# CHAPTER 22

# ANAESTHETICS

Healthcare professionals engaged in intensive care and delivery of anaesthesia must undergo appropriate training.

## 22.1 ANAESTHETIC AND POST-ANAESTHETIC CARE OF CHILDREN

### 22.1.1 LOCAL AND REGIONAL ANAESTHESIA

#### DESCRIPTION

Local anaesthesia is accomplished by either local infiltration of soft tissue or the instillation of local anaesthetic into potential or existing body spaces such as the epidural space, sub-arachnoid spinal spaces or around major nerves or plexuses.

Appropriate care is always used to limit overdose and avoid toxicity. Use appropriate agents, avoid adrenaline (epinephrine) where end-artery blood supply exists and ensure the agents are in the correct sites. This should be learnt under appropriate learning conditions.

#### MEDICINE TREATMENT

Choice of local anaesthetic agent should be guided by desired onset and duration of action. Bupivacaine is the local anaesthetic agent of choice due to duration of action. These agents, particularly bupivacaine, are cardiotoxic – every effort must be made to prevent intravascular injection. The use of ultrasound is strongly advised. Maximum doses must be strictly adhered to.

**Table 1: Local anaesthetic agents**

| Local anaesthetic | Onset of action | Duration of action | Maximum dose with adrenaline (epinephrine) | Maximum dose without adrenaline (epinephrine) |
|---|---|---|---|---|
| Lidocaine | 2–5 minutes | 1–2 hours | 7 mg/kg (0.3 mL/kg of 2% solution) | 3 mg/kg (0.15 mL/kg of 2% solution) |
| Bupivacaine | 10–40 minutes | 4–6 hours | 2–3 mg/kg (0.4–0.6 mL/kg of 0.5% solution) | 2–3 mg/kg* (0.4–0.6 mL/kg of 0.5% solution) |

*In infants under 12 months, overweight children, or children with liver dysfunction (where levels of $\alpha$-acid glycoprotein are likely to be low), use a maximum dose of 2 mg/kg.
*If using continuous regional anaesthesia technique (e.g. via indwelling catheter), use 2 mg/kg as maximum dose over a 4–6 hour period.

**Note**: Lipid emulsion 20% must be readily available where these techniques are performed, in the event of inadvertent intravascular injection or drug error leading to overdose and Local Anaesthetic Systemic Toxicity (LAST). For management of LAST, see below.
**Note**: Do not use adrenaline (epinephrine) containing local anaesthetic solutions in sites where vascular (end-artery) compromise may result from vasoconstrictor use, i.e. fingers, toes, penis and eyes.

**Caudal anaesthesia**
Caudal anaesthesia is a commonly utilised technique in children and provides good analgesia for common procedures. This technique must be learnt in an appropriate learning situation, as it has the potential to cause serious harm.

- Calculate the maximum dose of bupivacaine allowed for patient weight.
- Dilute with 0.9% sodium chloride (ONLY) to the desired volume.
- Adjuncts can be used to prolong and improve the quality of the block:
    - Dexamethasone 0.1–0.5 mg/kg given IV prolongs the duration of analgesia provided by the caudal anaesthesia.

**Note**: Only medicines with proven safety should be injected into the caudal space due to the potential for neurotoxicity and other adverse effects.

**Table 2: Recommended volumes for caudal anaesthesia**

| Level of analgesia required | Volume of local anaesthetic required |
|---|---|
| Low thoracic level | 1.25–1.5 mL/kg |
| High lumbar level | 1–1.25 mL/kg |
| Sacral level | 0.5–1 mL/kg |

**Other regional anaesthetic techniques**
These techniques should be learnt in an appropriate learning situation. The use of ultrasound is strongly recommended to improve safety. Always adhere to maximum allowable local anaesthetic doses.

Epidural volumes should take into consideration the dermatomal and visceral cover required. Generally allow 0.5 – 1 mL/dermatome, staying within the toxic dose range.

