Temperature control and hypothermia

Objectives

When you have completed this unit you should be able to:

- Keep infants warm.
- Explain why infants can develop hypothermia.
- Recognise the signs and list the dangers of hypothermia.
- Prevent and treat hypothermia.
- List the causes and complications of pyrexia.

Measuring body temperature

1.1 How do you measure an infant's temperature?

An infant's skin temperature, rather than the oral or rectal temperature, is usually measured. As infants commonly become cold rather than hot, it is preferable to measure axillary (arm pit) or abdominal skin temperature as the skin is the first part of the body to cool down.

NOTE

In contrast, the oral or rectal temperature is useful in detecting a fever in older children and adults as the body core (centre) is the first part of the body to heat up.

Skin temperature can be measured with:

1. **A digital thermometer:** The digital thermometer is placed in the infant's axilla (armpit) for 2 minutes before the reading is taken. Thermometers should be stored dry when not in use to prevent cross-infection.
2. **A telethermometer:** (electrical thermometer). If a telethermometer is used, the probe is usually placed over the left, lower abdomen or the lower back. Avoid the right, upper abdomen as the liver produces a lot of heat and this may give too high a reading. Telethermometers should be calibrated regularly.

A low reading glass mercury thermometers should no longer be used in children due to the risk of mercury poisoning if the thermometer should break in the mouth.

2.2 What is the normal range of body temperature?

This depends on the site where the temperature is measured:

1. The normal axillary temperature is 36.5–37 °C.
2. The normal abdominal skin temperature is 36–36.5 °C.

All newborn infants have the same range of normal body temperature.

NOTE

The normal oral temperature is 37–37.5 °C and rectal temperature is 37.5–38 °C. Neither are routinely used in newborn infants.

Heat production and loss

2.1 What determines body temperature?

The body temperature depends on a balance between:

1. The rate of heat production (how fast heat is produced).
2. The rate of heat loss (how fast heat is lost).

If the rate of heat production is low or the rate of heat loss is high, then the body temperature may fall. Similarly, excessive heat production or reduced heat loss causes an increased body temperature (fever or pyrexia).

2.2 How do newborn infants produce heat?

Adults and older children are able to increase their heat production by shivering and doing physical exercise. Newborn infants cannot shiver or exercise. However, during the first few weeks of life the infant is able to break down (metabolise) *brown fat* which releases large amounts of heat. Brown fat is a special tissue laid down in the neck, chest and abdomen of the fetus during the last weeks of pregnancy. It is brown in colour, due to the presence of many nerves and blood vessels, and differs in many ways from the ordinary white fat that is found under the skin. When the body temperature drops, the infant breaks down brown fat and, thereby, produces heat to correct the body temperature.

To a lesser degree the infant is also able to use other energy stores to produce heat, such as:

- White fat which is found under the skin.
- Glycogen which is stored in the liver.
- Milk feeds.

2.3 Which infants produce too little heat?

The following infants are often unable to produce enough heat to maintain a normal body temperature:

1. **Preterm infants.** They are born before adequate stores of brown fat have been deposited.
2. **Underweight for gestational age or wasted infants.** They have used up their stores of brown fat before delivery.
3. **Infected or hypoxic infants.** Generalised infection or severe hypoxia prevents the normal breakdown of brown fat and, thereby, decreases the production of heat. Infected and hypoxic infants, therefore, commonly present with a drop rather than a rise in body temperature.

Infection in newborn infants causes a fall rather than a rise in body temperature.

2.4 How do infants lose heat?

Infants lose heat from the skin to the environment by the following methods:

1. **Convection.** This is the loss of heat from the infant's skin to the surrounding air. Infants lose a lot of heat by convection when exposed to cold air or draughts.
2. **Conduction.** This is the loss of heat when the infant lies on a cold surface. Infants rapidly lose heat by conduction when placed naked on a cold table, weighing scale or X-ray plate, or are wrapped in a cold blanket or towel.
3. **Evaporation.** This is the loss of heat from an infant's wet skin to the surrounding air. Infants lose heat by evaporation after delivery or after a bath. Even an infant in a wet nappy can lose heat by evaporation.
4. **Radiation.** This is the loss of heat from an infant's skin to distant cold objects, such as cold windowpanes, walls and the incubator hood. Many people find radiation difficult to understand as the loss of heat from a warm to a distant cold object is not affected by the temperature of the surrounding air. Even if the room and incubator are warm, an infant may still radiate heat to a cold windowpane. The closer the infant is to the cold window, the more heat will be lost. Curtains reduce radiant heat loss at night when windows are coldest.

