Chapter

18

Infant Hernia Repair and Prevention of Postoperative Apnea

William D. Ryan, Adam C. Adler, and Ronald S. Litman

A two-month-old, 6 kg male infant is scheduled for inguinal hernia repair. The patient was born at 32 weeks of gestation and is currently breast-fed.

What Is an Inguinal Hernia?

An inguinal hernia is a protrusion of a portion of fatty tissue or intestine through the inguinal canal, a tubular passage in the lower abdominal wall. It occurs in 1–5% of all newborns but its prevalence is higher in infants born prematurely and in boys. It is most common in boys because the spermatic cord and testicles descend through the inguinal canal during development.

An *incarcerated* inguinal hernia occurs when the protruding tissue cannot be massaged back into the abdomen. It can lead to strangulation, in which blood supply to the protruding tissue becomes jeopardized. Strangulated hernias require immediate surgical intervention.

Inguinal hernia repair is one of the most commonly performed surgical procedures in children. A unilateral hernia is usually diagnosed on routine physical exam in healthy school aged children. Bilateral hernias occur more commonly in premature infants and, because of the potential risk of incarceration, will usually be repaired before the child is discharged from the hospital. Therefore, these children will present with all of the usual medical problems associated with prematurity.

Which Anesthetic Method Will You Choose for This Procedure?

There are many ways to anesthetize children for hernia repairs. Different factors are taken into consideration when deciding on an anesthetic technique, including the health of the child, preference of the surgeon, and the skills of the anesthesiology provider. Older children with uncomplicated unilateral hernias can receive maintenance of general anesthesia by facemask or laryngeal mask with inhaled agents. When laparoscopic examination of the contralateral side is performed, endotracheal intubation and neuromuscular blockade may be indicated, depending on the surgeon's preference for abdominal wall relaxation and desired degree of intra-abdominal insufflation.

The anesthetic technique for bilateral hernia repair for the small infant is different from that of the older child. The hernias can consist of large bulging sacs (in the male) and can present a surgical challenge. For these cases we prefer general anesthesia with neuromuscular blockade and endotracheal intubation. In some cases of extreme prematurity and small size (e.g., less than 3 kg), when the infant is scheduled to return to the intensive care unit, we may choose to maintain endotracheal intubation into the postoperative period while the infant fully recovers. Caudal analgesia is performed for postoperative pain relief.

Pain relief for inguinal hernia repair is accomplished using regional analgesia. Caudal analgesia with dilute local anesthesia is often used for bilateral repair, and a peripheral nerve block is used for unilateral repair. However, in ambulatory children in whom a caudal block may cause lower extremity weakness, bilateral peripheral nerve blocks are performed. Analgesia may be supplemented with a small dose of an IV opioid and ketorolac.

Premature infants often exhibit central apnea following the administration of general anesthesia (GA). There are several anesthetic strategies designed to prevent this complication and these include the use of regional anesthesia instead of GA, and administration of caffeine in the perioperative period to boost ventilatory drive. Most reported studies investigating the use of spinal or epidural anesthesia report a lower

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incidence (not a complete absence) of postoperative apnea, as long as additional systemic sedative agents are avoided. When adjuvant sedatives, such as ketamine, are administered intraoperatively, the risk of postoperative apnea increases to a level similar to that of GA.

Caffeine is a respiratory stimulant which can decrease the incidence of postoperative apnea, bradycardia, and hypoxemia in susceptible infants. For NICU patients undergoing surgery, communication between the anesthesiologist and neonatologist is essential. The patient may currently be receiving caffeine and may not require a perioperative dose. Other patients may be going home soon after surgery; thus, a perioperative dose of caffeine will complicate discharge planning.

Almost all studies on the risk of postoperative apnea following GA were performed prior to the advent of short-acting anesthetic agents, such as sevoflurane, desflurane, and remifentanil. Some studies have shown that these newer agents of limited duration result in a decreased incidence of postoperative apnea. However, definitive data on the association of postoperative apnea with use of these agents is lacking.