For wound infusion catheters infusions of bupivacaine:

- If < 4 months or < 5 kg: use 0.1% bupivacaine at 0.2 ml/kg/hour
- If > 4 months or > 5 kg: use 0.2% bupivacaine at 0.2 ml/kg/hour

| Procedure | Regional nerve block options | Dosing* (volume) |
|---|---|---|
| Umbilical herniorrhaphy | Rectus sheath | 0.2 – 0.3 mL/kg/side |
| Inguinal herniorrhaphy | Caudal | 1 – 1.25 mL/kg |
| | Ilio-inguinal/iliohypogastric nn. | 0.15–0.2 mL/kg/side |
| Orchidopexy | Caudal | 1 – 1.25 mL/kg |
| | Ilio-inguinal/iliohypogastric nn. | 0.2–0.3 mL/kg/side |
| Circumcision | Dorsal penile nerve | 0.5 - 1 mL/kg |
| | Caudal | 1 mL/kg |
| | Pudendal nerve | 1 mL/kg |
| Laparotomy (supra-umbilical) | Thoracic paravertebral | 0.5 mL/kg/side |
| | Subcostal transversus abdominus plane** | 0.3–0.5 mL/kg/side |
| | Epidural with catheter | |
| | Wound infusion catheter | |
| Laparotomy (infra-umbilical) | Caudal | (see table above) |
| | Epidural + catheter | |
| | Quadratus lumborum | 0.5 mL/kg/side |
| | Lumbar paravertebral plane | 0.5 mL/kg/side |
| | Transversus abdominus plane** | 0.3–0.5 mL/kg/side |
| | Wound infusion catheter | |
| Laparotomy (midline) | Rectus sheath block** | 0.1–0.3 mL/kg/side |
| | Caudal (only blocks lower midline) | 1.25–1.5 mL/kg |
| | Epidural with catheter | |
| | Wound infusion catheter | |
| Thoracotomy | Thoracic paravertebral | 0.5 mL/kg/side |
| | Intercostal nerves | 0.5 - 2 mL per nerve |

| Procedure | Regional nerve block options | Dosing* (volume) |
|---|---|---|
| | Epidural with catheter<br>Wound infusion catheter | |
| Appendicectomy (laparoscopic) | Transversus abdominus plane**<br>Quadratus lumborum | 0.3–0.5 mL/kg/side<br>0.5 mL/kg/side |
| Femur fracture/ Osteotomy | Fascia iliaca<br>Femoral nerve<br>+/- sciatic nerve<br>Caudal<br>Epidural with catheter | 0.2 - 0.5 mL/kg<br>0.2 – 0.4 mL/kg<br>0.3 – 0.5 mL/kg<br>(see table above) |

**Provides somatic analgesia only.

## 22.1.2 GENERAL ANAESTHESIA

## 22.1.2.1 PREPARATION

### DESCRIPTION

All patients should be starved before general anaesthesia to prevent regurgitation and aspiration of gastric contents. The preoperative starvation period is:

» clear fluid: 1 hour,
» breast milk: 4 hours, and
» solids, breast milk substitutes, non-human milk: 6 hours.

Clear fluids include water, clear juices without pulp and tea without milk.

Premedication of children for anaesthesia is largely a sedative/anxiolytic intervention.
The goal of anxiolytic premedication is to minimise emotional distress and facilitate mask acceptance for induction of anaesthesia.
The choice of agent should be guided by the child's condition (previous experiences, comorbidities, severity of anxiety).
Children who are distressed on induction of anaesthesia are more likely to develop distress in the early post-operative period. An active approach to reducing emotional distress with non-medicine and medicine measures is advised.

Avoid sedative premedication in children less than 6 months, children with evidence of airway compromise, obstructive sleep apnoea (OSA) or hypotonia.

## GENERAL AND SUPPORTIVE MEASURES

» Distraction techniques, e.g. videos, games, reading, music.
» Caregiver presence is strongly encouraged. Counsel appropriately as to what is expected.
» Medical play is a useful technique that helps address anxiety.

## MEDICINE TREATMENT

**Premedication**

Midazolam and ketamine are bitter tasting. To facilitate acceptance, mix with the recommended dose of paracetamol syrup/ibuprofen syrup or something sweet tasting such as apple juice.

| Agent | Route | Dose | Time to peak effect (minutes) |
|---|---|---|---|
| **Midazolam** | Oral<br>Intranasal**<br>Intravenous | 0.25–0.5 mg/kg (max. 15 mg)<br>0.3 mg/kg<br>0.025–0.1 mg/kg* | 10–30<br>10–15<br>3–5 |
| **Clonidine** | Oral | 3–5 mcg/kg | 60–90 |
| **Ketamine** | Oral<br>Intranasal**<br>Intramuscular | 6–10 mg/kg<br>1–5 mg/kg<br>2–4 mg/kg | 30<br>20<br>20 |

*Titrate to effect. Repeat dose at 5 minute intervals until desired level of sedation is achieve.
**Off-label route sometimes employed in practice.

