Thoracoscopic Posterior Tracheopexy Is a Feasible and Effective Treatment for Tracheomalacia

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Abstract

Background: Posterior tracheomalacia is characterized by collapsibility of the posterior trachea and is often present in patients with congenital esophageal atresia (EA) with or without tracheoesophageal fistula (TEF). It can lead to a variety of symptoms from mild expiratory stridor and difficulty clearing secretions to severe respiratory distress, especially in the setting of increased work of breathing. Depending on the severity of symptoms, treatment ranges from medical therapy, including airway clearance techniques, aerosolized medications, and steroids to surgical treatment. The purpose of this study is to review our institution's experience with posterior tracheopexy.
Materials and Methods: A retrospective review was conducted from 2017–2019 at a freestanding quaternary care children's hospital.
Results: The analysis included 8 patients. The median age at surgery was 6 (range 3–8) years and 4 (50%) of cohort were male. The majority of patients ($n = 6$, 75%) had a history of prior EA and TEF repair and 3 (38%) had associated VACTERL anomalies. All patients demonstrated severe tracheomalacia on preoperative bronchoscopy with collapse of the posterior membrane. In regard to surgical approach, most cases (6/8, 75%) underwent thoracoscopic repair. The median operative time was 218 (193 thoracoscopic, 218 open) minutes. The median length of stay was 3 days, and 2 (25%) patients had a postoperative complication of chylothorax (1 thoracoscopic and 1 open), both of which resolved without invasive intervention. The current median length of follow-up is 3 months, and all patients reported symptomatic improvement. One patient who had initial symptomatic improvement has undergone repeat tracheopexy for recurrence.
Conclusion: Posterior tracheopexy is an effective treatment option for symptoms associated with tracheomalacia. The thoracoscopic approach is feasible in experienced hands and with the support of a multidisciplinary team.

Keywords: posterior tracheopexy, tracheomalacia, thoracoscopic tracheopexy

Introduction

POSTERIOR TRACHEOMALACIA is characterized by excess laxity of the membranous portion of the trachea, which results in movement of the posterior wall during expiration and occlusion of the airway.[1,2] It has been associated with tracheoesophageal fistula (TEF) and congenital heart disease.[3,4] Symptoms vary with the severity of tracheomalacia and range from decreased secretion clearance and recurrent pneumonias to brief resolved unexplained events.[5]

Mild tracheomalacia can be managed medically with medications as needed with symptoms or illness. Mild to moderate tracheomalacia may require daily airway clearance therapy with aerosolized medications and steroids or antibiotics for exacerbations. For severe disease, surgical treatment may be considered, including aortopexy to lift the trachea anteriorly and decrease the degree of tracheal collapse.[6] Another treatment approach to target the posterior membrane intrusion is posterior tracheopexy. This is a recently described approach and can be performed either through an open thoracotomy or thoracoscopically.[7] In this report, we review our institution's experience with posterior tracheopexy for tracheomalacia.

Materials and Methods

Study design

After approval from the Colorado Multi-Institutional Review Board, a retrospective review was performed of all

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patients between 2017 and 2019 who had undergone a posterior tracheopexy by a single surgical team at our quaternary care children's hospital. The surgeons' case log was reviewed to identify patients.

Multidisciplinary approach

These patients are managed by a multidisciplinary aerodigestive team, which consists of pediatric pulmonologists, gastroenterologists, surgeons, otolaryngologists, anesthesiologists, occupational therapists, speech language pathologists, and dieticians. Preoperative evaluation includes flexible and rigid bronchoscopy with dynamic and static evaluation and inspiratory/expiratory airway computed tomography with contrast to evaluate for extrinsic compression and tracheobronchial collapse. Postoperative evaluation includes respiratory and gastrointestinal symptom review and bronchoscopy as indicated.

Anesthetic approach and surgical procedure

The anesthetic approach for these patients has been previously described.[8] In brief, anesthesia is induced with an inhalational agent, maintaining spontaneous ventilation for airway patency. Once intravenous access is established, total intravenous anesthesia with propofol and remifentanil is instituted to maintain a steady state of anesthesia and to minimize air pollution in the operating room. Lung isolation is managed with an extraluminally placed Arndt bronchial blocker to permit flexible bronchoscopic guidance through the endotracheal tube by the otolaryngologist. Constant communication throughout the repair is necessary between the surgical and anesthesia teams to maintain adequate ventilation and near normal respiratory mechanics.

The thoracoscopic procedure is performed with the patient in a left lateral position, using three thoracic ports. The trachea is separated from the surrounding tissue and the esophagus. Under bronchoscopic guidance, stitches are placed in the posterior membranous portion of the trachea and secured to the anterior spinal ligament; the esophagus is moved slightly to the left of the spine. A chest tube is left in place, and the incisions are closed. Local anesthetic is infiltrated in the port sites to augment postoperative analgesia.

