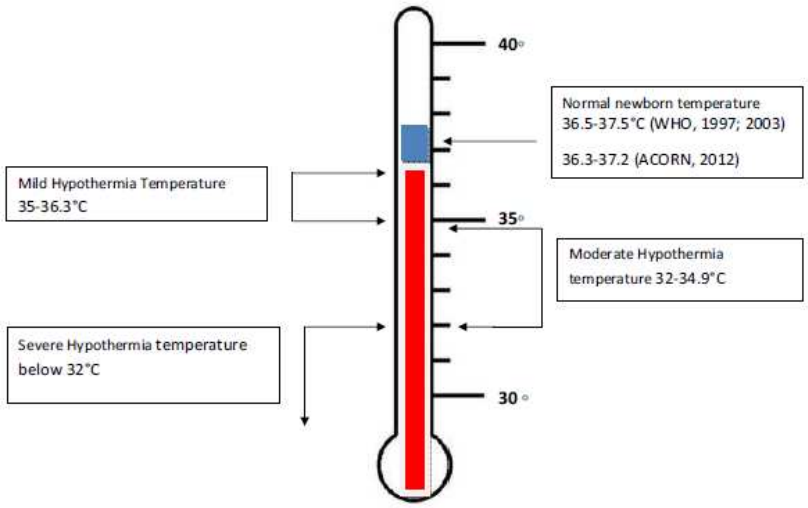
The average "normal" axillary temperature is considered to be 37°C (Leduc & Woods, 2013). The Canadian Paediatric Society recommends taking temperature via the axillary route to screen low risk newborns from birth to 2 years (Leduc & Woods, 2013). There is a lack of evidence on what constitutes the "normal" temperature range for a newborn. The American Academy of Pediatrics (AAP) and the American College of Obstetricians and Gynecologists (ACOG) (1997) and the World Health Organization (WHO) (1997; 2003) define normal axillary temperatures to be between 36.5°C and 37.5°C. The Acute Care of at-Risk Newborns Neonatal Society (ACoRN) define normal axillary temperature to be between 36.3°C-37.2°C (ACoRN, 2012).

1. Hypothermia

Hypothermia occurs when the newborn's axillary temperature drops below 36.3°C (ACoRN, 2012) or below 36.5°C (AAP/ACOG, 1997; WHO, 1997). The following characteristics put newborns at a greater risk of heat loss:

- A large surface area-to-body mass ratio
- Decreased subcutaneous fat
- Greater body water content
- Immature skin leading to increased evaporative water and heat losses
- Poorly developed metabolic mechanism for responding to thermal stress (e.g. no shivering)
- Altered skin blood-flow (e.g. peripheral cyanosis)

(Aylott, 2006; Blackburn, 2007; Galligan, 2006; Hackman, 2001; WHO, 1997)



NOTE: The smaller or more premature the newborn is, the greater the risk of heat loss. When heat loss exceeds the newborn's ability to produce heat, its body temperature drops below the normal range and the newborn becomes hypothermic.

1.1 Sources of heat loss

There are four ways in which a newborn loses body heat:

- ***Evaporation****:* when amniotic fluid evaporates from the skin. Evaporative losses may be insensible (from skin and breathing) or sensible (sweating). Other factors that contribute to evaporative loss are the newborn's surface area, vapor pressure and air velocity. This is the greatest source of heat loss at birth.
- ***Conduction****:* when the newborn is placed naked on a cooler surface, such as table, scale, cold bed. The transfer of heat between two solid objects that are touching, is influenced by the size of the surface area in contact and the temperature gradient between surfaces.
- ***Convection****:* when the newborn is exposed to cool surrounding air or to a draft from open doors, windows or fans, the transfer of heat from the newborn to air or liquid

is affected by the newborn's large surface area, air flow (drafts, ventilation systems, etc), and temperature gradient.

- ***Radiation**:* when the newborn is near cool objects, walls, tables, cabinets, without actually being in contact with them. The transfer of heat between solid surfaces that are not touching. Factors that affect heat change due to radiation are temperature gradient between the two surfaces, surface area of the solid surfaces and distance between solid surfaces. This is the greatest source of heat loss after birth.