Midazolam:

- This is a commonly used premedication agent that is generally well tolerated.
- Can be safely used in most children, but caution is advised in children with:
  - Risk factors for paradoxical excitation, e.g. children under 3 years, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorder (ASD).
  - Avoid in patients with obstructive sleep apnoea (OSA), as can cause respiratory depression.

**OR**

Clonidine:

- Preferred agent in children with:
  - Behavioural disorders such as ADHD, and children with ASD.
  - Obstructive sleep apnoea.
- Does not cause respiratory depression.

- Can cause bradycardia, which is clinically insignificant.
- Provides analgesia in addition to anxiolysis and sedation.
- Is tasteless and well tolerated. Even smaller children will swallow the tablets, but they can also be crushed and added to juice or water.

*LoE II*[1]

**Alternative in certain circumstance**

Ketamine:

- Is cardio stable and does not cause respiratory depression.
- Provides analgesia in addition to anxiolysis and sedation.
- In exceptional circumstances, can be used IM, e.g. when dealing with a combative child who is unable to understand what is needed and will not accept other routes of administration.

Intranasal administration of medicines can be administered with the patient reclining (or held) at 45 degrees, preferably using a mucosal atomiser device. The syringe is held horizontally and applied to the nare, and the contents expelled in one rapid dose. Use undiluted medicines to minimise the volume of drug. Doses of 1 mL or more should be divided between two nares.

## 22.1.2.2 INDUCTION OF ANAESTHESIA

Induction should be learnt in an appropriate learning situation.

### DESCRIPTION

Anaesthesia should only be administered by medical practitioners with appropriate training in anaesthesia. Induction of anaesthesia is the critical part of the transition from consciousness to general anaesthesia. This is a period which requires highly skilled and attentive care. Depression of the respiratory and cardiovascular systems often occur. The degree of depression depends on the agents used and the patient's condition.

The following monitors are mandatory to ensure the delivery of safe anaesthesia:

» Clinical observation – a dedicated medical doctor is mandatory.
» 3-lead ECG with heart rate display.
» Automated blood pressure.
» Pulse oximeter.
» Capnograph, displaying end-tidal $CO_2$ in mmHg, kPa or % and capnogram.
» Temperature

## MEDICINE TREATMENT FOR INDUCTION OF ANAESTHESIA

### Inhalational agents

Non-irritant inhalational agents, delivered with oxygen with/without medical air/nitrous oxide, are used for induction of anaesthesia. Nitrous oxide can be used to increase the onset of anaesthesia by its 'second gas effect', but should be limited to use with a minimum oxygen concentration of 30%, with oxygen analysis, by an experienced user. The following agents are used for gas induction of anaesthesia:

- Sevoflurane (preferred)
- Halothane

*LoE III*[2]

**Intravenous agents** (Use reduced doses if inhalational agents also used).

- Propofol, IV, titrate up to 3.5 mg/kg. Titrate as necessary to achieve required sedation. (Acts within 30 seconds. Effect lasts 3–10 minutes).

**OR**

- Ketamine, IV, 1–2 mg/kg. (Acts within 60 seconds. Effect lasts 5–10 minutes).

**OR**

- Etomidate, IV 0.3 mg/kg. Give slowly. This is regarded as being more 'cardio stable' and is generally reserved for patients who are at risk of cardiovascular collapse, but must be used with caution even in these patients. A single dose can cause adrenal suppression.

### Muscle relaxant during induction for intubation

**Note**: These agents cause muscle paralysis and apnoea. It is good practice to use a nerve stimulator when non-depolarising muscle relaxants are used to monitor the degree of paralysis/weakness.

Ventilate all patients receiving muscle relaxants.

