Thoracoscopic Repair of Tracheoesophageal Fistula in Newborns

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Background: Advancements in minimally invasive surgery in neonates have allowed even the most complex neonatal procedures to be approached using these techniques.

Methods: During a period of 15 months, 8 patients born with a proximal esophageal atresia and a distal tracheoesophageal fistula underwent repair thoracoscopically. Weights ranged from 2.1 to 3.4 kg and operating times ranged from 55 to 120 minutes.

Results: All procedures were completed successfully thoracoscopically, and there were no operative complications. One patient had a small leak on day 4 that resolved spontaneously on day 8. All other patients were shown to have a patent anastomosis with no leak by Barium swallow on day 5.

Conclusion: This initial report shows that esophageal repair in the neonate is technically feasible and may provide advantages in terms of exposure and esophageal length, as well as the recognized advantages of avoiding a thoracotomy.

INDEX WORDS: Tracheoesophageal fistula, esophageal atresia, thoracoscopy.

RECENT ADVANCEMENTS in technique and instrumentation in pediatric endoscopic surgery have allowed significantly more complex and delicate procedures to be performed, even in small neonates. Over the last 5 years the number and breadth of minimally invasive surgical (MIS) procedures performed in infants has increased dramatically.[1-3] However, 1 procedure, successful ligation of a tracheoesophageal fistula with repair of the esophageal atresia, has remained relatively elusive. In 1999 a stepping stone was laid when a successful thoracoscopic repair of a pure esophageal atresia was completed in a 2-month-old boy.[4] One year later we reported on the first successful repair of an esophageal atresia with tracheoesophageal fistula (TEF) in a newborn using a completely thoracoscopic approach.[5] These accomplishments provided the needed experience to allow us to undertake a prospective study to thoracoscopically repair all TEFs in hemodynamically stable patients.

MATERIALS AND METHODS

From March 2000 to July 2001 8 consecutive patients with esophageal atresia and a distal tracheoesophageal fistula were referred to the author for repair. Four diagnoses had been made prenatally, and the babies were delivered at the high-risk, perinatal/neonatal center. Four others had postnatal diagnosis and were transferred after birth.

Gestational age of the patients ranged from 31 weeks to 40 weeks at the time of delivery. Three other infants with TEF also were referred during this period but were excluded because of size and associated anomalies. These 3 weighed 800 g, 1,100 g with a tetralogy of Falot, and 1,800 g with an omphalocele. The other patients ranged in weight from 2.1 to 3.4 kg (mean, 2.6). Preoperative evaluations found small ASD and PDA in 2, a VSD in one, and a tetralogy of Falot with a right-sided aortic arch in 1. There were no other major congenital anomalies. Two patients required intubation before surgery for increasing respiratory distress.

The gap length was estimated preoperatively based on the position of the tip of the nasogastric tube and the apparent bifurcation of the trachea as seen on the chest x-ray. This ranged from 2 to 3½ vertebral bodies. At the time of surgery the longest gap was closer to 4 vertebral bodies because this patient had a trifurcation type fistula.

Six other patients with TEF were referred to our practice during the study period and underwent repair via a standard thoracotomy by surgeons not currently performing the procedure thoracoscopically.

All patients underwent standard tracheal intubation with no attempt made to obtain single lung ventilation. Each patient was placed prone with the right side elevated 30°. One patient, with a right-sided aortic arch, was approached through the left chest with the left side elevated. This positioning provided access to the area between the anterior and posterior axillary line for trocar placement while allowing gravity to retract the lung. The chest was entered in the fifth intercostal space between the mid and posterior axillary line with a veres needle. The pleural space was insufflated to a pressure of 4 mm Hg at a flow of 1 L/min of CO_2. This caused the collapse of the right lung and essentially achieved one-lung ventilation. An initial 3-mm port was placed, and a 2.7-mm 30° lens was used to survey the thoracic cavity. The Azygos vein was visualized and used to determine the relative position of the fistula.

A total of 3 ports, 2, 3 mm and 1, 5 mm were placed to perform the operation. In the initial case a fourth port was necessary to place a lung retractor. The 5-mm port was placed superiorly and was used to introduce the Ligasure (Valleylab, Boulder, CO) device, surgical clips, and suture for the anastomosis.

The operation proceeded in a similar fashion to that in the open

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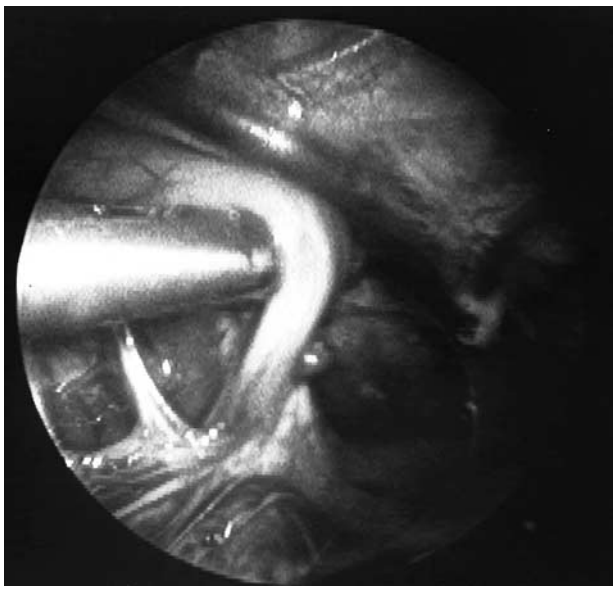

Fig 1. Mobilization of the lower esophageal segment. Fistula is seen going into the membranous trachea

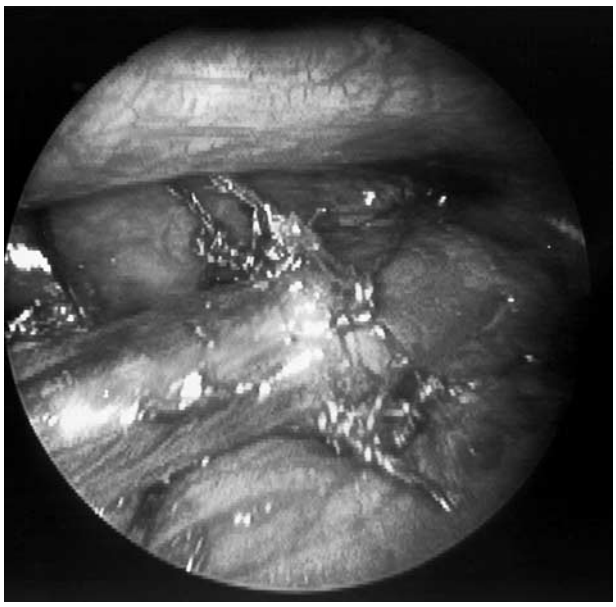

Fig 2. Completed anastomosis.

technique. The Azygos vein was sealed with the Ligasure and divided. The pleura was incised, and the upper and lower esophageal segments identified. The fistula was mobilized (Fig 1) and closed proximally with two 5-mm titanium clips. The fistula was divided distally, and the lower esophageal segment was mobilized for a short distance.

The upper pouch was identified with the help of the anesthesiologist who placed downward pressure on the nasogastric tube. The common wall between the trachea and esophagus was divided sharply taking care not to injure the membranous portion of the trachea. The upper pouch was mobilized up to the thoracic inlet. An initial stay suture of 4-0 Ethibond was placed between the 2 esophageal ends and was used to approximate the upper and lower pouch. An esophagotomy was made in the upper pouch so that the lumen could be visualized in both segments. A posterolateral row of approximately 4 interrupted sutures was placed. With the posterior row intact, the nasogastric tube was passed under direct vision into the lower segment and on into the stomach. By placing traction on the previously applied stitch, the esophagus was rotated right and left to provide exposure of the medial and anterior walls so that the anastomosis could be completed (Fig 2). A single 10F chest tube was placed through the lower trocar site with the tip near the anastomosis. The other trocar sites were closed with absorbable suture.

RESULTS

All procedures were accomplished successfully thoracoscopically. The average operative time was 95 minutes (range, 55 to 120 minutes). Four patients were extubated on postoperative day (pod) 1, two on pod 2, and 1 each on pod 3 and 4. One patient required reintubation 4 hours postextubation for increasing respiratory distress (patient 1). He was reextubated on pod 3. The fifth patient had an extremely long gap (4 vertebral bodies) with significant tension on the anastomosis. He was kept sedated and intubated for 4 days. Esophageal contrast studies were obtained on pod 5 in 7 patients, and the anastomosis was patent with no evidence of a leak in each case (Fig 3).

