



Operative Techniques

Thoracoscopic posterior tracheopexy during primary esophageal atresia repair: a new approach to prevent tracheomalacia complications[☆]

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ABSTRACT

Background: Esophageal atresia (EA) is usually accompanied by some form of tracheomalacia (TM). During the early phases in life, excessive dynamic collapse of the trachea can cause a wide spectrum of symptoms ranging from mild complaints to apparent life-threatening events (ALTE's) or brief resolved unexplained events (BRUE's). Therapeutic strategies for severe TM include aortopexy to lift the anterior weakened cartilaginous rings or posterior tracheopexy of the floppy membranous tracheal intrusion. In this study, we describe the development of a new approach in which the posterior tracheopexy is performed directly during the primary thoracoscopic correction of EA.

Methods: In 2017, all nine consecutive EA patients with trachea-esophageal fistula underwent a rigid tracheo-bronchoscopy (RTB) evaluation during induction of anesthesia prior to the thoracoscopic EA repair. A floppy posterior membrane was diagnosed in four patients. During the subsequent thoracoscopic procedure, the posterior membranous trachea was fixed to the anterior longitudinal spinal ligament with non-absorbable sutures. Then, the anastomosis was made between the two esophageal pouches.

Results: On preoperative RTB, two patients had a severe (70–90%) mid-tracheal collapse of the pars membranacea and two patients had a moderate (33–40%) mid-tracheal collapse. Thoracoscopic posterior tracheopexy with two or three sutures was possible in all four patients, prior to the formation of the esophageal anastomosis. Median time per suture was 6 min (range 4–12 min). All operative procedures were uneventful. A median follow-up of 6 months (range 4–9 months) revealed that all patients showed further recovery without any TM symptoms or ALTE/BRUE.

Conclusions: This is the first report that introduces a new approach to thoracoscopic posterior tracheopexy during primary EA repair. We believe that this technique can prevent the potentially deleterious sequelae of mild to severe TM that may complicate the lives of EA patients. Also, a second, sometimes complex surgical procedure can be prevented as the posterior tracheopexy is performed during the primary thoracoscopic EA correction.

Level of Evidence: IV.

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Esophageal atresia (EA) is usually accompanied by some form of tracheomalacia (TM) [1]. TM is a process characterized by flaccidity of the supporting tracheal cartilage, widening of the posterior membranous wall, and reduced anterior–posterior airway caliber. These factors cause tracheal collapse, especially during times of increased expiration, such as coughing, crying, or during feeding. In neonates, this diagnosis can be difficult to recognize, as the respiratory symptoms are not very specific. At an older age, collapse of the airway might cause apparent life-threatening events (ALTE) or brief resolved unexplained events (BRUE), apneas and asthma-like symptoms [2].

Symptomatic TM affects up to 16–33% of patients after EA and trachea-esophageal fistula (TEF) repair [3–5]. EA patients with severe

TM often require tracheostomy ventilation and secondary surgery at a later age [6,7]. Surgical strategies to treat severe TM include aortopexy via thoracotomy or thoracoscopy to lift the aorta and anterior trachea to relieve the tracheal collapse [8,9]. However, if a floppy pars membranacea is causing the TM, posterior tracheopexy to the anterior longitudinal spinal ligament is indicated. This procedure is performed through thoracotomy or sternotomy in case of concurrent cardiac surgery [10,11] or by thoracoscopy [12].

In this paper, we introduce a new approach to thoracoscopic posterior tracheopexy. This technique was initially developed in patients that had undergone previous EA repair and needed renewed mobilization of the esophagus in order to approach the posterior tracheal membrane. This has led us to perform the posterior tracheopexy immediately during primary thoracoscopic repair of EA with TEF, in case flaccidity of the posterior membrane was diagnosed on rigid tracheo-bronchoscopy (RTB). The aim of this approach is to prevent the possible

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deleterious consequences of TM that may complicate the lives of patients with EA with TEF.

1. Materials and methods

1.1. Patients

In 2017, all nine consecutive EA with TEF patients underwent an RTB evaluation during induction of anesthesia prior to the thoracoscopic EA repair. The severity of the TM was estimated, and the collapse of the bronchi and trachea at three levels (lower, middle and upper level) were scored in a standardized way [13]. Patients were considered eligible for posterior tracheopexy as a preventive measure when moderate (33–66%) or severe (67–100%) tracheal collapse by posterior membranous intrusion was noted [4]. TM was diagnosed in four of the nine patients.

1.2. Evolution of technique

We developed the technique of thoracoscopic posterior tracheopexy in three patients after previous EA repair. Two of the patients came from another institute after previous EA correction through a right-sided extrapleural thoracotomy approach. One of these two patients had a tracheal diverticulum (old TEF remnant), and one had a recurrent TEF. The third patient had a thoracoscopic EA correction 5 weeks before and had developed TM symptoms in the postoperative course. Although the thoracoscopic re-interventions were feasible, the thoracoscopic mobilization of the esophagus is technically demanding and can cause postoperative morbidity. The first patient had an uneventful recovery, but the second patient needed a re-intervention to further alleviate tracheal collapse by thoracoscopic aortopexy. This patient subsequently developed a chylothorax. In the third patient, the esophageal anastomosis showed signs of leakage after the early re-intervention, only 5 weeks after the initial thoracoscopic EA correction. This patient required chest tube drainage and prolonged antibiotic treatment (Table 1a). Based on the course of these three patients, we then decided to perform preventive posterior tracheopexy in patients with a flaccid posterior tracheal membrane on RTB during the primary thoracoscopic EA and TEF repair.