- Suxamethonium, IV, 1–2 mg/kg. Onset of action: 30–60 seconds. Duration of action: 5–10 minutes.
  - **Note**: Avoid suxamethonium in patients with or at risk of hyperkalaemia, scoline apnoea, certain neuromuscular diseases and a family history of malignant hyperthermia.

**OR**

- Rocuronium bromide, IV, 0.3–1 mg/kg. Onset and duration of action is dose dependent. Onset of action: 1–3 minutes. Duration of action: 30–60 minutes.

**OR**

- Vecuronium, IV, 0.1 mg/kg. Onset of action: 2–3 minutes. Duration of action: 30–40 minutes.

**OR**

- Cisatracurium, IV, 0.1–0.15 mg/kg. Onset of action: 3 minutes. Duration of action: 30–45 minutes. This is the agent of choice in patients with renal dysfunction.

**Endotracheal intubation**

**Caution**
This procedure should be learnt under supervision.

The condition of the patient and the surgical requirements dictate the choice of airway management – face mask, supraglottic airway device or endotracheal tube (ETT). Traditionally, uncuffed endotracheal tubes were preferred in children. More recently, cuffed endotracheal tubes have been demonstrated to be safe and may offer several advantages over uncuffed tubes. Care must be taken not to overinflate the cuff as this can lead to ischaemia of the tracheal wall and the development of severe complications like sub-glottic stenosis. It is advisable to check cuff pressures with a manometer 4-hourly, and to limit pressures to 15–20 $cmH_20$. Use the smallest volume of air to maintain an adequate seal.

To estimate the correct ETT size, the table below can be used as a guide. Alternatively, formulas can be used:
ETT size (ID (mm)): Age (years)/4 + 3.5 (cuffed ETT)
Age (years)/4 + 4 (uncuffed ETT)

Confirm clinically with auscultation that air entry is heard bilaterally, and observe airway pressures.

**Table 3: A guide to endotracheal tube sizes and lengths in children with head in the neutral position**

| Age | Weight (kg) | ETT* | Oral (measurement at lips, cm) | Nasal (measurement at nostril, cm) |
|---|---|---|---|---|
| Preterm | 1 | 2.5 | 7 | 8.5 |
| Preterm | 2 | 2.5–3 | 8 | 9.5 |
| Term | 3 | 3–3.5 | 9.5 | 11.5 |
| 2 months | 4.5 | 3.5 | 11 | 12.5 |
| 1 year | 10 | 4 | 12 | 14 |
| 18 months | 12 | 4.5 | 13 | 15 |
| 2 years | 15 | 5 | 14 | 16 |
| 4 years | 17 | 5.5 | 15 | 17 |
| 6 years | 21 | 6 | 16 | 19 |
| 8 years | 25 | 6.5 | 17 | 20 |
| 10 years | 31 | 7 | 18 | 21 |

*If using a cuffed endotracheal tube, use a half-size smaller.

## 22.1.2.3 MAINTENANCE OF ANAESTHESIA

### DESCRIPTION

After induction, the focus shifts to the maintenance of an adequate level of hypnosis, immobility and analgesia. Anaesthetic goals include maintaining normothermia and normoglycaemia, maintenance of cardiovascular stability, prevention of hypoxia and hyper/hypocapnia, providing appropriate analgesia, and the prevention of post-operative complications.

### MEDICINE TREATMENT DURING MAINTENANCE OF ANAESTHESIA

**Inhalational (volatile) anaesthesia**

These are delivered with a combination of oxygen and medical air/nitrous oxide. The recommendation is to use a combination of oxygen and air, especially if unable to monitor inhaled oxygen concentration. The use of nitrous oxide risks hypoxia, and offers little benefit intraoperatively. The use of nitrous oxide should be limited to use with a minimum oxygen concentration of 30%, with oxygen analysis. The use of nitrous oxide to provide analgesia is variable depending on altitude and is discouraged, as this effect is limited to the period of its use, with no provision for post-operative analgesia.

The Minimum Alveolar Concentration (MAC) defines the anaesthetic depth for inhaled agents at which 50% of patients respond to a painful stimulus with movement.

**Table 4: Age-related MAC values**

| Age (months) | Isoflurane | Sevoflurane |
|---|---|---|
| 1 | 1.6 | 3.2–3.3 |
| 2 | 1.9 | 3.2–3.3 |
| 14 | 1.8 | 2.5 |
| 44 | 1.6 | 2.5 |

Intravenous anaesthetic agents

These agents can be delivered by continuous infusions where volatile agents are contraindicated.

