CHAPTER 10
Anaesthesia and Perioperative Care

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Introduction

The practice of providing surgical anaesthesia for children dates back to 1842, when Dr. Crawford Long used ether for an amputation on an 8-year-old boy. Since that event, many paediatric patients have been administered anaesthesia with ether. Today, however, essentially all of the anaesthetic drugs used in the adult population are used in paediatrics. Major steps forward—such as the use of endotracheal intubation (1936), the Jackson-Rees modification of the T-piece (1950), the precordial stethoscope (1953), the use of muscle relaxants (1940s), and the introduction of the newer inhalation anaesthetic agents (1960s)—have allowed the administering of anaesthesia to become safer.

Today, anaesthesia is provided for the paediatric patient on a daily basis in many hospitals throughout the world, despite ongoing challenges. In Africa, for example, the paediatric patient presents for surgery with a pathophysiological picture that can be very different from that of a similar patient in the typical Western hospital setting. The addition of malnutrition, tropical diseases such as tuberculosis and malaria, delayed presentation, poor primary care, and chronic disease states can compound the acute surgical problem that is prompting intervention. In many African settings, the basic hospital infrastructure, theatre supplies, and essential monitoring equipment—all of which make paediatric anaesthesia safer—are commonly unavailable. Anaesthesia supplies appropriately sized for neonates and small children, such as endotracheal tubes, blood pressure cuffs, and even small syringes that allow for safe anaesthesia care, are not available in many hospitals. These issues, as they relate to providing anaesthesia care for neonates and paediatric patients who require surgery in the African setting, challenge even the most skilled of anaesthesia care providers.

This chapter provides an overview of some of the challenges when providing anaesthesia care for children in Africa. The chapter reviews the cardiac, respiratory, and renal differences of children in comparison to adults. Additionally, it addresses preoperative assessment, including guidelines for nothing by mouth (NPO, or *nil per os*), general and regional anaesthesia, intraoperative monitoring, airway management, and postoperative care.

Differences in Anatomy and Physiology

Cardiovascular Function

Neonatal myocardial function demonstrates a cardiac output that is relatively fixed due to the inability of the neonate to increase the stroke volume, which would allow for a higher cardiac output. The neonate cardiac muscle has fewer contractile elements per gram of tissue when compared to an adult heart; this affects the neonate's ability to compensate for hypovolaemic states. Also, the parasympathetic nervous system is more developed than the sympathetic nervous system until the age of 6 months, when the two systems become more balanced. This imbalance in the autonomic nervous system in the neonate predisposes the neonate to bradycardia during times of stress, even with simple airway suctioning, and certainly during airway intubation attempts. This difference between the neonate and the adult is evident during times of hypovolaemia, such as during intestinal obstruction, many neonatal emergencies, and delayed medical management for many surgical cases because neonates cannot increase their heart rates sufficiently to overcome the decrease in stroke volume.

Congenital heart disease (CHD) is common in the neonatal surgical patient in comparison to the normal population. Many congenital surgical problems have associated cardiac anomalies; therefore, any neonate presenting for surgery needs to have an appropriate cardiac exam. If a murmur is present, then a further work-up may be indicated prior to surgical intervention, and anaesthetic adjustments must be made in an effort to maximise the oxygen delivery and blood pressure. A chest x-ray and oxygen saturation determination will help to determine the need for further more specialised work-up, if available. The need for antibiotic coverage perioperatively should be considered in all patients with a cardiac defect. Currently, an antibiotic given preoperatively either 60 minutes orally or 30 minutes intravenously (IV) will cover the risk of endocarditis.[1]

