In the study of holistic perspectives in perioperative care the following article focuses on the care required for paediatric patients through the perioperative period. This incorporates an understanding of the anatomical, physiological and pharmacological differences from adult practice, acknowledging the most important principles of patient safety. The planning, implementation, equipment adaptations and psychological challenges associated with this group will be discussed in relation to improving the overall perioperative experience.

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The differences of anaesthetic care in paediatrics compared to adults

As a second year student operating department practitioner (ODP), I have selected the 2-5yr old child as the target patient group. Having experienced a placement in an ear, nose and throat (ENT) clinical environment, I felt this enabled me to incorporate any research undertaken with direct reflection on practice.

It is important to acknowledge the underlying principles of safe paediatric anaesthesia encompassing the basics of anatomy, physiology and pharmacology, accentuating the differences between adults and children and how these will affect anaesthetic practice. I have considered how principles of adult anaesthesia are modified to suit paediatric anaesthesia, incorporating the equipment considerations and psychological challenges associated with this age group and their families.

Preparation for anaesthesia and the implication of anatomical and physiological differences

Physiologically, a higher metabolic rate and an increased oxygen consumption level are among the most important differences between paediatric and adult patients.

There are physiological adaptations in paediatric respiratory and cardiac systems to meet this increased demand (Brown 2000). The higher metabolic rate explains why induction and emergence from anaesthesia is much faster in children, also why a child may desaturate much faster than an adult (De Melo 2001). Additionally respiratory rates are faster due to paediatric lung immaturity and smaller lung volume reserves (Wolf & Jenkins 2005). Many older anaesthesia ventilators intended for adults cannot accurately supply the low tidal volumes and rapid respiratory rates necessary for small children. An inadvertently dispensed large tidal volume to a small child could damage the lungs due to too much inspiratory pressure (Simpson & Popat 2002).

Paediatric breathing equipment therefore needs to have a small deadspace and low resistance to breathing as children have less muscle to draw in gases (Paul 2006). The efficiency of breathing circuits is measured by the fresh gas flow required to eliminate CO2 rebreathing (Wolf & Jenkins 2005). The Ayres T-Piece with Jackson Rees modification system is valve-less, low resistance, simple and lightweight. It is classified as a Mapleson F circuit (Simpson & Popat 2002). It has a small dead space which is important to avoid rebreathing and reduced alveolar ventilation (Paul 2006).

Because there are no valves and very little resistance to breathing it has proved very suitable for children less than 20kg (Simpson & Popat 2002 p351). A paediatric filter, angle piece and mask are then attached directly to the breathing circuit with the catheter mount omitted as this just increases the dead space and rebreathing.

Paediatric airway equipment is also prepared in advance ready for intubation and other airway maintenance techniques. Laryngoscopes are available in a choice of sizes and different blades, because in small children the larynx sits at a higher and more anterior position in the neck, around the level of the 4th and 5th cervical vertebrae (Wolf & Jenkins 2005). A child’s larynx is more conical in shape with the narrowest part of the airway at the level of the cricoid ring, unseen further down the airway and not at the level of the vocal cords as in an adult (Brown 2000). As a small child develops the cricoid ring increases in size faster than the trachea, therefore by eight to ten years of age the child’s larynx has reached its adult pattern (Chamley et al 2005).
Because of the higher position of the larynx and the shape and size of the epiglottis, intubation may be easier in very small children using a straight bladed laryngoscope. For example, the Wisconsin, Robertshaw, Magill or Miller straight blades may offer a better view of the epiglottis (Booker 2000). A curved Mackintosh blade is generally easier once the child is slightly larger and this may be the personal preference of the anaesthetist (Wolf & Jenkins 2005). Care is taken with the child’s teeth as they are often wobbly and it may be safer to remove a tooth than risk inadvertent aspiration (Booker 2000). During intubation the head should be level with the table as there is no advantage in flexing the neck until the child is at least six years old, due to the large occiput (De Melo 2001). The view of the upper airway may also be further narrowed by large tonsils and adenoids as seen in ENT surgery. A young child’s larynx is particularly susceptible to oedema formation (Black 2008), a potentially serious complication of intubation. This can manifest in significant narrowing and increased airway resistance even after mild trauma. Children, until approx ten years of age, are traditionally intubated using an uncuffed tube allowing a slight air leak with positive pressure ventilation. If the leak is too large it will compromise ventilation, consequently it is important to select the correct size tube, as one that is too large may cause oedema resulting in airway obstruction on extubation (Gwinnutt 2004). More recently, reviews Weber et al (2009), small cuffed tubes are increasingly used in children with studies now providing evidence of their safety. The presence of a cuff makes a better seal between the cuff of the tube and the trachea, enabling control of any leak by adding air in the cuff instead of re-intubation with a different-sized tube (Weber et al 2009). During preparation of paediatric airway equipment it is important to ensure that all appropriate tube sizes are available, particularly one size larger and smaller than the tube intended for use. In the 2-5yr old age group, the anaesthetist may be intubating with either an endotracheal tube (ETT), or for example in ENT surgery, a preformed RAE (Ring, Adair and Elwyn) tube (De Melo 2001).