- Propofol, IVI, 7.5–15 mg/kg/hr. Infusions of more than 4 mg/kg/hr for more than 24 hours should be avoided due to the risk of propofol infusion syndrome.
- Ketamine, IVI, 10–40 mcg/kg/min. Excessive salivation can be managed with an anti-sialogogue such as glycopyrrolate.

Analgesia

- Multimodal analgesia (the use of multiple pharmacological agents in combination) is strongly advised to facilitate optimal pain management through synergy of various agents, and to minimise the dose of opiates

required for effective analgesia. This allows for avoidance of the unwanted side effects typically associated with opioids, e.g. respiratory depression, nausea, hypotension, sedation.

Simple analgesia

- Oral paracetamol is cost effective and has excellent bioavailability. Oral paracetamol can be administered when patients are being kept NPO for general anaesthesia. (See Table 5 for dosing.)

- Ibuprofen syrup, 5–10 mg/kg orally (can be given preoperatively).

**Table 5: Paracetamol doses in children**

| Route | Loading Dose | Maintenance dose | | | Maximum daily dose |
|---|---|---|---|---|---|
| | | Neonates | Infants 30 days to 3 months | 3 months to 12 years | |
| **Oral** | 20 mg/kg | 5 – 10 mg/kg 6 to 8 hourly | 10 mg/kg 6 hourly | 15 mg/kg 6 hourly | 90 mg/kg/day Neonates: 60 mg/kg/day |
| **Intravenous** | 20 mg/kg | 5 – 10 mg/kg 6 to 8 hourly | 10 mg/kg 6 hourly | 15 mg/kg 6 hourly | 90 mg/kg/day Neonates: 60 mg/kg/day |
| **Rectal** | 40 mg/kg | 30 mg/kg/dose 6-hourly | | | 5 g/day |

Opiate Analgesia

For most cases, unless a regional technique has been employed, a combination of a short and longer acting opioid are used. Fentanyl is a short-acting opioid used to provide intraoperative analgesia, and morphine is a long-acting opioid used for both intraoperative and post-operative analgesia.

- Fentanyl, IV, 0.5–2 mcg/kg boluses as required, titrated to indicators of pain – patient movement, heart rate, BP and respiratory rate (where patient is breathing spontaneously). Note that these parameters are non-specific indicators for pain. Correlate with painful stimuli and expected procedure-specific pain severity. Fentanyl is a potent opioid with a rapid onset and short duration of action. Bradycardia may occur, but blood pressure is usually preserved. Apnoea can occur. Respiratory support may be required.

- Morphine, IV, 0.05–0.2 mg/kg boluses as required. Morphine is a delayed onset, long-acting opioid. Respiratory depression (decreased minute ventilation or apnoea) precedes analgesic effect. Respiratory support may be required. Can cause bradycardia and hypotension, especially in patients who are hypovolaemic or unstable. Note that there is no ceiling dose for morphine – children who have developed opioid

tolerance or with severe pain may need higher doses. Titration is an important aspect of safety.

| Drug | Onset of action | Duration of action | Dose |
|---|---|---|---|
| Fentanyl | 1–5 minutes | 30–60 minutes | 0.5–2 mcg/kg |
| Morphine | 20–50 minutes | 4–6 hours | 0.05–0.2 mg/kg |

- Ketamine, IV, 0.3 mg/kg stat. Consider using to decrease opioid requirements and address elements of neuropathic surgical pain.
- Local anaesthetic infiltration of the wound by the surgeon with bupivacaine +/- adrenaline (see maximum allowable dose) or regional anaesthesia technique.

Muscle relaxant during maintenance phase

- Rocuronium bromide, IV:
  - Maintenance doses: IV, 0.3–1 mg/kg, as needed (may be guided by nerve stimulator). Note that repeated doses may lead to prolonged muscle relaxation.

**OR**

- Vecuronium, IV:
  - Maintenance doses: IV, 0.1 mg/kg, as needed (may be guided by nerve stimulator).