Respiratory Function

The neonatal airway's narrowest location is the cricoid cartilage and not the vocal cords, as it is in the adult. Also, the glottis is more anterior, with the epiglottis being less rigid, which tends to occlude the airway opening when attempting an intubation. All of these anatomical differences between a neonate and an adult can result in a more difficult intubation when attempting to place the endotracheal tube, but with a skilled anaesthesia care provider, this also can become routine. The induction and intubation of a neonate requires special care because the oxygen saturation will decrease much faster than in an adult patient due to the higher neonatal oxygen consumption and high minute ventilation/functional residual capacity (FRC) ratio in the neonate. A premature infant will have an immature chemoreceptor ventilatory drive and at times slow respiratory effort with an elevation in carbon dioxide levels. For many premature infants, apnea, which is cessation of ventilation for 20 seconds with bradycardia, can be a serious postoperative problem that needs careful monitoring.[1]

Renal Function

The newborn's immature renal function can contribute to many fluid and electrolyte problems in the surgical patient. Glomerular filtration rates (GFRs) reach adult levels by 1 year of age, and the newborn's inability to concentrate urine certainly affects the ability of the newborn to respond to times of hypovolaemia. The infant's inability to balance sodium levels appropriately prompts careful attention to the balance of sodium because the renal system's immaturity results in an overall sodium loss.

Temperature Regulation

Temperature regulation differences result in the newborn having hypothermic periods in the perioperative period. The infant's relatively large surface area, inability to shiver, large head size (related to heat loss), and poor insulation can cause dangerously low temperature levels, which can cause hypoventilation and even cardiac arrhythmias. The room temperature for the newborn needs to be closely monitored; in areas where the outside environment has more impact on the theatre temperature, the use of warming pads and even small heating units may need to be utilised to maintain the patient's body temperature. The use of the type of heating pad that can be purchased in most African capital cities needs to be monitored in the theatre setting, as this pad can cause burns in the neonate if the controls and the patient's temperature are not monitored diligently. Also, the use of warmed fluids at appropriate levels needs to be considered in any theatre where paediatric surgery is more common.

Haematology

The red blood cells in the newborn are very different from those of adult haemoglobin because fetal haemoglobin dominates, and at 6–8 months of age, this subunit of haemoglobin is absent. Foetal haemoglobin has a higher affinity for oxygen; hence, the oxygen-carrying capacity is higher. Many paediatric patients in the African setting may present for surgery with a relative anaemia, and some may need further investigations. Although nutritional causes of anaemia need to be considered first, there are many potential causes, such as malaria, sickle cell disease, intestinal worms, and even drug-induced anaemias. Many paediatric patients can have elective surgery when their haemoglobin is less than 8 gm/dl, but these patients will have a better postoperative course with supplemental oxygen. In the context where sickle cell haemoglobin analysis is not available, blood is given to sickle cell disease patients who present for surgery with a haemoglobin level below 8g/dl.

Preoperative Assessment and Preparation

The emotional stress evident in the eyes of the paediatric patients and parents in the preoperative setting prompts one to make every effort to alleviate this aspect of the anaesthesia and surgical experience. The preparation by the anaesthesia care provider should include a preoperative visit at which the provider determines the need for surgery, the physiological implications for anaesthesia, the necessary laboratory evaluations, and the psychological condition of the patient and family. If this is done in advance, and all questions by the family as well as the surgical team are answered, then the overall care of the paediatric patient will improve. The patient may indeed benefit from a preoperative sedative or other medication so that the transfer from floor care to the theatre care will be smoother.

Psychological factors, which include the patient's age, the cultural norms for surgery, the impact of previous medical care prior to the patient arriving at the institution, and the pathophysiological condition of the patient, all impact the preoperative preparation. Children between the ages of 6 months and 5 years tend to demonstrate the most fear when presenting to the theatre setting. A carefully arranged preoperative environment that can help with these fear issues may allow for easier transfer to the operating theatre. Also, a good physical exam that includes the cardiorespiratory system, nervous system, and gastrointestinal system will allow the anaesthesia care provider the opportunity to develop an anaesthesia plan that is more informed and safe.

Disorders of the central nervous system (CNS) are common in the paediatric patient; trauma—which is very high in this population in every country in the world—can produce closed head injury patients who present in the acute and the chronic phases of trauma. Seizure disorders with anticonvulsant drugs need to be evaluated for their efficacy and such haematologic side effects as low platelets. Cerebral palsy, neuromuscular diseases, and polio are all common aetiologies for a paediatric patient who presents for an orthopaedic procedure or an emergency surgery, and special care needs to be taken in the anaesthesia plan for such populations.

