

Neonatal emergencies

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There are four classic components to general anesthesia. These are amnesia, analgesia, immobility and loss of consciousness, while the fifth component is autonomic stability. However, historically it was not clear that the newborn required general anesthesia when undergoing surgery. Since no one remembers anything from the first year of life irrespective of the use of anesthetics, for many years it was felt that anesthesia was simply not necessary. This belief was compounded by the fact that even if one wanted to provide general anesthesia to the newborn it was difficult to do. For example, at equipotent doses MAC of potent inhaled vapor general anesthetics can produce unacceptable levels of hypotension in the newborn. There are many reasons why this occurs. MAC is lower than expected in the very young, minute ventilation of an infant is two to three times greater than in an older child, and because of differences in blood proteins vapor anesthetics are less soluble –and therefore more potent– than in the older child. All of these work to produce a relative overdose and related hypotension which is hard for the infant to compensate for because they have a fixed stroke volume and require an increase in heart rate to increase cardiac output.

In addition, until recently it was not clear if the newborn actually experienced pain, so given the physiologic risks of anesthesia why bother? However, things changed in the 1980's as a result of a legal case. A mother of a very sick preterm infant who required surgery requested her child be anesthetized. She was assured this would happen. Subsequently the surgery was performed and the child survived but died a week later. In a review of the hospital record it was discovered that «anesthesia» consisted of pancuronium and oxygen—at the time the standard of care. This case and the resulting public outcry demanded a change in how general anesthesia was provided

to newborns. This change in practice was further supported by the work of Anna Taddio in Canada showing that even in the absence of memory untreated pain could have adverse consequences.

The solution to the problem of providing «safe» anesthesia to newborns came with the introduction of high doses of opioids, particularly fentanyl, to produce analgesia (anesthesia) in the newborn. In a landmark paper, Robinson and Gregory demonstrated that high doses of fentanyl could produce general anesthesia in the newborn. Subsequently, Yaster demonstrated that 10 to 12.5 µg/kg of fentanyl could produce general anesthesia for 60 to 90 minutes in neonates. It is very important to understand, however, that the anesthesia provided by high dose opioids is not anesthesia as we originally defined it (amnesia, analgesia, and immobility). Rather it is manifested by an absence of a hemodynamic response to surgery.

While the introduction of fentanyl to newborn anesthesia was a step forward, it was not without problems. Fentanyl as well as most other opioids are metabolized less rapidly, have reduced clearance, and a longer half-life of elimination in newborns as compared to older children and adults. Hence, whenever these drugs are given to newborns prolonged postoperative ventilation may be necessary. Beyond these pharmacokinetic and pharmacodynamic differences, there are also clinically relevant physiologic differences in cardiopulmonary, renal, hepatic and other organ systems that affect how the neonate behaves when anesthetized, while body composition, including total blood volume and total body water can impact hemodynamic responses as well.

When planning to anesthetize an infant, it is important to be able to differentiate not only the patient's underlying condition, but the urgency of the surgery itself. For example,

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necrotizing enterocolitis or other conditions in which bowel is at risk may require surgery as soon as possible, while other cases, such as meningocele closure should be done in a timely fashion once the patient has been stabilized.

In addition, it is always important when planning your anesthetic to take into account the unique features of the disease and procedure. For example, considering children born with abdominal wall defects, such as gastroschisis or omphalocele, one should be aware that these conditions differ in both appearance and their association with other congenital anomalies. Specifically, children with omphalocele may have associated cardiac or metabolic abnormalities that are not generally seen with gastroschisis. Hence, a thorough preoperative assessment is indicated. Despite these differences, however, there are common elements to the anesthesia for both conditions. Both may require volume resuscitation, and both should also be considered as «full stomachs» for induction. It is also helpful to understand that, like many procedures, the approach to repairing these defects has evolved over time. In the past a primary repair was commonly attempted in order to minimize the risk of infection and avoid repeat trips to the operating room. But this approach can result in decreased ventilatory reserve as well as elevated intra-abdominal pressure, decreased organ perfusion, decreased venous return, decreased cardiac output, and ultimately an abdominal compartment syndrome. In order to minimize these risks, algorithms were developed to help decrease the risk of performing a «too tight» closure. For example, monitoring either central venous or intra-gastric pressure can guide the decision to perform a staged repair with the use of a silo to house and slowly re-introduced herniated viscera back into the abdomen. These days, with the introduction of spring-loaded silos that can be placed in the neonatal intensive care unit, staged closures are much more common, and often the infant does not arrive to the operating room until the abdominal contents have been slowly reintroduced into the stretched abdomen and the abdominal wall defect is small.

