# Anaesthesia and Analgesia

# 5

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## Contents



P. Puri and M. Höllwarth (eds.), *Pediatric Surgery: Diagnosis and Management*,
DOI: 10.1007/978-3-540-69560-8_5, © Springer-Verlag Berlin Heidelberg 2009

## 5.1 Introduction

Over the past 70 years or so, provision of anaesthesia for the child requiring surgery has developed from being a relatively haphazard affair to achieving the status of a recognized subspecialty. The improved outcomes seen following surgery, where even very young and ill infants and children are concerned, have been due in no small part to advances in anaesthetic management. Equally important has been an increased appreciation of the need for an efficient smooth-working team. The success of major paediatric surgery depends on the maximum cooperation between surgeon, anaesthetist, paediatrician, and nursing and paramedical personnel. It is appropriate therefore that everyone involved in the care of the hospitalized child, whether working inside or outside the operating theatre, should be familiar with the basic techniques used in maintaining a favourable physiologic milieu in the face of surgical intrusion, while at the same time ensuring adequate anaesthesia.

## 5.2 Pre-operative Evaluation and Preparation

The cornerstones of pre-operative anaesthetic management are a detailed knowledge of the child's personal and family history combined with a physical examination. Consideration must also be given to the specific surgical procedure to be undertaken and its implications in terms of potential blood loss, monitoring requirements and post-operative care.

### 5.2.1 History

Particular attention should be paid to a history of prematurity, respiratory disease, e.g. bronchopulmonary dysplasia or asthma, congenital heart disease, any suggestion of neuromuscular disease (patients with conditions like Duchenne's muscular dystrophy may exhibit severe adverse reactions following exposure to certain anaesthetic agents), recent upper respiratory tract infection or vaccination (see below), and any family history of anaesthesia-related problems. Allergies and current or recent drug therapy should be recorded.

### 5.2.2 Physical Examination

The anaesthetist should make a brief appraisal of the child's overall condition and follow this with a careful physical examination, paying particular attention to the respiratory and cardiovascular systems. Airway anatomy should be carefully assessed in order that potential difficulties with endotracheal intubation can be anticipated.

### 5.2.3 Laboratory Investigations

Most older children presenting for minor surgery do not require any pre-operative laboratory workup. Minimum laboratory data required for infants and children undergoing major surgery include full blood count, blood urea and serum electrolytes, blood glucose and calcium, coagulation profile and urine specific gravity. Additional investigations may be required in specific circumstances.

### 5.2.4 Premedication

Sedative premedication is not used in neonates or in other situations where it may cause increased risk, e.g. children with airway compromise. Its use in other children appears to have declined in recent years—this may be due in part to the fact that increased parental involvement in perioperative care serves to reduce the incidence of separation anxiety. Midazolam and diazepam (for older children) are the most commonly used premedicant drugs.

## 5.3 Operating Theatre and Anaesthetic Equipment

The primary objectives of anaesthesia are the provision of sleep, analgesia, life support, intensive surveillance and appropriate operating conditions for the patient, irrespective of age, requiring surgery. In order for these to be achieved it is imperative that both operating theatre environmental conditions and anaesthetic equipment be appropriate for infants and children. Appropriate measures should be taken to minimize the risk of heat loss, especially where surgery on infants is concerned.

### 5.3.1 Breathing Systems

An appropriate anaesthetic circuit for use in infants and children needs to be light, have minimal resistance and dead space, allow for warming and humidifying of inspired gases and be adaptable to spontaneous, assisted or controlled ventilation. The most widely used system continues to be the T-piece designed by Philip Ayre and later modified by Rees. Connectors and tubes should also offer minimal flow resistance and dead space. Knowledge of the probable diameter and length of the endotracheal tube appropriate for any given child is essential. Use of an endotracheal tube (ET) of too large a diameter may result in tracheal wall damage, while excess length leads to endobronchial intubation. The presence of a cuff limits the diameter of the tube that can be used, with consequent increased resistance to airflow. Face-masks are generally used for only brief periods in infants and children, but should provide a good fit and have a low dead space. Use of the laryngeal mask airway (LMA) is increasing in paediatric anaesthesia practice.

### 5.3.2 Laryngoscopes

Because of the anatomical peculiarities of the infant's airway, most anaesthetists prefer to use a laryngoscope with a straight blade in this age group, lifting the epiglottis forwards from behind to facilitate endotracheal intubation. Standard curved blades, available in various sizes, are appropriate for older children.

