Anaesthesia for specialist surgery in infancy

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Abstract
Common indications for neonatal surgery include inguinal hernias and hypertrophic pyloric stenosis. Less common conditions that have major implications for anaesthesia include tracheoesophageal fistula, congenital diaphragmatic hernia, exomphalos, gastroschisis and congenital lobar emphysema. The anaesthetic management of these conditions is outlined in this article.

Keywords Congenital lobar emphysema; diaphragmatic hernia; exomphalos; gastroschisis; pyloric stenosis; tracheo-oesophageal fistula

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Learning objectives

After reading this article you should be able to describe:

- the peri-operative management of a neonate with a diaphragmatic hernia
- how you would anaesthetize a neonate with a tracheo-oesophageal fistula
- the acid–base derangement seen in pyloric stenosis and outline the peri-operative assessment and fluid management.

Meticulous anaesthetic technique is the key to successful anaesthesia in infants. Emphasis on maintenance of adequate oxygenation, ventilation, mean arterial pressure, perfusion and careful fluid management, temperature regulation and glucose control are fundamental elements (see Principles of anaesthesia for term neonates on pages 103–106 of this issue). Knowledge of neonatal physiology (see Adaptation for life: neonatal physiology on pages 89–95 of this issue) and pharmacology (see Neonatal pharmacology on pages 96–102 of this issue) is essential to provide safe anaesthetic care in this population. Premature infants are a special population and present added challenges that are outlined in Special considerations in the premature and ex-premature infant on pages 107–110 of this issue.

Herniorrhaphy in the ex-premature infant

The incidence of inguinal hernias in infants increases with decreasing gestational age, and may be as high as 20% in premature infants. There is no consensus on the optimum timing of surgery in a premature infant with an asymptomatic inguinal hernia. It is a balance between postponement to improve the physiological development and clinical stability of the premature infant against the surgical risks associated with delaying surgery. These risks include hernia incarceration, gonadal infarction, gonadal atrophy and hernia recurrence. The reported risk of hernia incarceration in premature infants is reported as 4.6–16%; the risk increases when surgery is delayed. Herniorrhaphy is often performed before 60 weeks postconception age (PCA) or before discharge from the neonatal intensive care unit (NICU), but early surgery (within one week of diagnosis) has recently been recommended to avoid the aforementioned surgical complications. Surgery may be open or laparoscopic and performed under regional or general anaesthesia (Table 1). The choice of technique must be considered on an individual patient basis. The variables that must be considered include: urgent versus elective surgery; extent of surgery (size of hernia, unilateral or bilateral hernia, oedematous field); patient weight and degree of prematurity; history of apnoea or bradycardia; and the presence of comorbidities such as severe bronchopulmonary dysplasia.

Anaesthetic technique

General anaesthesia: general anaesthesia with endotracheal intubation is the usual technique chosen. In larger infants, a laryngeal mask airway may be considered for open procedures. Intravenous (IV) or inhalational induction is suitable. Desflurane is ideal for maintenance of anaesthesia in intubated infants because of its favourable emergence characteristics. For open procedures postoperative analgesia is provided by a caudal block for bilateral herniorrhaphy, an ilioinguinal block is appropriate for unilateral surgery. Local infiltration by the surgeon provides adequate analgesia for laparoscopic procedures although it is prudent to consent for a caudal in case of conversion to open surgery. Paracetamol should also be given.

Regional anaesthesia may be provided by a spinal, combined spinal and caudal, or a caudal technique alone. The duration of surgical anaesthesia offered by a single-shot spinal technique varies from 75 to 120 minutes dependant on the type and dose of local anaesthetic used. Prolongation can be achieved with an additional caudal block. Addition of clonidine to the local anaesthetic will prolong anaesthesia but increases the risk of apnoea and sedation, and is therefore used in children over the age of 1 year who are not scheduled to have a day-case procedure. A comparison of awake spinal and awake caudal anaesthesia in preterm infants found caudal anaesthesia to be technically less difficult than spinal anaesthesia. It also had a higher success rate with a lower incidence of conversion to general anaesthesia (see Further reading). Advocates of regional anaesthesia claim that there are fewer perioperative episodes of bradycardia, desaturation and apnoea than with repair under

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Risk-benefit of regional versus general anaesthesia for inguinal hernia repair