Among the most common newborn urgencies is pyloric stenosis. In general pyloric stenosis manifests itself in an otherwise healthy infant during first 6 weeks of life. Its hallmark is projectile vomiting. Because stomach acid is lost patient the infant can develop metabolic alkalosis, hypochloremia, hypokalemia, and hypovolemia. Only after resuscitation has occurred and electrolyte abnormalities have been corrected should surgery proceed. Patients with pyloric stenosis are always considered to have a «full stomach» when induced. This was particularly true in the past when barium swallow was used to make the diagnosis. Surgery involves making a small incision on the surface of the hypertrophic pylorus-previously via an open procedure, and more recently as a laparoscopic surgery. Intraoperative anesthesia for this surgery generally involves inhalation anesthesia which can be supplemented

by a small dose of opioid or a largely opioid based technique can be used-not with fentanyl, but with remifentanyl. Both of these techniques allow for extubation following this brief surgery and remifentanyl use is associated with a rapid return to normal respiratory patterns in newborns at risk for post-operative apnea.

Although generally not a newborn emergency *per se*, another procedure performed in infants is hernia repair. As with pyloric stenosis, these patients can receive a light general anesthetic, but in addition, some centers advocate for use of a regional technique such as single-shot spinal anesthesia. At centers that use this technique, the success rate is high, the need to convert to a general anesthetic technique has been low, and their incidence of perioperative apnea has been low as well. While not the ideal technique at many institutions as it requires a fair amount of surgical buy in, in these days of concern about the anesthetic neurotoxicity and the developing brain, spinal anesthesia may experience a broadening of popularity in our youngest patients because of its anesthetic-sparing effects.

Esophageal atresia and tracheoesophageal fistula comprise another classic spectrum of newborn diseases. Like omphalocele, this anomaly is often associated with other congenital anomalies, as in VATER syndrome. While historically there are two standard techniques in anesthetizing a patient with a tracheoesophageal fistula, intubation of awake infants for surgery is no longer routinely performed. More commonly now the patient is anesthetized via mask with spontaneous ventilation. Following a «deep» intubation the endotracheal tube is deliberately passed into the right mainstem bronchus and then slowly pulled back to just above the carina (and below the fistula) to allow ventilation of both lungs while minimizing gastric insufflation. Once the tube is positioned properly, controlled ventilation can be utilized. While an opioid-based anesthetic can be utilized, inclusion of neuraxial anesthesia is an option. In these infants a caudal catheter can be inserted and threaded to the thoracic level where a band of neuraxial analgesia can be used in conjunction with a light general anesthetic.

This approach of a combined light general anesthetic with neuraxial analgesia via a threaded caudal catheter is one that we also use when anesthetizing newborns for closure of bladder exstrophy, a congenital malformation affecting the genitourinary tract. Initial surgical reconstruction often involves a primary single-staged closure of the bladder. In the neonate, manual approximation of the malleable pelvis without osteotomy may be sufficient to facilitate the closure, but beyond the first week of life pelvic osteotomies are often performed to reduce the risk of wound dehiscence and bladder prolapse. Because these infants remain in traction for 4 to 6 weeks after surgery, we often tunnel a threaded caudal catheter in order to allow for a long term infusion of local anesthetic to provide post-operative analgesia.

In conclusion, providing safe neonatal anesthesia requires an understanding of neonatal physiology, knowledge of the unique disease processes encountered

in these young patients, and facility with the various anesthetic options that can be utilized to craft a safe anesthetic plan.

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