For the open procedure, a right muscle sparing thoracotomy is performed. The pleura is opened over the esophagus, and the esophagus is moved to the right off the spine. The trachea is dissected away from the surrounding tissue. Under bronchoscopic guidance, stitches are placed in the posterior membranous portion and secured to the anterior spinal ligament. A chest tube is left in place, and the incisions are closed.

Data review

The electronic medical records of all patients were reviewed for demographic information, age at surgery, gestational age in weeks (WGA) at birth, presence of comorbidities such as VACTERL, esophageal atresia (EA), TEF, and congenital cardiac anomalies. Intraoperative characteristics were reviewed, including surgical approach, length of surgery, presence of a trainee, and estimated blood loss (EBL). Postoperative outcomes were examined, including length of stay (LOS), LOS in the ICU, complications, recurrence, respiratory symptoms, readmissions, and mortality.

Statistics

Descriptive analysis was performed. Medians with interquartile ranges (IQRs) were used for continuous variables, and proportions were used for categorical variables. All analyses were performed using Stata software.

Results

Patient characteristics

There were 8 patients included in this review. There was an equal distribution of gender and the median age at repair was 6 (IQR: 5–8) years. The median WGA was 38 (IQR: 36–39) weeks. The majority of patients had some comorbidity burden—38% ($n = 3$) had VACTERL syndrome, 75% ($n = 6$) had TEF, and 63% ($n = 5$) had cardiac anomalies (Table 1). All patients had severe tracheomalacia on preoperative bronchoscopy.

Operative technique

The majority ($n = 6$, 75%) underwent thoracoscopic repair. The groups had similar baseline characteristics. The median length of surgery was 193 (IQR: 120–305) minutes in the thoracoscopic group compared with 218 (IQR: 190–246) minutes in the open group. The most recent thoracoscopic repairs were significantly shorter in duration, each performed in 120 minutes. The median EBL was 5 (IQR: 5–20) mL in the thoracoscopic group compared with 13 (IQR: 5–20) mL in the open group (Table 2). None of the thoracoscopic cases were converted to open. No patients required blood transfusion. One patient had a concurrent aortopexy for external tracheal compression. All cases were performed with trainees.

TABLE 1. PATIENT CHARACTERISTICS, OPERATIVE DETAILS, AND OUTCOMES AFTER POSTERIOR TRACHEOPEXY

	$n = 8$
Patient characteristics	
WGA[a]	38 (35–39)
VACTERL[b]	3/8 (38)
Cardiac anomalies[b]	5/8 (63)
EA/TEF[b]	6/8 (75)
Gender (% male)[b]	4/8 (50)
Age at repair (years)[a]	6 (5–8)
Operative details	
Length of surgery (minutes)[a]	218 (128–278)
Technique (% thoracoscopic)[b]	6/8 (75)
EBL (mL)[a]	5 (5–15)
Outcomes	
LOS (days)[a]	3 (2.5–6)
ICU LOS (days)[a]	1 (0.5–1)
Complications[b]	2/8 (25)
Recurrence[b]	1/8 (13)
Length of follow-up (months)[a]	3 (2–13)

[a]Median (interquartile range).
[b]Proportion n/n (%).
EA, esophageal atresia; EBL, estimated blood loss; LOS, length of stay; TEF, trachea-esophageal fistula; WGA, gestational age in weeks.

Outcomes

The overall median LOS was 3 (IQR: 2.5–6) days; and this was higher in the open group (median 7 (3–10) days) compared with the thoracoscopic group (median 3 (2–3) days). Early in the series, posterior tracheopexy patients went to the ICU for the first postoperative day for monitoring, but the 2 most recent cases have recovered without incident on the floor. The patients who underwent thoracotomy both required epidural placement for pain control. Those who underwent thoracoscopy were managed with local anesthetic infiltration at the end of the case and oral analgesics postoperatively, receiving four doses of oxycodone on average. There were three complications in 2 patients. These included chylothorax ($n=2$) and urinary tract infection ($n=1$). Both cases of chylothorax were managed nonoperatively, and there was 1 case in each surgical approach (Tables 1 and 2). There were no deaths.

Out of the 8 cases performed, there was only 1 patient who required reoperation for recurrence of posterior malacia. Although there was initial improvement in symptoms, the patient developed recurrent croup with severe coughing, which may have disrupted the suture pexy. This case was initially performed thoracoscopically and was corrected again in the same manner.

All other patients experienced symptomatic improvement on their first postoperative visit, reporting improved secretions and cough, and fewer respiratory infections. No patients were readmitted for any reason within 90 days of surgery. After that period, 3 patients were admitted for viral upper respiratory infection. In regard to gastrointestinal function, those with a history of EA/TEF had the same level of dysphagia, dysmotility, and reflux postsurgery as they did before surgery as assessed by symptom report at their postoperative visit. Otherwise, there were no reports of new onset dysphagia. The median follow-up time was 3 (IQR: 2–13) months.