The incidence of congenital cardiac diseases is more common in the paediatric surgical patient than it is in the general population. If a murmur is discovered in the preoperative work-up, it needs to be evaluated. Even a pulse oximetry reading that is normal rules out many intracardiac shunt lesions, which can be very helpful information for the anaesthesia plan. Respiratory problems, such as adenoid hypertrophy, cleft palate, upper airway infections, and asthma, are commonly seen in the surgical patient and add to the anaesthesia risks. Typically, if a patient presents with an acute productive cough, fever, or wheezing, then elective surgeries need to be cancelled for a minimum of 2 weeks to allow for resolution of the underlying infectious process and the corresponding airway effects. For the preterm infant, the incidence of apnoea and bradycardia increases the need for cardiorespiratory monitoring in the postoperative period for 12–24 hours, depending upon the severity of the problem.

Fasting Guidelines

The preoperative NPO guidelines for surgical procedures for the paediatric population will be different from those for the adult population. An infant younger than 12 months of age can have breast milk or clear liquids up to 4 hours presurgery. After the age of 12 months, clear liquids up to 4 hours and solids (including formula) up to 6 hours presurgery are allowed. All children on diets with fatty foods need to wait 8 hours after a solid meal for elective surgery. Of course, emergency surgery cases need to proceed without consideration of the NPO status, and precautions should be taken to avoid pulmonary aspiration of gastric contents. The glucose status of a neonate who presents for surgery and has had an intravenous line needs close evaluation so that hypoglycaemia does not interfere with the anaesthesia management.

Premedication

The use of preanaesthetic medication to remove anxiety is common in the paediatric population. The use of anticholinergics, benzodiazepines, and narcotics can be adjusted by the anaesthesia care provider to produce the desired effect with weight-appropriate doses. There are risks involved in a setting with few nurses per patient population in the ward, as an elevated dose of the drug may be given inadvertently because the doses are small volumes for the paediatric patient and the side effects may be difficult to detect.

Premedication should be individualised to each patient on the basis of age, weight, level of anxiety, previous anaesthetic experience, allergies, and expected level of cooperation. The oral route remains the commonest way of giving premedication. It has the advantage of being painless, but may have an unpredictable onset or a bitter taste. Midazolam, a short-acting water-soluble benzodiazepine, is widely used for premedication in paediatric practice. It has a fairly reliable onset and duration of action and can be given through a variety of routes, including oral, nasal, sublingual, rectal, intravenous, and intramuscular (IM). It does not appear to prolong recovery room stay or time to hospital discharge. Other commonly used premedication drugs include fentanyl, ketamine, sufentanil, clonidine, and, increasingly, dexmedetomidine. Although some of these agents may not be available, each institution needs to assess its drug availability and budget and then seek an alternative to these agents if they are available.

Premedications should be avoided in the patient with elevated intracranial pressure and carefully titrated in the patient with congenital heart disease as well as the severely depressed child who presents for emergency surgery. The generalities that are presented in this section prompt anaesthesia care providers and surgeons to carefully assess their specific clinical situations and then determine whether the use of premedication is safe and advantageous for their specific population of paediatric patients.

Anaesthetic Management

At the end of the preoperative assessment, an anaesthetic plan is made that takes into consideration the medical condition of the child, the needs of the proposed surgical operation, and a way of allaying any anxiety being felt by the parents and the child. All medications and materials, including blood and intravenous fluids, must be ready before induction begins. All equipment, including the anaesthetic machine, must be checked and confirmed to be working properly.

Adequate preoperative preparation (including building rapport with the patient) and the rational use of premedication will facilitate safe and atraumatic induction of anaesthesia.