### 5.3.3 Ventilators

Most infants and children can be ventilated using standard adult ventilators provided the ventilator is of low internal compliance and equipped with paediatric breathing tubes. The ventilator should be capable of delivering small tidal volumes and rapid respiratory rates, and have an adjustable inspiratory flow rate and inspiratory to expiratory ratio so that peak airway pressure is kept as low as possible. Pressure-controlled ventilation is widely used in order to minimize the risk of pulmonary barotrauma. A suitable temperature-controlled humidifier should be incorporated in the inspiratory side of the ventilator circuit. The ability to deliver air and oxygen mixtures through the ventilator or the anaesthetic circuit should be available.

### 5.3.4 Monitoring Equipment

A complete range of monitoring equipment suitable for paediatric use is required.

## 5.4 Induction of Anaesthesia

The anaesthetic agents employed in infants and children are identical to those used in adults. The choice of induction technique depends on (a) the age, size and physical status of the child, (b) the relative hazard of regurgitation, and (c) the personal preference of the anaesthetist. Where the older child is concerned, his or her preference may also be taken into consideration. The introduction of local anaesthetic creams has helped reduce the "fear factor" for those children needing intravenous (i.v.) cannulation prior to induction of anaesthesia, especially those requiring multiple anaesthetics. Many are also helped by having a parent remain with them until they are asleep—this was almost unknown 30 years ago but is now commonplace. Inhalational induction is still preferred, especially in

younger children, by many paediatric anaesthetists, and is particularly appropriate when difficulty with venous access is anticipated, where a slower induction is desired because of concern regarding loss of airway control, or when the child specifically requests it.

## 5.5 Intravenous Agents

Sodium thiopentone was for many years the drug of choice for i.v. induction of anaesthesia in patients of all ages. It has now been replaced in most centres by propofol, which provides an equally rapid and smooth induction combined with more rapid and complete recovery, and also has an anti-emetic effect. Pain on injection can be prevented in most instances by the prior addition of lignocaine to the propofol solution. Ketamine is associated with greater cardiovascular stability than many other anaesthetic drugs and is a potent analgesic. It may be used with beneficial effect on the rare occasions when it is necessary to induce anaesthesia in the shocked child.

## 5.6 Inhalational Agents

### 5.6.1 Halothane

For decades, halothane was the most popular volatile anaesthetic for inhalational induction in infants and young children. This is largely because it is usually associated with a smooth induction without irritant effects on the airway. Its use has been superseded to such an extent in adult practice by newer agents that it has become difficult to obtain, much to the chagrin of many paediatric anaesthetists who still consider that it has a useful role.

### 5.6.2 Isoflurane

Inhalational induction of anaesthesia with isoflurane is not as rapid or as smooth as with halothane. Indeed, this agent has been shown to be associated with a significant incidence of hypoxic episodes during induction of anaesthesia in older children. It has considerable potentiating effects on non-depolarizing muscle relaxants, so that lower doses of the latter can be used. It is an excellent agent for maintenance of anaesthesia.

### 5.6.3 Enflurane

This agent is not widely used in paediatric anaesthesia because its irritant effects render it relatively unsatisfactory for inhalational induction while it offers few particular advantages during the maintenance period.

### 5.6.4 Desflurane

Airway irritant effects also render desflurane unsuitable for inhalational induction. However, recovery times in infants are shorter than those following other volatile anaesthetics. The agent has been recommended for maintenance of anaesthesia in the ex-premature infant prone to apnoea and ventilatory depression.

### 5.6.5 Sevoflurane

Induction time with sevoflurane is shorter than with halothane in older children. However, this does not appear to be the case where infants are concerned. The agent has been reported to cause more respiratory depression than halothane in infants and young children, but perhaps not to a degree that is clinically significant. It has become the most widely used volatile agent for inhalational induction and is also popular for maintenance of anaesthesia.

### 5.6.6 Nitrous Oxide

This gas does not provide adequate anaesthesia when used alone with oxygen. It is most often employed as a carrier that supplements potent volatile anaesthetics, thereby reducing the concentration required and minimizing cardiovascular depressant effects. One limitation to its use is the fact that it is many times more soluble in blood than is nitrogen. As a result, the inhalation and subsequent diffusion of the gas causes an increase in the volume of compliant spaces. It follows that the agent should not be used in patients with congenital diaphragmatic hernia, lobar emphysema or bowel obstruction.

## 5.7 Neuromuscular Blocking Agents

### 5.7.1 Succinylcholine

Because of the number of side-effects, including bradycardia, hyperkalaemia and triggering of malignant hyperpyrexia reactions associated with this agent, its use has declined dramatically in recent years. However, it remains pre-eminent in rapidly providing optimum conditions for endotracheal intubation, and therefore retains a limited place in emergency paediatric anaesthetic practice. For elective surgery, intubation is now more frequently facilitated by either deep inhalational anaesthesia or use of a non-depolarizing muscle relaxant.