Discussion

Tracheomalacia can be associated with significant morbidity. Treatment of tracheomalacia is evolving and posterior tracheopexy may be an appropriate alternative to tracheal resection or aortopexy, especially in the cases of clear posterior membrane collapse. The approach to posterior tracheopexy is also evolving, with the minimally invasive approach only recently described,[7,9] and further research is needed to define the optimal therapeutic approach for this problem.

This study demonstrates that the thoracoscopic approach of posterior tracheopexy for tracheomalacia is effective and feasible. All patients reported symptomatic improvement after the surgery, and in our series complications are few with minimal morbidity. Although the small number of subjects in this series provides inadequate power to verify differences between the two operative approaches, there are cosmetic benefits and a trend toward a shorter LOS and decreased pain medication requirement when performing these with a minimally invasive approach, especially when it can be performed safely in experienced hands.

This series represents one of the larger studies to date describing the outcomes with a thoracoscopic surgical approach for tracheomalacia. Similar to other studies, our multidisciplinary team recommended tracheopexy in patients with severe tracheomalacia, including patients who had other comorbidities, including VACTERL, EA/TEF, and cardiac anomalies.[10] As our study confirms, significant clinical improvement has been noted after posterior tracheopexy.[11]

Other studies describe performing tracheopexy concurrently with EA/TEF repair or at a younger age.[7,10,12] As some of these patients will have improvement in the symptoms from tracheomalacia, our practice is to re-evaluate these patients for surgery after 2 years of age. The older age of our cohort may contribute to the reduced LOS compared with other studies.[10,13] The complication of chylothorax has also been noted in other series.[7] A similar study that utilized a mix of robotic ($n=6$) and thoracoscopic ($n=4$) cases reported similar outcomes in regard to symptomatic improvement and LOS.[14]

Some questions have been raised about worsening postoperative dysphagia after posterior tracheopexy given the need for esophageal mobilization to correct the defect. In our limited assessment, we did not detect an increase in incidence or severity of postoperative dysphagia. We believe moving the esophagus to the left of the spine alters its course less in the upper to mid chest. The only patients reporting these symptoms were those who had dysphagia before treatment related to their EA/TEF.

Another concern is whether thoracoscopic surgery can be performed in patients who have undergone previous thoracic

TABLE 2. COMPARISON IN BASELINE CHARACTERISTICS, OPERATIVE DETAILS, AND OUTCOMES BETWEEN THORACOSCOPIC AND OPEN POSTERIOR TRACHEOPEXY

	Thoracoscopic (n=6)	*Open* (n=2)
WGA[a]	38 (35–39)	36 (33–38)
VACTERL[b]	2/6 (33)	1/2 (50)
Cardiac anomalies[b]	4/6 (67)	1/2 (50)
EA/TEF[b]	4/6 (67)	2/2 (100)
Age at repair (years)[a]	6 (4–7)	7 (5–8)
Length of surgery (minutes)[a]	193 (120–305)	218 (190–246)
EBL (mL)[a]	5 (5–10)	13 (5–20)
LOS (days)[a]	3 (2–3)	7 (3–10)
ICU LOS (days)[a]	1 (0–1)	1 (1–1)
Complications[b]	1/6 (17)	1/2 (50)
Recurrence[b]	1/6 (17)	0/2 (0)

[a]Median (interquartile range).
[b]Proportion *n/n* (%).
EA, esophageal atresia; EBL, estimated blood loss; LOS, length of stay; TEF, trachea-esophageal fistula; WGA: gestational age in weeks.

surgery for their EA/TEF repairs due to previous surgical scarring. In our series, four thoracoscopic repairs were performed in patients with previous EA/TEF repairs. Although adhesions were noted between the esophagus and the trachea intraoperatively, the procedure could still be performed safely and effectively without the need to convert to an open thoracotomy.

The benefit of a dedicated multidisciplinary team must also be emphasized. A core group of clinicians allows for consistent evaluation, intervention, and management of these patients with lifelong follow-up. Optimized outcomes are partly due to the increased consistency and familiarity with the care processes, preoperative optimization of symptomatic patients, and appropriate identification of patients who may benefit from surgery. This is most notably highlighted by progressively reduced operative times and reduced need for postoperative intensive care monitoring.

There are limitations to this study. The small sample size limits the power of the study to detect true differences between the two surgical approaches. Furthermore, as a retrospective review, some long-term outcomes may not be captured, and selection bias can cloud the analysis. Despite the short-term nature of this study, we plan to examine the long-term outcomes of these patients through our longitudinal multidisciplinary clinic and will also assess the quality of life in these patients before and after surgery.

In conclusion, with appropriate experience, thoracoscopic posterior tracheopexy represents an effective novel treatment strategy for severe tracheomalacia with a low incidence of complications.

Disclosure Statement

E.D. is a board member and consultant for Triple Endoscopy, Inc., and is a consultant for Boeringer Ingelheim. J.P. is a board member and consultant for Triple Endoscopy, Inc.

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