Induction of Anaesthesia

Like premedication, induction of anaesthesia should be tailored to the individual patient. The same factors used to determine suitable premedication come into play when choosing an induction method. Inhalational and intravenous routes of induction are more common than rectal and intramuscular routes, although ketamine can be used in the paediatric population when an IV line is not in place or not needed for a very short procedure such as a dressing change.

Because of their fear of needles, inhalational induction is most common for children up to 10 years of age (and perhaps even well into the teenage years) who are undergoing elective surgery. This method is particularly useful because inhaled anaesthetic drugs increase in concentration in the alveoli of children more rapidly than they do in adults. Inhalational induction should be a slow, smooth process with care taken to keep the airway patent at all times. Sevoflurane is replacing halothane as the agent of choice because it appears to have fewer cardiovascular side effects while being faster in onset and recovery. However, many anaesthesia care providers in developing countries may not have access to sevoflurane, and halothane will be the available agent. Halothane in the hands of a trained paediatric anaesthesia care provider will allow for a very smooth induction with the patient ventilating spontaneously, but very careful cardiac monitoring needs to be vigilantly performed.

Intravenous induction is the method of choice when there is a pre-existing IV or when inhalational induction is contraindicated (e.g., in the event of trauma or any full stomach scenario). Thiopentone, ketamine, and propofol remain the main induction agents. Etomidate, when available, can also be useful. Intramuscular induction is often used in the older uncooperative child who cannot be reasoned with, such as a child with autism or mental retardation. In settings where resources are limited, intramuscular ketamine can be useful for very short procedures such as circumcision and wound debridement.

If the patient is cooperative, monitors are applied before induction; otherwise, they are put on as early as possible during induction and kept on until the patient is fully awake. The use of a precordial stethoscope and, if available, a pulse oximeter can provide sufficient monitoring for the induction period, allowing one to assess the airway and cardiac system with limited monitoring equipment.

Maintenance of Anaesthesia

The anaesthetic may be continued by using inhalational agents, intravenous agents (including muscle relaxants and opioids), or a combination of these agents in a balanced technique. During this stage, the airway is kept patent by either a face mask, a laryngeal mask airway (LMA), or an endotracheal tube.

Airway Management

One of the greatest challenges in paediatric anaesthesia is the management of the airway, particularly in neonates. Combinations of anatomical, physiological, and developmental factors conspire to make airway management in children more difficult than that in adults. Normal respiratory rates are 40 per minute in neonates and 20–30 per minute in infants. The smaller size of the paediatric airway means that any small decrease in diameter, such as occurs from secretions, bronchconstriction, oedema, or compression, may more readily lead to significant airway obstruction. Respiration is mainly diaphragmatic in infants; therefore, any slight abdominal distention will greatly embarrass respiration. Oxygen consumption in the neonate is approximately 7 ml/kg per minute, as opposed to 3–4 ml/kg per minute in the adult. For infants and children, the higher oxygen requirements per kilogram produce hypoxia more rapidly when there is airway obstruction. Perioperative paediatric airway obstruction occurs commonly when the consciousness level is depressed and the airway is not properly positioned to maintain its patency.[2]

Airway Maintenance Equipment

Paediatric airway equipment is usually designed to minimise trauma, dead space, airway resistance, and rebreathing. Equipment for airway maintenance includes face masks (Figure 10.1), oropharyngeal and nasopharyngeal airways (Figure 10.2), breathing circuits and Ambu bags, laryngoscopes, endotracheal tubes, and laryngeal mask airways.

Face Masks

Face masks come in different sizes (00 for neonates, 0 for infants, 1 for small children, 2 for bigger children), shapes, and colours (see Figure 10.1). The neonatal face mask has minimal dead space and is designed to limit rebreathing. It must fit closely over the mouth and nose without obstructing the nares.

Breathing Circuits

The Ayre's T-piece breathing circuit (Figure 10.3) is used for children weighing less than 20 kg because it is a low-resistance circuit. For children weighing more than 20 kg, an adult circuit (Bain or Magill) can be used. The Ayre's T-piece can be used for both spontaneous and assisted ventilation.

Figure 10.1: Various sizes of paediatric masks.