### 5.7.2 Atracurium and Vecuronium

These two drugs are the most widely used muscle relaxants in paediatrics. They were originally introduced because their duration of action was intermediate between that of succinylcholine and older agents such as pancuronium and because they offered increased cardiovascular stability. In addition, atracurium is attractive in that its metabolism is independent of hepatic and renal function. Because of their pharmacokinetic profiles, both drugs are suitable for use by continuous intravenous infusion, although atracurium infusion requirements show marked individual variation.

### 5.7.3 Mivacurium

Mivacurium is a short-acting non-depolarizing neuromuscular agent that is rapidly hydrolysed by plasma pseudocholinesterase. The time course of block produced by the drug is more rapid in younger paediatric patients. Satisfactory intubating conditions are not achieved as quickly as with succinylcholine but serious side-effects occur less frequently.

### 5.7.4 Rocuronium

This agent has a relatively rapid onset and intermediate duration of action in most children, although neuromuscular blockade may be prolonged in young infants.

## 5.8 Maintenance of Anaesthesia

Because of the vulnerability of the infant's respiratory system, spontaneous respiration is not used for long periods in the anaesthetized neonate. Mechanical ventilation helps ensure adequate gas exchange and also leaves the hands of the anaesthetist free to perform other tasks. Manual ventilation allows rapid detection of airway obstruction or disconnection, and is particularly useful during thoracic surgery.

The most widely used agents for maintenance of anaesthesia in the paediatric population are isoflurane, sevoflurane and desflurane, usually combined with 50% oxygen in nitrous oxide, along with a small dose of relaxant. Consideration should be given to the use of air and oxygen mixtures in preterm neonates. Older children may be allowed to breathe spontaneously for longer periods; the use of mechanical ventilation often being dictated by the nature of the surgical procedure.

## 5.9 Reversal and Extubation

If a volatile agent has been used for the maintenance of anaesthesia, it should be discontinued shortly prior to the end of surgery. When muscle relaxants have been used in intubated patients any residual relaxation is reversed by either neostigmine (0.06 mg/kg) or edrophonium (1 mg/kg) combined with either atropine (0.02–0.03 mg/kg) or glycopyrrolate (0.01 mg/kg) once surgery has been completed. Controlled ventilation is continued with 100% oxygen or with oxygen in air until spontaneous respiration has returned. Infants should not be extubated until fully awake and breathing adequately. In most cases, reversal of neuromuscular blockade and resumption of spontaneous respiration occurs rapidly. If difficulty is encountered this may be due to hypothermia, acidosis or hypocalcaemia, or the fact that an incremental dose of relaxant has been given too close to the end of surgery.

## 5.10 Recovery from Anaesthesia

Immediate recovery from anaesthesia and surgery should be in a fully equipped recovery area with a one-to-one ratio of personnel trained in paediatric nursing. Monitoring of vital signs, adequacy of protective

airway reflexes, and correct positioning to prevent airway obstruction, regurgitation and aspiration are the priorities. The recovery room nurse also monitors the wound site for bleeding, checks the security of dressings, and the adequacy of pain relief. The main factors influencing the rate of recovery in children include the use of premedicant drugs, the induction and maintenance techniques, the age of the child, and the duration of surgery. Parental involvement in the early recovery phase is now encouraged in many units.

## 5.11 Post-operative Care

Most children may be offered a drink or light snack as soon as they have recovered consciousness. Exceptions should be made following endotracheal intubation, some dental or oral procedures, and when local anaesthetic drugs have been used on the upper or lower airway. In addition to post-discharge guidance provided by the surgical team, parents or guardians should also be given both verbal and written instructions regarding post-operative pain management and what to do if problems arise.

## 5.12 Monitoring

The clinical condition of the anaesthetized child can deteriorate more rapidly and with less warning than that of patients in any other age group. It follows that careful and continuous monitoring is essential. While no piece of machinery will adequately replace the careful anaesthetist, a number of devices providing helpful information that cannot be gleaned by clinical means alone are available. The monitoring employed in any particular case depends on the physical status of the child and the surgical procedure to be undertaken.

## 5.13 Cardiovascular Monitoring

### 5.13.1 Precordial and Oesophageal Stethoscope

Although its use in paediatric anaesthetic practice has declined, the stethoscope is particularly valuable, allowing continuous monitoring of heart and breath sounds both cheaply and simply. In the neonate, the intensity of the heart sounds varies with the stroke volume so that an indication of cardiac output is provided. Use of a monaural earpiece greatly improves the comfort of the listener.

