ABC of preterm birth

Care in the early newborn period

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The first week after birth is a time of major metabolic and physiological adaptation for newborn infants. Preterm infants have to cope with additional stresses because most of their organ systems are immature or because of associated illnesses, such as congenital infection. Very preterm infants (< 32 weeks' gestation) or ill infants often need intensive monitoring and support during this critical period of postnatal adaptation.

Temperature control and fluid balance

Preterm infants are susceptible to heat and fluid loss, especially immediately after delivery and in the first few days after birth. Hypothermia is associated with increased morbidity and mortality. Trials in the 1950s showed that reducing heat loss improves survival for preterm and low birthweight infants. Measures to prevent cold stress should start immediately after delivery—for example, resuscitating newborns under radiant heaters, drying them, and wrapping them in warmed towels straight away. A randomised controlled trial showed that wrapping the infant in polyethylene immediately (without drying) is at least as effective in reducing evaporative heat loss in extremely preterm infants (< 28 weeks' gestation).

Maintaining the neutral thermal environment

After admission to the neonatal unit unnecessary oxygen and energy consumption must be minimised. Several options are available for nursing preterm infants in a neutral thermal environment. Bigger and more mature infants (weighing > 1800 g) can usually maintain their body temperatures in open cots with clothing (including a hat), covers, and possibly a heated mattress. Smaller and less mature infants, particularly very preterm infants, are usually cared for in air heated perspex incubators or in open cots, where they are placed under clear polyethylene blankets and there are overhead radiant heaters. The air temperature of the incubator or the power of the overhead heater can be set to respond to changes in the temperature of the infant's abdominal wall to try to maintain the infant's temperature at 36.5°C to 37°C.

Closed incubators allow adjustment of the ambient humidity, and this further reduces heat and fluid evaporation. Consequently, incubator care is associated with less insensible water loss, and lower fluid requirements, than nursing infants in open cots under radiant heaters. Both closed incubator and open cot care have other potential advantages. Environmental noise and light can be reduced with incubator care and this may improve sleep patterns. Open cots, however, allow easy access for carers. Additionally, parents might find it easier to bond with their babies if they are nursed in an open cot rather than in a closed incubator. At present there are insufficient data to determine whether open cots or incubators confer more beneficial effects on important clinical outcomes.

Preterm infants have higher fluid requirements than term infants, especially in the first week after birth, mainly because they lose more fluid through the skin and through breathing. As fluid input for preterm infants must take into account these variable losses, prescriptions are usually tailored to individual infants. Additionally, preterm infants have immature renal tubular function in the first few days after birth. This is associated with an inadequate capacity to excrete sodium and so preterm

This is the seventh in a series of 12 articles

Clothes, covers, and hat help to maintain body temperature of newborns when they are nursed in an open cot

Heat and fluid loss

Preterm infants are susceptible to heat and fluid loss because:

- High surface area to volume ratio
- Thin non-keratinised skin
- Lack of insulating subcutaneous fat
- Lack of thermogenic brown fat
- Inability to shiver

Potential adverse consequences of hypothermia

- High oxygen consumption can lead to hypoxia
- High use of glucose can lead to hypoglycaemia
- High energy expenditure can cause reduced rate of growth
- Low surfactant production can cause respiratory distress
- Vasoconstriction may cause poor perfusion or metabolic acidosis
- Delayed adjustment from fetal to newborn circulation

The neutral thermal environment is the ambient temperature at which oxygen consumption and energy expenditure is at the minimum to sustain vital activities

Covering the preterm infant with a polythene blanket reduces heat and fluid loss

infants have a lower sodium requirement than term infants. Fluid and electrolyte balance must be monitored frequently to avoid dehydration or excessive fluid input.

Glucose homeostasis

Hypoglycaemia is common in preterm infants, with risk inversely related to gestational age. Very preterm infants must maintain high energy output to overcome thermal stress and to support respiratory efforts. Growth restricted preterm infants are at great risk of hypoglycaemia because they have limited fat and glycogen reserves at the time of delivery.

The level or duration of hypoglycaemia that is harmful to a preterm infant's developing brain is not known. Hypoglycaemia is a potentially more serious complication for preterm infants than term infants because preterm infants have a relatively impaired ability to produce alternative brain fuels, such as ketones. Interventions, such as giving more milk or starting an intravenous glucose infusion, are necessary when the laboratory measured blood glucose level remains < 2.0 mmol/L.

Conversely, very preterm infants are also susceptible to hyperglycaemia and glycosuria, which can disturb fluid balance by inducing an osmotic diuresis. If glycosuria persists despite reducing the glucose input, insulin may be needed.

Haemodynamic status

Hypotension is associated with adverse outcomes, particularly intraventricular haemorrhage and periventricular leucomalacia. Hypotension and suboptimal systemic perfusion can be secondary to several problems. Management should be directed at treating the underlying cause (for example, giving volume replacement or antibiotics) and should include measures to improve systemic perfusion, such as inotrope support.

Optimal arterial blood pressure for preterm infants meets perfusion needs for vital organs. Reference ranges for blood pressure in healthy preterm infants in the first week after birth have been published. As a rule of thumb, the mean blood pressure (mmHg) should not be lower than the number of weeks of the infant's gestational age.

Although relatively easy to measure and monitor, arterial blood pressure does not correlate well with cardiac output and systemic perfusion in preterm infants. Other variables including heart rate, peripheral oxygen saturation, acid-base status, and urine output can be measured. These too are relatively poor measures of organ perfusion. Doppler ultrasonography assessments of systemic perfusion might be more useful for determining when to intervene and which intervention is most appropriate. Currently, these techniques are not widely available.

