

Postoperative care of neonates

This article deals with the care of the surgical neonate in the postoperative period. This is a time for physiological optimisation following the major stress of a surgical insult. For the surgical neonate particular vigilance is required with attention paid to pain and analgesia, temperature, apnoea and fluids, electrolytes and nutrition.

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Infants can present with an enormous variety of conditions (**TABLE 1**) and despite their age can come from vastly different physiological backgrounds. Ex-preterm residents and graduates of the neonatal intensive care unit will present with many more challenges than an otherwise healthy term infant with an isolated surgical problem. In addition the practice of paediatric surgery is very broad based. However these infants share many similar physiological needs that require particular consideration in the postoperative period and it is these common topics that will be briefly discussed in this introduction to the subject.

Most surgery on neonates for congenital abnormalities happens postnatally. Early communication between the obstetrician, neonatologist, surgeon and anaesthetist, as well as the nursing team involved in caring for the infant, is essential.

Cessation of breathing activity that lasts longer than 15-20 seconds, or shorter if it is associated with a bradycardia, cyanosis or pallor. In extremely low birthweight babies an apnoea of even six seconds can result in desaturation. It is rare in full term babies but occurs, to an extent, in most preterm infants. While the exact pathophysiology is unclear, the neural and chemical systems that regulate pulmonary ventilation are known to be immature in preterm infants.

The precise age at which former preterm babies no longer have an apnoea risk is debatable. The known risk factors include gestational age at birth, post conceptional age, previous history of postoperative apnoeas and anaemia (haematocrit < 30%). The risk for a child born at 35 weeks falls to <1% at 54 weeks post conceptional age, but this increases to 56 weeks for a child born at 32 weeks¹.

These infants must therefore be admitted to hospital following their surgery and monitored with both pulse oximetry and an apnoea monitor. It is possible to reduce the risk by administering caffeine to these patients although monitoring is still required.

Temperature control

Man is homeothermic with a body temperature maintained within a narrow

Keywords

apnoea: temperature control; thermoneutral environment; analgesia; regional anaesthesia; fluid and electrolyte balance; TPN

Key points

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1. Following surgery, neonates are susceptible to apnoea and poor temperature control.
2. Pharmacodynamics and pharmacokinetics in neonates differ markedly from older children and so maturity as well as weight needs to be taken into consideration when drawing up a drug dosing schedule.
3. Regional anaesthesia is a good way of achieving analgesia in surgical neonates.
4. Fluid losses and electrolyte balances need careful monitoring in postoperative infants.

Environment and monitoring

Surgical neonates have the potential to develop postoperative apnoeas and poor temperature regulation. Therefore it is imperative that they are cared for in areas where there are both appropriate facilities and trained staff to monitor their condition and intervene when necessary.

Apnoea monitoring

Central apnoeas can be defined as the

Congenital

- Oesophageal atresia and tracheoesophageal abnormalities
- Congenital diaphragmatic hernia
- Abdominal wall defects
- Pyloric stenosis
- Neonatal intestinal obstruction
- Anorectal anomalies
- Patent ductus arteriosus

Acquired

- Inguinal hernia
- Intussusception
- Necrotising enterocolitis
- Circumcision

TABLE 1 Common surgical conditions presenting for surgery in the neonatal period.

- Increased oxygen consumption
- Impaired respiratory responses
- Decreased drug metabolism
- Depressed immune function
- Poor platelet function
- Reduced ability of wound repair

TABLE 2 Systemic effects of hypothermia in the neonate.

range. This is required for optimal enzyme activity and metabolic processes. Neonates are at considerable disadvantage for this type of system due to their immature control systems. Both hypothermia and hyperthermia are witnessed more frequently in babies than in adults.

Babies have numerous ways to lose heat and unlike adults have less efficacious systems for generating heat. A neonate has a high body surface to body weight ratio, a poorly developed subcutaneous fat layer and a high insensible water loss. These allow heat to be lost by radiation, convection, evaporation and through respiration. By understanding these mechanisms it is possible to minimise heat loss during anaesthesia, surgery and the recovery period and avoid the systemic effects of hypothermia (**TABLE 2**).

Generation of heat by the neonate involves a system of non-shivering thermogenesis achieved by metabolism of brown fat. This brown fat is deficient in premature infants. The thermoregulatory centre in the hypothalamus governs temperature control. It receives afferent signals from the temperature receptors in the skin and triggers an appropriate reflex response. However, general anaesthetic agents and opiates depress the response from the hypothalamus.

While much of this discussion is focussed on hypothermia and its prevention, it is worth noting the dangers of hyperthermia to the neonate. Over heating has been associated with sudden death.

