A Manual of Neonatal Intensive Care

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Special care baby units

Special care and intensive care

For reasons that are as much political as medical, two categories of 'out-of-the-ordinary' care are recognized for the neonate – special care and intensive care. Both should include adequate facilities for the resuscitation of infants who are apnoeic at birth, but intensive care includes the management of respiratory failure, and total parenteral nutrition, the care of severe infectious and metabolic illnesses, and postoperative care. Such patients need a nurse to patient ratio of at least three to one to cover each twenty-four hours.

Special care units are for infants requiring less intensive therapy or observation, with conditions such as neonatal jaundice, transient respiratory disorders, and, of course, the very low birthweight but asymptomatic infant. This level of care requires a nurse to patient ratio of one to one to cover each twenty-four hours (DHSS, 1971).

For the purpose of this book, however, I will refer to all units as Special care baby units (SCBU), and the readers will no doubt have a clear – if not altogether unbiased – opinion of what level of care their own units provide.

Criteria for admission to and discharge from the SCBUs

Too many infants are admitted to SCBUs when their mothers could look after them just as well, if not better, on the postnatal ward. Furthermore, early separation of the mother from her baby is damaging for both, and should be avoided unless it is absolutely necessary. For this reason the basic criteria for admission to a SCBU should be:

i. illness in the infant;
ii. birthweight less than 2 kg.

Asymptomatic babies over 2 kg, more or less irrespective of the length of their gestation periods, should be nursed with their mothers on the postnatal wards. Instrumental or surgical delivery does not require SCBU admission. Many minor problems in the neonatal period can be managed while keeping the infant with his mother on the postnatal ward (Table 1.1).

Table 1.1 Unjustifiable causes for admission to SCBU
i.e. conditions which can be satisfactorily managed on the postnatal ward

Forceps delivery Caesarean section Breech delivery Ventouse extraction Other malpresentation	Infant in good condition after delivery.
Multiple pregnancy	
Mild birth asphyxia	i.e. IPPV necessary but infant vigorous, normal by 10 minutes of age
Birthweight 2.0–2.5 kg	Infant in good condition irrespective of gestation period
Small for dates	
Meconium staining	But *no* respiratory symptoms
Traumatic cyanosis	
Adverse previous history	(Obstetric complications, neonatal death, stillbirth etc.)
Maternal illness or injury	(e.g. Epilepsy, steroid therapy)
Jittery	
Jaundice	≤18 mg% (308 μmol/l) in asymptomatic term infant
Feeding problems	
Mucousy	
Vomiting	Without persisting weight loss or signs of intestinal obstruction
Minor infections	(e.g. Urinary, skin, conjunctiva)
Malformation	(e.g. Cleft palate, mongolism, CDH)
Social problems	

IPPV = intermittent positive pressure ventilation.

Once a baby over 2 kg has recovered from the condition necessitating admission to the SCBU, he can be discharged. If the mother is still in hospital, the infant should be reunited with her on the postnatal ward to establish breast feeding. Most healthy infants weighing 2.0–2.1 kg who are feeding satisfactorily – albeit three-hourly – may be safely discharged from hospital, provided that the mother can keep her baby well swaddled in a room at 70 to 75°C. To avoid the anxiety which the community services currently feel about such infants, it helps to alert and enlist the support of the mother's GP, midwife and health visitor prior to discharge.

Parental access

One of the major advances in neonatology over the last five years has been the recognition of psychological problems caused by even short-term separation of a well neonate from his mother. This separation may have long-term effects on the patterns of behaviour and response between the mother and her baby, and on the infant's intellectual development. The psychologically more arduous and much more protracted separation of a sick, very low birthweight infant from his mother may have more severe effects, including an increased risk of non-accidental injury and 'failure to thrive'.

It is therefore essential that both parents have *ad libitum* access to their baby in the SCBU. They should be encouraged to hold the baby's hand and soothe him no matter how ill he is and how much complicated monitoring paraphernalia he is connected to. Their infant's condition and progress must be frequently explained to them by senior members of both the nursing and medical staff. Siblings and grandparents should also be allowed into the units. As the infant's condition improves, his parents should be encouraged to take him out of the incubator for a cuddle and to help with bathing and tube feeds.