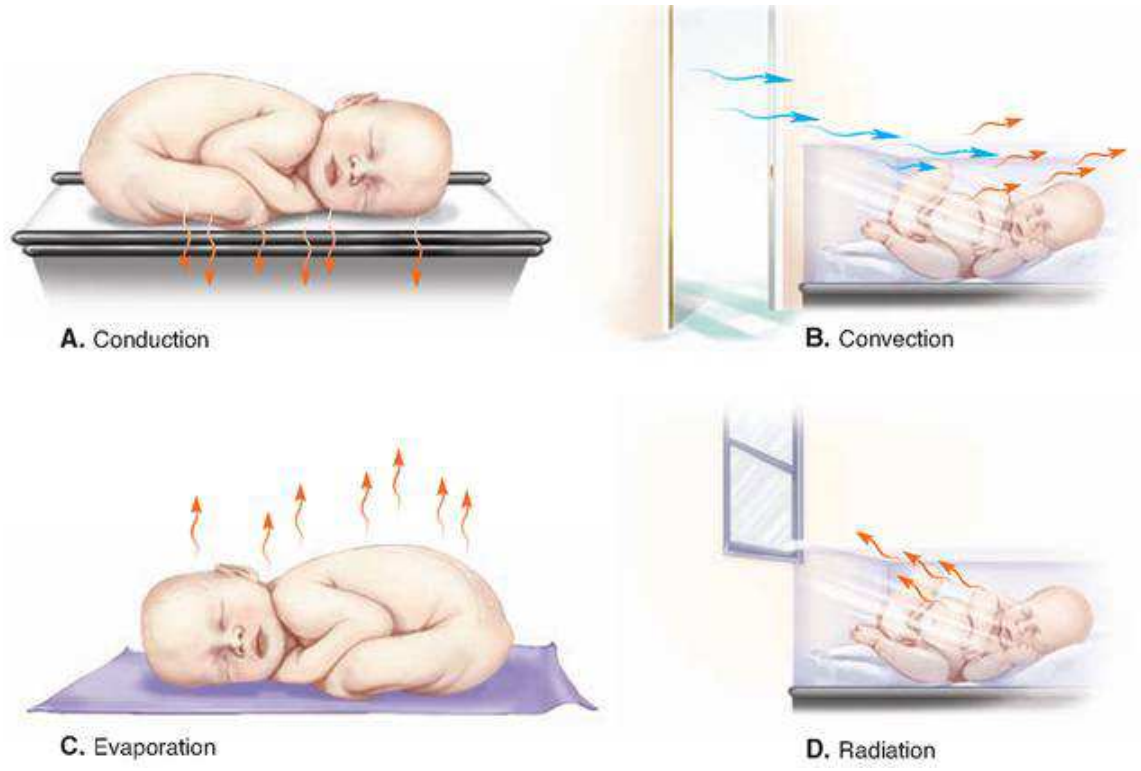


Figure 2: Heat Loss in the Newborn. (The-Crankshaft Publishing, n.d)

Most cooling of the newborn occurs immediately after birth. During the first 10 to 20 minutes, the newborn may lose enough heat for the body temperature to fall by 2-4°C if appropriate measures are not taken. Continued heat loss will occur in the following hours if proper care is not provided. The temperature of the environment during delivery and the postnatal period has a significant effect on the risk to the newborn of developing hypothermia.

1.2 Mechanisms of heat production

Table 1: Mechanisms of heat production in the newborn

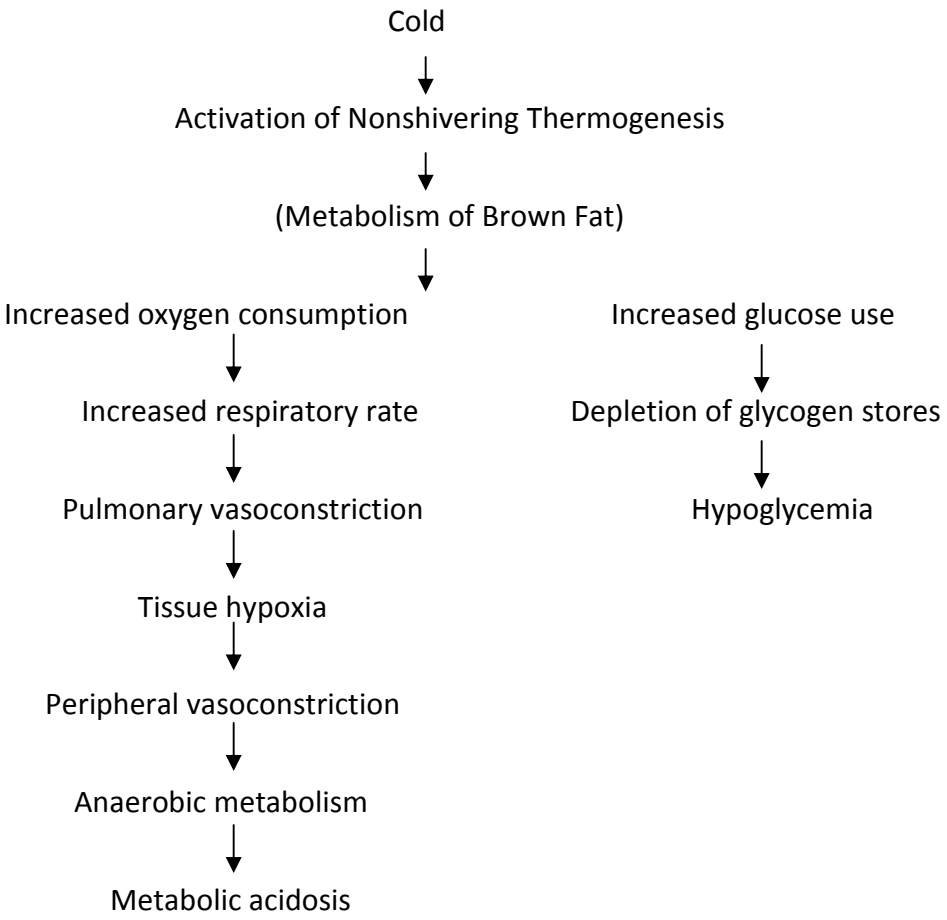
MECHANISM	SOURCE
Metabolic processes	• The brain, heart, and liver produce the most metabolic energy by oxidative metabolism of glucose, fat and protein. • The amount of heat produced varies with activity, state, health status, environmental temperature.
Voluntary muscle activity	• Increased muscle activity during restlessness and crying generate heat. • Conservation of heat by assuming a flexed position to decrease exposed surface area.
Peripheral vasoconstriction	• In response to cooling, peripheral vasoconstriction reduces blood flow to the skin and therefore decreases loss of heat from skin surfaces.
Nonshivering thermogenesis	• Heat is produced by metabolism of brown fat. • Thermal receptors transmit impulses to the hypothalamus, which stimulate the sympathetic nervous system and causes norepinephrine release in brown fat (found around the scapulae, kidneys, adrenal glands, head, neck, heart, great vessels, and axillary regions). • Norepinephrine in brown fat activates lipase, which results in lypolysis and fatty acid oxidation. • This chemical process generates heat by releasing the energy produced instead of storing it as Adenosine-5-Triphosphate (ATP).

(Blackburn, 2007; Knobel & Holditch-Davis, 2007; Philip & Silverman, 2004)

1.3 Consequences of hypothermia in the newborn

Treating hypothermia in the newborn is important in order to avoid serious and potentially life-threatening complications. Increased cellular metabolism takes place as the newborn tries to stay warm, leading to increased oxygen consumption, which puts the newborn at risk of hypoxia, cardiorespiratory complications, and acidosis. These newborns are also at risk for hypoglycemia because of the increased glucose consumption necessary for heat production. Neurological complications, hyperbilirubinemia, clotting disorders, and even death may result if the untreated hypothermia progresses (Hackman, 2001)

Figure 3: Effects of cold stress in the newborn



(Askin, 2008, p. 534).