Temperature measurement

Core temperature is the temperature of the deep tissues and can be measured reliably from the pulmonary artery, tympanic membrane and distal oesophagus, but can also be estimated adequately from oral, rectal, axillary or bladder temperatures². Skin temperature varies with the environmental temperature and with heat balance. Both skin and core temperatures should be measured.



FIGURE 1. Easy access to the infant permits nursing interventions to be carried out without disturbing the baby. *Photo: Eddie Lawrence.*

Provision of a thermoneutral environment

The thermoneutral range is an environmental temperature range across which the body can maintain temperature regulation by skin blood flow alone. This is about 35–37°C in neonates, whereas in adults the thermoneutral range is about 20–28°C. Sick neonates are especially sensitive to alterations in the environment. For babies in the recovery period, a thermo-neutral environment is best achieved by placing them in either an incubator or a cot with a radiant warmer. There is much debate about the advantages of one system over the other. Radiant warmers allow easy access to the infant while minimising alterations to the baby's environment (**FIGURE 1**). However they are associated with an increase in insensible water loss seen most significantly in very preterm infants in the first week of life³. Furthermore, research has shown there are more non emergency nursing interventions carried out with open care systems⁴, and an increase in handling is associated with an increased metabolic demand. A recent review⁵ however was unable to distinguish which method was better for maintaining body temperature in newborn babies.

Analgesia

For many years it was thought that neonates were unable to feel pain. This belief, coupled with the lack of pharmacodynamic and pharmacokinetic data regarding the use of analgesics in the neonate, led to neonates receiving

inadequate pain relief. The International Association for the Study of Pain describes pain as an unpleasant sensory and emotional experience resulting from a stimulus causing, or likely to cause, tissue damage, or expressed in terms of that damage. With this definition in mind it is difficult to compare pain in a neonate with that of an older child or adult, who not only can express what they are feeling, but also relate it explicitly to previous experience. Nociception therefore is a more appropriate term to describe neonatal pain perception.

A pain system exists in the fetus and it continues to evolve during the neonatal period. Compared with adults it is an underdamped poorly discriminative system with a potential for very exaggerated responses. In addition the physiological and behavioural responses to nociception are varied. This makes pain evaluation challenging in the neonate. Numerous scales which collate multiple behavioural and physiological indicators are available. Changes in facial activity and heart rate remain the most sensitive markers of nociception in the neonate⁶. Notwithstanding the humanitarian need to alleviate a patient's discomfort, there is evidence to suggest that early untreated pain can result in heightened responses to pain in later life⁷.

As with older children and adults, a postoperative pain management scheme should be planned in advance. Analgesia for the neonate falls into two broad

Post conceptual age	Max daily dose	Loading dose	Suggested scheme
Term and pre-term > 32 weeks	60mg/kg/day	Oral:30mg/kg Rectal:40mg/kg	Oral:20mg/kg/8 hours Rectal:30mg/kg/12 hours
Pre-term 28-32 weeks	40mg/kg/day	Rectal:20mg/kg	Rectal:20mg/kg/12 hours

TABLE 3 Suggested dosing schedule for paracetamol.

categories; systemic drugs and local anaesthetic techniques. However drug pharmacokinetics and pharmacodynamics differ significantly in a neonate compared to an adult and so dosing schedules of drugs cannot be scaled down simply according to weight.

Neonates have a greater fraction of body weight present as water and so in theory should have a greater volume of distribution. They have a lower concentration of plasma proteins that bind drugs, especially alpha-1 glycoprotein and albumin, hence there is a greater fraction of unbound drug with potential for an increase in drug effect and toxicity. Further, bilirubin, which is often present at higher concentrations in the neonate, will compete with exogenous drugs for albumin. The lower renal perfusion and reduced glomerular filtration rate seen in neonates explains the reduced clearance rates of drugs that rely on the kidney for elimination. Hepatic enzyme systems required for drug metabolism are incompletely developed at birth. All these factors have to be taken into account.

Systemic analgesic drugs

Paracetamol is the most widely used antipyretic and mild analgesic used in children. The exact mode of action of paracetamol remains unclear however it is known to have both a central and a peripheral mode of action. Centrally it is an inhibitor of prostaglandin synthesis, which explains its antipyretic action. Peripherally it acts by blocking impulse generation within the bradykinin-sensitive chemoreceptors responsible for the generation of afferent nociceptive impulses⁹.

The dosing schedule (TABLE 3) is based upon reaching a plasma level of 10–20mg/mL which results in effective fever control and analgesia⁹. The drug can be administered by the oral and rectal route.

