4 Intrathoracic Intracorporeal Thoracoscopic Elongation – External Traction

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Introduction

In the old days, colon interposition was the only option to restore the continuity of the esophagus in case of LGEA. The child would receive a cervical esophagostomy and a gastrostomy, and at around the age of 1 year, final reconstruction was undertaken. As time progressed, newer techniques were adopted from experience in adult cancer surgery and gastric pull-up became more popular. Obviously, these procedures came with a significant number of complications, and gradually it became obvious that the native esophagus is the best option when reconstructing the esophagus [1]. Consequence of this was the delayed primary anastomosis technique that could be accomplished after 2–4 months. However, in extreme cases with a gap of more than 6 vertebrae, delayed technique would not be sufficient in bridging the gap. In 1997, Foker [2] developed a traction technique to induce additional growth to overcome greater defects. With the advances of minimal invasive surgery techniques in neonates in recent years, thoracoscopic repair of long-gap esophageal atresia has come into scope of practice [3, 4]. In this chapter, we describe the thoracoscopic external elongation technique in LGEA in the first week of life without a gastrostomy. With this newer method of thoracoscopic external elongation for LGEA, the neonates can start oral feeds within the first 2 weeks of life and usually may be discharged home at the same time as neonates with a type C atresia [4].

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Preoperative Assessment and Preparation

Diagnosis of Long-gap esophageal atresia can be suspected antenataly by the presence of polyhydramnios, the inability to swallow amniotic fluid, and an empty stomach on antenatal ultrasound. The diagnosis can be further substantiated by an MRI scan and amniotic fluid examination. Parents can be counseled on the outcome and expectations.

Delivery is preferably in a center of expertise; otherwise, the neonate should be transported to a center of expertise in the first few days of life [5].

Diagnosis can be ascertained by introducing a Replogle® tube in the proximal esophagus and making a thoraco-abdominal X-ray showing the curling of the catheter in the upper pouch and the absence of air in the abdomen.

Echocardiogram and ultrasound of the kidneys are part of the preoperative workup. The rest of the VACTERL screening and karyotyping can be carried out at convenience if there is no obvious suspicion of major genetic disease. An intravenous line is placed and an α-EEG (electroencephalogram) and near-infrared spectrometry (NIRS) are used during anesthesia.

The procedure is explained to the parents and consent is obtained.

A preoperative multidisciplinary meeting is conducted with all the disciplines involved to discuss the procedure in detail.

Anesthesia

The procedure is started with a rigid laryngo-tracheo-bronchoscopy with patient under anesthesia but spontaneous breathing (without paralysis). After evaluation of the larynx, trachea, and bronchae and exclusion of possible proximal fistula, laryngeal web, or tracheomalacia, the neonate is intubated. An arterial line is placed for arterial and blood pressure monitoring, a central venous line (if not umbilical vein) for venous pressure monitoring, an epidural catheter for pain management, and a urine catheter for urine output monitoring. The neonate is placed in a left ¾ prone position with a pad underneath the left armpit (Fig. 4.1). The Replogle® tube is freed up for maneuvering during dissection of the proximal pouch.

Thoracoscopic Procedure

A little stab wound is made approximately 1 cm below and anterior to the angle of scapula. A 5-mm camera port is introduced into the pleural cavity using open technique. The trocar with a Silicone tubing on the shaft is fixed in place with Vicryl 2′0′. The CO_2 insufflator is set at 3 mm Hg pressure and 0.5 l/min flow. Slow insufflation allows gradual collapse of the lung under vision. Communication with the anesthesiologist is essential to monitor the status of the patient. Usually, the respiratory frequency is increased to 40–60/min with the same minute volume. If the patient tolerates the pressure and the flow, the CO_2 insufflation can be increased to 3–5 mm Hg and 1–2 l/min.

Fig. 4.1 Positioning of the patient

Under direct vision, two 3-mm trocars can be introduced forming a triangle around the first trocar and fixed in place.

The procedure is started on the distal pouch. By following the vagal nerve toward the hiatus, the distal pouch can be found. By blunt dissection, the pleura is opened and the distal pouch can be dissected with careful mobilization of the vagal nerves. Usually, the hiatus has to be opened to fully mobilize the pouch. Sometimes there is a band running up from the distal pouch that can be used to exert some traction to allow further mobilization.