**OR**

- Cisatracurium, IV. Preferred in patients with renal impairment:
  - Maintenance doses: IV, 0.1–0.2 mg/kg.

Reversal of muscle relaxant

Always reverse non-depolarising muscle relaxants. A combination of an acetylcholinesterase inhibitor and either glycopyrrolate OR atropine to counteract the excess acetylcholine which will produce muscarinic side effects. Glycopyrrolate is preferred as it has a slower onset of action, producing less tachycardia and less central nervous system effects with a longer duration of action.

- Acetylcholinesterase inhibitor: Neostigmine, IV, 50 mcg/kg.

**PLUS**

- Glycopyrrolate, IV, 10 mcg/kg **OR** atropine, IV, 20 mcg/kg.
  For convenience, can be dosed as follows:
  - 1 mL of neostigmine 2.5 mg/mL **plus** 2 mL glycopyrrolate 0.2 mg/mL **plus** 7 mL sodium chloride 0.9%. Give 1 mL/5 kg of this solution IV.

To reduce secretions, only if required (especially if ketamine is given):

- Glycopyrrolate, IV, 5–10 mcg/kg (preferred).
  **OR**
- Atropine, IV, 20 mcg/kg.

**Prophylaxis for Post-Operative Nausea and Vomiting (PONV)**
A risk assessment should be conducted for every child.
The postoperative vomiting in children score (POVOC) can be used:

1. Duration of surgery > 30 minutes.
2. Age > 3 years.
3. Strabismus surgery.
4. Personal or direct family history of PONV.

**Table 6: POVOC score**

| Number of risk factors | Incidence of postoperative vomiting (%) | Recommended Intervention |
|---|---|---|
| 1 | 10 | Dexamethasone, IV, 0.15 mg/kg |
| 2 | 30 | Dexamethasone, IV, 0.15 mg/kg + Ondansetron, IV, 0.15 mg/kg |
| 3–4 | 55–70 | Dexamethasone, IV, 0.15 mg/kg + Ondansetron, IV, 0.15 mg/kg + Intra-operative fluid administration up to 30 mL/kg |

Other strategies to decrease PONV are encouraged and include avoidance of nitrous oxide, multi-modal analgesia to reduce opioid requirements, and the consideration of a total intravenous anaesthesia technique.
The risk for PONV increases significantly peri-adolescence. During this time, girls are at higher risk when compared to boys.

**Hypotension under General Anaesthesia**
An appreciation of normal values for age for blood pressure are essential for the safe conduct of anaesthesia in children. Most cases of hypotension in children are due to hypovolaemia, and a bolus of 5 – 10 mL/kg of isotonic fluid should be given, and the response assessed. With persistent hypotension, a cause needs to be sought and addressed. For the diagnosis of hypotensive states or shock, and appropriate management, please refer to Intensive Care Chapter: section 23.8. Inotropes and vasopressors

## 22.1.3 POST OPERATIVE CARE

Vital signs should be monitored more frequently in the immediate post-operative period after discharge from the recovery area. Inadequately treated pain has adverse effects on multiple organ systems. Pain management should be individualised for each patient – according to the expected severity and type of pain. Analgesia should be prescribed regularly if pain is expected to be moderate to severe.

## MEDICINE TREATMENT

Analgesia should be prescribed according to the predicted severity of pain. Procedures associated with mild pain include incision and drainage of an abscess, manipulation of a mildly displaced fracture, and inguinal hernia repair. Procedures associated with moderate–severe pain include tonsillectomy, laparotomy, appendicectomy, testicular torsion, and severely displaced fractures.

Avoid 'as necessary' or 'pro re nata' (PRN) dosing. Scheduled analgesia is essential in managing moderate and severe pain.

**Table 7: Recommended post-operative analgesia**

| Predicted pain severity | Principles of management | Suggested regimen |
|---|---|---|
| Mild pain | Simple analgesia should suffice. | Paracetamol ± Ibuprofen |
| Moderate pain | Simple analgesia + opioid<br>Dose regularly. | Paracetamol +<br>Ibuprofen +<br>Morphine PO |
| Severe pain | Simple analgesia + strong opioid.<br>Dose regularly. | Paracetamol +<br>Ibuprofen +<br>Morphine IV |
| Adjuncts | | Ketamine |

Simple analgesia: Paracetamol

- See doses above

Simple analgesia: Non-Steroidal Anti-Inflammatory Drugs (NSAIDs)

- Ibuprofen, oral, 5–10 mg/kg/dose 8 hourly

Opioid analgesia

- Strong opioid: Morphine, oral:
  - 0–1 month of age: 0.05 mg/kg 6 hourly.
  - 1–12 months of age: 0.05–0.2 mg/kg/dose 4–6 hourly.
  - > 12 months of age: 0.2–0.4 mg/kg/dose 4–6 hourly.