Non steroidal anti-inflammatory drugs should be avoided in infants less than six months of age¹⁰.

Morphine can be administered safely to neonates with appropriate facilities, monitoring and dosing. In addition to

acknowledging that the maturing neonate has changing hepatic enzyme and renal systems that account for a different pharmacokinetic profile compared to older children and adults, it is important to remember that opiates can also exhibit exaggerated respiratory depressant effects in neonates.

Respiratory responses to hypercapnoea and hypoxaemia are immature at birth and result in respiratory depression. It follows that there is greater opioid-induced respiratory depression observed in neonates than in older infants. By 3–6 months however the ventilatory depression seen is no greater than in adults with similar plasma concentrations of morphine¹¹.

Morphine clearance in term infants greater than one month old is comparable with children aged 1–17 years. In neonates aged 1–7 days, the clearance of morphine is one-third that of older infants and the elimination half-life is approximately 1.7 times longer at 6.5 hours. In preterm neonates the elimination half-life is longer still at nine hours^{12,13}. Thus there can be accumulation of active metabolites, since these are normally excreted renally.

Suggested morphine infusions for the postsurgical neonate are 0.01–0.02 mg/kg/hr but may need to be scaled down in view of past medical history¹³. Neonates on a morphine infusion should be observed with an apnoea monitor and have their oxygen saturations measured continuously in an environment where there are staff skilled in airway management.

Codeine, a less potent opioid, can be administered orally or rectally in a dose of 0.5–1mg/kg¹⁴.

Local anaesthetic techniques

Peripheral nerve block and local infiltration – anaesthetists will often perform peripheral nerve blocks or ask surgeons to infiltrate the surgical wound with local anaesthesia in order to try to minimise the need for systemic analgesics.

Regional anaesthesia is a commonly used technique for achieving excellent analgesia in neonates¹⁵. Techniques for central neuroaxial blockade include spinal,

epidural and caudal anaesthesia (both as a single shot and using an infusion with a catheter). In addition to pain relief, regional anaesthesia can attenuate the stress response to surgery and can decrease the need for postoperative ventilation. Generally infusions are made up of local anaesthetic with or without the addition of opioids. Catheters are left in place for around 72 hours. There is no overall agreement as to how a patient with an epidural infusion should be monitored¹⁶. However if an epidural or caudal infusion is planned then the patient should be nursed in a high dependency unit. The catheter insertion site should be inspected regularly. Infusions must be administered through dedicated pumps and ideally should be purchased pre-prepared or prepared by the hospital pharmacy to avoid drug error and infection.

The maximum dose of local anaesthetic should not be exceeded in order to prevent local anaesthetic toxicity. In neonates this is half the maximum dose of older children. However the most important cause of local anaesthetic toxicity is intravascular injection. Due to its mode of action, toxic doses of local anaesthetic will cause a membrane stabilising effect on the brain and the heart. Neonates are unable to communicate any of the initial common symptoms such as dizziness or tingling of the tongue. Instead they will become drowsy, lose consciousness before progressing onto seizures and eventually cardiovascular collapse. It is for this reason that immediate access to resuscitation facilities should be available when nursing **patients of any age** receiving an epidural infusion. Treatment involves basic life support, with control of seizures and discontinuation of the infusion.

Fluids, electrolytes and nutrition

At birth all neonates are born with an excess of total body water (TBW), predominantly extracellular fluid, which they need to remove. The more premature the infant is, the greater its percentage composition of total body water. Thus a term baby can be expected to lose 5–10% of its weight in the first week; this rises to 5–15% for preterm infants. These facts demonstrate the importance of individualising fluid and electrolyte regimes. During the second and subsequent weeks, neonates undergo rapid growth and have associated high energy and electrolyte requirements.

Neonates are highly susceptible to catabolic stress because they often have markedly increased energy needs and reduced energy stores. Most postoperative neonates will require intravenous fluids. Meticulous attention to fluid and electrolyte balance, nutrition and temperature maintenance will allow achievement of homeostasis and growth while minimising developmental complications.

In calculating fluid requirements pre or postoperatively, several factors have to be taken into account:— maintenance requirements, correction of ongoing losses and replacement of deficit losses due to fluid compartment shifts (third space).



FIGURE 2. Babies undergoing phototherapy are susceptible to dehydration. *Photo: Eddie Lawrence.*

Maintenance

Maintenance requirements consist of insensible water losses, urine and stool water. Insensible water loss occurs mainly from evaporation of water through the skin (~ 66%) and through the respiratory tract. Factors influencing the amount of insensible water loss include the maturity of the neonate, ambient temperature and humidity and the environment in which the neonate is nursed. Premature infants have thinner skin, due to lack of keratinisation, and are thus prone to higher insensible water losses. Environments with a high ambient humidity may reduce insensible loss whereas the use of a radiant warmer or phototherapy may increase insensible water loss (**FIGURE 2**). Renal function also matures with age; preterm infants are more susceptible to dehydration and volume

overload as they are less able to concentrate or dilute urine in response to changes in intravascular fluid status.

