**Moderators:** Debnath Chatterjee, MD. Assistant Professor of Anesthesiology, The Children's Hospital - Aurora, CO
Kelly Stees, MD. Pediatric Anesthesia Consultants, Rocky Mountain Hospital for Children - Denver, CO

**Goals:**
1. Review the anatomy, clinical presentation and preoperative workup for a neonate with EA/TEF.
2. Discuss the advantages of thoracoscopic compared to open TEF repair.
3. Review the strategies for one-lung ventilation in neonates.
5. Review intraoperative and postoperative complications associated with EA/TEF repair

**Case History:**
A one-day-old 36 wga infant weighing 2550 grams is scheduled for bronchoscopy and thoracoscopic repair of EA and TEF. Pregnancy was complicated by a maternal subarachnoid hemorrhage at 20 wga treated with craniotomy and aneurysm clipping. Infant was born by spontaneous vaginal delivery. Due to feeding difficulties and respiratory distress, the infant was evaluated in the NICU. Attempts at placing a nasogastric tube were unsuccessful. A chest radiograph revealed nasogastric tube tip in upper thoracic region and an air lucency overlying the lower neck and upper chest that was suspected to be a dilated esophageal pouch; air was noted in the stomach and intestines. Surgical service was consulted for presumed diagnosis of EA/TEF.

**Questions:** What is incidence of EA? What percent of EA births are preterm? What are the other associated anomalies that need to be evaluated in EA/TEF neonate prior to surgical repair?

**Case history and physical exam (continued):**
ECHO revealed normal cardiac anatomy and function, moderate PDA with left to right shunt and stretched PFO with left to right shunt. Renal ultrasound was normal. Neonate is stable on low flow oxygen via a nasal cannula. He has an orogastric tube to low intermittent wall suction. Intravenous access includes an umbilical venous and arterial line and one peripheral IV.

Physical exam revealed a vigorous infant with no dysmorphic facial features; mild respiratory distress with subcostal retractions and coarse breath sounds bilaterally; CV regular rate and rhythm 2/6 systolic flow murmur at LSB, pulses 2+ throughout; abdomen was soft nontender, nondistended.

**Questions:** The surgeon is planning a thoracoscopic repair. What are the benefits to thoracoscopic repair of EA/TEF as compared to traditional open repair via thoracotomy? What is the experience of minimally invasive surgical repair in infants less than 5kg? What does the literature report as significant outcomes of interest? Are there specific cases that a thoracoscopic approach is not feasible?

**Case progression:**
Neonate is brought to the operating room. Bronchoscopy revealed mild tracheomalacia and fistula location proximal to carina. Surgeon is requesting semi-prone positioning for thoracoscopic repair of the EA/TEF.
**Questions:**
What is your plan for induction? Will you obtain additional IV access? What is your plan for intubation and ventilation? Would you maintain spontaneous ventilation? When is one-lung ventilation required? What techniques could you use to adequately ventilate this neonate to allow for optimal surgical visualization?

**Intraoperative course:**

Intraoperative course was complicated by frequent desaturations and poor $P_aCO_2$. Infant remained hemodynamically stable throughout.

**Questions:**
Describe the significant physiologic changes introduced by neonatal thoracoscopy. What are the most common problems encountered during intraoperative course? Would you consider extubation in OR? What are common early and late postoperative complications? What is rate of complications in thoracoscopic versus open TEF repair?

**Postoperative course:**

Neonate was transported to NICU and was extubated on POD #1. Swallow study on POD #7 was normal without evidence of anastomotic leak. Oral feeds were initiated and chest tube was removed.

**Discussion:**

Esophageal atresia affects one in 3000-5000 births, of which 30% are born prematurely, 85% have an associated TEF and 50% have at least one additional anomaly. Although the first description of this congenital anomaly was described in 1703, the first attempted TEF repair was performed in 1936 and first successful repair was not until 3 years later. By 1965, there was increased understanding of physiology and advancements in surgical and anesthetic techniques to achieve an 80-90% success rate for Waterston A babies (TEF without coexisting morbidities). Drs. Lobe and Rothenberg published the first thoracoscopic EA/TEF repair in 1999. Advancements in minimally invasive surgical techniques and equipment have made complex thoracoscopic procedures (such as EA/TEF repair) safe and efficacious in infants and children.

The advantages of the thoracoscopic approach include reduction in the musculoskeletal sequelae that often develop following open thoracotomy in the newborn period. These have been well described as “winged” scapula, asymmetry of thoracic wall and thoracic scoliosis. In addition, surgeons have described superior visualization of fistula and surrounding structures including vagus nerve with the thoracoscopic approach. The ability to see all structures clearly allowed less traction on the trachea and surrounding structures which can perhaps decrease postoperative stridor and risk of recurrent laryngeal nerve injury.

Anesthetic implications of neonatal thoracoscopic surgery include thorough preoperative evaluation (i.e. identification of coexisting VACTERL anomalies), intraoperative anesthetic management and monitoring paying special attention to physiologic alterations induced by endoscopic procedures, and postoperative care. Strategies for intraoperative ventilation mandate communication with the surgeon. Often the preferred technique is to avoid mainstem intubation and achieve lung collapse with $CO_2$ insufflation pressures of 4-6 mmHg. The advent of the neonatal insufflator with low flow, which releases puffs of air for only 1.7 seconds, has alleviated the problem of overinsufflation in neonates. Mainstem intubation may be necessary if the fistula is located just above or at the carina. Intentional left main bronchus intubation can result in prolonged postoperative LUL collapse from bronchial edema. The most common intraoperative complications include displacement of ETT and problems with oxygenation/ventilation. It is common for neonates to desaturate with insufflation of right pleural cavity and collapse of right lung. This often necessitates increasing the $F_1O_2$ and gentle hand ventilation to maintain $S_aO_2 > 85%$. Aggressive ventilation should be avoided as it can lead to gastric distension and worsen thoracoscopic view. Ventilation can be difficult to monitor due to frequently inaccurate or absent $P_aCO_2$ during esophageal anastomosis. With $CO_2$ insufflation, arterial blood gases commonly reveal increased arterial $CO_2$ and reduced pH. Significant physiologic changes with thoracoscopic approach can be crucial in all neonates and especially in those with associated cardiac abnormalities. One-lung ventilation increases pulmonary


vascular resistance through hypoxic pulmonary vasoconstriction. Animal models showed that although pulmonary blood flow was decreased, mixed venous oxygen saturation and cardiac index were not affected by OLV; increases in PVR can reopen foramen ovale or prevent PDA closure in neonates causing a return to fetal circulation even in absence of congenital heart disease. Right-sided thoracoscopy reduces venous return, cardiac index and mean arterial blood pressure even at low insufflation pressures as a result of direct compression of vena cavae and right atrium. Carbon dioxide absorption results in hypercarbia and acidosis that may be poorly tolerated.

In comparing thoracoscopic to open repair, the outcomes of interest include operative time, postoperative anastomotic leaks and stricture development, days of mechanical ventilation and days of total hospitalization. Long-term complications include recurrent fistula or stricture, musculoskeletal sequelae and chronic pain issues.

The literature has multiple case reports of successful thoracoscopic repairs as well as multi-institutional retrospective reviews supporting the safety and efficacy of this approach. A randomized trial is necessary to show that it is a better technique than the traditional open repair, but with continued advancement in minimally invasive surgery worldwide, it is becoming a surgical preference in many institutions. We as pediatric anesthesiologists need to be educated on the surgical approach as well as the anesthetic implications in order to continue providing phenomenal care for each and every neonate.

References: