We present a patient with surgically corrected tracheoesophageal fistula in whom we encountered severe and unexpected ventilatory difficulties secondary to a large tracheal diverticulum. The diverticulum was large enough to admit the endotracheal tube tip inadvertently as it was placed to an appropriate length. In so doing it prevented effective ventilation and presented a confusing clinical picture until bronchoscopy revealed its presence. Subjected to manual ventilation at high pressure, the blind pouch may have perforated with persistent effort.

This report highlights an unexpected cause of ventilatory difficulty. The clinical constellation of absent breath and gastric sounds, lack of chest excursion, and the absence of end-tidal carbon dioxide despite visualization of the intralaryngeal entry of an endotracheal tube suggested a mechanical tube obstruction. When this was not verified on inspection of the withdrawn tube and was reproducible with reintubation, only an intratracheal anatomic anomaly could explain this scenario. All anesthesiologists should be alert to this possibility when caring for children who have undergone tracheoesophageal fistula repair.

REFERENCES


Aortic Compression by Transesophageal Echocardiographic Probe in Infants and Children Undergoing Cardiac Surgery

ROBERT J. LUNN, M.D.,* WILLIAM C. OLIVER, JR., M.D.,* DONALD J. HAGLER, M.D.,†
GORDON K. DANIELSON, M.D.‡

* Instructor in Anesthesiology.
† Professor of Pediatrics.
‡ Professor of Surgery.

Received from the Departments of Anesthesiology, Pediatrics, and Surgery, Mayo Clinic and Mayo Foundation, Rochester, Minnesota. Accepted for publication May 4, 1992.

Address reprint requests to Dr. Lunn: Department of Anesthesiology, Mayo Clinic, Rochester, Minnesota 55905.

Key words: Anesthesia: pediatric. Complications, monitoring: transesophageal echocardiography. Surgery: cardiac.

Transesophageal echocardiography (TEE) is being increasingly used to monitor cardiovascular function during surgery in both adults and children. There have been few adverse effects reported from the use of TEE in adults or children. We have encountered four cases of descending aortic compression due to a TEE probe, which, if not detected, could have caused significant complications. Although three cases involved infants less than 2 yr of age, the most recent case involved a 9-yr-old boy. In this report, we present the first two of these cases.
CASE REPORTS

Case 1. A 5.5-month-old, 5-kg girl with a history of congestive heart failure due to a large nonrestrictive ventricular septal defect (VSD) with a large left-to-right shunt was scheduled for surgical repair of the VSD. She underwent an uncomplicated anesthetic induction using halothane, fentanyl, and pancuronium. She was orotracheally intubated with a 4.0-mm-ID endotracheal tube. There was an audible leak around the endotracheal tube at 20 cmH₂O. Monitoring included a blood pressure cuff on her right arm, pulse oximeter on her left hand, a 22-G 2.5-inch catheter (Cook®) in her left femoral artery, and a 5-Fr double-lumen central venous pressure catheter (Cook®) in her right internal jugular vein.

After orotracheal intubation, a 5.0-MHz, 6.7-mm-diameter esophageal ultrasound transducer probe (Aloka Company, Ltd., North Bradford, CT) was easily passed into the distal esophagus, and a systematic echocardiographic evaluation was performed before incision. During this evaluation, when the left pulmonary veins were being visualized, the femoral arterial pressure trace suddenly became dampened. The oximeter probe on the left hand continued to function, and the electrocardiogram and central venous pressure monitor were unchanged. The maneuver that caused the aortic compression involved anteflexion and leftward rotation of the esophageal probe. Subsequent manipulation of the TEE probe coincided with the sudden return of the arterial trace. This aortic compression was reproduced easily whenever the probe was rotated and anteflexed into the same position, and the femoral pressure remained dampened until the probe was rotated away from the aorta.

The probe was finally repositioned in such a way that it would not interfere with aortic flow. Subsequent closure of the VSD using hypothermic cardiopulmonary bypass was uneventful. There were no postoperative complications.

Case 2. A 22-month-old, 8.5-kg girl with tricuspid atresia, pulmonary atresia, atrial septal defect, and a small VSD with normally related great arteries was scheduled for operation. Other pertinent history included an absent left kidney, slight lumbar scoliosis, and a previous right modified Blalock-Taussig shunt placed when she was 6 days old.