	General	Regional
Advantages	Secure airway	Avoids airway instrumentation
	No time limit for surgery	Decreases apnoea/bradycardia if sedation avoided
	Familiarity with technique	Avoids general anaesthesia if multiple comorbidities
		Minimizes systemic analgesics/hypnotics
		May maintain cardiovascular stability and mean arterial blood pressure
Disadvantages	May increase apnoea/bradycardia	Technically difficult
	May require postoperative respiratory support	Failure rate 10—20%
	May predispose to poor CVS stability and low mean arterial blood pressure	Airway not secured
		Time limit for surgical duration
		May require supplemental sedation
		Contraindicated in some infants
		Does not eliminate apnoea/bradycardia
		No muscle relaxation
		Movement of surgical field at high respiratory rates
		Not suitable for laparoscopic surgery

Table 1

general anaesthesia. A Cochrane review (see Further reading) with a total of 108 patients, found no reliable evidence that spinal anaesthesia decreased the incidence of postoperative apnoea or bradycardia. However, when the data were re-analysed excluding infants who had received ketamine sedation, there was a reduction in apnoea in the spinal group. More information will become available when results of the GAS Consortium study are published (http: www.controlled-trials.com/ISRCTN12437565).

Postoperative care

Regardless of technique used, premature infants are at risk of developing postoperative apnoea. Apnoea monitoring is required postoperatively in term infants aged less than 44 weeks PCA or in ex-premature infants until 60 weeks PCA.

Hypertrophic pyloric stenosis

Pyloric stenosis is a common disorder of infancy, with an incidence of 1:350 live births. The incidence is higher in first born Caucasian males with a positive family history. The underlying abnormality is hypertrophy of the longitudinal and circular muscles of the pyloric sphincter with oedema of the pyloric mucosa, leading to gastric outlet obstruction.

Diagnosis

The typical presentation is an otherwise healthy 3—6-week-old baby, with a history of progressive non-bilious projectile vomiting, failure to thrive and a palpable 'olive' sized mass in the right upper quadrant. Clinical diagnosis may be confirmed by ultrasound.

Biochemistry

Biochemical abnormalities are present to a varying degree. The classically described abnormality is hypokalaemic hypochloraemic hyponatraemic metabolic alkalosis with compensatory respiratory acidosis. This is rarely seen in modern practice due to early diagnosis and intravenous fluid resuscitation. Vomiting normally results in equal loss of gastric acid and alkaline duodenal fluid. However, with gastric outlet obstruction, gastric acid along with a variable amount of Na^+ and K^+ is lost in vomitus without loss of HCO_3^- from the duodenum. The resultant systemic alkalosis overwhelms the capacity of the proximal convoluted tubule to reabsorb HCO_3^-, producing an alkaline urine. As extracellular fluid volume depletion increases, aldosterone is secreted, leading to renal conservation of Na^+ in exchange for K^+. Eventually hypokalaemia forces Na^+ exchange preferentially with H^+ instead of K^+ in the renal tubules. This produces the characteristic 'paradoxical acid urine' in the face of systemic alkalosis. If the infant presents with a long history, the systemic alkalosis may have progressed to a metabolic acidosis, with lactic acidosis from dehydration and ketosis due to starvation. Up to 2% of infants may have jaundice, a result of starvation decreasing glucornyl transferase activity; this resolves after pyloromyotomy.

Surgical approach

Pyloromyotomy may be performed using open surgical techniques (through a right upper quadrant, midline epigastric or periumbilical incision) or laparoscopically. Laparoscopy requires low-pressure abdominal insufflation (usually less than 10 mmHg), which should not interfere with neonatal ventilation. Regardless of approach, the pylorus muscle is carefully divided whilst leaving the mucosa intact.

Anaesthetic management

Preoperative: pyloric stenosis is a medical, not surgical, emergency. Resuscitation with correction of hydration and electrolyte abnormalities is the priority. Continuous nasogastric (NG) drainage and 'nil by mouth' should be instituted. Assessment of hydration status includes vital signs, percentage weight loss, skin turgor, anterior fontanelle tension, tongue moistness, mental alertness and urinary output (frequency of wet nappies). For severe dehydration (>15% loss of body weight) a 20 ml/kg bolus of 0.9% normal saline (NS) is indicated. Further fluid