

Anaesthetic Guidelines for Rural Hospitals

By Dr David McCoy BM, DA(UK)

On behalf of the Rural Health Task Group of the Academy of Family Practice/Primary Care.

This series is also being produced as a booklet for the use of doctors in Rural Hospitals and will be obtainable from SA Family Practice in 1997.

PAEDIATRIC ANAESTHESIA

The series will have the following sections:

1. Introduction to anaesthetics and anaesthetic safety checklist
2. Anaesthesia, intubation and extubation
3. The pre-operative assessment
4. Anaesthetic drugs I
5. Anaesthetic drugs II
6. Spinal anaesthesia
7. Caesarean Sections
8. Paediatric anaesthesia
9. Complications during anaesthesia
10. Local and regional anaesthesia
11. Ventilation and breathing systems
12. Blood transfusion

NO. 8

anatomical and physiological characteristics that are different from adults. These peculiarities make the potential for a serious anaesthetic accident much, much higher in babies and children.

The differences between children and adults is particularly acute in the under-five year age group (see Figure 1). The older a child, the smaller are the differences with adults, and the less dangerous it becomes.

As a general rule, unless you have formal anaesthetic training, no general anaesthesia should be performed on any child under the weight of 10kg. Even with formal training, it will be better to refer infants and small children to a regional centre where possible.

Exceptions to this rule can be made for brief and minor surgical procedures that can be carried out using small amounts of Ketamine. It is also wise that all general anaesthetics or significant surgery on children, involve the most experienced anaesthetist available.

HOW CHILDREN DIFFER FROM ADULTS

Metabolism

Babies and children have a much higher metabolic rate than adults. For this reason, they use up oxygen more quickly, and can become hypoxaemic and cyanosed much more suddenly. Therefore, never perform any type of anaesthetic on children without oxygen. Always preoxygenate children before an induction for at least three minutes, and if you are going to perform a gas induction, do it with 100% oxygen.

Babies and small children also have low glycogen stores. Therefore, it is important not to interrupt a child's feeds any more than you must, and when you do, you must always use IV fluids containing at least 5% dextrose.

Airway

The size and shape of the infant's jaw makes it difficult to maintain a clear airway with simply a face mask. Infants therefore require tracheal intubation to maintain a clear airway.

INTRODUCTION

Many of the general rules about anaesthesia that have been discussed in earlier chapters apply to children as well as to adults, and this chapter should be read in conjunction with previous chapters. A separate chapter on paediatric anaesthesia is however necessary because children have a number of

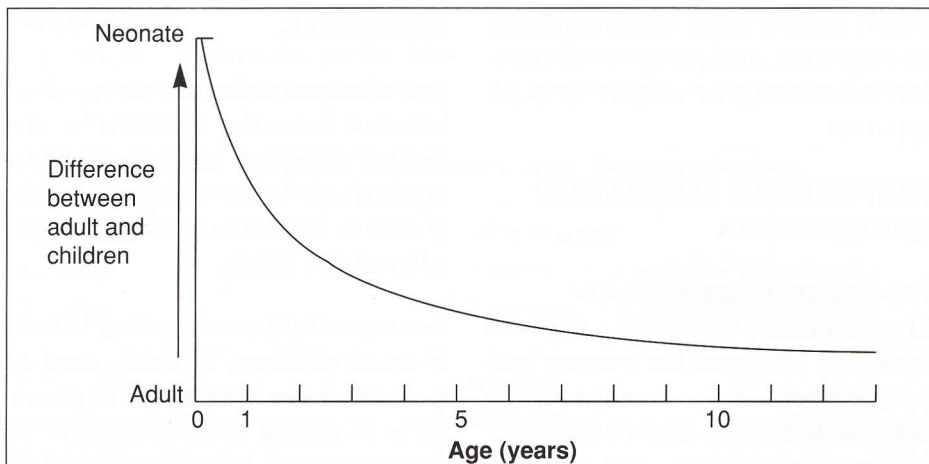


Figure 1: A schematic representation of the difference between adult and paediatric physiology

Anaesthetic Guidelines for Rural Hospitals

is smaller, even a small amount of swelling or oedema can cause serious narrowing or blockage, and lead to respiratory obstruction and stridor. A circumferential swelling of 0,5mm can reduce the volume of gas flow in a neonate by as much as 60%, given a constant pressure gradient. Similarly, the use of an endotracheal tube in an infant airway causes a sixteen-fold increase in resistance to airflow. Therefore, controlled ventilation must always accompany intubation in an infant.

Respiratory system

Small children are obligatory nasal breathers so that obstruction of the nasal airways can lead to airway problems, especially in the post-operative period. The relatively small upper airways are readily obstructed by rhinorrhea and secretions (as well as the large tongue), and therefore, an upper respiratory tract infection should be taken seriously, and is a justifiable reason for postponing non-essential surgery.