Maintenance requirements are usually in the order of 100-120 mL/kg/24hr, with 2-3 mmol/kg/24hr of sodium and 1-2 mmol/kg/24hr of potassium. During periods of rapid growth, electrolyte requirements can increase markedly.

Ongoing losses

All measurable sources of fluid and electrolyte losses need to be considered. Sources include diarrhoea, ostomy, naso/orogastric drainage and cerebrospinal

fluid, including ventricular drainage. For example infants with pyloric stenosis may have considerable gastric fluid losses accounting for their presentation with dehydration and hypokalaemic, hypochloreaemic metabolic alkalosis. Correction of their fluid and electrolyte disturbance is mandatory prior to surgery. Similarly, ileostomy sodium and bicarbonate losses may be in the region of 90 and 110 mmol/L respectively. Inadequate correction of fluids and electrolytes may result in volume depletion and a metabolic acidosis.

Fluid compartment shifts

These are difficult to determine with any accuracy, guidance is often taken in the form of the response of the neonate to replacement of the above volumes with respect to alterations in heart rate, urine

output, capillary refill, blood pressure and core – peripheral temperature difference.

Assessment of fluid loss

A number of methods of determining overall fluid losses are in common use.

Weight – this may often be a poor determinant of intravascular volume. Changes in interstitial fluid volume, as with the long-term use of paralytic agents and peritonitis, can lead to an increased weight in the face of a decrease in intravascular volume.

Growth charts – these are only useful as a measure of long-term progress.

Skin and mucosa manifestations – the assessment of skin turgor, fullness of the anterior fontanelle and hydration of the mucous membranes are all unreliable clinical signs with large inter-observer variation.

Cardiovascular signs – tachycardia, delayed capillary refill, hepatomegaly and blood pressure all have to be interpreted with caution and serial recordings and response to interventions are of more value.

Laboratory tests – these will often form the mainstay of assessment. Investigations such as serum urea and electrolytes, plasma osmolality, urine electrolytes and specific gravity and blood gas analysis can give useful information as to adequacy of fluid and electrolyte replacement therapy.

Common neonatal conditions

Several common neonatal conditions warrant special mention as regards meticulous fluid and electrolyte replacement.

Respiratory distress syndrome – excessive fluid can lead to hyponatraemia and volume overload worsening the pulmonary condition and increasing the risk of bronchopulmonary dysplasia, while inadequate fluid administration may lead to hypernatraemia and dehydration.

Bronchopulmonary dysplasia – these infants have higher energy requirements as a result of their increased work of breathing. Diuretics, often used in treatment, may precipitate electrolyte disturbances.

Patent ductus arteriosus – avoiding volume overload is critical as this may significantly worsen an infant's respiratory status. Indomethacin, or other non-steroidals, used in treatment may also decrease urine output.

Perinatal asphyxia – these infants often

have multiple organ involvement. They are prone to acute tubular necrosis and resultant oliguria. Their central nervous system injury may be of such a degree that inappropriate secretion of antidiuretic hormone results. Restriction of fluid intake may be necessary to avoid volume overload.

Total parenteral nutrition (TPN)

Infants whose nutritional status is marginal and whose bowels cannot be used for nutrient absorption should receive their fluids and electrolytes as part of a total parenteral nutrition programme. Although TPN may be given via a peripheral vein in the short term, if these needs are likely to be ongoing a definitive route via the central veins is required. TPN should be managed by a multidisciplinary group with a specific interest in this area in order to optimise its benefit and minimise its side effects. The particulars of the content of TPN are beyond the remit of this article, suffice it to say that the majority of calories should be non-protein and that energy requirements are smaller, as there is no gut metabolism to be accounted for.

Conclusion

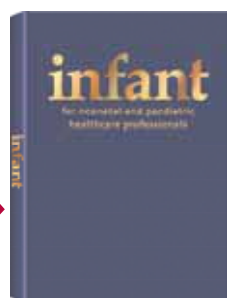
While the principles of recovery in a neonate are similar to older children and indeed adults, most neonatal systems are continuing to develop and are not fully mature. For this reason care of these patients should be undertaken in a specialist unit with appropriately trained medical and nursing staff who have access to proper equipment and perioperative facilities.

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