### 5.13.2 ECG

As myocardial ischaemia is uncommon in children the principal function of the ECG is to monitor heart rate and detect arrhythmias, especially bradycardia. Primary arrhythmias are uncommon except in those with congenital heart disease, but causes of secondary arrhythmias include hypoxia, hypercarbia and surgical stimulation, e.g. strabismus surgery. ECG monitoring may also detect inadvertent i.v. injection of local anaesthetics.

### 5.13.3 Blood Pressure

Routine non-invasive monitoring of blood pressure during anaesthesia and surgery is carried out with automated devices using oscillometry. The appropriate cuff size must be used in order to obtain accurate measurements. Direct intra-arterial monitoring is the most accurate measurement of blood pressure and provides a "beat to beat" assessment. Its use is generally restricted to very ill children or those undergoing major surgery. All the proximal and distal arteries of the arms and legs may be used.

### 5.13.4 Central Venous Pressure

Central venous pressure monitoring is useful in infants and children undergoing major surgery with anticipated large fluid shifts, if significant blood loss (and replacement) is expected, and during surgery for congenital heart disease. The right internal jugular vein is usually the simplest to cannulate. Monitoring of left atrial pressure and pulmonary capillary wedge pressure is rarely indicated in infants or children.

## 5.14 Respiratory Monitoring

### 5.14.1 Pulse Oximetry

Hypoxia is the most common critical incident in paediatric anaesthesia. As detection of cyanosis in infants and young children is difficult, the routine use of pulse oximetry is now mandatory. Thermal injury and pressure necrosis have been reported when sensor probes have been applied too tightly.

### 5.14.2 Capnography

The measurement of $pCO_2$ in inspired and expired gases is also mandatory. Capnography is not only a monitor of the adequacy of ventilation but also gives warning of disruption in gas supply, inadequate fresh gas flow and oesophageal intubation.

## 5.15 Temperature

Monitoring temperature is important in paediatrics because of the increased risk of both hypo- and hyperthermia. Common sites for temperature probes used perioperatively include the pharynx, oesophagus and rectum.

## 5.16 Neuromuscular Blockade

Monitoring neuromuscular blockade using a peripheral nerve stimulator is routine practice when non-depolarizing muscle relaxants have been administered.

## 5.17 Fluid Balance

Healthy children undergoing minor operations can reasonably be expected to tolerate oral fluids a short time after completion of surgery and do not require intraoperative i.v. fluids. The goal of intraoperative fluid management in those who are dehydrated pre-operatively or who are undergoing major surgery is to sustain homeostasis by providing the appropriate amount of parenteral fluid to maintain adequate intravascular volume, cardiac output, and, ultimately, oxygen delivery to tissues at a time when normal physiological functions are altered by surgical stress and anaesthetic agents. The composition of the administered fluid will vary according to the maturity of the child and preoperative electrolyte and glucose levels. Because of the problems associated with hyperglycaemic states in infancy, care should be taken with the use of 10% dextrose infusions. Blood and fluid loss can be extensive and very difficult to measure during neonatal surgery. The former is best estimated by the use of small volume suction traps, by weighing small numbers of surgical swabs before they dry out, and by serial haematocrit measurements. During lengthy surgery, serum electrolytes and blood glucose should be measured at regular intervals. Urine output may be monitored by the use of adhesive collecting bags or bladder catheterization. Estimated third space loss may be replaced by continuous administration of lactated Ringer's solution at 3–5 ml/kg/h. The adequacy of volume replacement can be assessed by monitoring blood pressure, central venous pressure, peripheral circulatory state and urine output.

## 5.18 Special Considerations for the Premature Infant

Congenital defects occur more commonly in preterm infants, so that surgery is frequently required. Organs and enzyme systems are very immature and meticulous attention to detail during anaesthetic and surgical management is imperative if survival rates are to be high. The large body surface area and lack of subcutaneous fat make maintenance of body temperature very difficult, so that a high neutral thermal environment is essential. Respiratory fatigue occurs very easily and may be exacerbated by residual lung damage following mechanical ventilation, persistent fetal circulation and oxygen dependency. The response to exogenous vitamin K is less satisfactory than in term infants and there is an increased risk of bleeding. In addition, anaemia is common because of reduced erythropoiesis, a short erythrocyte life span and iatrogenic causes

such as frequent blood sampling. Fluid and electrolyte management can be difficult—insensitive losses are high and hypoglycaemia and hypocalcaemia occur easily, while renal function and the ability of the cardiovascular system to tolerate fluid loads are reduced.