Both retrospective and prospective studies have been performed in an attempt to delineate the types of patients at risk for postoperative apnea. Characteristics of premature infants that are more likely to develop postoperative apnea include low gestational age, low postconceptional age (PCA), preoperative apnea of prematurity, and anemia (usually defined as a hemoglobin level <10 g/dL) (Figure 18.1). The PCA at which postoperative apnea will not occur is unknown; however, there are no reports of postoperative apnea in infants aged greater than 60 weeks PCA (Figure 18.2). (These statements are based on older studies that attempted to determine PCA-based risk, but the term "postconceptional age" has been abandoned in favor of the more reliable "postmenstrual age.") The true risk for an individual patient is indeterminate and is likely a continuum based on the infant's gestational and chronological age, and coexisting medical conditions.

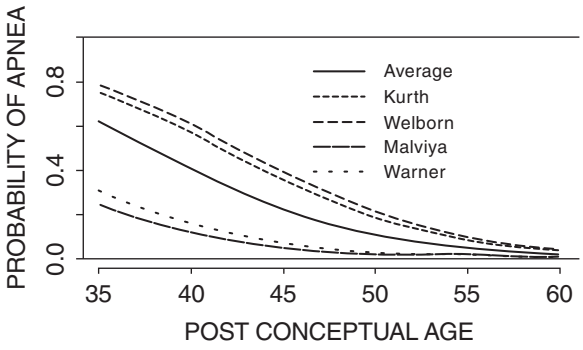

Figure 18.1 Predicted probability of apnea in recovery room and postrecovery room by weeks postconceptual age as demonstrated by review of multiple studies. Reproduced with permission from: Cote CJ, et al., *Anesthesiology* 1995;82(4):809–22. Copyright © 1995, Wolters Kluwer Health

Describe the Implications of Spinal Anesthesia in Infants

The most common use of spinal anesthesia in the pediatric population is for inguinal surgery in the preterm infant at risk for postoperative apnea following general anesthesia, especially in light of recent evidence of the possibility of neurotoxic effects of general anesthesia on the developing brain. Spinal anesthesia is most practical when the duration of the surgical procedure is less than 90 minutes. If the procedure is expected to be longer, a combined spinal-epidural or a continuous caudal-epidural anesthesia technique can be used. Contraindications to spinal anesthesia include infection at the site,

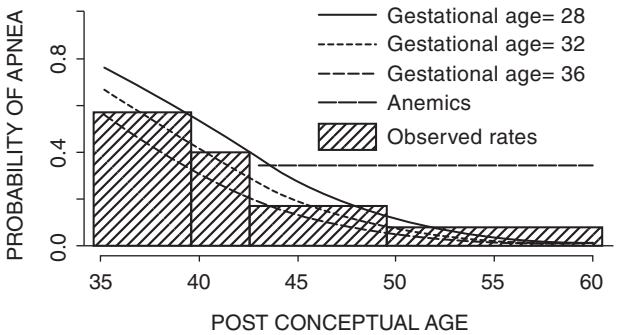

Figure 18.2 Predicted probability of apnea for all patients, by gestational age and weeks postconceptual age. Patients with anemia are shown as the horizontal hatched line. Bottom marks indicate the number of data points by postconceptual age. The risk for apnea diminishes for infants born at a later gestational age. The shaded boxes represent the overall rates of apnea for infants within that gestational age range. The probability of apnea was the same regardless of postconceptual age or gestational age for infants with anemia (horizontal hatched line). Reproduced with permission from: Cote CJ, et al. *Anesthesiology* 1995;82 (4):809–22. Copyright © 1995, Wolters Kluwer Health

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increased intracranial pressure (ICP) and clinically significant hypovolemia.