After routine induction of anesthesia with fentanyl and pancuronium, a 4.5-mm-ID endotracheal tube was placed orally. An air leak around the endotracheal tube was detected at 25 cmH₂O. A 22-G catheter (Cook®) was placed percutaneously in the left femoral artery, and a 5-Fr double-lumen catheter (Cook®) was placed in the right internal jugular vein. Other monitors included an electrocardiogram, blood pressure cuff, and pulse oximeter probe on the left arm. A 5-MHz, 9-mm-diameter single-catheter biplane TEE probe (Aloka Company) was advanced easily into the esophagus. Before surgical incision, the femoral arterial trace became dampened with anteflexion and leftward rotation of the TEE probe. Anteflexion and leftward rotation of the TEE probe allowed imaging of the left pulmonary vein from the longitudinal scan. The pulse oximeter probe and blood pressure cuff continued to function normally on the left arm. As before, this distal thoracic aortic compression could be reproduced easily and would remain until the probe position was changed.

The probe was repositioned so it did not interfere with the femoral pressure. Modified Fontan procedure was uneventful, and no apparent postoperative complications ensued.

DISCUSSION

Intraoperative TEE has been used extensively in adults to assess overall cardiac function, to evaluate prosthetic or repaired valves, and to evaluate hemodynamics after cardiopulmonary bypass. It is also commonly used in adults undergoing noncardiac surgery as a monitor for myocardial ischemia or venous air embolism.

In the past, TEE has been used mainly in older children because only adult-sized probes were available. For smaller children and infants undergoing cardiac surgery, epicardial echocardiography has been used at some centers. Epicardial echocardiography can provoke dysrhythmias or hemodynamic compromise; however, these usually are self-limited and are largely dependent on user experience.

With the development of smaller, high-resolution TEE probes with color flow imaging capabilities, TEE is being used more frequently in smaller infants and neonates. A recent study reported the use of TEE in 45 infants, including 13 patients less than 10 days old and with weights as low as 2.4 kg.

TEE offers several advantages over epicardial imaging. It is less invasive in the operative field during the examinations, and its use can be extended into the intensive care unit postoperatively. In addition, TEE occasionally detects defects not recognized by epicardial imaging, such as atrioventricular valve insufficiency or residual intracardiac shunts. TEE has been used successfully in infants to assess ventricular performance, detect new or residual shunts, evaluate systemic and pulmonary venous return, evaluate valve function, and assess surgical repairs. For these reasons, we have found intraoperative TEE to be useful in infants and small children undergoing cardiac surgery.

There have been few complications reported using TEE in adults or older children. There is low risk during diagnostic TEE in unanesthetized, critically ill adults. Many of these complications (e.g., arrhythmias, hypotension) are related to the underlying cardiac disease. Several animal studies have concluded that prolonged intraoperative use of TEE probes causes no esophageal injury from pressure or temperature. A multicenter survey on the safety of TEE in adults reported a mortality rate of 0.0098%, with one death (from hemorrhage) in more than 10,000 TEE examinations.

Many previous studies of TEE in children have been based on the use of adult-sized probes (10–12 mm in diameter) in older children. Most of these studies reported only minor problems, such as blood staining of the probe. Two reports on the use of pediatric-sized probes noted very few complications. There has been one report of an apparent airway obstruction from a 9-mm TEE probe with a tip measuring 10 × 14 mm; this patient was a 5.5-yr-old, 15-kg boy undergoing cardiac surgery. We have seen increased airway pressures related to the use of TEE probes in some children. The lack of complications when using pediatric-sized TEE probes in infants and young children is supported by the low complication rates reported for gastrointestinal endoscopy in this age group. The risk of perforations from upper gastrointestinal endoscopies in infants and children is approximately 0.1%.
Although there were no long-term problems from aortic compression in the cases reported here, there was potential for compromised aortic flow, which could have resulted in long periods of lower body hypoperfusion. In such a case, aortic compression would have been undetected if a radial arterial catheter instead of a femoral arterial catheter had been used to measure systemic pressure. Although it is impossible to determine precisely at what level the aorta was compressed, the esophagus crosses the diaphragm at the level of T10, so it is likely that the compression occurred near or slightly above this area (fig. 1). The artery radicularis magna anterior or artery of Adamkiewicz, which supplies a major part of the blood to the lower anterior spinal cord, arises below T9 in 85% of people.21 The renal arteries arise from the aorta at approximately L1 or L2. Therefore, prolonged aortic compression by a TEE probe above these levels could compromise blood flow to these organs and lead to ischemic damage.