1.4 Signs and symptoms of hypothermia

- Acrocyanosis and cool, mottled, or pale skin
- Hypoglycemia
- Transient hyperglycemia
- Bradycardia
- Tachypnea, restlessness, shallow and irregular respirations
- Respiratory distress, apnea, hypoxemia, metabolic acidosis
- Decreased activity, lethargy, hypotonia
- Feeble cry, poor feeding
- Decreased weight gain

(ACoRN, 2012; Aylott, 2006; Blackburn, 2007)

NOTE: All these signs are non-specific and may indicate other significant conditions such as bacterial infection in the newborn.

1.5 Prevention and management of hypothermia

The “warm chain” is a set of interlinked procedures to be performed at birth and during the next few hours and days after birth in order to minimize heat loss in all newborns (WHO, 1997). Failure to implement any one of these procedures will break the chain and put the newborn at risk of getting cold. Ideally, hospitals that care for sick and low birth weight newborns should have additional equipment such as overhead heaters, heated mattresses, incubators and low-reading thermometers that read temperatures down to 25°C. These should be used with caution and following manufacturer’s directions.

A newborn’s temperature should be monitored closely under the following conditions:

- Difficulty maintaining the “warm chain” or providing an optimal thermal environment
- Low birth weight and/or ill newborn
- Resuscitation required at birth
- Suspicion of hypothermia or hyperthermia
- With rewarming or cooling down
- If the newborn has been re-admitted to hospital for any reason

Table 2: Ten steps of the "warm chain" (adapted from WHO, 1997)

STEPS	PROCEDURE
1. Warm delivery room	• The temperature of the delivery room should be at least 25°C, free from the drafts from open windows, doors, or fans. • Supplies needed to keep the newborn warm should be prepared ahead of time. • Adults should never determine the temperature of the delivery room according to their comfort.
2. Immediate drying	• Immediately dry the newborn after birth with a warm towel or cloth to prevent heat loss from evaporation (For newborns <29 wks GA refer to the NRP guidelines).
3. Skin-to-skin contact	• While the newborn is being dried, place on the mother's chest or abdomen (skin-to-skin contact) to prevent heat loss. -If mother is unable the cold newborn may go skin-to-skin with the partner • Cover the newborn with a second towel and put a cap on the head to prevent heat loss from convection. • Leave the newborn skin-to-skin on the mother and keep covered. • Newborns should be uncovered as little as possible during assessments and interventions. • Newborns can be maintained in skin-to-skin contact with the mother: -while she is being attended to (placenta delivery, suturing) -during transfer to the postnatal unit, recovery room -during assessments and initial interventions -for the first hours after birth
4. Breastfeeding	• Initiate as soon as possible, preferably within one hour of birth.
5. Postpone weighing and bathing	• Weighing can be done following the period of uninterrupted skin-to-skin contact and the first feed. Place a warm blanket on the scale. • Bathing the newborn soon after birth causes a drop in the body temperature and may propagate hypothermia and hypoglycemia. • Following the transition period (6-8 hours) newborns may be assessed for bathing readiness. Bathing may be considered when vital signs are stable. • If a hypothermic newborn has thick wet hair, consider washing the hair only, drying the hair thoroughly and then place a cap on the head. • Bathing should be done quickly in a warm room, using warm water. Tub bathing is the preferred method of bathing to prevent heat loss for all stable newborns both term and preterm. The water should be deep enough to cover the newborn's shoulders. Note: Newborns with an umbilical catheter should not be tub bathed. • Immediately after the bath dry thoroughly, immediately diaper and place skin-to-skin. If skin-to-skin is not possible double wrap the newborn with warm blankets ensuring the head is covered. • After skin-to-skin, dress the newborn, apply a dry cap and wrap in dry warm blankets.
6. Appropriate clothing/blanket	• Dress newborn in loose clothing and blanket.