The appropriate tube size (A) and length (B) may be estimated using the following age calculations for a potentially good fit (Figure 1) (Paul 2006, p57-58). However these calculations are only a guide and the tube size, length and position must be checked to avoid generally right endobronchial intubation, being further confirmed through the use of capnography and auscultating listening for bilateral air entry to the chest (Phillips 2004).

A) A tube size may be calculated based on age
\[
\text{Age/4 + 4.5mm}
\]

B) A tube length may also be calculated based on age
\[
\text{Age/2 + 12cm}
\]

Figure 1

During shorter procedures a laryngeal mask airway (LMA) may be used with spontaneous or mechanical ventilation. The LMA is available in a number of sizes, and is selected according to a child’s weight (Hall 2001). They are advantageous in paediatric anaesthesia, discusses Booker (2000), having less resistance than an ETT. The LMA provides a substitute form of airway management, but is not appropriate for controlled ventilation in small children (Gwinnutt 2004) because of the danger of gastric inflation. Because paediatric patients can deteriorate rapidly, a specific paediatric intubation trolley is immediately available. This holds an extensive range of differently sized paediatric equipment (Oakley & van Limborgh 2005), such as small cannulae, paediatric sized tubes, guedels, nasal and oropharyngeal airways, stylet, bougie and Magill forceps ready for use. The paediatric trolley may also incorporate difficult intubation tools such as a fibre optic laryngoscope (Hall 2001). In the anaesthetic room suction apparatus should be instantly accessible, along with atropine and refrigerated suxamethonium, in case of unpredicted laryngospasm or other airway problems occurring causing hypoxia and bradycardia (Paul 2006).

Physiologically small children have a higher metabolic rate and greater oxygen requirement than adults and adapt their respiratory and cardiac systems to meet demands. Cardiac output is increased to carry the additional oxygen requirement around the body. This is achieved by increasing heart rate as smaller children have less ability to increase stroke volume (Craft & Upton 2000). The circulating volume of a smaller child is approx ‘80’mls per kg, this then drops to ‘70’mls per kg as an adolescent (Tam 2006 p494). A child can only tolerate a blood loss of approximately ten percent. Although heart rate is faster and cardiac output is increased, the actual workload of achieving this is minimized by having a lower peripheral vascular resistance so that blood pressure is actually lower (Booker 2000). Both blood pressure and heart rate gradually reach an adult level on the approach to puberty (Craft & Upton 2000). Small children may be prone to bradycardia, this may be induced as a result of vagal stimulation, for example during laryngoscopy or squint surgery and the anaesthetist monitors heart rate whilst having anti-cholinergics ready (Brown 2000).

The increased metabolic rate of small children also results in a faster turnover of extracellular fluid. The interruption of normal fluid intake can lead to rapid dehydration, so replacement fluids must be determined hourly, based on the child’s weight to provide maintenance fluid and cover ongoing losses (Wilson 2005, Tam 2006). Hartman’s solution may be selected instead of saline because it is more physiological and hyperchloraemic alkalosis is avoided. It is important not to give too much intravenous fluid; this can be avoided through use of a burette or pump set to provide the required amount (Wilson 2005).

A child has a greater surface area to volume ratio than an adult so the potential for heat loss is greater, particularly by radiation (Simpson & Popat 2002). During anaesthesia the body’s normal response to cold is lost, temperature can drop quickly because normal peripheral vasoconstriction is inhibited (Booker 2000). Smaller children need increased operating room temperatures as there may be insufficient body fat for insulation making it important to maintain a warm environment and
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minimise heat loss (Donnelly 2005). Heat losses may be further reduced by using a heating blanket and warming intravenous fluids (Craft & Upton 2000). The child’s temperature should be monitored in theatre using a temperature probe, allowing it to be regulated accordingly (Smith 2005).