Figure 10.2: Oropharyngeal airway.

Figure 10.3: An Ayre's T-piece.

Laryngoscopes

The relatively high position and inclination of the larynx in infants make a straight laryngoscope blade (e.g., the Miller 0 (Figure 10.4) or the infant Magill) a good choice, whereas children older than 1 year of age can generally be managed with a curved blade (e.g., size 2 Macintosh (Figure 10.5)).

Laryngeal Mask Airways

LMAs (Figure 10.6) are useful airway management tools. They are less traumatic than endotracheal tubes and do not require laryngoscopy to insert. They do not, however, protect against regurgitation and aspiration. Sizes 1, 1½, 2, 2½, and 3 can be used in children from 2 months to 12 years of age, according to the weight of the child.

Endotracheal Tubes

Endotracheal tubes used for children younger than 6 years of age are usually uncuffed. Table 10.1 provides a guide for choosing an appropriate endotracheal tube.

Mask Ventilation

Due to the neonate's relatively large head, a small roll should be positioned under the shoulders to prevent hyperflexion of the head and align the axis of the mouth, pharynx, and larynx to allow for easy flow of air. For the older child, no pillow or roll is needed. An appropriately sized oropharyngeal airway can improve mask ventilation.

Figure 10.4: Miller's blades and handle.

Figure 10.5: Macintosh blade and handle.

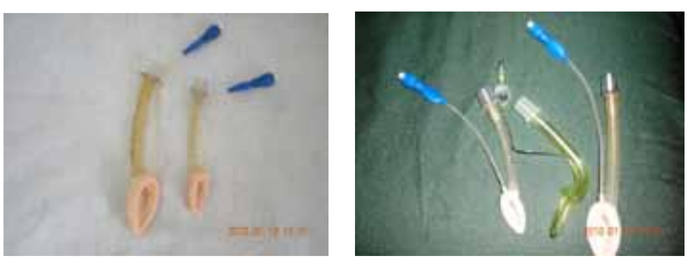

Figure 10.6 Laryngeal mask airways.

Table 10.1: Endotracheal tube sizes for children.

Age	Size of endotracheal tube (mm)
Premature	2–2.5
Full-term newborn	3.0
6–12 months	3.5
1–2 years	4–4.5
>2 years	4.5 + [age (in years) ÷ 4]

Laryngoscopy and Intubation

The airway should be ventilated in all but the shortest of procedures because the paediatric airway is very prone to obstruction during anaesthesia. For neonates and infants, a slight external pressure on the larynx helps to bring the glottis into view. A small leak should be allowed around the tube to prevent oedema formation and postoperative airway obstruction, which may follow prolonged intubation.[3] If the patient is at risk of aspiration, a pharyngeal gauze pack should be placed around the tube.

A gaseous induction using 100% oxygen with halothane is the technique of choice in small children and those with difficult airways. The aim is to attain a plane of anaesthesia that is deep enough to allow laryngoscopy. Once the pupils become constricted and central, laryngoscopy and orotracheal intubation can be performed. Suxamethonium at a dose of 2 mg/kg can be used to facilitate intubation. Atropine (0.02 mg/kg) or glycopyrrolate (0.01 mg/kg) should be given to prevent bradycardia and to dry secretions. Both lungs should be auscultated for bilateral air entry after intubation, and the endotracheal tube should be secured firmly in position.

Signs of respiratory obstruction include an increase in respiratory rate (>50 per minute in an infant and 30 per minute in a child); a "see-saw" pattern of chest and abdominal breathing movements; flaring of the alar nasi; and the use of accessory muscles of respiration (sternomastoids, scalene muscles) resulting in suprasternal, intercostal, and subcostal retraction.

In acute airway obstruction, for which one cannot intubate or ventilate, cricothyrotomy may be the only option. Cricothyrotomy is difficult in a small child and carries many risks. Where difficult tracheal intubation is anticipated, experienced help should be sought beforehand. There are fibre-optic laryngoscopes suitable for use in children, but this requires expertise and experience and is not an option in emergency airway obstruction.

