Esophageal atresia surgery in the 21st century

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The results of thoracoscopic repair of oesophageal atresia with or without tracheo-oesophageal fistula are presented. Twenty-six children had the repair perfomed thoracoscopically (22 in Edinburgh and 4 by Edinburgh surgeons in other institutions). Twenty infants had oesophageal atresia with tracheo-oesophageal fistula and 6 had isolated oesophageal atresia without fistula. Details of the technique are presented. Birth weights ranged from 1.4 to 3.9 kg and children were operated between 1 day and three months of age. There were 7 minor anastomotic leaks all managed conservatively, 1 recurrent fistula managed thoracoscopically and 9 anastomotic strictures. One child had a tracheo-bronchial fistula not seen at original thoracoscopy. There were 3 deaths (one child with Edward's syndrome, one with associated congenital diaphragmatic hernia and one late death with severe cardiac disease). Thoracoscopic repair of oesophageal atresia is feasible and the long term outcome appears favorable.
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The first thoracoscopic repair of esophageal atresia was at the International Pediatric Surgical Endoscopy (IPEG) meeting in Berlin in 1999.[1] The operation was on a 2-month-old infant with isolated esophageal atresia in whom imaging had demonstrated the two pouches to be in close proximity. In 2000, Rothenberg[2] reported the first "Thoracoscopic repair of a tracheoesophageal fistula in an infant."

The first successful open thoracotomy division of a tracheoesophageal fistula and repair of esophageal atresia in Scotland was performed by my predecessor Fred Robarts (personal communication) at The Royal Hospital for Sick Children in Edinburgh in 1948. The patient grew up to be a doctor herself and still practices in England. It was appropriate, therefore, that the first successful thoracoscopic division of a tracheoesophageal fistula and primary repair of esophageal atresia in the UK should be by his successor at the same hospital in 2001. The baby was a 2.25-kg, 37-week gestation female infant who has progressed well with no complications.

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Technique

The baby is anesthetized via a mainstem intubation of the trachea. Some use a bronchial blocker to achieve single lung ventilation, but we find that this merely adds to the anesthetic time and affords little advantage over endotracheal intubation. When the first port is inserted, CO_2 is insufflated at a flow rate of 0.5 L per minute to a pressure of 6 mm Hg. Initially there is usually a period of desaturation and a rise in pCO_2, requiring ventilation to be adjusted accordingly. Within a few minutes, however, the baby stabilizes and the other two ports can be inserted.

The baby is best positioned semiprone on the table (Figure 1).

The first port (5 mm) is inserted below the tip of the scapula. CO_2 is insufflated to a pressure of 6 mm Hg and the lung gradually collapses. A short 4.5-mm, 30-degree telescope is used. Two further ports are inserted, both 3.5 mm, one up in the axilla and the other more posteriorly in a line with the other two (Figure 2). It is important that valved ports are used with good seals around the instruments to maintain the tension pneumothorax. The pressure may read 6 mm Hg on the insufflator but with a leaky seal the lung will not collapse.

Figure 1   Baby semiprone with tip of scapula and three port sites marked. (Color version of figure is available online.)

The port alignment gives a comfortable, relaxed position of the surgeon's arms to facilitate the operation. The assistant stands to the right of the surgeon to hold the camera. An excellent view of the structures in the posterior mediastinum is thus achieved. The distal pouch is identified usually below the azygos vein and often seen to inflate with ventilation. Recognition of the upper pouch is facilitated by the anesthetist gently pushing on the Replogle tube. If necessary, the azygos vein is divided. In our first case, we divided this between 5-mm clips but found that the sutures in the confined space can loop around, potentially dislodging them. Since then we have divided the vein after sealing it with a 3-mm PlasmaKinetic forceps or with monopolar diathermy. Others divide the vein between ties. In favorable cases, the ends may be in proximity above the azygos which can then be left intact (Figure 3).

First, the lower pouch is mobilized. The mediastinal pleura can be opened with scissor dissection or with blunt forceps. The distal esophagus is mobilized circumferentially as close as possible to the trachea. The fistula can be clipped

Figure 2   Port sites and comfortable instrument position. (Color version of figure is available online.)
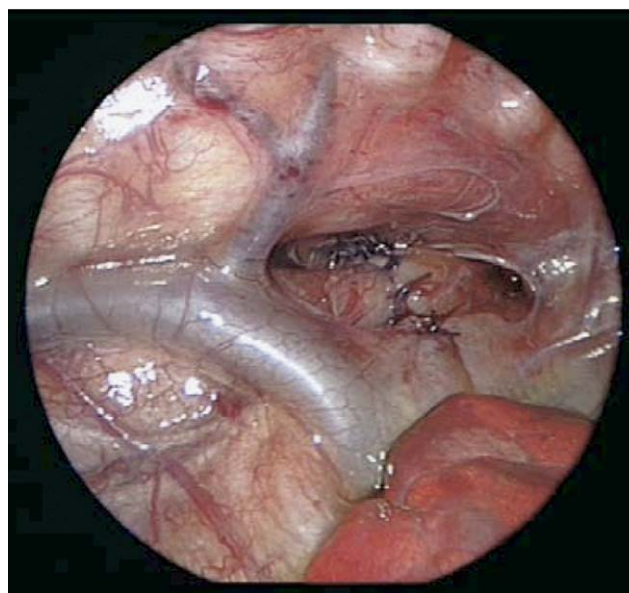

Figure 3   Esophageal anastomosis completed with intact azygos vein. (Color version of figure is available online.)