7. Mother and newborn together	• Keep mother and newborn together 24 hours a day (rooming-in), in a warm room (at least 25°C). • Newborn should be fed on demand. • Skin-to-skin can be used to rewarm a newborn experiencing mild to moderate hypothermia (see table 3).
8. Warm transportation	• Keep newborn warm while waiting for transportation. • Dress the newborn and wrap in blankets if a transport device is used.
9. Warm assessment (if newborn not skin-to-skin with mother)	• Lay on a warm surface in a warm room. • Put under an additional heat source as necessary (i.e. radiant warmer). • Utilize servocontrol if on radiant warmer for >10 minutes.
10. Training and raising awareness	• Alert health care providers and families to the risks of hypothermia and hyperthermia. • Teach the principle of thermal protection of the newborn. • Provide on the job training and supervised practice to ensure that the 10 steps of the warm chain become part of the routine care of the newborn. • Demonstrate and provide supervised practice on the appropriate use of equipment for low birth weight/preterm newborns.

(ACoRN, 2012; Kattwinkel, 2011; Provincial Council for Maternal & Child Health, 2012)

Table 3: Methods used to treat hypothermia* (ACoRN, 2012; WHO, 2003)

SEVERITY OF HYPOTHERMIA	METHODS USED
Mild hypothermia (body temperature 35-36.3°C)	• Skin-to-skin contact, in a warm room (at least 25°C). • Place cap on newborn head • Cover mother and newborn with warm blankets
Moderate hypothermia (body temperature 32-34.9°C)	• Under a radiant heater • In a warmed incubator • In a heated water-filled mattress (i.e. KanBed) • If no equipment is available or if the newborn is clinically stable, skin-to-skin contact with the mother can be used in a warm room (at least 25°C)
Severe hypothermia (body temperature below 32°C)	• Using a warm incubator (should be set at 1 to 1.5°C higher than the body temperature) and should be adjusted as the newborn's temperature increases • If no equipment is available, skin-to-skin contact or a warm room or cot can be used

Note: Refer to institutional policies and procedures

2. Hyperthermia

Hyperthermia is defined as body temperature above 37.3°C or 37.5°C (ACoRN, 2012; WHO, 2003). Hyperthermia is frequently a result of environmental factors that cause overheating. It is less likely to be a sign of sepsis in the newborn. However, regardless of cause, hyperthermia can have detrimental consequences.

2.1 Causes of hyperthermia

- Overheating from incubators, radiant warmers, or ambient environmental temperature
- Maternal fever
- Maternal epidural anesthesia
- Phototherapy lights, sunlight
- Excessive bundling or swaddling
- Infection
- CNS disorders (i.e. asphyxia)
- Dehydration

(ACoRN, 2012; Baumgart, 2008; Blackburn, 2007)

2.2 Signs and symptoms of hyperthermia

- Tachycardia, tachypnea, apnea
- Warm extremities, flushing, perspiration (term newborns)
- Dehydration
- Lethargic, hypotonia, poor feeding
- Irritability
- Weak cry

(ACoRN, 2012; Baumgart, 2008; Blackburn, 2007; Weber, 2000; Verklan & Walden, 2010)

2.3 Consequences of hyperthermia

- Hypotension and dehydration (as a result of increased insensible water loss)
- Seizures and apnea (as a result of high core temperature)
- Hypernatremia

(Blake & Murray, 2006; Verklan & Walden, 2010)

2.4 Management of hyperthermia

The usual approach to treating the hyperthermic newborn is to adjust environmental conditions. The newborn should be moved away from the source of heat, and undressed partially or fully, if necessary. If the newborn is in an incubator, the air temperature should be lowered. It is important that the newborn be breastfed frequently to replace fluids (WHO, 2003).