Muscle Relaxants

Muscle relaxants are used to facilitate tracheal intubation and provide muscle relaxation during surgery, thus permitting lighter planes of anaesthesia and reducing the risk of cardiovascular depression. They are used in intraperitoneal, intrathoracic, and intracranial procedures.

Muscle relaxants are classified into depolarising and nondepolarising groups. Succinylcholine is the only depolarising neuromuscular blocker in use today, and it remains the agent with the quickest onset and shortest duration of action. Unfortunately, succinylcholine is associated with some life-threatening side effects (hyperkalaemia, malignant hyperthermia), and its use has reduced somewhat in recent years.

Nondepolarising muscle relaxants are classified based on structure and mode of elimination. The benzoquinolones are atracurium, cis-atracurium, and mivacurium, which may be available in some African urban centres. The first two are eliminated by Hoffmann degradation and ester hydrolysis by nonspecific plasma esterases. Mivacurium is metabolised by plasma cholinesterase.

The aminosteroids (pancuronium, vecuronium, and rocuronium) are metabolised in the liver, and their inactive end products are eliminated by the kidney.

Monitoring

The purpose of monitoring is to measure physiological variables and to indicate trends of change, thus enabling corrective action to be taken. The anaesthetist remains the most important monitor and must remain in close contact with the patient during all aspects of the anaesthetic.

The precordial (or oesophageal) stethoscope is an invaluable monitor for many paediatric anaesthetists. It provides a direct way to continuously monitor heart rate and rhythm as well as breath sounds; it allows early detection of changes in the rate and character of these sounds.

The electrocardiogram (ECG) is useful for diagnosing rate-related arrhythmias, especially bradycardia and supraventricular tachycardia (SVT). The ECG is an index of electrical activity. A normal waveform may exist, however, in the presence of reduced cardiac output, so the ECG should be interpreted in the context of other information obtained from monitors of the patient's circulation.

The patient's circulation may be monitored by observation of the peripheral perfusion, peripheral pulse, blood pressure, urine output, and arterial oxygen saturation. Observation of the patient's extremities yields information about the state of the patient's circulation. When the skin is warm and dry all the way to the fingers and toes, one can infer that tissue perfusion and therefore cardiac output is adequate. Cool extremities thus indicate hypovolaemia and reduced cardiac output. Palpation of peripheral pulses is another way of obtaining the same information. As intravascular volume decreases, the pulse volume decreases, especially in the wrists and feet. Adequate production of urine implies adequate renal perfusion and probably adequate perfusion of other vital organs. Measurement of urine output is particularly indicated in critically ill or shocked patients or when massive fluid shifts are expected. A urine output of 0.75–1 ml/kg per hour is desirable. Blood pressure provides another indirect means of measuring circulating blood volume and cardiac output due to the relationship.

$$\text{Blood Pressure} = \text{Cardiac Output} \times \text{Peripheral Resistance}.$$

Methods of measuring blood pressure range from palpation and auscultation to direct intraarterial manometry.

A pulse oximeter measures oxygen saturation continuously and thus provides another indirect assessment of the function of the circulatory system. Estimation of blood loss is a useful monitor in maintaining the overall integrity of the cardiovascular system.

Apart from monitoring the patient's colour, respiratory rate, and breathing pattern, auscultation of both lungs should be performed frequently.

Airway pressure monitors and disconnection alarms are desirable in ventilated patients. A capnograph, when available, can be used to confirm correct placement of an endotracheal tube and to continuously assess the adequacy of ventilation.

It is important to remember that monitors only provide information. It is the duty of the anaesthetist to interpret this information and then act appropriately. The postoperative paediatric patient needs close monitoring in the recovery room and wards when narcotics are used for surgical pain management. The vigilance of the nursing staff and anaesthesia care provider will decrease much of the morbidity and mortality associated with many paediatric, and especially neonatal, surgical patients.