(as in our initial cases) or preferably ligated. I use a 5/0 ethibond suture to transfix and ligate the fistula before division distally. The upper pouch is then identified and only minimal mobilization is required. The tip of the pouch can either be excised or delicately opened at the tip with a 3-mm monopolar hook. If excised, it is helpful to cut across the tip partially at first so that the distal end can be grasped with forceps and later excised as the anastomosis progresses.

The anastomosis is achieved with interrupted 5/0 vicryl on a 10-mm round-bodied needle. Suturing is easiest with a pair of right- and left-handed 3-mm needle holders with curved tips. In our first case, I likened the procedure to suturing inside a matchbox, the space being very limited. If there is any tension on the anastomosis, the ends can initially be approximated using a tumbled square knotting technique, which enables the ends to be gently eased together. This technique is especially necessary in cases of isolated esophageal atresia without a distal fistula. Once the first few sutures are positioned, a silastic transasastomotic nasogastric tube is passed by the anesthetist and advanced into the distal esophagus by the surgeon. This has two functions: one to facilitate the anastomosis and the second to enable feeds to be commenced the following morning. As this is a transpleural approach, a chest drain is also inserted via the lowest port site. Once the ports are removed, the port sites are closed with vicryl to the deeper layers and subcuticular sutured skin closure or tissue glue to skin.

Results

A total of 26 cases have been performed to date: 22 cases in Edinburgh and 4 by Edinburgh surgeons in conjunction with

colleagues in Belfast, Birmingham, and Gdansk. Of these, 6 have had isolated esophageal atresia without a fistula and have been performed after 3 months.

In those cases with a distal TOF, birth weights have ranged from 1.4 to 3.9 kg and gestation from 31 to 41 weeks. Associated abnormalities include cardiac (4), right arch (2), vascular ring (1), radial aplasia (2), accessory thumb (1), hypospadias (1), VACTERL (1), duodenal atresia (1), and upper pouch fistula (1).

The ages at surgery were <24 hours (5), 2 days (8), 3 days (5), 4 days (1), 5 days (1), and >3 months (6). In 4 cases, the azygos vein was divided between clips; in 12 cases, PlasmaKinetic diathermy was used; in 2 the monopolar hook; in 4 it was left intact. The tracheoesophageal fistula was clipped in 4 cases and suture ligated in 16. In all cases, the esophageal anastomosis was with 5/0 vicryl.

Our first case in July 2001 was a 1.4-kg female infant. The tracheoesophageal fistula was successfully identified and divided, but a right-sided aortic arch and vascular ring made the upper pouch difficult to identify even after conversion to an open procedure. The patient was subsequently found to have trisomy 18 (Edward's syndrome) and died within a few days. Another death occurred in a 35-week premature infant with not only esophageal atresia and a distal TOF but also a left-sided diaphragmatic hernia. The latter was first repaired via an abdominal incision and 3 days later the TOF was approached thoracoscopically. Seven cases had a minor anastomotic leak on contrast studies, but all settled with conservative management. A recurrent fistula arose in one case and was successfully treated thoracoscopically. In another case, thoracoscopy failed to demonstrate a recurrent fistula, and at thoracotomy, there was found to be a tracheobronchial fistula arising from the lateral wall of the esophagus and going to the adjacent upper lobe of lung, seemingly unrelated to the original TOF! Anastomotic stricture requiring balloon dilatations occurred in 9 cases, including all of the isolated esophageal atresia (Type A) cases. One of the latter subsequently died of cardiac problems.

What have we learned?

We have learned from this experience that 5-mm clips are best avoided as they are difficult to apply in a neonatal thorax. In addition, they interfere with suturing and are in danger of being dislodged. The azygos vein can safely be divided with diathermy (even monopolar). Suture ligation of the tracheoesophageal fistula is preferable to clipping.

If you rely on positive pressure pneumothorax to deflate the lung, then absolutely gas-tight seals on ports are critical. Pressure and flow monitors on the insufflator are not good indicators of leak.

The procedure is facilitated by two experienced laparoscopic surgeons working as a team.

Conclusions

Thoracoscopic repair of esophageal atresia with or without a tracheoesophageal fistula remains a technically challenging operation, but it can be safely accomplished with meticulous attention to technical details. The thoracoscopic approach avoids the long-term morbidity and scarring associated with a thoracotomy.

Primary thoracoscopic repair of type A esophageal atresia with a long gap is feasible, although anastomotic leakage and stricture are common. The long-term outcome is favorable, and the patient's own esophagus is preserved.

Acknowledgments

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