- Strong opioid: Morphine, IV. Morphine infusion for older child (more than 3 months of age):
  - Ventilated: Morphine, IV, 20–40 mcg/kg/hour infusion.
    - i.e. Morphine 1 mg/kg mixed with 50 mL dextrose 5% or sodium chloride 0.9% at 1–2 mL/hour.
  - Unventilated: Morphine 5–20 mcg/kg/hour infusion.
    - i.e. Morphine 1 mg/kg mixed with 50 mL dextrose 5% or sodium chloride 0.9% at 0.25–1 mL/hour.

Adjuncts

- Ketamine, IV, 0.2–0.5 mg/kg/hour.
    - i.e. Ketamine 5 mg/kg mixed up to 50 mL sodium chloride 0.9% at 2–5 mL/hour.

Ketamine is a safe and effective analgesic adjunct, with significant opioid sparing effect, even at low doses. This dosing regimen will not result in haemodynamic changes, or unwanted psychotropic effects.

**Note**:
Patients on morphine infusions should have continuous oxygen saturation monitored and adequate nursing care. Label syringes appropriately.

### REFERRAL

» Inability to provide appropriate care.

## 22.1.4 MANAGEMENT OF ANAESTHETIC AND POST-ANAESTHETIC COMPLICATIONS

### DESCRIPTION

Various events may occur during and after anaesthesia, which require management.

### MEDICINE TREATMENT

Laryngospasm

1. Maintain a good seal and attempt bag-mask ventilation, maintaining continuous positive pressure.
2. Deepen the level of anaesthesia with a volatile anaesthetic agent (if laryngospasm is partial) – may overcome laryngospasm without the need for suxamethonium.
3. If laryngospasm is complete (no movement of air) and the patient starts to desaturate, act quickly and consider:
    - Propofol, IV, 1–2 mg/kg.
      **AND/OR**
    - Lidocaine, IV, 1–2 mg/kg.
    - Suxamethonium, IV, 1–2 mg/kg. If no IV access: Suxamethonium 3–4 mg/kg IM into the tongue (intralingually) with massage (submental route is preferred, see diagram below). Massage speeds onset of action significantly. (Produces 5–10 minutes of neuromuscular blockade within 30–60 seconds). Causes paralysis and apnoea.

**Note**: Do not wait for patient to become significantly hypoxic and bradycardic. Call for help early.

**Note**: Avoid suxamethonium in patients with or at risk of hyperkalaemia, scoline apnoea, certain neuromuscular diseases and a family history of malignant hyperthermia.

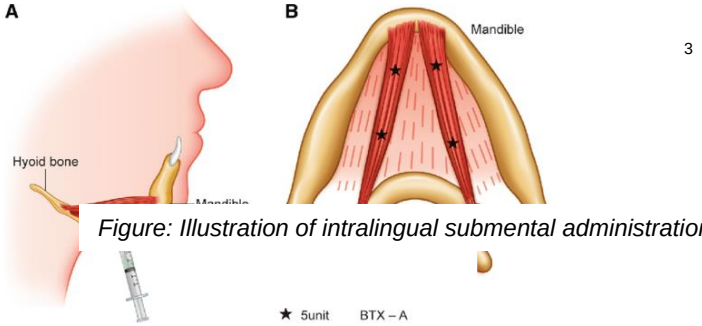



*Figure: Illustration of intralingual submental administration.*

| Route of administration | Quadriceps | Intralingual submental | Intralingual submental with massage |
|---|---|---|---|
| Time to 90% twitch suppression | 295 seconds | 265 seconds | 133 seconds |

**Bronchospasm**

Intraoperatively, exclude precipitating factors, e.g. ET tube at carina or mainstem bronchus intubation, blocked tubing or equipment, light anaesthesia, secretions, aspiration, allergic reactions.