Preoperative assessment

During the child’s preoperative assessment clinic (POAC) appointment there is an opportunity for the child to play with and become familiar with any theatre equipment such as monitoring or masks etc. The POAC appointment normally occurs a few days prior to the theatre date and helps to accustom the child to the environment. Young children, discusses Romino et al (2005), may become very distressed prior to the anaesthetic, consequently a parent or carer in the anaesthetic room is generally an advantage as it commonly lessens the level of anxiety in the child. However in cases of distraught or uncooperative children premedication may be used to ease apprehension for a smoother induction of anaesthesia (Simpson & Popat 2002). Midazolam can be given orally half an hour in advance of anaesthesia to give adequate sedation (Paul 2006). However the combined work of Dreger and Tremback (2006), O’Neill (2007) and Booker (2000) suggests that appropriate psychological preparation of the child, involving the parents in distraction techniques may completely remove the need for premedication. Additionally the routine use of a topical local anaesthetic agent, such as EMLA or AMETOP has revolutionized intravenous cannulation in children (Simpson & Popat 2002).

The anaesthetist will have met the patient and family pre-operatively, taken a full history and performed an examination concentrating on the airway and cardio-respiratory systems, and also prepared for any challenges presented by the child (Donnelly 2005). This is an appropriate time, discusses Colson (2006), to develop a relationship and build confidence with both the child and the parents and also to concentrate on any queries or fears. The anaesthetist uses this time to focus on the child involving them as much as possible, encouraging them to talk about their hobbies or discuss any toys they may have with them to build some degree of trust and rapport. The anaesthetist should also explain the planned approach, the method of anaesthesia induction and what to expect after the operation, so that both parent and child know what to expect (Donnelly 2005).

In the anaesthetic room

Prior to the child’s arrival in the anaesthetic room all equipment and drugs should be prepared, suitable for the age and weight of the child, as a child may be small or large for the norm of their relative age group (Paul 2006). Therefore for drugs to be given accurately, detailed care and attention is needed when calculating the dose for children considering their age, weight and developmental stage (Dunn 2005). This is because children’s bodies respond differently to medicines than do those of adults, and young children respond differently from older children (DH 2007). Bernius et al (2008) discuss that currently avert paediatric drug dispensing errors, affirms Thomas (2005), and studies have documented a high rate of errors made when undertaking these drug calculations. Opportunities for error are exaggerated by several distinctive characteristics of paediatric emergency care, with the preparation of drugs, equipment size and fluid volume determination for resuscitation all dependent on the accurate weight of the child (Wong et al 2009).

While the dose of emergency medications is standardized in adults, discusses Kaji et al (2006), paediatric dosages are weight based. Adrenaline is the most repeatedly used resuscitation drug in children experiencing cardiac arrest or anaphylaxis. While there is little deviation in adrenaline dosages dispensed to adults in cardiac arrest, the appropriate paediatric dosage is based almost exclusively on weight. Administer too little and the drug is ineffective with failure to resuscitate, administer too much and there is a risk of intracranial haemorrhage and hypertension (Kaji et al 2006). The potential risk of adverse events in the perioperative environment is increased further with the rising number of children being classified as overweight or obese (University of Michigan Health System 2008). The prevalence of overweight children having surgery presents challenges with an augmented risk of problems before, during and after surgery (University of Michigan Health System 2007). A new study from the University of Michigan found that obese children are much more likely to have problems with airway obstruction, difficult mask ventilation, oxygen desaturation or other airway problems during surgery. The study concludes that an increased awareness and identification of the risk factors these children face will be important in optimising their anaesthetic management during the perioperative phase (University of Michigan Health System 2008).

Once a child arrives in the anaesthetic room routine monitoring should ideally be attached (De Melo 2001). There is then a further opportunity to play games with the child, perhaps using the pulse oximeter to draw lines on the monitor and ease tension whilst they become familiar with their surroundings (Colson 2006). Routine monitoring should ideally be in place on induction of anaesthesia but is sometimes only fully applied once the child is asleep, along with capnography (Gomez & Gothard 2006). Romino et al (2005) maintain that in distressed or very small children, anaesthesia can frequently be induced with the child sitting on the parent’s lap having a cuddle and playing games. The cannula may then be inserted in the child’s hand behind the parent’s back so that anaesthesia can be commenced and the parent leaves the anaesthetic room.

Induction of anaesthesia

There are two principal methods according to Wolf & Jenkins (2005) of inducing general anaesthesia in children: inhalational or intravenous. The inhalational method involves breathing a mixture of volatile anaesthetic agent and oxygen, with or without nitrous oxide, until loss of
Consciousness is achieved. If cannulation has been successful, intravenous induction occurs when an appropriate dose of anaesthetic drug is injected to generate unconsciousness in the child (Mellor 2004). If the child has a difficult airway, as I have seen in practice, an inhalational approach may be used after successful intravenous access is secured. Nevertheless, the challenges associated with the small size of children and the psychological and behavioural issues due to immaturity, make induction of anaesthesia more challenging compared to the adult (Dreger & Trembaek 2006). Inhalational induction is an excellent technique for the child that fears needles, is relatively uncooperative or where cannulation has failed (Macfarlane 2006).