## 5.19 Anaesthesia for Specific Surgical Conditions

### 5.19.1 Oesophageal Atresia

Once a diagnosis of oesophageal atresia (with or without fistula) has been made, the blind upper pouch should be continuously aspirated using a Replogle or similar tube. In general, the operation may be safely delayed pending improvement of any aspiration pneumonia that has developed. Pre-thoracotomy bronchoscopy is practised in some centres and may influence subsequent management. Anaesthesia is similar to that for other neonatal procedures, but special care must be taken with positioning of the endotracheal tube, the tip of which should be located above the carina but below any fistula present. Surgical retraction during the operation may compromise either respiratory or cardiac function, so that close monitoring is essential. If serious contamination has not occurred and unless the surgeon deems the anastomosis to be especially tight, extubation is usually possible shortly after the conclusion of surgery.

### 5.19.2 Congenital Diaphragmatic Hernia

This condition was formerly regarded as one of the great emergencies of paediatric surgical practice, but it is now considered that the timing of repair should be based on the optimization of clinical parameters rather than a specific time period post-delivery. Pre-operative ventilatory and haemodynamic support along with correction of metabolic disturbance are almost invariably required. Inhaled nitric oxide, high frequency oscillation ventilation, liquid ventilation and extracorporeal membrane oxygenation may also be used. Positive pressure ventilation using bag and mask should be avoided prior to endotracheal intubation, as expansion of the viscera contained within the hernia will cause further lung compression. Nitrous oxide should be avoided for the same reason. A reasonable anaesthetic technique includes controlled ventilation with fentanyl 0.01–0.02 mg/kg, intermediate-acting muscle relaxant and 100% oxygen or oxygen in air as required. Great caution should be exercised in the use of volatile anaesthetic agents. Airway pressures should be kept as low as possible. Should advanced ventilatory techniques such as the use high frequency oscillation be required in order to achieve pre-operative stabilisation, these may be safely continued during surgery. Most infants will require mechanical ventilation in the post-operative period.

### 5.19.3 Intestinal Obstruction

The various forms of neonatal intestinal obstruction account for approximately 35% of all surgical procedures in the newborn. The major anaesthetic problems are those of fluid and electrolyte imbalance (which must be corrected pre-operatively), abdominal distension (causing respiratory embarrassment) and the risk of regurgitation and aspiration of gastric contents into the lungs. Following decompression of the stomach, a rapid-sequence induction incorporating pre-oxygenation, propofol and succinylcholine with gentle cricoid pressure is advised. Anaesthesia is then continued in the usual way. The same principles apply to the management of those older infants with a diagnosis of intussusception who require operative reduction.

### 5.19.4 Exomphalos and Gastroschisis

Anaesthetic concerns include heat and fluid loss from the exposed bowel and the fact that primary closure of the abdominal wall defect may push the diaphragm cephalad, thus compromising respiratory function. Special care must be taken to keep heat loss to a minimum. Fluid requirements are much greater than in normal neonates. To maintain plasma oncotic pressure, at least 25% of fluid intake should be given as colloid. The extent of respiratory compromise can assist the anaesthetist in advising the surgeon whether or not primary closure is feasible. A proportion of infants, especially after repair of gastroschisis, require post-operative mechanical ventilation. The introduction

of staged closure of gastroschisis using preformed silos has simplified anaesthetic and paediatric intensive care unit management.

### 5.19.5 Congenital Lobar Emphysema

This condition may cause severe respiratory distress in the neonatal period. Induction of anaesthesia for lobectomy should be as smooth as possible—struggling may trap large amounts of air in the affected lobe during violent inspiratory efforts. Nitrous oxide can also increase the volume of trapped air considerably and is contraindicated. Great care should be taken with controlled ventilation because of the risk of pneumothorax.

### 5.19.6 Myelomeningocele, Shunt (and Revision Shunt) for Spina Bifida

Surgery for myelomeningocele is carried out with the infant in the prone position and the chest and pelvis should be supported with pads so that the abdomen remains free from external pressure. If the defect is large, heat and fluid loss during surgery can pose problems and should be monitored as closely as possible. Endotracheal intubation may be difficult in the presence of hydrocephalus. Children who have had repeated shunt surgery and regular bladder catheterization may develop latex allergy and a latex-free anaesthesia technique should be used.

### 5.19.7 Tonsillectomy and Adenoidectomy

While most children presenting for these operations are comparatively healthy, some may have obstructive sleep apnoea syndrome, which can be associated with significant right heart strain and pulmonary hypertension, with the danger of perioperative upper airway obstruction and potential cardiovascular collapse. Sedative premedication is best avoided in this group because of the risk of causing complete upper airway obstruction. As far as is possible, short-acting anaesthetic agents that do not cause significant respiratory or cardiovascular depression should be used. Extubation should not take place until the child is awake, and careful post-operative monitoring, preferably in a high dependency unit, is required.