Narcotics

Opioids can be titrated for intraoperative and postoperative analgesia, and to provide a smooth awakening from anaesthesia. All the commonly used opioids are used in paediatric practice and, just as in adults, in high doses they all carry the risk of respiratory depression. Fear of this respiratory depression is not a reason to deny children the benefits of opioid pain relief. Careful titration to effect will often eliminate this complication.

Regional Anaesthesia

Regional anaesthesia (RA) is particularly suited to patients undergoing outpatient procedures and peripheral surgery. It has also been suggested that RA may improve pulmonary function in patients who have had thoracic or upper abdominal surgery. Advantages include the reduced need for deeper planes of general anaesthesia in patients who have had a nerve block to supplement their general anaesthesia (GA). RA also allows a pain-free awakening while minimising or avoiding the use of opioids altogether. In addition, there is often early ambulation and excellent postoperative analgesia.

The use of RA, however, has certain limitations in paediatric practice. Except in the older child and adolescent, blocks are rarely performed in the awake child and usually need to be part of a combined technique.

Regional anaesthetic techniques are particularly useful in children at risk for malignant hyperthermia or in those for whom it is necessary to preserve what little respiratory reserve they have (e.g., children with cystic fibrosis, severe asthma, or neuromuscular disorders).

The two classes of local anaesthetics, esters and amides, exhibit differences in distribution and metabolism in paediatric patients (especially neonates) when compared to adults. Awareness of these pharmacokinetic differences leads to safer use in this vulnerable patient population.

Ester local anaesthetics are metabolised by plasma cholinesterase, which has lower activity levels in neonates and infants up to the age of 6 months. This may theoretically lead to prolonged effects, but in practice, the effects of 2-chloroprocaine given for continuous caudal anaesthesia have been shown not to be prolonged, even when using relatively high infusion rates. In fact, in spite of the low plasma cholinesterase activity, plasma chloroprocaine levels remained low.

Amides are bound by plasma proteins and metabolised by the liver. Neonates have reduced plasma protein concentrations as well as reduced liver blood flow and immature liver enzymes. This all points to increased free drug in the plasma and potential toxicity, although the larger volume of distribution in neonates tends to offset these changes. It is thus important to follow guidelines on maximum recommended doses when doing regional blocks.

Essentially all RA blocks that are useful in the adult population can be used in the paediatric population, with special attention to the toxic drug doses and the anatomical landmarks. Many obstacles in performing RA in the paediatric population may be related to the availability of the appropriate sizes of needles for the patient, especially the neonate. Close post-block monitoring needs to be available. Especially if narcotics are to be used, the nursing staff needs to be carefully educated regarding the signs of toxicity and side effects of these drugs in the paediatric population. Table 10.2 gives the maximum recommended doses for commonly used local anaesthetic agents. Commonly performed regional procedures include caudals, epidurals, spinals, ilio-inguinal blocks, and penile blocks.

Table 10.2: Maximum recommended doses of local anaesthetics.

Local anaesthetic	Maximum dose (mg/kg)
2-Chloroprocaine	20
Lidocaine	7
Mepivacaine	7
Bupivacaine	2.5
Ropivacaine	3.5
Tetracaine	1.5

Postoperative Care

Following the end of the anaesthetic is a period of physiologic stabilisation that typically takes place in a postanaesthetic care unit (PACU), recovery room, or an intensive care unit (ICU). Emergence and recovery describe the transition from the anaesthetic state ultimately to the patient's baseline state. During this period, the patient typically awakens from general anaesthesia and regains protective reflexes.

The immediate postoperative period is a period of maximal hazard that calls for continuous patient monitoring. The commonest complications are airway obstruction, hypoventilation, and hypoxia.

For children who are intubated, the tube should remain in situ until they are fully awake. Laryngospasm is common at extubation, especially in patients who are neither very deeply anaesthetised nor fully awake. The pharynx should be carefully suctioned before extubation. Oxygen should be administered immediately after extubation, and the patient observed for adequate depth of respiration, oxygen saturation, activity, and colour. These children should be cared for by trained staff in the recovery room and should be returned to the ward only after regaining full consciousness and protective reflexes. They should be pain-free, comfortable, have stable vital signs, and there should be no active bleeding from the surgical site.