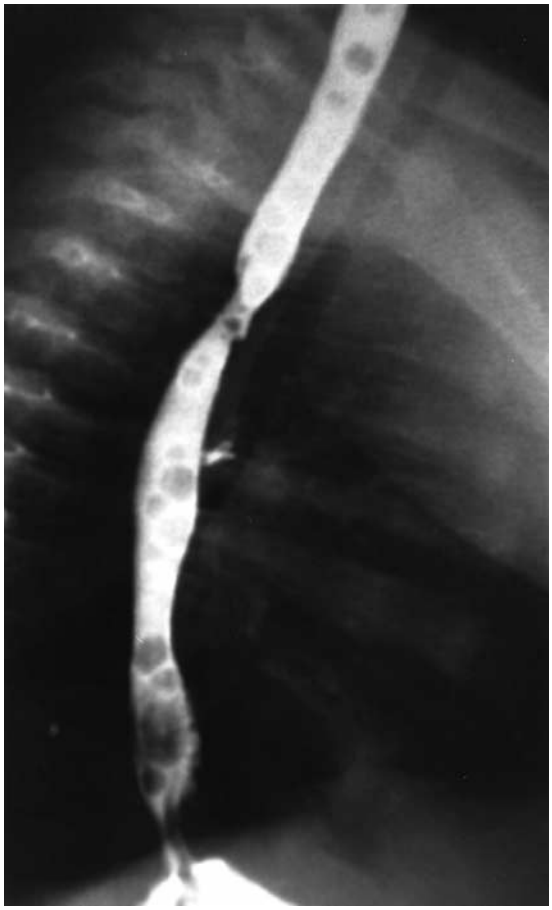

Fig 3. Esophagram 5 days postoperatively.

The first patient had clinical evidence of a leak, saliva in the chest tube, on pod 4. He was kept on "nothing by mouth" status, and drainage stopped after 24 hours. He was studied on day 8 with no evidence of a leak.

At initiation of oral feedings 2 patients were found to have poor oral motor coordination resulting in primary aspiration. These 2 underwent a laparoscopic Nissen fundoplication and placement of a gastrostomy tube at 3 weeks of age to protect their airway. Each later required 2 esophageal dilations during the period when their oral intake was limited. Both were on full oral feedings with no evidence of anastomotic stricture at 3 and 6 months of age, respectively. The other 6 patients all tolerated initial oral feedings without problems, but 1 required a single esophageal dilatation and a second, now 4 months out, still is requiring intermittent dilatations. Both of these patients have gone on to need a laparoscopic fundoplication because of severe gastroesophageal reflux but did not require gastrostomy tubes. The eighth case, the patient with the right-sided arch and tetralogy of Falot, initially did well but had a cardiac decompensation on the eighth postoperative day requiring emergent shunt surgery. Initially he required nasogastric feedings for approximately 2 weeks postoperatively but now is tolerating full oral feedings.

DISCUSSION

Recent advances in minimally invasive surgery (MIS) in infants and children have allowed for a wide expansion of applications over the last few years. Procedures that were thought impossible previously in children, let alone neonates, have become commonplace at a number of pediatric centers. We first reported our experience in infants less than 5 kg 4 years ago. That study found that complex procedures such as Nissen fundoplications, bowel resections, and thoracic procedures, such as lung biopsy and PDA ligation, were not only possible but were associated with less morbidity than standard open techniques. Others have reported similar positive findings. Fujimoto et al[2] reported that there is a decreased stress response as measured by interleukin-2 and other stress mediators when MIS techniques are used in infants, and this correlated with improved clinical outcomes. Concerns that neonates could not tolerate, or would be adversely affected by, abdominal insufflation or single-lung ventilation has not been borne out.

With these encouraging results, the impetus to develop the tools and techniques to perform even the most complicated procedures in neonates became a driving force. Much of the needed technological development has been directed at providing the instrumentation to perform minimally invasive cardiac bypass surgery (Mini-CAB). The use of robotics also has been touted as a way to perform these finer and more delicate dissections and anastomoses, but the current models are much too bulky and expensive to warrant their routine use in neonates.