A suitable volatile agent for inhalational induction is sevoflurane as this provides a rapid onset and offset of action (Black & McEwan 2004). When sevoflurane is used together with nitrous oxide, the speed of onset and depth of anaesthesia is augmented using the second gas effect. Consequently induction is both rapid and smooth and may be less upsetting for both parent and child (Hardcastle 2007).

Gas induction (Macfarlane 2006) is normally induced via a face mask held over the nose and mouth whilst inhaling the anaesthetic gases. When a child has been unhappy with a mask, the anaesthetist may remove the mask section and deliver the gas via a cupped hand held close to the face. The hand is then gradually positioned under the chin, controlling the head and finally substituted with the mask. It is however a two person technique. Once anaesthesia is obtained the ODP or practitioner may assist in airway maintenance and ventilation whilst cannulation is achieved (Macfarlane 2006). In some cases the ODP has cannulation skills and may perform the cannulation whilst the anaesthetist maintains the airway.

If the child has a cannula in place, then an intravenous induction can be commenced with an induction agent e.g. propofol, thiopentone or ketamine (Pardo & Sonner 2007). Propofol is commonly used in anaesthesia and is coupled with speedy recovery and decreased nausea and vomiting (Lupton & Pratt 2008). It is therefore popular, according to McMillian (2005) for day case anaesthesia. Induction with propofol may be linked with pain on injection which can be avoided by mixing with lidocaine (Hardcastle 2007). Induction doses may also be associated with apnoea or lowered blood pressure, state Goel et al (2008), requiring careful monitoring of respiratory and cardiac function. A child may be small or large for the norm of their relative age group and must be weighed for drug doses to be accurately calculated (Paul 2006). The anaesthetist will therefore have pre-calculated all drugs including emergency drugs such as atropine for use if necessary.

Safe anaesthesia depends on the patient being fasted. Should this not be the case an intravenous modified rapid sequence induction may be required if possible with pre-oxygenation (Mellor 2004). Thiopentone is an appropriate induction agent and suxamethonium or rocuronium may be used as muscle relaxants to facilitate rapid intubation (Hardcastle 2007). Very small children require more relaxant on a body weight basis, compared to adults, to produce an equivalent level of muscle paralysis acceptable for intubation. If suxamethonium is selected an anti-cholinergic must be accessible in case of bradycardia e.g. atropine or glycopyrrolate (Mellor 2004).

Ketamine produces a dissociative anaesthesia and is a short acting general anaesthetic that may sustain blood pressure and spontaneous respiration, thus making intubation potentially unnecessary as it should not alter pharyngolaryngeal reflexes significantly (Phillips 2004). Ketamine, according to Paul (2006), may therefore be ideal in emergency medicine, as airway reflexes are protected making the fasting state of the patient less crucial than with other agents. It is also an ideal sedative agent providing effective relief from anxiety, pain and memory of unpleasant procedures used for emergency medicine in paediatric patients. In certain poor risk situations and critically ill children, ketamine may be ideal for inducing anaesthesia due to the stimulating effect on the cardiovascular system (Paul 2006).

Children are generally recovered in a child friendly environment preferably away from adult patients. A specific paediatric recovery area has supplementary equipment to support the child such as a range of smaller non-invasive blood pressure cuffs, face masks, breathing systems, airways, laryngeal masks and tracheal tubes (De Melo 2001). The Association of Anaesthetists of Great Britain and Ireland (2002) and Donnelly (2005) recommend that staff should be specifically trained and qualified in the recovery of paediatric patients. Parents, confirms Paul (2006), are usually encouraged to be with their child in recovery to minimize any emotional trauma as soon as they are awake and suitably recovered.

As a student ODP I have attempted to emphasize an understanding of the underlying principles of safe paediatric anaesthesia. This has encompassed the differences that exist between adults and children, how these will affect anaesthetic procedures and the psychological challenges unique to this age group and their families. The areas deliberated have highlighted the understanding and skills required to plan, assess, implement and evaluate the care needed for the paediatric age group of 2-5yr olds for a safe journey through the perioperative period.
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No competing interests declared

Acknowledgement

Dr A George MB CHB DA FFARCSI for his editorial assistance

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