### 5.19.8 Muscle Biopsy

This operation represents an example of a procedure that, although relatively minor and innocuous from the surgeon's viewpoint, may pose considerable problems for the anaesthetist. It is most frequently performed to either confirm or exclude a diagnosis of possible neuromuscular disease. Children presenting for muscle biopsy may have decreased respiratory and cardiac reserve, and be at increased risk of perioperative aspiration. They may also have metabolic derangements and can be prone to developing hypoglycaemia. Use of succinylcholine is absolutely contraindicated as it has been associated with lethal hyperkalaemia in this patient population, while there may be increased sensitivity to non-depolarizing muscle relaxants. Many paediatric anaesthetists also prefer to avoid volatile agents, thus necessitating the use of a continuous infusion anaesthetic technique, most commonly with propofol.

### 5.19.9 Herniotomy in the Ex-Premature Infant

Improved survival rates in premature and low birth weight infants have led to increased numbers of them presenting for inguinal hernia repair. While the surgical procedure may be relatively straightforward, these babies represent a considerable challenge for the anaesthetist. They must be managed by anaesthetists and surgeons with adequate training and ongoing experience in hospitals with appropriate facilities and personnel. Ex-premature infants up to 60 weeks post-conceptual age are at risk of life-threatening apnoea after anaesthesia and surgery. They should have respiratory monitoring for at least 12 h post-operatively and should not be managed as day cases. Intravenous caffeine 5 mg/kg given i.v. at induction appears to reduce the risk of apnoeic episodes, but respiratory monitoring is still required. Regional techniques also reduce, but do not eliminate, the risk of post-operative apnoea and may require supplementary sedation or light general anaesthesia.

## 5.20 Post-operative Analgesia in Children

There have been significant improvements in pain relief following surgery in children. In the past this was usually achieved by intramuscular injection of narcotics—many children suffered in silence, believing "the cure to be worse than the disease". Nowadays, a variety of different drugs and more effective and humane routes of administration are employed, which can and should be used to provide optimum post-operative analgesia for children. Prevention of pain whenever possible using multi-modal analgesia can be adapted for day cases, major surgery, the critically ill child and the very young. Most paediatric acute pain services use techniques of co-analgesia based on four classes of drugs, namely local anaesthetics, opioids, non-steroidal anti-inflammatory drugs (NSAIDs) and paracetamol (acetaminophen). For many day-case procedures opioids can and should be omitted altogether because combinations of the other three classes usually provide excellent pain control. In children's hospitals or other centres where significant numbers of children undergo anaesthesia and surgery, the establishment of a dedicated paediatric pain service is the desirable standard of care.

### 5.20.1 Local and Regional Anaesthesia

The use of regional anaesthesia reduces intraoperative anaesthetic requirements and provides excellent post-operative analgesia for infants and children. The incidence of major complications is extremely low even when central blocks, e.g. epidural analgesia, are used. Commonly used simple techniques include topical application of local anaesthetic gel as in the case of circumcision and direct instillation of local anaesthetic at the surgical site by the surgeon, e.g. for inguinal hernia repair or orchidopexy. Alternatively, the anaesthetist may perform either a penile or ilio-inguinal block for the same procedures. Numerous other local, regional and central anaesthetic blocks, often performed with ultrasound guidance, are used on an increasingly regular basis for virtually all types of surgery, including open cardiac surgery, and in many instances their efficacy in the post-operative period can be prolonged for as long as necessary through the use of continuous infusion techniques.

Until recently, the most widely used local anaesthetic agent for regional blockade was racemic bupivicaine. This has now largely been replaced by either ropivicaine or levobupivicaine, both of which appear to offer greater safety. However, it remains essential to adhere to published maximum dosage guidelines (2 mg/kg in infants, 2.5 mg/kg in children for single bolus injection with either drug). Use of some adjunctive agents, e.g. clonidine, ketamine with single dose or continuous epidural blockade, is increasingly popular as both the effectiveness and duration of blockade appear to be enhanced.

### 5.20.2 Opioids

Morphine remains the most widely used opioid for intra and post-operative analgesia in infants and children. Bolus injections of 0.1–0.2 mg/kg or infusions between 0.01 and 0.03 mg/kg/h provide adequate analgesia with an acceptable level of side-effects when administered with an appropriate level of monitoring. It should be noted that morphine elimination half-life is prolonged in the newborn when compared with older infants and children. Patients in this age-group are also more susceptible to the drug's respiratory depressant effects, Patient-controlled analgesia (PCA) is now widely used in children as young as 5 years and compares favourably with continuous infusion. Nurse-controlled analgesia (NCA) is useful in younger children or in those without the physical or mental capacity to use PCA successfully. Oral, sublingual, transdermal, intranasal and rectal routes of opioid administration have all been described and may have a role to play in specific cases. Use of the intramuscular route is no longer considered appropriate. Tramadol, oxycodone and pethidine may have some applicability as alternatives to morphine in the perioperative period. Fentanyl, alfentanil and remifentanil may have a role in intensive care practice after major surgery.