Preoperative application of a topical anesthetic cream over the lumbar spine will decrease pain of the spinal injection. Some pediatric anesthesiologists prefer to obtain IV access and some administer atropine prior to performance of the block.

The choice of intrathecal local anesthetic agent will depend on the expected duration of surgery. A larger dose is required than for adults because of the relatively larger ratio of cerebrospinal fluid to bodyweight in neonates (6–10 mL/kg) compared with adults (2 mL/kg) and the resulting dilutional effect. Most reports in the literature use 1% tetracaine or 0.5–0.75% bupivacaine at doses varying from 0.3 to 1 mg/kg to provide 45–90 minutes of effective surgical anesthesia up to the T5–6 level. To prolong the duration of the spinal block, epinephrine can be added using an "epi wash" which involves drawing up epinephrine (1:1,000) into a tuberculin syringe and then ejecting it all out, thereby leaving a small amount lining the syringe and the hub of the needle prior to drawing up the local anesthetic solution.

Spinal anesthesia can be performed in either the sitting or lateral position, and is largely determined by the personal preference of the anesthesiologist. Lumbar puncture is performed at the L4–5 interspace because the spinal cord in the small infant ends at a more caudad level (L3) than in older children (L1). This landmark can be found parallel to the top of the iliac crest. With a sterile aseptic technique, a 1.5-inch, 22-gauge spinal needle is most often used and inserted approximately 1–2 cm until a light "pop" is felt as the needle penetrates the dura and subarachnoid membrane. When the stylet is removed, free flow of CSF is observed, and the syringe is firmly attached to the hub of the inserted spinal needle. (A common cause of a failed spinal block is leakage of the local anesthetic solution during injection.) The local anesthetic solution is injected over 5–10 seconds. Once the block has been performed, the infant is rapidly placed supine on the operating room table. Tape is then placed across the legs to prevent the infant from being lifted up from the table by OR staff, which may result in a high spinal block. When the electrocautery pad is placed on the infant's back, the entire infant should be lifted parallel to the table. The blood pressure cuff should be placed on a numb lower extremity to minimize stimulation of the conscious infant. Once the spinal block is completed, the anesthesiologist will know within several minutes if the block is successful when the infant's legs become limp. Conversely, if the infant's legs do not become limp within several minutes, the block was probably not successful. When this occurs we do not reattempt the spinal. Rather, we proceed with general anesthesia for the case.

With a successful spinal block, the anesthesiologist is left with a conscious infant who must be kept calm during the surgical procedure because crying or fussing increases intra-abdominal pressure, which increases the technical difficulty of inguinal surgery. Most infants will sleep during the procedure or rest quietly if offered a pacifier dipped in glucose water.

What Is the Course of Action When the Infant Is Inconsolable During the Surgical Procedure?

First, the anesthesiologist and surgeon should determine whether the surgical area is properly anesthetized. In some cases of a patchy block, the surgeon can administer local anesthesia into the wound with satisfactory results. However, if doubt remains, induction of general anesthesia is the most prudent action. If the infant is merely agitated without pain, and does not become consoled with small sugar-water feedings, the anesthesiologist's options for pharmacologic sedation are limited because the addition of sedative agents of any class will increase the risk of intra- and postoperative apnea. One exception to this is the addition of modest concentrations (<50%) of N_2O. However, N_2O does not reliably sedate all infants. If additional sedation is required to complete the surgical procedure, administration of general anesthesia is probably the best course of action.