Because of characteristics related to their lung physiology, children have a less effective reservoir of air for gas exchange. This is another reason why children become rapidly hypoxic during periods of apnoea.

However, for the same reasons, inhalational induction and awakening at the termination of anaesthesia are more rapid in children than in adults.

Cardiovascular system

Small children have a high cardiac output that is mostly produced from a fast heart rate. However, because of a predominant parasympathetic tone, bradycardia occurs much more readily in children in the presence of vagal stimulation or hypoxaemia.

Blood volume in children is an

Cardiovascular characteristics		
Age	Mean rate (range)	Blood volume (mls/kg)
Neonate	140 (100-180)	90
1 year	120 (80-150)	80
2 years	110 (80-130)	80
6 years	100 (70-120)	70
10 years	80 (60-120)	70

extremely important consideration for any major surgery or for skin grafting. In small children, you only need a small amount of blood loss to cause significant hypovolaemia, and even the amount of blood that is mopped up onto swabs will be significant. Have a lower threshold for replacing blood loss than in adults.

The total blood volume is easily remembered by the 80mls/kg rule, although more accurate estimations by age group are given above.

Finally, remember that cardiac arrest in children under anaesthesia is much more a result of asystole than of ventricular fibrillation.

Central nervous system

The blood-brain barrier is underdeveloped in infants, and is the reason why infants are more susceptible to depressant drugs, including opioids. Infants also have a parasympathetic preponderance which causes vagal bradycardia to be common, and peripheral vasoconstriction to be relatively non-apparent.

PERFORMING PAEDIATRIC ANAESTHESIA

Pre-operative assessment

Always ensure that your patient is optimally prepared for surgery and anaesthesia. Upper respiratory tract infections and fevers are common in children, and are contraindications to non-essential elective surgery.

Premedication

The only form of premedication that is obligatory to consider is atropine. This protects the child against both bradycardia and troublesome secretions, and the dose is 20mcg per kilogram. Use it routinely in children under the age of six years. However, atropine should be avoided in children with pyrexia, as it can cause severe hyperthermia.

Atropine is usually given one hour pre-operatively, although some anaesthetists give it intravenously in theatre. Atropine in a drawn-up syringe should always be immediately available at induction, and during anaesthesia.

Fluid balance

Babies and small children are less able to handle fluid deprivation, fluid loss or over hydration. Be meticulous in your calculations, and think about what kinds of fluids are being lost and replace them appropriately.

You must consider the child's fluid balance from the moment he/she has become ill or been starved pre-operatively to the moment he/she is able to have a normal oral intake of food and fluids.

Because fluid overloading is easy in small children, IV fluids must be delivered via burettes and paediatric IV giving sets. In infants, 60 drops per ml burette should be used so that the rate can be controlled down to small volumes.

Anaesthetic guidelines

Summary of physiological characteristics of children and their implications

- Babies and children have a much higher metabolic rate than adults, as well as a less effective reservoir of air for gas exchange. They use up oxygen quickly, and can become hypoxaemic and cyanosed much more suddenly.
- Babies and small children have low glycogen stores. It is important not to interrupt a child's feeds any more than you must.
- The size and shape of the infant makes it difficult to maintain a clear airway with simply a face mask. The use of an endotracheal tube, however, causes a marked increase in airflow resistance. Therefore, infants require tracheal intubation to maintain a clear airway, and controlled ventilation to accompany the intubation.
- Small upper airways are readily obstructed by rhinorrhea and secretions, and therefore, an upper airway respiratory tract infection should be taken seriously.
- In small children, you only need a small amount of blood loss to cause significant hypovolaemia. Have a lower threshold for replacing blood loss than in adults.
- Bradycardia occurs much more readily in children in the presence of vagal stimulation or hypoxaemia.
- Cardiac arrest in children under anaesthesia is more commonly a result of asystole than of ventricular fibrillation.
- The blood-brain barrier is under-developed in infants, so that infants are more susceptible to depressant drugs.

Temperature regulation

Temperature regulation in children is poor, and the risk of hypothermia is big. Prevention of body cooling starts in the ward, or in the outpatient department. Make routine precautions to keep children warm and well covered in theatre. Plastic surgical drapes keep fluids off the skin and minimise heat loss from evaporation. If possible, the humidification of the inspired gases will also limit heat loss from evaporation. Infusion fluids and blood should never be transfused without prior warming, as with skin preparation solutions and body cavity washouts.

Intubation

For the above reasons, intubation and extubation must be performed

carefully and gently in small children. Do not use a tube size that is well fitting because it will cause pressure on the tissues of the glottis and lead to oedema following extubation. This oedema can then cause obstruction and stridor up to eight hours later. The general guide to endotracheal size is provided below, but always check that there is a bit of an air leak after insertion. Furthermore, only use uncuffed tubes in children below the age of eight years.

Because the trachea is short in young children, bronchial intubation can occur more easily. Therefore, always auscultate both lung fields to ensure that this has not happened.