Otherwise, a first traction suture may be used to facilitate maximum mobilization. For introduction of the first traction suture, the optimal location in the upper thorax is determined with a thin needle somewhere between the posterior scapula ridge and the vertebra. A small stab wound is made and an Endoclose® needle retractor with a Vicryl 3×0 enclosed is introduced into the thorax. After taking a big bite that includes mucosa (Fig. 4.2), the suture can be pulled out with the same Endoclose®. Both ends of the suture are clamped with a mini-Mosquito. After maximal mobilization from the hiatus, the three other traction sutures can be introduced through the same incision, thus completing a total of four sutures in all quadrants. All four sutures are then placed in the Endoclose® and pulled outside through the same skin incision through a 3 cm piece of Silicone tubing which serves as a protective bumper during traction.

The next step is the mobilization of the upper pouch. Upper pouch is identified by the anesthetist manipulating Replogle® tube. The pleura over the proximal pouch is bluntly opened and the proximal pouch is mobilized. If the anesthesiologist is asked to maintain some pressure on the Replogle® tube and by pushing up the pouch with the open beak of a Maryland dissection may be easier and atraumatic. Sometimes there are dense adhesions (common wall) between esophagus and trachea. This may be overcome by dissecting a little higher up where the adhesions are less dense and then come back down again. This will help in the division of the common wall between esophagus and trachea. It is important to dissect all around the upper pouch as high as possible and gain maximum length. As long as you keep flush on the esophagus, there is little risk of damaging the recurrent nerve. In case of a proximal fistula, depending on the level of the fistula, this can be approached

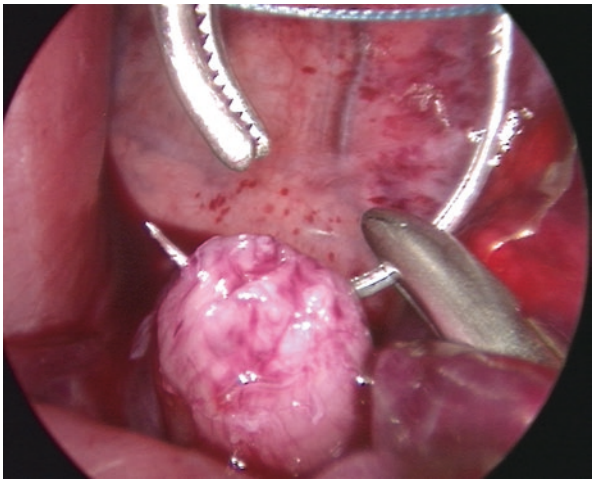

Fig. 4.2 Placing of the first traction suture into the distal pouch after mobilization of the distal esophagus out of the hiatus

from the neck in case of a high fistula or (more often) thoracoscopically during dissection of the proximal pouch. There is no contraindication for external traction elongation technique in case of a proximal fistula. The traction sutures can be placed away from where the fistula is closed. The procedure for placing the traction sutures is the same as for the distal pouch.

Finally, two clips are applied to each bundle of the traction sutures close to the tips of the pouches (Fig. 4.3). Under direct vision, gradually maximal traction is applied to both ends and secured with a mini-Mosquito on the sutures outside against the Silicon tubing (Fig. 4.4).

The thoracoscopy is terminated by removing the 3-mm trocar and suction through the 5-mm trocar under direct vision to ensure insufflation of the lung. The defects are closed with Vicryl 5′0′ subcutaneously and Steristrips® to the skin. It is essential that no more traction should be applied afterward in the following days to prevent disruption of the sutures.

Laparoscopic Gastropexy

In the past, patients would get a gastrostomy to overcome the time to surgery. This gastrostomy would prevent the stomach from migrating up into the thorax.

When performing the traction technique in the first week of life without a gastrostomy, there is a risk of migration of the stomach into the chest. Therefore, it is necessary to perform a laparoscopic gastropexy.

At the end of the thoracoscopy, the patient is turned into a supine position. A small incision is made in the left upper ridge of the umbilicus and a 5-mm trocar is introduced. After insufflation with CO_2 with a pressure of 5 mm Hg and a flow of 2 l/min, a 3 mm trocar is introduced under direct vision in the left lower quadrant.