Perioperative Anaesthesia Complications

Complications may occur during anaesthesia and in the immediate postoperative period. The commonest complication is airway obstruction from failed or difficult intubation, wrong positioning, mucous plug, blood clot, or subglottic oedema following endotracheal extubation. Laryngospasm and bronchospasm may occur, especially if tracheal intubation is attempted under light planes of anaesthesia. Hypothermia and hypoglycaemia are common in preterm neonates and newborns of diabetic mothers. Bradycardia, when it occurs, is a late sign and should be promptly treated with atropine. Nausea and vomiting, postoperative bleeding, pain, and emergence delirium following ketamine anaesthesia are other complications that may be seen in the postoperative period. These can be recognised only by careful monitoring and should be treated promptly.

Most healthy children do well, have an uneventful stay in the PACU, and are quickly reunited with their parents. The need for adequate recovery room nursing care should always be emphasized for the paediatric surgical postoperative patient. The anaesthesia care provider must be readily available in case of a cardiorespiratory event and be in a position to respond quickly with a resuscitation trolley, which should be located in this area of the theatre suite.

Table 10.3: Evidence-based research.

Title	Sedation with ketamine for paediatric procedures in the emergency department: a review of 500 cases
Authors	Ng KC, Ang SY
Institution	Department of Emergency Medicine, K K Women and Children Hospital, Singapore
Reference	Singapore Med J. 2002; 43(6):300–304
Problem	The severe shortage of anaesthesia providers in most developing countries leaves the surgeon in the unfortunate position of doubling up as the anaesthetist or using supervising nurses to administer anaesthesia. In this environment, ketamine has proven itself as a good anaesthetic agent with a commendable safety profile. Familiarity with ketamine would seem to be necessary to practice anaesthesia in Africa.
Comparison/ control (quality of evidence)	This is a review article.
Historical significance/ comments	This review article discusses the effectiveness of ketamine for sedation in children during painful procedures. The authors reviewed the use of intravenous and intramuscular ketamine in 500 children for procedures ranging from repair of lacerations, manipulation and reduction of fractures, incision and drainage of abscesses, to removal of foreign bodies. Ninety-six percent of their patients experienced no adverse effect with the use of ketamine and were discharged to home well. Only one patient had adverse effects and had to be admitted overnight. They conclude that ketamine is a relatively safe and effective drug for use in children.

Evidenced-Based Research

Tables 10.3 and 10.4, respectively, present a review article on the use of ketamine in children and a discussion of using ketamine in and out of the operating room.

Table 10.4: Evidence-based research.

Title	Ketamine: a new look at an old drug
Authors	Raeder JC, Stenseth LB
Institution	Department of Anesthesia and General Practice Medicine, Ullevaal University Hospital, Oslo, Norway
Reference	Current Opinion in Anaesthesiology 2000; 13(4):463–468
Problem	Although ketamine has proven itself to be a safe general anaesthetic in poorly equipped conditions, recent research suggests more uses both in and out of the operating room.
Historical significance/ comments	This article discusses how the clinical uses of ketamine have expanded beyond dissociative anaesthesia to its effects on immunofunction and more exploration of its analgesic effects. The role of the N-methyl-d-aspartate (NMDA) receptor in analgesia, wind-up phenomena, and possible opioid tolerance hints at more uses for ketamine.

Key Summary Points

1. There are many cardiovascular, respiratory, and renal physiological differences between a neonate and an adult surgical patient.
2. The neonate is more prone than an adult to cardiovascular and respiratory complications in the perioperative setting.
3. Fasting guidelines for the paediatric surgical patients need to be strictly followed to avoid complications.
4. A trained paediatric anaesthesia care provider will need specialized anaesthesia training and skills to decrease the high complication rate seen in paediatric surgical cases.
5. Paediatric patients require supplies and equipment appropriately suited for their size and anatomical differences.

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