Although cardiorespiratory effects are uncommon after spinal block in infants, complications from spinal anesthesia are not infrequent. Intra- and postoperative apnea, bradycardia, and hypoxemia may occur, necessitating immediate ventilatory assistance and possible atropine administration. A "high spinal" will cause respiratory and neurological depression with rapid onset of hypoxemia. Therefore, vigilance is required during and after the administration of the spinal anesthetic. Hypotension from a spinal anesthetic-induced sympathetic block does not usually occur in children under the age of about five to seven years. This may be due to the relatively immature sympathetic nervous system in children compared with adults, or because of the relatively

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Table 18.1 Spinal vs. caudal epidural for the conscious infant. Reproduced, with permission, from "Regional anesthesia", authors Harshad Gurnaney, Andrew Costandi, James Quint, Ron Litman, Tarun Bhalla, and Joe Tobias. In: Litman RS, *Basics of Pediatric Anesthesia*, Philadelphia, 2016

	Advantages	Disadvantages
Spinal anesthesia	• Lower total dose of local anesthetic (1 mg/kg vs. 3–4 mg/kg) • Definite end-point (aspiration of CSF) • Rapid onset • Dense sensory and motor block	• Limited duration of action (60–90 minutes) • Technically difficult in small infants • Potential for high block with change in position
Caudal epidural	• High rate of success • Longer duration if catheter inserted • Minimal change in level with position	• High dose of local anesthetic agents required • Slow onset of action • Incomplete motor block

smaller intravascular volume in the lower extremities of children such that lower extremity vasodilation does not reduce preload to any appreciable extent (Table 18.1).

What Is Neonatal Apnea?

Neonatal apnea is defined as a cessation in respiratory flow of greater than 15–20 seconds or <15 seconds if accompanied by oxygen desaturation <90% and/or bradycardia of <100 beats/min. Apnea can be classified as central, obstructive, or mixed, depending upon the presence of inspiratory efforts or upper airway obstruction. Central apnea is cessation of air flow in the absence of respiratory effort. Obstructive apnea is cessation of airflow, usually at the level of the pharynx, with preserved respiratory efforts. Mixed apnea is defined as upper airway obstruction with inspiratory effort that precedes central apnea. Most neonatal apnea is central or mixed.

The prevalence of neonatal apnea is inversely related to gestational age. Apnea in term infants is uncommon and often related to other underlying medical conditions. Apnea in preterm infants is more common and is often expected in those born before 28 weeks' gestation.

What Are the Etiologies of Neonatal Apnea?

The most common cause of apnea in the neonatal intensive care unit (NICU) is related to prematurity and is thought to be a result of relative immaturity of ventilatory regulation, as well as an immature response to hypoxia and hypercarbia, and an exaggerated protective response to airway stimulation. However, there are other possible causes of apnea, such as sepsis or prenatal exposure to drugs that suppress respiration. Neurological conditions that cause apnea include intracranial hemorrhage and neonatal seizures. Cardiovascular conditions associated with apnea include pulmonary edema or congestive heart failure.

What Are Risk Factors for Neonatal Apnea?

Additional risk factors for development of neonatal apnea include airway structural anomalies, ambient temperature fluctuation, anemia, chronic lung disease, metabolic derangement, and necrotizing enterocolitis.

How Would the Discharge Criteria Differ If the Patient Was Premature or a Full-Term Infant?

The postconceptual age of the infant would determine if the patient is an appropriate candidate for discharge after recovering in the post-anesthetic care unit (PACU). Each institution has specific discharge criteria guidelines for preterm and term infants.

Some institutions have guidelines with no admission requirement for postop apnea monitoring in a term infant (greater than 37 weeks postconceptual age) for elective surgery because there is little evidence that term infants have an increased risk for apnea. Other institutions will not allow full term infants to have elective outpatient surgery until four to six weeks of age or may require that the infant be scheduled early in the day so that the infant can observed for a longer time in the PACU. If the infant exhibits a

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documented apnea event, then the episode will warrant an admission for observation. In studies of postoperative apnea in infants, while preterm infants have an increased incidence, the term infant does not have zero risk.

In a subanalysis of the GAS study (Davidson et al.) where general anesthesia was compared to awake regional anesthesia for inguinal hernia repair in both term and preterm infants less than 60 weeks, former premature infants had a 6.1% incidence of apnea compared to 0.3% of full-term infants.

Suggested Reading

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