### 5.20.3 Non-steroidal Anti-inflammatory Drugs (NSAIDs)

These drugs are important in the prevention and treatment of mild to moderate pain in children. They are highly effective when used in combination with local

or regional nerve blocks. They may also be used in combination with opioids, leading to a significant "opioid-sparing" effect, which not only reduces the opioid dose requirement but also lessens the incidence of opioid-related side-effects, e.g. ileus, urinary retention. NSAIDs, e.g. diclofenac in combination with paracetamol, produce better analgesia than either alone. They should be avoided in infants aged less than 6 months, children with aspirin or NSAID allergy, those with dehydration or hypovolaemia, children with renal or hepatic failure, coagulation disorders, peptic ulcer disease, or in those who are at significant risk of haemorrhage. Concurrent administration of NSAIDs with anti-coagulants, steroids or nephrotoxic agents is not recommended. NSAIDs may provoke bronchospasm in some asthmatic patients. However it is useful to check for past exposure to these drugs as many asthmatic children can take them with no adverse effects. There have been suggestions that they impair bone healing. The beneficial effects of their short-term use in most children undergoing orthopaedic surgery probably outweigh this possible risk but caution is recommended following some major orthopaedic surgery, e.g. spinal fusion, limb-lengthening procedures.

### 5.20.4 Paracetamol (Acetaminophen)

Paracetamol has both analgesic and antipyretic effects. Its analgesic potency is relatively low. On its own, it can be used to treat most mild and some moderate pain. In combination with NSAIDs or a mild opioid such as codeine, it can be used to treat or prevent most moderate pain. Oral formulations are widely available. Absorption from the rectum is slow and incomplete, except in neonates. Intravenous formulations have recently become available and may have higher analgesic potency. It is important to realise that the time to peak analgesia even after i.v. administration is 1–2 h. In younger infants and sick children, considerable downward dose adjustments are needed.

## 5.21 Day-Case Anaesthesia and Surgery

In many units, up to 75% of surgery in children is carried out on a day-care basis. The same standards of care apply whether surgery is carried out on in-patients or out-patients. Staff should have been trained in the care of children, the environment should be child-friendly and child-safe, and there should be free parental access to the conscious child. While many operations can be carried out as day cases, a number of procedures are not suitable. These include any operation following which there is a significant risk of post-operative haemorrhage, where there is a likelihood of post-operative pain requiring sophisticated control, and also body cavity surgery. Other factors that need to be considered include the age and maturity of the child, his or her overall medical condition, the presence of anaesthetic risk factors, and the family's social circumstances.

### 5.21.1 Preparation of Child and Parents

The child and parents should be provided with a clear verbal explanation of what will happen on the day of surgery and this should be reinforced by written information and guidance regarding pre-operative fasting. Pre-admission programmes, e.g. "Saturday Clubs" may be helpful.

### 5.21.2 Premedication

In many centres the majority of children presenting for day-case surgery are not routinely premedicated. Midazolam has for some years been the drug of choice but it has recently been suggested that clonidine may be preferable.

### 5.21.3 Anaesthetic Technique

The anaesthetic technique employed should be as simple and non-invasive as possible. Both inhalational and i.v. induction techniques may be used.

It is preferable to maintain spontaneous respiration during the maintenance period, although use of non-depolarizing muscle relaxants is not an absolute contraindication to day-case surgery. If possible airway control should be achieved with either a face-mask or laryngeal mask airway, with endotracheal tubes being

reserved for cases where they are specifically required, e.g. upper gastrointestinal endoscopy.

### 5.21.4 Analgesia for Day Cases

Good pain control is critical to the success of paediatric day surgery. Opioids are associated with a higher incidence of post-operative nausea and vomiting (PONV) and should be avoided if possible. Local analgesia is effective and safe, and should probably be used as part of the analgesic regime in all cases where it is practical to do so. Peripheral nerve blocks are highly effective. Single-injection techniques are preferred, the most useful being penile block, ilioinguinal-iliohypogastric block and great auricular nerve block. Some also consider that single-dose caudal epidural block is appropriate for paediatric day-case surgery although motor block may be a problem. NSAIDs should also be used routinely unless specifically contraindicated. These may be given, by a number of routes, either as a component of premedication or after induction. Paracetamol may also be given. Oral analgesics are the mainstay of continuing pain relief at home after day surgery and it is vital to encourage parents to give analgesics preemptively for 24–48 h and before any local anaesthetic has worn off. They should also be advised on whom to contact if pain control problems arise.