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2
Temperature control

In the era of sophisticated incubators and complex infant care centres, it should not be assumed that the control of a premature infant's thermal environment is either unimportant or easy. Indeed there is evidence that devices such as overhead radiant heaters have made the infant's thermal environment more dangerous and difficult to control.

Physiology

Heat loss

The newborn baby loses heat by conduction, convection, evaporation, and radiation. Since the neonate has a big surface area for a small body mass, his heat loss is considerable, particularly if he is naked.

1. Conductive losses are small, unless the infant is laid on a cold, uninsulated surface!

2. Evaporative heat loss is dependent on three things.

(a) How wet is the baby from sweating or being covered with liquor at delivery?

(b) How much is he exposed to drying factors?: e.g. is he in a draught.

(c) How immature and water permeable is his skin?

Evaporative and convective heat losses can cool an infant down by 0.25°C (0.5°F) per minute, and may be large in an infant nursed in very dry air, but is less than 25 per cent of the infant's heat loss when the air is 50 per cent saturated.

If incubator humidifiers are kept empty (to prevent colonization by pseudomonas), very small infants may not be able to sustain their body temperature, and with overhead radiant heaters, their insensible (evaporative) water loss may exceed 70 ml/(kg·day), doubling their fluid requirements.

3. Within most incubators, the fan causes considerable air circulation and small prems may only sustain their body temperatures if one end of the radiant heat shield (*vide infra*) is blocked off to stop the draught.

4. The infant exchanges radiant heat with every nearby object. In an incubator the effective temperature is a function of the temperature inside and outside, and to obtain the 'operative' temperature 1°C needs to be deducted from the incubator temperature for every 7°C the room temperature is below the incubator temperature. Radiant heat loss can be minimized by clothing the infant (including a thick hat – gauze is not enough), by using double-glazed incubators or by putting a small Perspex shield (a radiant heat shield) over the infant in a single-walled incubator.

One very important cause of heat loss in sick infants with both evaporative and convective components is the use of dry, cold gas blown down a funnel, into a head box, or down an endotracheal tube during assisted ventilation of any type. Such gases should always be warmed and humidified.

Heat conservation

The simplest way in which infants can conserve heat is by lying curled up in as tightly flexed a position as possible. This is the natural position for a mature infant, and can be imposed on a prone, premature infant. The sick neonate tends to lie supine in the 'frog' position with all his surfaces showing, thereby maximizing heat loss.

Skin vasoconstriction with cold is similar in neonates and adults, but even in the chubby, full-term infant, the insulation of the subcutaneous tissues is less than one half that of the adult; in low birth-weight infants it is even less.

Heat production

When a neonate is exposed to cold he becomes restless, but only shivers when the environmental temperature is much lower. During the first weeks of life non-shivering thermogenesis generates heat by the hydrolysis in brown fat, of triglycerides to free fatty acids and glycerol, and the subsequent resynthesis to form triglycerides. These pathways are exothermic and liberate approximately 2.5 calories/g of brown fat per minute, warming the blood passing through the tissues.

During brown fat metabolism oxygen is consumed and, if the infant is hypoxic, his response to cold will be jeopardized (Fig. 2.1). Ill, hypoxic infants, therefore, drop their body temperatures rapidly if transiently exposed to a cool environment. This metabolic response to cold is also inhibited by drugs, intracranial haemorrhage, hypoglycaemia and central nervous system malformations.