Patent ductus arteriosus

In the first few days after birth, patency of the ductus arteriosus is a major cause of hypotension and poor perfusion. Over one quarter of very preterm infants develop a clinically important patent ductus arteriosus. The risk of this is greatest in infants with severe respiratory distress syndrome. The clinical consequences are related to shunting of blood through the patent ductus from the aorta to the pulmonary arterial circulation. This "left to right" shunt alters the blood flow distribution to vital organs. Increased pulmonary blood flow can damage the preterm lungs. Preterm infants with a patent ductus arteriosus are at higher risk of more severe and prolonged respiratory distress syndrome, chronic lung disease, intraventricular haemorrhage, and death than similar infants whose ductuses have closed.

Nursing preterm infants in incubators allows the neutral thermal environment, noise, and light to be controlled effectively. Ports allow access to the infant

Risk factors for increased insensible fluid loss

- Short gestation
- High ambient temperature
- Radiant heater
- Phototherapy lamp
- Low ambient humidity

Variables that should be monitored in the very preterm infant

- Temperature: core and peripheral
- Heart rate
- Respiratory rate
- Peripheral oxygen saturation
- Blood pressure
- Urine output
- Partial pressure of oxygen and carbon dioxide
- Acid-base status
- Electrolyte balance
- Weight gain or loss

Risk factors for hypotension and poor perfusion

- Short gestational age
- Lack of antenatal steroids
- Positive pressure ventilation
- Patent ductus arteriosus
- Perinatal asphyxia
- Systemic infection

Doppler colour flow of patent ductus arteriosus with left to right shunt that can change blood flow distribution to organs. Courtesy of Drs N Evans and G Malcolm, Royal Prince Alfred Hospital, Sydney

The patent ductus arteriosus may be closed surgically, with transthoracic ligation, or pharmacologically, with prostaglandin synthase inhibitors, such as indometacin or ibuprofen. Current data on overall benefits and harms are insufficient to determine if surgical or medical treatment is the better initial treatment for symptomatic patent ductus arteriosus in preterm infants. In most centres, surgical ligation is reserved for instances where the ductus remains open despite pharmacological treatment. However, retrospective studies show that surgical ligation may be a better firstline treatment in extremely preterm infants, particularly if the ductus is large. Further randomised controlled trials are needed to clarify these issues.

Prophylaxis with indometacin

Prophylactic use of indometacin in very low birthweight infants confers short term benefits, including a fall in the incidence of symptomatic patent ductus arteriosus, a reduced need for surgical ligation, and a reduced incidence of intraventricular haemorrhage. Prophylactic indometacin does not, however, improve survival or longer term neurodevelopmental outcomes. The decision to use prophylactic indometacin will depend on the values that parents and carers attach to the short term benefits. In neonatal units without ready access to cardiac surgical services, a reduction in the need for surgical ligation may be considered a greater benefit than in units with these services.

Anaemia of prematurity

Anaemia is common in very preterm infants. Evidence exists that delaying umbilical cord clamping until 30-60 seconds after birth facilitates fetoplacental transfusion and reduces the need for blood transfusions in the early neonatal period. Further large trials are needed to clarify whether this practice improves important outcomes, such as longer term neurodevelopment for very preterm infants. Postnatally, repeated blood sampling is a major cause of anaemia of prematurity. Very preterm infants can lose 10-25% of their blood volume each week through blood sampling. Although transfusion with packed cells can replace these losses, uncertainty exists over the most appropriate indications for replacement transfusion. Given the potential complications, blood transfusions should be limited to the minimum needed to maintain optimal oxygen delivery to vital organs. Recombinant erythropoietin is an alternative to blood transfusion. Little evidence exists, however, to show that its use reduces the number of blood transfusions needed in extremely preterm infants—the population at greatest risk of anaemia of prematurity.

Conclusion

As well as respiratory and nutritional support, optimal care for preterm infants in the early neonatal period demands attention to several key inter-related issues, including temperature control, fluid and electrolyte balance, glucose homeostasis, and haemodynamic status. Maintaining metabolic and physiological stability at this time may have an important impact on survival and neurodevelopmental outcomes.

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The ABC of preterm birth is edited by William McGuire, senior lecturer in neonatal medicine, Tayside Institute of Child Health, Ninewells Hospital and Medical School, University of Dundee; and Peter Fowle, consultant paediatrician, Perth Royal Infirmary and Ninewells Hospital and Medical School, Dundee. The series will be published as a book in spring 2005.

Meta-analysis of need for surgical ductus ligation in trials of prophylactic indometacin in very low birthweight infants. Adapted from Fowle PW et al. *Cochrane Database Syst Rev* 2003;(4):CD000174

Aetiology of anaemia of prematurity

- Frequent blood sampling
- Low reticulocyte levels
- Low levels of endogenous erythropoietin
- Poor response to endogenous erythropoietin
- Shortened life span of neonatal erythrocytes

Risks of blood transfusion in preterm infants

- Fluid overload
- Transfusion associated infection:
 - Hepatitis B and C viruses
 - Human immunodeficiency virus
 - Cytomegalovirus
- Haemolytic transfusion reactions
- Immune mediated transfusion reactions
- Extravasation injury
- Graft versus host disease (rare)

Measures to reduce the risk of infection associated with transfusion

- Screen donors for transmissible viruses
- Limit exposure to multiple donors—multiple paediatric packs from single adult donor
- Use cytomegalovirus antibody negative blood
- Irradiate transfusion packs
- Use leucocyte depletion filters (removes cytomegalovirus)

Further reading

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