### 5.21.5 Discharge Criteria

Prior to discharge the child should be fully conscious, pain-free and able to move normally. Vital signs should be normal. There should be no respiratory distress or stridor. The ability to drink and tolerate clear fluids is desirable, but adequately hydrated children can be allowed home prior to drinking if they meet other discharge criteria.

### 5.21.6 Reasons for Hospital Admission

Approximately one per cent of children undergoing day-case surgery ultimately require overnight hospital admission. The reasons include persistently abnormal vital signs or level of consciousness, persistent nausea and vomiting, surgical or anaesthetic problems (unexpectedly prolonged or difficult surgery, regurgitation, aspiration, allergic reactions), bleeding and difficulties with pain control.

### 5.21.7 Transport Home

The child should travel home in a private car or taxi and should be accompanied by a responsible adult. Use of buses or trains should be avoided and the total travelling time should not be excessively long.

## 5.22 Some Topics of Current Interest to Both Anaesthetists and Surgeons

### 5.22.1 Fasting Prior to Anaesthesia and Surgery

Pulmonary aspiration of acid gastric contents has long been recognized as a cause of morbidity and mortality in patients undergoing anaesthesia and surgery. While the precise incidence of this dreaded complication is unknown, there is evidence that children are affected more frequently than adults, with as many as 26% of deaths associated with paediatric anaesthesia being attributed to aspiration in one series. Of the various preventive measures that have been advocated to reduce the incidence of this complication one, the preoperative fast, has long since achieved universal acceptance with the result that patients of all ages have been required to abstain from food and drink prior to induction of anaesthesia. For decades, children were “fasted from midnight the night before”. If surgery was delayed, fasting times became excessively long and apart from being uncomfortable for the child, there was the risk of hypoglycaemia and dehydration—there are obvious dangers involved in administering potent anaesthetic drugs to potentially hypovolaemic young children. Furthermore, fasting leads to children becoming hungry, thirsty and emotionally upset and it has been shown that inhalational induction of anaesthesia is accomplished with a reduced incidence of airway complications if children are calm and cooperative. It follows that the minimum “starve time” that will not

**Table 5.1** Fasting guidelines prior to anaesthesia and surgery

| |
|---|
| *Children scheduled for elective anaesthesia* |
| Clear fluids: 2 h minimum |
| Breast milk: 4 h minimum |
| Other fluids and all solids: 6 h minimum |
| *Children scheduled for emergency anaesthesia* |
| All fluids and solids: 6 h minimum |

significantly increase the risk of regurgitation and aspiration of gastric contents should be used in institutions caring for the child undergoing surgery. Table 5.1 outlines some current recommendations.

### 5.22.2 Upper Respiratory Tract Infection

In the past, almost all children with evidence of upper respiratory tract infection (URTI) had their surgery postponed. While most studies agree that children with active or recent URTI are at increased risk of perioperative complications, these are for the most part manageable and without long-term sequelae. Most paediatric anaesthetists now agree that children with mild uncomplicated URTIs undergoing procedures that do not involve instrumentation of the airway can be safely anaesthetized without any significant increase in risk. Most also agree that any child with severe symptoms should have surgery deferred for at least 4 weeks.

### 5.22.3 Anaesthesia and Immunization

Anaesthetists are often faced with a child who has been recently immunized presenting for either elective or emergency surgery. Questions frequently asked include whether or not the anaesthesia or surgery will affect the response of the child to the vaccine in achieving seroconversion, or more seriously whether the vaccine might cause major adverse consequences in these circumstances. A recent international survey carried out to ascertain the attitudes and practices of paediatric anaesthetists regarding anaesthesia in the child who had recently been immunized or who was scheduled for immunization in the near future revealed little consensus of opinion. It does seem prudent, however, to adopt a cautious approach where the timing of elective surgery is concerned, and guidelines issued as a result of this survey are summarized in Table 5.2.

**Table 5.2** Guidelines regarding anaesthesia, surgery and immunization

1. Postpone all elective procedures requiring anaesthesia rather than immunization, especially in infants.
2. Opportunistic immunization during anaesthesia is inadvisable.
3. Postpone anaesthesia for 1 week after vaccination with inactive vaccines: diphtheria, tetanus, pertussis, inactive polio, Hib, Meningitis C.
4. Postpone anaesthesia for 3 weeks after vaccination with live attenuated vaccines: measles, mumps, rubella, oral polio vaccine and BCG.
5. Delay immunization for 1 week after surgery has taken place.

## Further Reading

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