Clinical effects of cold

The deleterious effects of cold on the premature infant are listed in Table 2.1, part A. Although thermal stress can probably cause problems without the infant's temperature falling, more side effects will

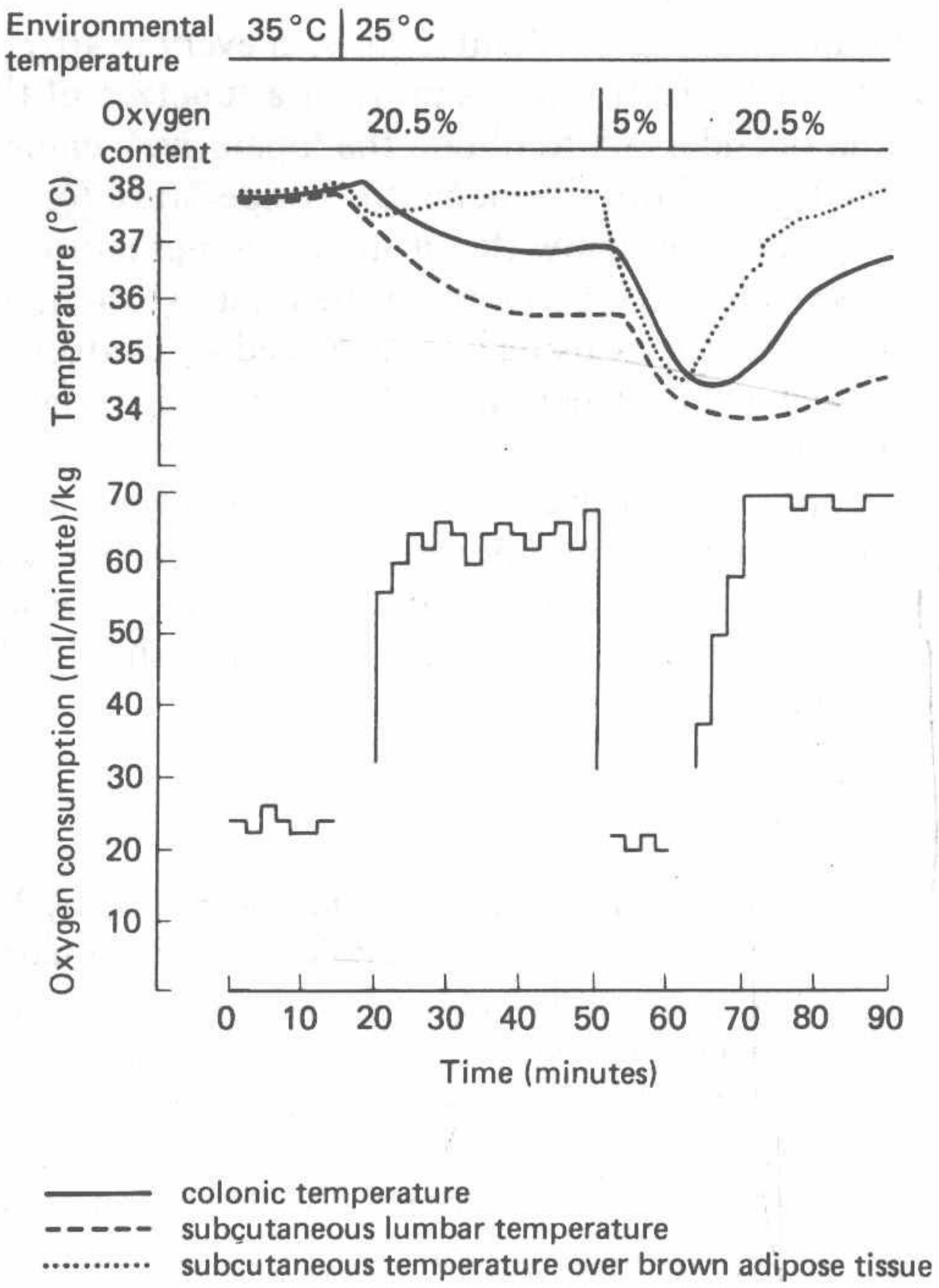

Fig. 2.1 The effect of cold and hypoxia on oxygen consumption and temperature in the neonatal rabbit. (From Dawkins and Hull, 1964, ***Journal of Physiology*** **172** 216–238