The benefits of performing a TEF using minimally invasive techniques are obvious, but the technical hurdles are many. The greatest advantage is avoiding a thoracotomy in a neonate. This has been shown to be associated with a high degree of scoliosis and shoulder girdle weakness later in development.[6] Another is the improved cosmetic result (Fig 4). An unanticipated benefit was the superior visualization of the anatomy and especially the fistula. Because the fistula was visualized perpendicular to its connection to the membranous trachea, the exact site for ligation could be identified easily, minimizing the residual pouch attached to the trachea. The use of the 5-mm titanium clips has proven to be simple and effective with no evidence of tracheal leak or recurrent fistula. We have adopted this method of fistula ligation in the few open procedures we have performed in the last 6 months.

A recognized advantage after the first case was performing the dissection and anastomosis in situ. Because the separation of the fistula and the upper pouch from the trachea was performed under direct magnified vision

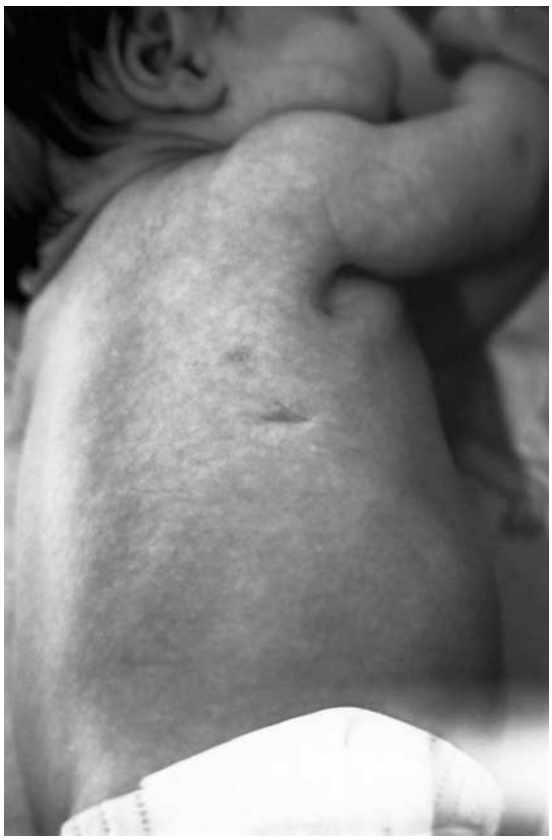

Fig 4. Incisions 10 days postoperatively. The lower trocar site is where the chest tube was placed.

from a lateral approach there was little manipulation or force applied to the trachea itself. This may help diminish the degree of tracheomalacia that these children have postoperatively. Also, the plane between the upper pouch and trachea was more obvious, making injury to the membranous wall of the trachea less likely.

Another advantage of performing the anastomosis in-situ may be less tension on the esophageal ends allowing longer gaps to be brought together without tearing. This appeared to be the case in one patient with a trifurcation fistula and long gap, although an anastomotic stricture that required dilation did develop.

The major technical hurdle in this operation is the suturing of the anastomosis. The placement of the sutures and knot tying are technically demanding and relatively imprecise. Also, as opposed to the open technique in which the entire posterior row of sutures can be placed and then brought together to disperse the tension along multiple points during knot tying, this method places all the tension on one suture at a time. So far, this has not been a significant problem, but it could prove to be. For this procedure to become more widely accepted it maybe necessary to develop a mechanical anastomotic device or self-knotting suture.

The rate of anastomotic narrowing requiring at least 1 dilatation in this series is 50%, a rate somewhat higher than historical controls. This may be secondary to inadequate approximation of the mucosal ends or an insufficient opening being made in the upper pouch. The type of suture being used also may be contributing to the problem. All of these variables are being reviewed.

Clearly, the technical and physiologic hurdles to accomplish this type of repair are many, and it will require continued advances before this surgery becomes commonplace. However, the ability to perform this complex reconstruction without a thoracotomy lays further ground work in minimizing surgical morbidity in even the smallest pediatric patients.

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