Anaesthesia for specialist surgery in infancy

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Abstract

Specialist surgery in infancy provides unique and significant challenges for paediatric anaesthetists. Both common (inguinal hernias and hypertrophic pyloric stenosis) and less common conditions (tracheo-oesophageal fistula, congenital diaphragmatic hernia, exomphalos (omphalocele), gastroschisis and congenital lobar emphysema) require a sound understanding of the relevant pathology and the particular issues that may be encountered in order to safely anaesthetise these infants. It is important to maintain a high attention to detail and to strive for excellent communication between all members of the perioperative team. In the last decade there has been a rise in the number of procedures in infancy being performed with a minimally invasive technique and this has a wide range of implications for anaesthesia.

Keywords Congenital diaphragmatic hernia; exomphalos; gastroschisis; infantile hernia; laparoscopy; necrotizing enterocolitis; pyloric stenosis; thoracoscopy; tracheo-oesophageal fistula

Royal College of Anaesthetists CPD Matrix: 2D02, 3D00

Learning Objectives

After reading this article, you should be able to:

- describe common surgical conditions encountered in infancy and the relevant pathology that may accompany them
- explain the basic surgical approach to these conditions
- summarize the anaesthetic implications of the most common surgical problems in infants
- describe the physiological changes observed during minimally invasive surgery in infancy
- evaluate the advantages and disadvantages of minimally invasive surgery

Minimally invasive surgery in infancy

In recent years there has been considerable growth in the number of surgical procedures in infancy being performed using a minimally invasive technique. Benefits may include improved cosmetic outcomes, reduced postoperative pain, reduced musculoskeletal damage and quicker recovery, but these potential benefits are offset by particular challenges for the anaesthetist. Some procedures will be prolonged despite increasing experience and comfort amongst surgeons, and a good understanding of the accompanying physiology and its management is important.

Laparoscopy

Procedures suitable for a laparoscopic approach include orchidopexy, pyloromyotomy, inguinal hernia repair, laparoscopic-assisted pullthrough for Hirschsprung's disease, duodenal atresia repair/stoma formation and exploratory laparoscopy for acute abdomen. A pneumoperitoneum is achieved using CO_2 insufflation leading to an increase in intra-abdominal pressure. In babies a lower inflation pressure (generally <10 mmHg) than in adults due to a more compliant abdominal wall.

Physiological effects: Cephalad displacement of the diaphragm restricts lung excursion, leading to a reduced functional residual capacity (FRC), reduced lung compliance and increased airway resistance. Infants have a high closing capacity relative to FRC, which makes them more prone to collapse of dependent airways and atelectasis. In addition, oxygen saturations may be compromised due to impaired ventilation-perfusion matching. Hypercarbia may be pronounced in infants due to more rapid absorption of CO_2 into the blood; this in turn requires a higher minute ventilation by way of higher inflation pressures and respiratory rate using positive pressure ventilation. Cardiovascular responses are variable, but derangements are unusual with insufflation pressures less than 10 mmHg. If higher pressures are needed (>15 mmHg) and the patient is unwell, compromised or hypovolaemic, the reduced venous return from inferior vena cava compression may cause a reduction in cardiac output and hypotension. Rarely, cardiovascular collapse has been described that has been attributed to gas embolism with initiation of the pneumoperitoneum.[1] Particularly small or premature babies may not be suitable for laparoscopic surgery as they may tolerate the physiological effects of a pneumoperitoneum poorly.

Anaesthetic technique: The use of cuffed endotracheal tubes (ETTs) is safe in infants and will prevent problems arising from a leak around the endotracheal tube. A positive end expiratory pressure (PEEP) of 3–8 cmH_2O is likely to be useful to offset any hypoxia and the occasional manual recruitment breath will help to re-expand collapsed dependent lung units and improve oxygen saturations. Release of the pneumoperitoneum will usually reverse any refractory respiratory compromise, and the surgeon should be notified if there are problems not improved by adjusting the ventilation. Effective neuromuscular blockade will improve ventilation and will allow lower insufflation pressures. The anaesthetist should be wary of the tube migrating caudad due to the increased intra-abdominal pressure as endobronchial intubation may occur. Analgesia during prolonged laparoscopic procedures can be provided using a remifentanil infusion (e.g., 0.2–0.4 μg/kg/minute) with a loading dose of morphine (e.g., 100 μg/kg) towards the end of surgery.