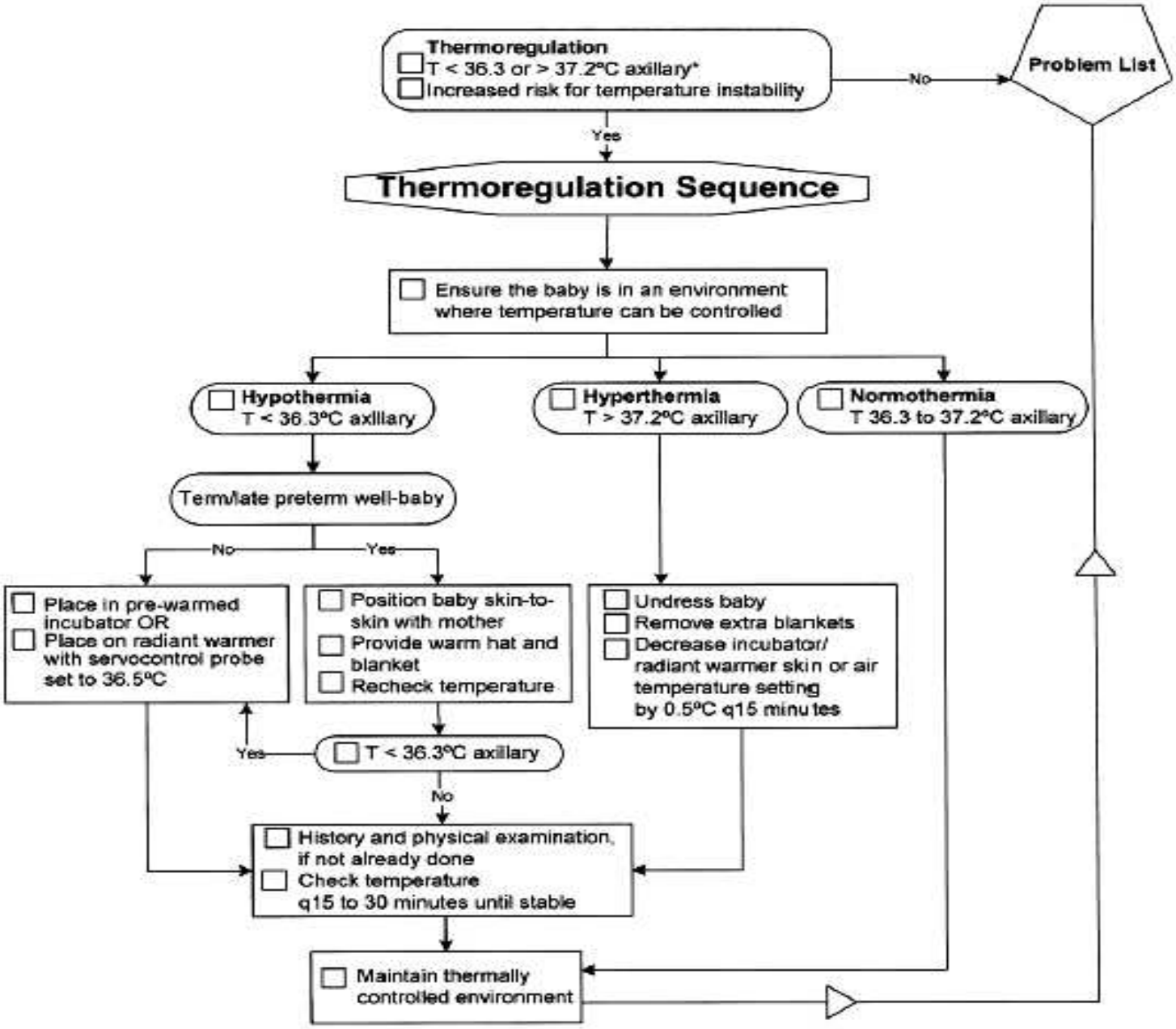
During the cooling process, the newborn's temperature must be monitored every 15-30 minutes until stable (ACoRN, 2012; Blake & Murray, 2006). Never turn off the incubator to cool off the newborn.

When hyperthermia is severe (i.e. body temperature above 40°C), the newborn can be given a bath. The water should be warm (about 2°C lower than the newborn's body temperature). Cooling devices are not recommended (ACoRN, 2012; Baumgart, 2008; Çinar & Filiz, 2006; WHO, 1997). If the newborn cannot breastfeed extra fluids should be given intravenously or by tube (WHO, 1997).

NOTE: In instances where interventions have not had an effect on regulating the newborn's temperature, the newborn should be assessed for infection.

Figure 4: The Thermoregulation Sequence

(ACoRN, 2012, p. 8-5)



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ADDITIONAL RESOURCES

American Academy of Pediatrics (AAP) - www.aap.org

Canadian Paediatric Society (CPS) - www.cps.ca

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- Managers, educators, and registered nurses from partner organizations
- Maternal-Newborn Nursing Professors (College and University)