Table 2.1 Deleterious effects of thermal stress on low-birthweight babies

A. **Cold**	B. **Heat**
↓Surfactant synthesis	↑Fluid loss (evaporative, sweating)
↓Surfactant efficacy	↑Postnatal weight loss
↓pH	Hypernatremia (hyperosmolarity)
↓Pa_{O_2}	↑Jaundice
Hypoglycaemia	Recurrent apnoea
↑O_2 consumption	↑***Neonatal mortality***
Diversion of cardiac output to brown fat	
↑Utilization of calorie reserves	
↑Postnatal weight loss	
↓Later weight gain	
Neonatal cold injury (? sclerema)	
↓Blood coagulability	
↑***Neonatal mortality***	

develop once his physiological responses to cooling are overcome and his body temperature falls.

Nearly half a century ago Blackfan and Yaglou (1933), demonstrated keeping the infant's body temperature higher significantly reduced mortality.

Clinical effects of overheating

There are also dangers from overheating (Yashiro *et al.*, 1973) including an increased mortality. Although the exact cause of this is not clear, various serious complications are listed in Table 2.1 part B.

Management of temperature control

Normal babies

Since oxygen is consumed in warming a cool infant, and cooling a hot infant, the ideal thermal environment is that in which the infant's oxygen consumption is minimal. This is known as the neutral temperature range.

The rates of minimal oxygen consumption rise during the neonatal period from 4.6 ml/kg per minute in the first few hours to 7 to 7.5 ml/kg per minute at one month. The bottom end of the neutral temperature range is higher in infants of low birthweight and steadily falls with increasing postnatal age.

By noting the environmental temperature at which oxygen consumption is minimal the ideal temperature in which to nurse naked and clothed newborn infants of different birthweights and postnatal ages has been worked out (Fig. 2.2).