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Thoracoscopy

Thoracic surgery in infants may be through an open thoracotomy or using video-assisted thoracoscope (VATS). In open procedures the surgeon generally retracts and collapses the lung, and no formal lung isolation is undertaken by the anaesthetist. Unlike in adults, this is possible and well-tolerated in infants due to more elastic and generally healthier lung tissue. Increasingly, thoracoscopic surgery is now being used even in very small babies (Figure 1). Procedures that can be performed thoracoscopically include tracheo-oesophageal atresia/tracheo-oesophageal fistula repair, lung resection for congenital anomalies, congenital diaphragmatic hernia repair and ligation of patent ductus arteriosus. The proposed benefits of a thoracoscopic approach over open surgery are broadly the same as those for laparoscopic surgery and include reduced pain, better cosmesis and shorter hospital stay. There is also some evidence that there is a lower incidence of late musculoskeletal complications in thoracoscopic surgery, as demonstrated by a higher rate of chest wall deformity and late scoliosis in infants who have had open thoracotomies.[2] To perform a procedure thoracoscopically, CO_2 is insufflated into the pleural space to achieve good surgical access and visualization. Although this is easier when one-lung ventilation is achieved, that can be challenging in babies due to their small size and limitations on the equipment available. For this reason, lung isolation should always be attempted with the caveat that a perfect result may not always be achievable.

Lung isolation: Lung isolation in infants is best achieved by use of a bronchial blocker, which may consist of a Fogarty catheter or a Foley urinary catheter inserted alongside or through the ETT. Double-lumen tubes and purpose-made bronchial blockers are not available in sizes appropriate for neonates. The aim is to get the blocker into the mainstem bronchus of the operative lung, and inflate a balloon to occlude ventilation of that lung. The lung may take some time to collapse as it is not possible to use suction through any of these catheters. A practical technique is to insert the blocker (usually a 3 Fr in neonates <5 kg) through the cords prior to intubation, inserting blindly to a depth of about 20 cm after which intubation is performed using a standard cuffed ETT. The tip of the catheter can be visualized by use of a fibreoptic scope passed through the ETT, and the balloon can be inflated under vision. The aim is to have the balloon just visible in the left or right main bronchus when inflated. Reduced breath sounds and chest wall movement on the blocked side help confirm lung isolation. Correct positioning can prove challenging in infants and lung isolation may be compromised if the tip of the catheter moves following re-positioning of the baby or due to surgical manipulation. The blocker position should always be re-checked by way of a fibreoptic scope when the patient is moved into the lateral position.

Physiological effects: The degree of hypercapnia and hypoxia observed in thoracoscopic surgery is likely to be greater than it is during open surgery.[3] Some infants will have healthy lungs and will therefore tolerate one-lung ventilation better than adults; however hypoxia can still be marked due to their increased oxygen consumption and immature hypoxic pulmonary vasoconstriction. Both of these factors magnify ventilation/perfusion mismatching and a high FiO_2 will sometimes be required to overcome this. Other significant physiological derangements include hypercapnia, hypotension and respiratory acidosis. It is rare for thoracoscopic procedures to cause hypotension from compression of the great vessels or mediastinal shift in babies, mainly because low insufflation pressures (<10 mmHg) are usually adequate to provide good surgical conditions.

Anaesthetic technique: Effective communication between the surgeon and the anaesthetist is essential. An IV or gas induction can be used followed by neuromuscular blockade. The use of intra-arterial monitoring will depend on the type of the surgery but can be helpful to assess oxygen and carbon dioxide tensions (especially as end-tidal CO_2 can be unreliable) and to monitor haemoglobin, glucose and electrolyte concentrations throughout surgery. Hypotension can be managed with IV fluid, blood and vasopressors. Remifentanil infusion in combination with volatile anaesthetic is an effective technique. If hypoxia is refractory or hypercapnia becomes extreme then intermittent re-inflation of the collapsed lung will be helpful. Regional analgesia in the form of paravertebral or intrapleural blocks are helpful for managing postoperative pain, although a morphine infusion is a simple and effective technique.

Inguinal hernia in infancy

Repair of inguinal hernia is one of the most common operations in paediatric surgery. Hernias can occur in term infants, however the incidence increases in babies of increasing prematurity. It is preferable that the surgery be performed electively, with the risk of incarceration increasing if the hernia is left untreated. The

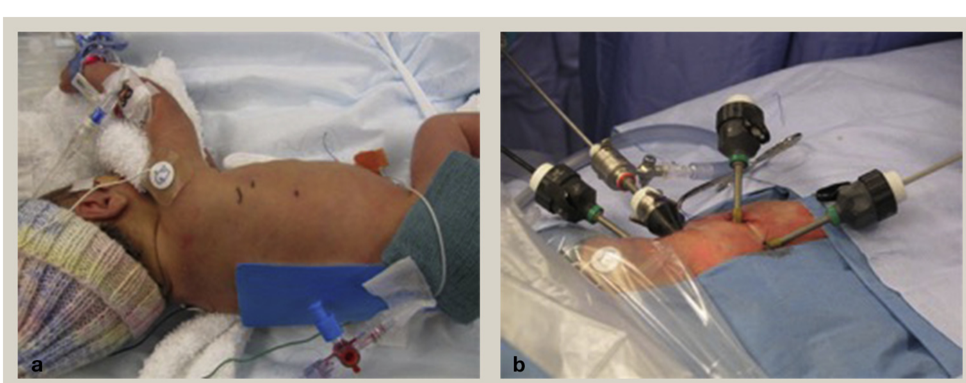

Figure 1 (**a**) Thoracoscopic positioning and (**b**) thoracoscopic ports.

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