1.3. Surgical technique

Thoracoscopic posterior tracheopexy is performed with the patient in a 3/4 left-lateral position at the left side of the table. The esophagus and trachea are dissected with 3-mm instruments. Usually, three or four intercostal trocars are placed to access the right hemithorax. A CO₂ pneumothorax is installed with a maximum pressure of 3–5 mmHg and a flow of 1 L/min. Details of primary posterior tracheopexy are illustrated in Fig. 1. First, the TEF is closed with a transfixing suture and transected. Then, the proximal pouch is mobilized from the membranous posterior tracheal wall. In redo surgery, sometimes a tracheal diverticulum has to be resected or a recurrent TEF has to be closed. The posterior tracheopexy is performed by placing

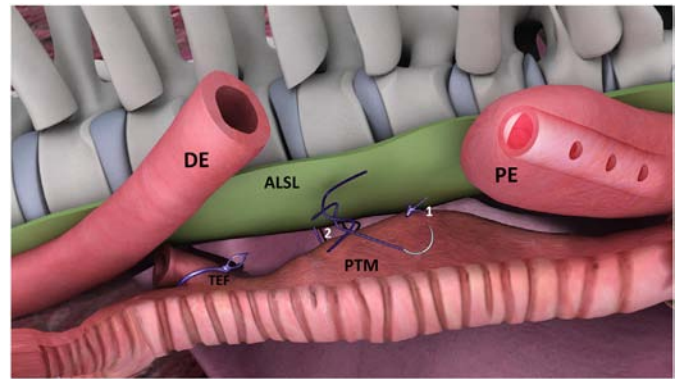


Fig. 1. Illustration of the thoracoscopic posterior tracheopexy during primary esophageal atresia correction. After closure and transection of the tracheo-esophageal fistula (TEF), the proximal esophageal (PE) pouch is mobilized from the posterior tracheal membrane (PTM). A nasal tube lifts the PE away from its position between the trachea and the spinal column. The posterior tracheopexy is performed by placing non-absorbable sutures (1,2) that pull and fixate the PTM to the anterior longitudinal spinal ligament (ALSL). Then, the PE and distal esophagus (DE) are approximated and joined by an end-to-end anastomosis.

two or three non-absorbable sutures (4 × 0 Ethibond®, Cincinnati, OH) that pull the membranous posterior tracheal wall to the anterior longitudinal spinal ligament (Fig. 2). The proximal esophagus is mobilized from its position between the trachea and the spinal column. The two ends of the esophagus are approximated and joined by an end-to-end anastomosis. The pneumothorax is evacuated; the wounds are closed with absorbable sutures without leaving a thorax drain. With an endotracheal fiberoptic scope, the initial result of the tracheopexy on the posterior tracheal wall can be evaluated at the end of the procedure.

2. Results

All nine consecutive EA patients were evaluated by RTB during induction of anesthesia prior to the thoracoscopic EA repair. Two patients had a severe (70–90%) mid-tracheal collapse of the pars membranacea, and two patients had a moderate (33–40%) mid-tracheal collapse. Thoracoscopic posterior tracheopexy with two or three sutures was possible in all four patients, prior to the formation of the esophageal anastomosis. All operative procedures were uneventful. Median time per suture placement required 6 min (range 4–12 min). A median follow-up of 6 months (range 4–9 months) revealed that all patients showed further recovery without any TM symptoms or ALTE/BRUE. Patients' characteristics and RTB findings are summarized in Table 1b.

One patient with primary posterior tracheopexy required an additional anesthesia for esophageal stenosis treatment 4 weeks after the esophageal anastomosis. RTB at induction of anesthesia showed a marked improvement of the posterior collapse from 90% to 10% (Fig. 3a, b). The other three patients had no RTB during their follow-up as no additional procedure under anesthesia was necessary.

Table 1a

Characteristics of patients that were operated by secondary thoracoscopic posterior tracheopexy after EA correction.

Patient number, gender Associated morbidity	Gestational age (weeks) Birth weight (grams)	Age at surgery	Pre-operative tracheomalacia symptoms	% Tracheal obstruction on RTB Additional surgical procedure	Complications
Patient 1, male	28 + 3 2400	3 months	ALTE/BRUE 10 times Tracheal diverticulum	95% Resection tracheal diverticulum	-
Patient 2, female Tetralogy of Fallot	30 + 5 1370	16 months	Tracheostomy cannula Recurrent TEF	90% TEF closure	Additional thoracoscopic aortopexy Chylothorax
Patient 3, male	41 + 4 2885	5 weeks	Cyanosis Expiratory stridor Oxygen dependence	99%	Esophageal anastomosis leakage

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