2.5 Which infants lose too much heat?

The following infants commonly lose too much heat and, therefore, may drop their body temperature:

1. **Small infants.** All small infants have a large surface area in relation to their body weight. Therefore, preterm and underweight for gestational age infants tend to lose heat rapidly.
2. Infants with **little subcutaneous fat.** Preterm, underweight for gestational age and wasted infants all have very little WHITE fat under their skin (subcutaneous fat) to insulate their body against heat loss. Most white fat is deposited under the skin during the last weeks of pregnancy. Therefore, preterm infants are born before they are able to build up stores of white fat. Underweight for gestational age and wasted infants also have little white fat as they have used up their white fat before delivery.
3. Infants in a **cold environment** may lose heat by conduction, convection, evaporation or radiation. Heat loss is greatest if an infant is left naked and not covered.
4. **Wet infants** lose heat by evaporation. Infants are wet after delivery, after a bath, and when lying in a wet nappy.
5. Infants with **poor muscle tone.** Hypotonic infants, such as preterm or ill infants lie with their arms and legs spread out. They, therefore, expose a greater area of skin for heat loss than do well, term infants who hold their arms and legs flexed against the body.

Hypothermia

3.1 What is hypothermia?

An abdominal temperature below 36 °C or an axillary temperature below 36.5 °C is abnormally low. These infants need to be warmed. Therefore, a working definition of hypothermia (low body temperature) is a body temperature below these values. Once the body temperature falls below 35 °C the infant is in danger of complications related to being too cold. As the rectal temperature is normally higher than that at other sites, a rectal temperature below 35 °C is particularly dangerous.

Hypothermia is an abdominal temperature below 36 °C or an axillary temperature below 36.5 °C

3.2 Which infants are at the greatest risk of hypothermia?

Infants who produce too little heat or lose too much heat are at the greatest risk. These high-risk infants are:

1. Preterm infants
2. Underweight for gestational age infants
3. Wasted infants
4. Infants who have not been fed
5. Infected infants
6. Hypoxic infants
7. Wet infants
8. Infants exposed to a cold environment
9. Infants who are nursed naked and not covered
10. Infants nursed close to a cold window

3.3 How do you prevent hypothermia?

1. **Identify all infants at high risk of hypothermia.** This includes all infants who are likely to produce too little heat or lose too much heat.
2. **Provide energy** (calories) by oral, nasogastric tube or intravenous feeding. This is very important in infants who are born with little brown and white fat. Early feeding with breast milk or milk formula feeds helps to reduce the incidence of hypothermia by providing the infant with energy needed to produce heat.
3. **Provide a warm environment for all infants.** The smaller the infant, the warmer the required environment. Most infants under 1800 g need some source of warmth. You should:
   - Use skin-to-skin care (kangaroo mother care) whenever possible.
   - Never place an infant in a cold incubator.
   - Keep the incubator ports closed.
   - Always wrap an X-ray cassette in a towel before use.

- Warm and humidify oxygen whenever possible.
- Do not nurse an infant near a cold window.
- Have curtains in the nursery.
- Not bath small or sick infants.

4. **Insulate the infant.** Dress the infant and use a woollen cap. The head of the newborn infant loses a lot of heat by radiation as the surface area of the scalp is large, the brain produces a lot of heat and there is little hair for insulation. A woollen cap is more effective than booties or leggings. It is best if all these are used. A woollen cap is particularly important if the infant is receiving headbox oxygen which has not been warmed. Most infants in incubators should wear a woollen cap.
5. **All wet infants must be dried** immediately and then wrapped in another, warm, dry towel. Do not leave an infant in a wet towel. Remember to dry the infant's head.
6. **Treat any infection or hypoxia.**
7. **Monitor the skin or axillary temperature** in all infants who are at an increased risk of hypothermia. It is essential to detect any drop in temperature as soon as possible.

A woollen cap prevents radiant heat loss from the infant's head.