Management

- Increase $FiO_2$.
- Increase volatile agent (except desflurane; if using, change to different agent).
- $\beta_2$-agonists can be delivered via different routes:
  - Nebulised fenoterol via in-line nebuliser (need independent oxygen source). Attach onto the circuit at the patient-end of HME and ventilate. Note that capnography will be inaccurate.
  - Salbutamol, IV, 15 mcg/kg over 10 minutes.
- Magnesium sulphate, IV, 30–50 mg/kg (maximum 2 g) slowly over 20 minutes.

If no response, consider:

- Ketamine, IV bolus, 0.5 mg/kg or consider infusion at 1–3 mg/kg/hr (may increase secretions).
- Adrenaline, IV, 0.1–1 mcg/kg or infusion at 0.05–1 mcg/kg/min.
- Hydrocortisone, IV, 1–2 mg/kg stat.

**Opioid-induced respiratory depression**

- For reversal of apnoea/respiratory depression: Naloxone, IV, 0.01 mg/kg, repeated every 2 minutes, if required, up to 4 times. Maximum dose: 0.4 mg.
- For reversal of post-operative sedation: Naloxone, IV, 0.002 mg/kg/dose, repeated every 2 minutes, as required, up to 4 times.

**Note**: All patients need to be kept under direct observation until the effect of the opiates has completely worn off. Further doses of naloxone may be needed as naloxone has a shorter duration of action than most opiates (e.g. morphine). Because naloxone antagonises opiates at the mu receptor, the analgesic effect will also be reversed. This occurs at higher doses of naloxone, hence the need for titration. The lowest dose of naloxone to reverse respiratory depression should be used.

**Post operative nausea and vomiting**

Use an agent of a different class if prophylaxis given.

- Ondansetron, slow IV, 0.15 mg/kg. (No benefit if already used as prophylaxis). Maximum dose: 4 mg. *LoE III*[4]

**Malignant hyperthermia**

Malignant hyperthermia is a life-threatening anaesthetic emergency triggered by exposure to volatile anaesthetic agents and suxamethonium. Management involves supportive and specific therapies, which centre on the administration of dantrolene. For a comprehensive management guideline, refer to the Association of Anaesthetists of Great Britain and Ireland's (AAGBI):

https://anaesthetists.org/Portals/0/PDFs/Guidelines%20PDFs/New%20archived/Guideline_malignant_hyperthermia_laminate_2011_archive%20version.pdf?ver=2021-01-13-160622-273

- Stop the triggering agent.
- Stop surgery or provide an alternate method of hypnosis intravenously (e.g. ketamine, propofol).
- Give dantrolene, IV, 2.5 mg/kg immediately. This is followed by 1 mg/kg IV boluses to a maximum cumulative dose of 10 mg/kg.

**Local Anaesthetic Systemic Toxicity (LAST):**

This is a life-threatening emergency caused by inadvertent intravascular injection or overdose of local anaesthetic agents. LAST is comprised of neurological and cardiovascular features with eventual cardiovascular collapse and cardiac arrest if high plasma concentrations are reached. The management is supportive and specific. For a comprehensive management guideline, refer to the Association of Anaesthetists of Great Britain and Ireland's (AAGBI) guideline:

*(https://www.aagbi.org/sites/default/files/la_toxicity_2010_0.pdf)*

- Stop injecting the local anaesthetic.
- Early administration of lipid emulsion 20% is a priority. Provide cardiovascular and respiratory support while awaiting lipid emulsion and until return of spontaneous circulation. Apply Advanced Paediatric Life Support algorithms should cardiac arrest occur. Good cardiopulmonary resuscitation is of paramount importance to ensure a good outcome. Treat arrythmias, but do not use lignocaine.
- Start lipid emulsion, IV, 1.5 mL/kg **AND** start infusion of 15 mg/kg/hr. The bolus of 1.5 mL/kg can be repeated after 5 minutes if the patient remains unstable. The maximum dose of lipid emulsion is 12 mg/kg. Propofol is not a suitable replacement.
- Treat seizures

**Dysrhythmias**

See Chapter 4: Cardiovascular System, section 4.1: Cardiac dysrhythmias.

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