Laryngeal spasm occurs much

more readily in children. The critical points are during intubation and during extubation. For this reason, the general rule of thumb is that children should be intubated 'deep' and extubated 'light'. In fact it is wisest to leave extubation until the child is awake enough to remove the tube himself/herself. However, in certain circumstances when it is important to ensure that the child does not cough and become restless due to the presence of the tube (eg following intra-ocular surgery, or following skin grafting), a 'deep' extubation can be considered.

In children under the age of two years, suxamethonium is often not required to facilitate intubation.

Breathing system

A full description of breathing systems will be provided in a future chapter. However, there are two important basic principles related to small children.

Firstly, because a child's tidal volume is small, it is important to keep the respiratory dead space to a minimum. This means that only good, tight-fitting paediatric face masks should be used. Secondly, it is important to minimise the amount of resistance to breathing, to prevent tiring and eventual hypoventilation.

The Ayres' T-piece apparatus with an open-ended reservoir bag (Jackson Rees modification), is the breathing system of choice. This can allow for both spontaneous and controlled ventilation, and has the advantage of reducing both dead space and resistance to a minimum. The minimum gas flow should be 3L/min, and for older children the flow rates can be calculated as 220ml/kg.

Monitoring

The importance of this cannot be

Maintenance fluid requirements – two alternative regimes

Up to 10kg	100ml/kg/day
10-20kg	1 000ml + 50 x [wt(kg) – 10] ml/kg/day
20-30kg	1 500ml + 25 x [wt(kg) – 20] ml/kg/day
0-3 months	6ml/kg/hr
3 months - 3 years	4ml/kg/hr
3-7 years	3ml/kg/hr
7 years	2ml/kg/hr

Anaesthetic guidelines

Size of endotracheal tube			Ventilation rate
Age	Diameter	Length (for oral intubation)	
Prem neonate	2,5	-	40
0-3 months	3,0	10	30
3-12 months	3,5	12	30
1-2 years	4,0	13	25
3-4 years	4,5	14	20
5 years	5,0	14	20
6-7 years	5,5	15	15
8 years	6,0	16	15
9 years	6,5	16	12

over-emphasised. Always use the pulse oximeter and always have a finger on the pulse. Constantly look at your patient and monitor her/him directly. Some anaesthetists suggest having a stethoscope fixed onto the child's chest throughout the operation so that heart sounds and respiration can be monitored constantly and simultaneously.

Post-operative care

Vomiting post-operatively is more common in children than in adults. Therefore put the child into a left lateral position as soon as possible after the operation.

The obsessional monitoring that you have initiated during the operation must continue post-operatively. Nurse the child in a lateral position as soon as possible, and provide oxygen until the child is well awake. Do not transfer the child out of the recovery room until he/she is well awake.

ANAESTHETIC TECHNIQUES FOR CHILDREN

Ketamine

Ketamine is an excellent induction and maintenance anaesthetic in children. The mental side-effects that make it unsatisfactory for adults are insignificant in smaller children.

The airway and respiratory activity is usually well maintained, and so it is only necessary most times to support the child's chin and allow him or her to breathe spontaneously, with additional oxygen providing you can eliminate the problem of increasing dead space (ie use a well-fitting paediatric mask) and ensure that there is no rebreathing.

Despite the safe properties of ketamine, respiratory obstruction, hypoxaemia and apnoea can still occur, and so you must always be prepared to intubate and ventilate with a bag and mask as necessary.

The analgesia and catatonia produced by ketamine are particularly useful for skin grafting of burns and allows exposed skin grafts to become adherent while the child remains immobile after surgery.

Halothane and oxygen

The use of halothane for the induction and maintenance of anaesthesia is also a safe and often-used technique. In small children, induction with halothane is easy (because children become anaesthetised very quickly) and you do not need to use an intravenous induction agent like thiopentone. Often, three to five breaths of halothane at 3-4% is enough to induce sleep after which the halothane can be reduced to 2%.

Although there has been controversy about the effect of repeated use of halothane in children, the incidence of this extremely small, and it remains the inhalational anaesthetic of choice in children. Both enflurane and isoflurane have side-effects that make them less appropriate choices in children.

Suxamethonium

Although there are no contraindications to the use of suxamethonium to facilitate intubation, this is often not required in children under the age of two years. However, if you do use it, give a dose of 2mg/kg in infants. Otherwise, the dose is 1mg/kg.

Children are more likely to become bradycardic from suxamethonium which is another reason for the use of atropine pre-operatively.

Relaxants

For many operations, muscular paralysis is not required in young children because their muscular tone and activity can be abolished by anaesthetic agents such as halothane. However, if a non-depolarising relaxant is thought to be necessary, the rule of thumb is: use a 'scaled-down' adult dose initially, and to restrict 'top-up' doses to one tenth of the initial dose.

Residual paralysis or difficulty in reversal are likely to be related to acid-base abnormalities or to hypothermia, correction of which restores muscle activity to normal.