3.4 What is the best environmental temperature?

The best environmental (e.g. room or incubator) temperature depends on:

1. The **weight and gestational age** of the infant. The lower the weight and the earlier the gestational age, the higher is the required environmental temperature. Infants that are underweight for gestational age or wasted also need a higher environmental temperature.
2. The **postnatal age** of the infant. The greater the postnatal age the lower is the required environmental temperature, i.e. as the infant gets older, a lower environmental temperature is needed.
3. **Illness.** Sick infants need a higher environmental temperature.

For example, a 1000 g preterm infant on day 1 may need an environmental temperature of 37 °C to keep warm while a healthy term infant on day 5 may need an environmental temperature of only 20 °C.

In clinical practice each infant must be handled as an individual and the above factors, which influence the infant's temperature needs, must be regarded only as guidelines. The environmental temperature for each infant should be adjusted in order to give a normal abdominal skin or axillary temperature. This can be achieved automatically if a servo-controlled incubator or radiant warmer is used.

The infant's energy and oxygen needs are lowest when the skin temperature is *normal* and the infant is nursed at the correct environmental temperature. Both energy and oxygen needs increase if the infant's skin temperature is either above or below normal. Infants gain weigh fastest when they are kept at the correct environmental temperature.

The environmental temperature should be adjusted to give a normal axillary or skin temperature.

NOTE

The neutral thermal environment (best room or incubator temperature) is that environmental temperature at which the skin temperature is normal and the infant's metabolic rate is at its lowest. In this state the infant uses the least amount of oxygen and energy. The energy in feeds, therefore, can be used for growth rather than for generating heat. It is important to ensure that all infants are nursed as close as possible to their own neutral thermal environment.

3.5 How do you keep an infant warm?

There are a number of ways to keep an infant warm:

1. **Maternal body heat (skin-to-skin care).** Infants can very easily and effectively be kept warm by placing them naked against the mother's bare breasts. The infant should wear a woollen cap and nappy. Both mother and infant should be covered. The mother's body heat will keep the infant warm. This simple method is an important part of kangaroo mother care (KMC).

Kangaroo mother care is the best method of keeping a well infant warm.

2. **A closed incubator.** This is the traditional way of nursing most small or sick infants as the temperature can be carefully controlled. Today more and more infants are being nursed with KMC rather than in an incubator.
3. **Radiant warmers** (overhead radiant heaters). A radiant warmer is used for resuscitating an infant or for nursing a very sick infant in an intensive care unit. Water loss by evaporation is higher than in a closed incubator. A thick plastic sheet or 'bubble wrap' over the infant reduces water loss. As soon as ill infants have improved they should be moved out of a radiant heater and into a closed incubator or KMC.
4. **Warm room.** Most healthy, term infants can be nursed in a cot or bassinet in a warm nursery, ward or home. The room temperature should be about 20 °C. The infant should be dressed to prevent heat loss by radiation to cold windows or walls.
5. **Hot room.** Many low birth weight infants can be kept warm in a bassinet if they are nursed in a room where the temperature is kept at 25–30 °C. The smaller the infant, the higher the required room temperature will be. However, keeping the mother and infant together with KMC is preferable.
6. **Dressing the infant.** The infant can be kept warm by covering the body with an insulating layer and, thereby, preventing heat loss by convection to cold air and radiation to cold objects in the room. This is done by dressing the infant in a nappy, jacket, woollen hat and booties. A woollen cap is most important in preventing heat loss by radiation. Often infants in closed incubators are dressed.
7. **Thermal blanket.** An infant can be kept warm for hours if wrapped in a thermal blanket, silver swaddler or heavy gauge aluminium foil normally used for cooking. This is an effective method of preventing heat loss during transport if KMC or a transport incubator is not available. The infant must be warm and dry before being wrapped in a thermal blanket. Never put a cold infant into a thermal blanket or use a thermal blanket in an incubator.
8. **Perspex heat shield.** A transparent perspex shield can be placed over an infant in an incubator to reduce heat loss by radiation.

A woollen cap and perspex heat shield reduces heat loss by radiation in infants nursed in an incubator.