These cases demonstrate clearly that small TEE probes can cause aortic compression in infants and young children in certain situations. An awareness that certain positions of the TEE probe may lead to reduced perfusion of the lower body in small children and infants should encourage careful monitoring of the probe position and the duration of probe position. The force used to image vital structures should be the minimum necessary, and when left for monitoring, a neutral flexible probe position should be maintained. Monitoring lower extremity perfusion with a pulse oximeter, blood pressure cuff, or arterial catheter may aid in recognizing aortic compression during TEE use. Echocardiographers should be cautious with the use of TEE in small infants and children, recognizing that oversized probes may inadvertently compress vital structures, resulting in airway or vascular compromise. If severe compression of the airway or vascular structures occurs, TEE monitoring may need to be aborted.

**References**


Subdural Injection of Morphine for Analgesia Following Cesarean Section: A Report of Three Cases

H. S. CHADWICK, M.D.,* CHRISTOPHER M. BERNARDS, M.D.,† DANIEL W. KOVARIK, M.D.,‡ JEFFREY J. TOMLIN, M.D.§

The subdural area is a potential space between the dura and the arachnoid membranes. It exists in the spinal meninges just as it does in the cranial meninges. In the past 17 yr a number of clinical reports have described the unintentional catheterization of this potential space1–3 and the delayed subdural migration of an epidural catheter.4,5

Recently Miller et al. reported a case of confirmed subdural administration of morphine.6 In that case, a young woman having a cesarean section under presumed epidural anesthesia was given 1.0 mg preservative-free morphine via the lumbar catheter. The patient had good postoperative analgesia, which lasted for 22 h with no side effects. The authors speculated that subdural injection of morphine may result in higher cerebrospinal fluid levels of drug than does epidural injection. In another recently published case, Brown et al. reported an intended epidural placement for long-term management of a patient with cancer pain, but a postoperative epidurogram showed the catheter to be subdural.7 It was left in place and used for pain management. Although the patient had required as much as 1,000 mg oral morphine daily, a dose of morphine usually administered intrathecally was chosen because of the potential for the catheter to migrate into the subarachnoid space. The patient achieved good pain control with an initial dose of 0.75 mg morphine. In both of these cases, the authors noted a markedly reduced dose requirement compared to that usually required by the epidural route, suggesting the potential for respiratory depression in the event of unintentional subdural morphine administration with usual epidural doses.

We report three cases of radiographically confirmed subdural catheters that were used for cesarean section anesthesia. All three patients were given subdural morphine for post–cesarean section analgesia. The dose of morphine chosen, more typical of an epidural dose than of a subarachnoid dose, was considerably greater than those reported previously.

CASE REPORTS

Case 1. A 30-yr-old woman (gravida 1, para 0), 151 kg in weight and 157 cm in height, was admitted to labor and delivery for evaluation. Ultrasound examination revealed an intrauterine pregnancy at an estimated gestational age of 38 weeks with breech presentation. Version was not attempted because fetal parts could not be palpated. Past medical history and laboratory evaluations were unremarkable. Physical examination was remarkable only for obesity. The patient gave consent for an elective primary Cesarean section under epidural anesthesia.

The patient received 1,000 ml lactated Ringer's solution. With the patient in the sitting position, an 18-G Tuohy needle was advanced in

* Associate Professor, Anesthesiology.
† Assistant Professor, Anesthesiology.
‡ Pediatric Anesthesia Fellow.
§ Staff Anesthesiologist, Evergreen Hospital Medical Center.
Received from the Department of Anesthesiology, University of Washington School of Medicine, Seattle, Washington. Accepted for publication May 5, 1992.
Address reprint requests to Dr. Chadwick: Department of Anesthesiology, University of Washington School of Medicine, RN-10, Seattle, Washington 98195.