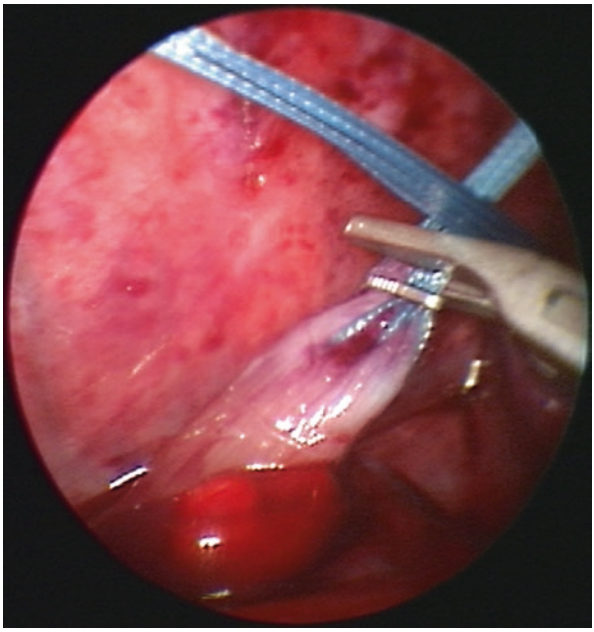

Fig. 4.3 Clip placement on the sutures

Fig. 4.4 Placement of mini-Mosquitos on traction sutures

A needle holder can be introduced to lift the liver and to identify the stomach. The optimal spot for the gastropexy is determined. A small stab wound is made and the Endoclose® is introduced with a 4′0′ Vicryl suture. The needle can be picked up with the needle holder and a bite can be taken somewhere between the lesser and larger curvature of the stomach. The suture can then be withdrawn outside with the Endoclose® through the same skin incision but through a separate opening in the muscle. The same procedure is repeated with a second suture and the sutures are tied subcutaneously, thus pulling the stomach against the abdominal wall. The skin is closed with a Steristrip®. The trocars are withdrawn under direct vision, and the subcutis is closed with Vicryl 5′0′ and Steristrips® for the skin.

Fig. 4.5 Postoperative X-ray showing distance between the clips

Postoperative Care

The patient is kept sedated for comfort, but not paralyzed. A postoperative X-ray is obtained to determine the position of the clips and to measure the distance. The child is nursed on its left side or in a semi-prone position to avoid lying on the mini-Mosquitos and traction sutures. The sutures are checked twice daily to ensure that they are still under tension, but no additional traction should be applied at any time.

Over the next few days, the progress of approximation can be followed by measuring the clip distance on X-ray (Fig. 4.5). Usually after 3–4 days there is no more advancement, mostly due to adhesion with the lung.

In this case, the patient is returned to the operating theater to carefully release the adhesions thoracoscopically. This is usually a short procedure of 30 min. The surgeon may be tempted to anastomose at this time, but it usually better to wait for another 1–2 days to allow for some growth.

Thoracoscopic Anastomosis

Once the clips have reached each other on X-ray evaluation, then thoracoscopic anastomosis may be accomplished. The trocars are reinserted after insufflation with a pressure of 4–5 mm Hg and a flow of 2–3 l/min.

Both pouches are maximally mobilized again (Fig. 4.6). The distal pouch is opened and two sliding sutures are placed on two opposite sides, preferably with different colors. It is important to include the mucosa in the sutures. The traction sutures from the distal pouch can then be cut and removed. Next the proximal pouch is opened and the traction sutures are removed. 2–3 Vicryl 5′0′ sutures are placed on the posterior side of the anastomosis completing the posterior wall. The two sliding sutures can be pulled tight and tied off before advancing a 6Fr. nasogastric tube into the stomach. The anterior wall is closed with another 3–4 Vicryl 5′0′ sutures. In case of doubt, a thoracic drain can be left in place.

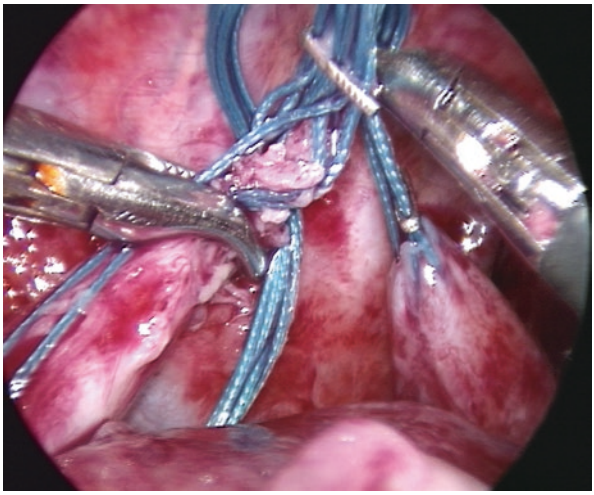

Fig. 4.6 Clips have come together. Preparation for anastomosis

All trocars are removed under direct vision and CO_2 is vented through the last trocar. All wounds are closed subcutaneously and the skin is closed with Steristrips®.