The most appropriate method should be chosen for each individual. There is no excuse for an infant ever becoming hypothermic because hypothermia is preventable. Skin-to-skin care by the mother, father, family member, nurse, doctor or paramedic is always available.

Hypothermia is preventable.

3.6 When does a small infant no longer need an incubator?

Most small infants are able to maintain their body temperature in a warm room when they reach a weight of 1800 g. However, many small infants can maintain their body temperature much sooner with KMC. Most well infants can be moved from an incubator to KMC by 1600 g.

3.7 How do you recognise a hypothermic infant?

Hypothermic infants present with the following signs:

1. They are cold to the touch.
2. They are lethargic, hypotonic, feed poorly and have a feeble cry.
3. Their hands and feet are usually pale or blue, but their tongue and cheeks are pink. Note that they are not centrally cyanosed. The pink cheeks may incorrectly suggest that the infant is well.
4. Peripheral oedema or sclerema (a woody or plastic feel to the skin).
5. Shallow, slow respiration or signs of respiratory distress.
6. Bleeding from the mouth, nose or needle punctures. Hypothermic infants often die of massive pulmonary haemorrhage.

The more severe the hypothermia (especially if the body temperature falls below 35 °C) the more clinical signs will be present.

3.8 What metabolic problems are common in hypothermic infants?

1. **Hypoglycaemia.** This is a common cause of death in cold infants and the most important complication of hypothermia. Cold infants use a lot of energy in an attempt to warm themselves. As a result they use up all their energy stores, resulting in hypoglycaemia.
2. **Hypoxia.** When haemoglobin becomes cold it takes up, but will not release, oxygen. The oxygen is trapped in the haemoglobin and not released to the body cells. The cold infant, therefore, appears centrally pink even while dying of hypoxia. Hypothermia also increases the oxygen needs of the body and this make the hypoxia worse.

3. **Metabolic acidosis.** Due to poor peripheral perfusion, blood does not carry enough oxygen to the cells. The resulting hypoxia causes a metabolic acidosis.

NOTE

A cold infant increases its metabolic rate to produce heat and rapidly breaks down glucose. This in turn increases the oxygen needs of the cells, aggravating any hypoxia. The resultant anaerobic metabolism of glucose causes an excess lactic acid production. Disseminated intravascular coagulopathy is also common in marked hypothermia.

Hypothermic infants often die of hypoglycaemia.

3.9 How do you treat hypothermia?

1. **Warm the infant** in a closed incubator, overhead radiant warmer or warm room. Skin-to-skin care is a very effective method of warming a cold infant. The incubator temperature should be set at 37 °C until the skin temperature returns to normal. Warm water (37 °C) has also been used to correct hypothermia.
2. **Provide energy** while the infant is being warmed. Hypoglycaemia may occur during warming. Energy can be given as oral or nasogastric milk, or intravenous maintenance fluid containing 10% dextrose water (e.g. Neonatalyte).
3. **Provide oxygen.** Although centrally pink, cold infants are often hypoxic. Therefore, give 30% oxygen (FiO_2 0.3) while the infant is being warmed. A normal oxygen saturation in a cold infant does to exclude tissue hypoxia as oxygen is trapped in the red cells.
4. **Give 4% sodium bicarbonate.** Most hypothermic infants have a metabolic acidosis. If intravenous fluid is given, add 10 ml 4% sodium bicarbonate to 100 ml of maintenance fluid (Neonatalyte). Obtain a blood gas analysis if possible and half correct any base deficit.
5. **Observations.** Monitor and record the infant's temperature, pulse, respiration, skin colour and blood glucose concentration until they are normal and stable.
6. **Antibiotics.** Give parenteral antibiotics if there are any signs of infection.

Pyrexia

4.1 What is pyrexia?

Pyrexia or fever (high body temperature) is defined as an abdominal skin temperature of 37 °C or more, or an axillary temperature of 37.5 °C or more. As newborn infants can only sweat a little, they are unable to cool themselves and, therefore, easily become too hot.

Pyrexia may be caused by:

1. **A high environmental temperature.** This is usually due to the incubator or room being too hot for the infant's needs, or the infant being placed in the sun or too close to a heater.
2. **Infection.** However, most infants become hypothermic when infected.