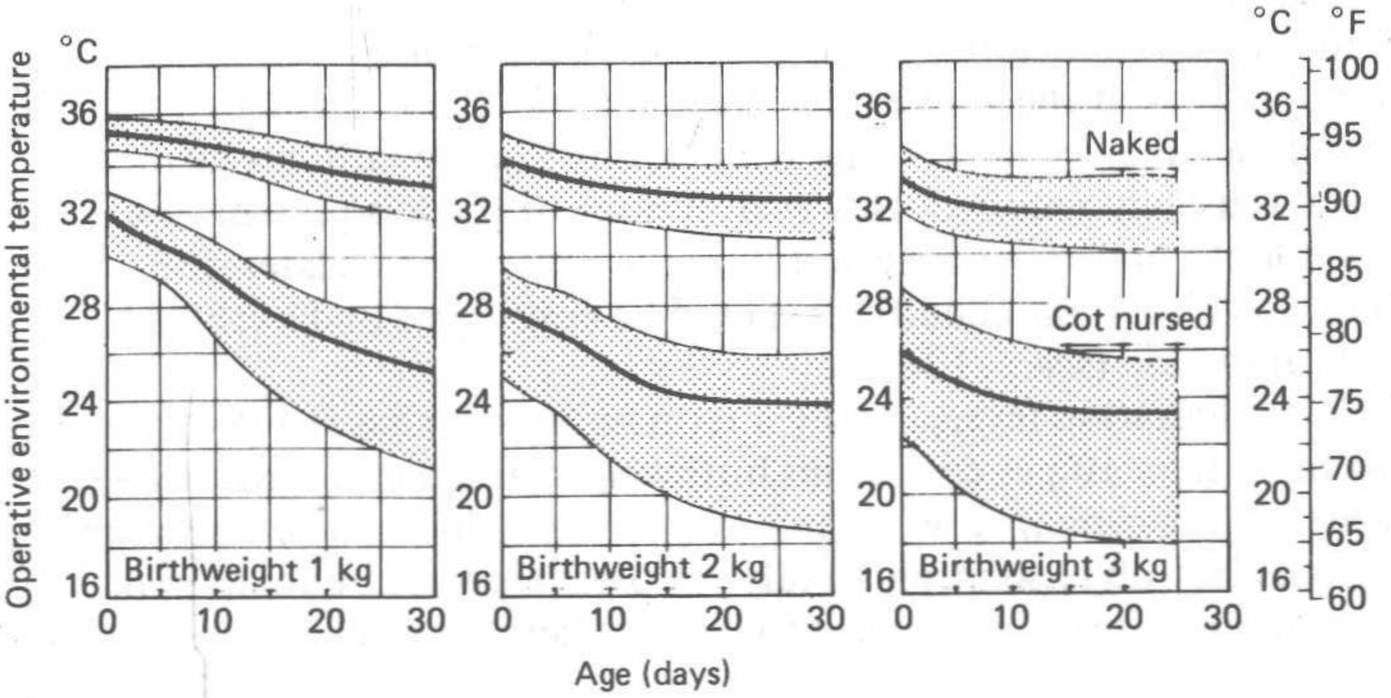

Fig. 2.2 Temperature at which to nurse newborn babies in a draught free environment at 50% relative humidity. The dark line indicates the 'optimum' temperature and the shaded areas the range of temperature within which the baby can maintain a normal body temperature. (From Hey, 1971)

Babies with low body temperatures

This may indicate serious problems such as sepsis, brain damage, hypoxia or hypoglycaemia which must be excluded.

However, in addition to therapy for these conditions, the infants should be nursed under a radiant heat shield in an incubator with its temperature set according to Fig. 2.2. A thick gamgee hat should be put on to minimize radiant heat loss from the scalp. If the temperature is not rising within an hour try the following:–

1. Increase incubator temperature further.
2. Increase room temperature, i.e. increase the environmental temperature to reduce radiant heat loss.
3. Clothe the baby if he is capable of generating body heat, but if the baby is seriously ill and cannot generate endogenous heat, clothes shield him from external sources of warmth.
4. Close off the end of the heat shield to decrease convective loss (draughts).
5. Put water in incubator humidifier to prevent evaporative loss.
6. Add an overhead radiant heat source in addition to the incubator heat, but beware of excessive evaporative water loss.
7. In the short term put hot water into the humidifier; giving the infant a 'sauna' will raise his temperature more quickly.

Babies with a fever

These babies should be examined carefully for signs of illness, but pyrexia is often due to:

i. incubator/room temperature too high;
ii. lying in direct sunlight – or phototherapy – effectively a radiant heat source;
iii. over-swaddling the infant – causing heat stroke!

Combinations of the above three are common. These nursing errors should be remedied, and, if the temperature rapidly falls, no further action is usually required. However, if none of them is present, the infant looks unwell, or if he is still febrile sixty minutes later, the following important conditions should be considered and excluded.

1. Infection (*see* p. 126).
2. Dehydration fever; usually a term infant who has fed poorly and lost more than 10 per cent of his birthweight. His serum osmolarity will exceed 300 mosmol/kg water and rehydration with milk or intravenous glucose electrolyte solution rapidly restores temperature to normal.
3. Brain damage with injury to hypothalamic centres.

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3
Infant feeding

For a full discussion of this enormous subject the reader is referred to Fomon (1974).

Which milk to give

Many cow's-milk based formulae are now available as alternatives to breast feeding, expressed breast milk (EBM), or drip breast milk (DBM) collected from the contralateral breast during suckling. Most of the milks have been extensively modified from what was originally produced from the cow and there is little difference between the various brands (Table 3.1). In general, the mineral content of the milks has been reduced to be nearer that of breast milk; the protein has been modified to produce a casein: lactalbumin ratio and an amino acid breakdown pattern which approximates to that of breast milk; and the fat has more unsaturated fatty acids like breast milk. Whether the chemical and nutritional differences between breast milk and the various formulae matter is disputed, but what evidence there is is reviewed below.

Calories

The fact that all the milks have similar *calculated* caloric values (Table 3.1) disguises the fact that the number of calories *absorbed*, particularly from fats, is very variable. Drip breast milk is also low in calories.