Postoperative Care

Ventilation is reduced according to pain management and the patient may be extubated when appropriate. When the patient is recovering well, a contrast study is performed after 5 days post surgery. If there is no leakage demonstrated on the contrast study (Fig. 4.7), oral feeds may be started.

Follow-up is according to protocol for all patients with esophageal atresia, including a resuscitation course for the parents before hospital discharge.

Outcome

The thoracoscopic external traction elongation technique was successfully performed in 11 patients with LGEA in our hospital between 2007 and 2018 [4]. In two patients, the procedure failed. The first patient was early in our experience where we applied too much traction on the sutures leading to rupture of the pouches and leakage in the mediastinum. We abandoned the technique and performed a jejunal interposition. In the second patient, the proximal pouch was perforated in the neonatal ICU by the Replogle® tube. Because of a short proximal pouch in this patient, the patient underwent a gastric pull-up. In the remaining nine patients, esophageal anastomosis was accomplished at a median age of 12 days (range 7–138 days) and first oral feeding was started 16 days postoperatively. All patients needed multiple dilatations and ten patients required a fundoplication. Median follow-up was 7 years.

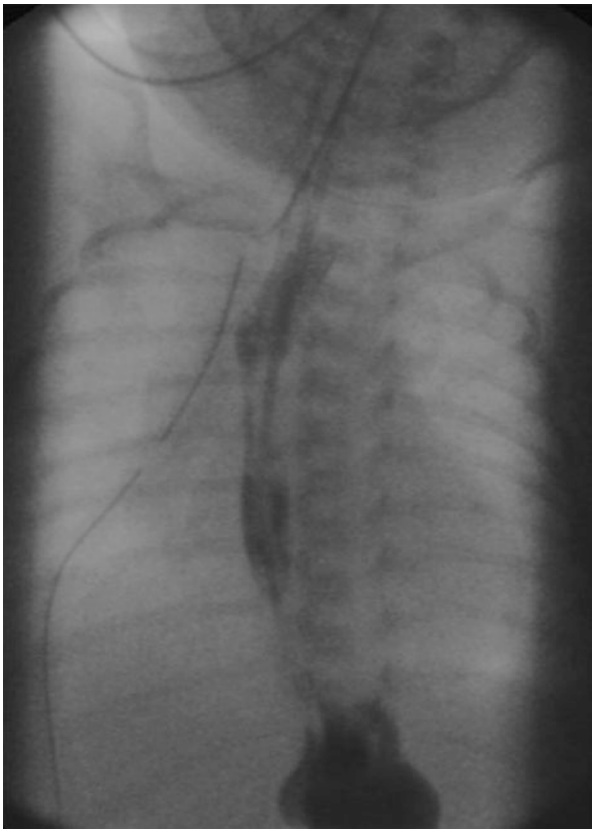

Fig. 4.7 Contrast study 5 days postoperatively demonstrates no leakage

Reflux symptoms were common after thoracoscopic traction technique, five patients reported mild symptoms while one reported moderate reflux complaints.

The thoracoscopic external traction elongation technique without a gastrostomy is a new and promising technique that allows anastomosis within the first 2 weeks of life, almost similar to neonates with a type C esophageal atresia. There is no need for a gastrostomy with all its sequelae. There are no feeding difficulties (aversion and swallowing problems) due to long-term abstinence of oral feeding or the discomfort from sham feeding, and the patients are usually discharged within the first few weeks of life instead of waiting 2–6 months before undergoing reconstruction.

There are only a few centers worldwide that have published on their outcome of thoracoscopic elongation of the esophagus and all of them are usually at a later age.

Patkowki et al. [6] performed internal traction (discussed in a separate chapter). Earlier they would wait for a long period before making the anastomosis. However, after seeing the results from early repair, they have changed their technique to perform early traction and anastomosis. Tanaka et al. [7] also use thoracoscopic internal traction technique for their patients with LGEA (discussed separately). During a consensus meeting on long-gap esophageal atresia by the European Reference

Network of esophageal atresia, the thoracoscopic primary traction technique was recognized as a promising new technique that should be performed at centers with expertise [5].

Further Reading

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