4.2 Is pyrexia dangerous?

Yes. Pyrexia is an important cause of recurrent apnoea which can result in death if the infant is not cooled. Prolonged pyrexia can also lead to dehydration and increases the body's oxygen and energy needs.

Case study 1

A preterm female infant is brought to the nursery from the labour ward wrapped in a wet towel. The axillary temperature is 32.5 °C. The infant's estimated gestational age is 35 weeks. The cheeks and tongue are pink but the hands and feet are grey and feel cold. The infant is lethargic.

1. Does the infant have hypothermia? Give your reasons.
Yes. An axillary temperature below 36 °C is below the normal range and is defined as hypothermia.

2. What is the probable cause of the peripheral cyanosis in this infant?
The peripheral cyanosis was almost certainly caused by hypothermia, and should, therefore, disappear when the infant's temperature returns to normal. Cold infants are often centrally pink even if they are hypoxic.

3. Why do you think this infant is cold?
Because the infant was not well dried after birth and wrapped in a second warm, dry towel. This is a common error. The labour ward may also have been cold. Therefore body heat would be lost by both evaporation and convection. In addition, the infant is preterm. Preterm infants lose heat rapidly as they have little subcutaneous fat.

4. How should this infant have been kept warm in the labour ward?
The easiest way to have kept this infant warm after delivery would have been to dry her well and then place her in the KMC position, naked against the mother's breasts. The mother's skin would have kept the infant warm.

5. What should be the management of this infant?
The infant should be removed from the wet towel and dried well. Do not forget to dry the infant's head. Then place the infant in a prewarmed closed incubator set at 37 °C or under an overhead radiant heater. If neither is available, skin-to-skin care (KMC) or a warmed room can be used. Give 30% head box oxygen while the infant is being warmed. Energy must be given intravenously as an infusion of maintenance fluid (e.g. Neonatalyte). As soon as possible, nasogastric milk feeds must be started to prevent hypoglycaemia. Careful observations should be kept until the infant is warm and appears clinically normal.

6. What investigations do you think should be done when the infant arrives in the nursery?
The blood glucose concentration must be determined and the temperature must be carefully monitored with a digital or low reading thermometer until the infant is warm. Any hypoglycaemia must be treated.

Case study 2

A 5 day old male term infant is bathed in a cold ward. Afterwards the infant appears well but feels cold. A telethermometer reading over the right upper abdomen gives a result of 34 °C. The infant, which weighed 2400 g at birth and is clinically wasted, is rapidly warmed by placing it next to a wall heater.

1. Give 3 probable reasons why this infant became hypothermic.
The infant is underweight for gestational age and is also wasted. Both these conditions may cause hypothermia as the infants have little white and brown fat. In addition the infant probably became cold after the bath because he was not well dried and the room was cold.

2. What error was made when the infant's temperature was determined?
The temperature should not be taken over the liver as this is a very warm organ. The skin temperature should have been taken over the left side of the abdomen. An axillary temperature could also have been taken.

3. When should this infant be fed?
As this infant is at high risk of hypoglycaemia it should be given a feed as soon as possible. Check the blood glucose concentration.

4. How should the infant be kept warm during the next few days?
It should be dressed and given a woollen cap. If the room becomes cold at night, the infant can be kept warm in the mother's bed or be given KMC

Case study 3

A term female infant is brought to an outlying clinic on a cold winters day. The mother delivered 30 minutes before and has to be referred to hospital because of a retained placenta. The infant's axillary temperature is 34.5 °C but the infant appears active. Neither the clinic nor the ambulance has an incubator.

1. How can you warm this infant in the clinic?

You can use a heater, warm room or warm water to correct the infant's temperature. One of the staff or a family member could give skin-to-skin care. The infant can also be warmed by placing her skin-to-skin against the mother and wrapping both in blankets.

2. When should the infant be moved to hospital?

If possible, it is best to warm the infant first before moving it to hospital.

3. How can the infant be kept warm in the ambulance?

The infant should be warmly dressed if you have clothes. If not, provide skin-to-skin care or wrap the infant in a blanket. A thermal blanket (or aluminium foil) can also be wrapped around the infant. Remember that the infant must be warmed before it is placed in a thermal blanket. Skin-to-skin care can be provided by the ambulance crew if necessary. This is a simple but very effective method of keeping an infant warm during transport