Fats

The fatty acid composition of breast milk varies with the mother's dietary fatty acid intake and, similarly, the fatty acid composition of the infant's adipose tissue will vary with the fatty acid composition of the milk drunk, be it from the breast or from the manufacturer's packet. Whether these differences are relevant to atherogenesis remains uncertain.

Newborn artificially-fed, premature infants may have marked steatorrhoea, losing up to 50 per cent of ingested long-chain fat in their stools. Even breast fed infants may lose 20 per cent (Shaw, 1976).

Table 3.1 Composition of commonly used milks

	Cow	Breast	Drip breast milk**	SMA Gold Cap	Cow and Gate Premium	Osterfeed	Milumil
Carbohydrate (g/100ml)	4.7	7.4	7.1	7.2	6.9	7.0	8.4
Fat (g/100ml)	3.8	4.2	2.2	3.6	3.45	3.82	3.1
Protein (g/100ml)	3.3	1.1	1.3	1.5	1.8	1.45	1.9
(Casein: lactalbumin ratio)	4:1	2:3	2:3	2:3	2:3	2:3	4:1
Cals/100ml	65	70	54	66	65	68	69
Na mmol/l	25	6.4	4.8	6.4	10	8.3	13
K mmol/l	36	15	16	14	15	15	14
Ca mmol/l	32.5	9.0	6.0	11	12	9	18
PO_4 mmol/l	32	4.8	–	10.7	10.0	10.0	17.8
Fe mg%	0.15	0.08	–	1.27	0.65	0.96	0.7
Vit A μg/100ml	17–38	60	–	80	80	100	57
Vit D μg/100ml	0.5	0.8*	–	1.1	1.1	1.00	1.0
Vit E μg/100ml	60	350	–	950	1000	480	800
Folic acid μg/100ml	3.7	5.2	–	3.2	3.5	3.4	5.0

*Water soluble vitamin D.
**Data of Lucas, Gibbs and Baum, 1978 for milk thirty to ninety days postpartum.

Protein

Infants less than 1.5 kg at birth gain weight less well on EBM than on formulae with a protein content of 1.8 to 2.2g/100 ml (p. 17). Paradoxically, excessive protein, particularly of the wrong lactalbumin to casein ratio, may also retard growth probably by causing a metabolic acidaemia (Table 3.2; Räihä *et al*., 1976).

Table 3.2 Percentage incidence of metabolic acidosis (base deficit ≥8.0 mol/L) with different protein intake. (From Svenningsen and Lindquist, 1973.)

	Protein in milk (g/100 ml)		
	1.69	*2.29*	*3.89*
Normal term infant	2.7%	3.1%	7.7%
SFD term infant	8.3%	9.5%	16.7%
Premature infant	10.3%	24.5%	37.5%

SFD = small for dates

Highly modified cow's-milk formulae have no free amino acids (unlike EBM). Whether this has any clinical implications is unknown.

Sodium

On EBM, or modified milks with a low sodium content, infants weighing less than 1.5 kg may become hyponatremic (less than 120 mmol/1), particularly if they have poor renal sodium conservation. Up to 10 mmol/kg per day of supplementary sodium may be required.

Calcium and phosphorus

The newer cow's-milk based formulae still have a higher phosphate content than breast milk, but clinically important hyperphosphataemia is unusual and therefore hypocalcaemic tetany or convulsions are rare.

Iron

Most formulae now have iron added to them, whereas EBM is very low in iron (Table 3.1). However, EBM iron is probably in a form which is better absorbed than the iron in formula milks (Saarinen and Siimes, 1979).

Premature babies may become iron deficient in the first few months, since they are born before their body iron stores are laid down transplacentally and need iron supplements (p. 217).

Vitamins

Vitamin C deficiency may lead to hypertyrosinaemia in premature infants on very high protein intakes (p. 189). Adequate vitamin D is present in a water soluble form in breast milk, and 400 u/l of fat soluble vitamin D are added to most formulae. Infants between 1.5 and 2.5 kg birthweight should receive a further 200 to 400 units of vitamin D daily, but infants less than 1.5 kg require at least 1500 units of vitamin D daily to prevent rickets.