

Clinical Results of Tracheobronchoplasty Using Polytetrafluoroethylene Vascular Graft with Rings

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Received Date: June 16 2024

Accepted Date: June 18 2024

Published Date: July 18 2024

ABSTRACT

Background : The surgical method and results of tracheobronchoplasty (TBP) using a ringed polytetrafluoroethylene (PTFE) vascular graft are discussed in this study.

Methods : We have registered every patient who received PTFE-TBP at the Mayo Clinic in Florida for severe expiratory central airway collapse between January 1, 2018, and August 20, 2021. Pulmonary function testing, 6-minute cough-specific quality of life questionnaire (CSQLQ), St. George's Respiratory Questionnaire (SGRQ) for preoperative and postoperative patients The walk test and dynamic bronchoscopy videos that were blinded during the 3-month follow-up were utilized to evaluate the results.

Results : PTFE-TBP was performed on 14 patients (median age, 62.5 years; 64.3% female). The typical length of stay in the hospital was five days, the median time spent in the intensive care unit was one day, and the median operation time was 355 minutes. A complication of Claudien-Dindo grade 3 occurred in one patient. Comparison of the results from the preoperative and postoperative questionnaires showed enhancement of the median CSQLQ score by 22 (P [.005] and the median SGRQ score by 14.79 (P [.013]). The results of the 6-minute walk test and preoperative and postoperative lung function showed no discernible differences. Improved median collapsibility of the mid trachea (P <.001), distal trachea (P <.001), left main bronchus (P <.001), right main bronchus (P <.001), and bronchus intermedius (P <.001) were all shown by postoperative bronchoscopy.

Conclusions : According to bronchoscopy, preoperative and postoperative quality of life surveys, and patients' symptoms, PTFE-TBP significantly improves patients' symptoms and expiratory central airway collapse.

INTRODUCTION

The role of expiratory central airway collapse (ECAC) in a range of respiratory diseases is becoming more widely acknowledged. There are two distinct subtypes of ECAC: extreme dynamic airway collapse (EDAC), in which there is a forward narrowing of the airway tracheobronchomalacia (TBM), which involves the anterior or lateral collapse of cartilaginous tissues, and displacement of the posterior membrane. Currently, individuals with an airway collapsibility of greater than 90% are advised to undergo tracheobronchoplasty (TBP). A flexible polypropylene hernia mesh is sutured to the posterior portion of the trachea and mainstem bronchi during 1 TBP procedure.^{2, 3} Up until 2018, our university used this as the conventional TBP approach. We looked into different surgical methods due to suboptimal airway patency. Based on the positive outcomes of polytetrafluoroethylene (PTFE) in patients, We decided to utilize this material for patients with ECAC who had congenital tracheal or bronchial abnormalities.⁴ Compared to flexible mesh, the ringed grafts offer the airway's membranous wall better structural support. We present our group of 14 patients who had PTFE grafts that were ringed.

METHODS AND PATIENTS

All patients who had PTFE-TBP at our institution between January 1, 2018, and August 1, 2021 were included. Every patient had a stent trial and had their severe ECAC verified by dynamic bronchoscopy. We examined surgical outcomes and patient demographics. results. Preoperative and postoperative St George's Respiratory Questionnaires (SGRQ), the Cough-Specific Quality of Life Questionnaire (CSQLQ), and subjective assessments during the three-month follow-up were used to assess the patients' symptoms. The 6-minute walk test and the preoperative and postoperative pulmonary function tests (PFT) were used to compare the functional outcomes. (6MWT) outcomes and dynamic bronchoscopy observations at a three-month interval. Preoperative and postoperative dynamic video footage bronchoscopy were randomized and their identifiable

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information removed. Two pulmonologists then evaluated the movies independently. At five points along the airway, the degree of collapsibility was measured and reported to the closest decile.

Statistical analysis

Continuous variables were given as medians (interquartile range), and the Wilcoxon signed rank test was used to compare them. Categorical variables were summarized as counts (percentages). The correlation between the assessments made by each pulmonologist was determined by the intraclass correlation coefficient. Every test had two sides. P values less than .05 are deemed significant. IBM SPSS Statistics was used for the analysis.

Surgical technique

A typical posterior-lateral thoracotomy is used by us. The graft's length is severed, allowing the ringed PTFE to unfold. It is then divided into two rings-long strips (each strip). We often use four interrupted Prolene sutures in a succession. Using a parachute approach, each double-arm suture passes through the PTFE mesh on either side of each ring, with six to ten sutures per mesh strip. The ends of each strip are positioned anteriorly and extend over the edge of the trachea by a few millimeters when the lateral sutures are inserted through the cartilage with a horizontal mattress. We apply three or four mesh strips to the trachea. The bronchus intermedius, the right upper lobe, the left and right mainstem bronchi, and one or two sections bronchus (Section 1). We determine each strip's width by using preoperative computed tomography (CT) scans. Every strip is usually oversized by two or three millimeters more than the posterior membrane diameter that we wanted. We employ a knot and execute intercostal nerve cryoablation. pusher to save surgical times and improve visualization of knot insertion.

RESULTS

There were fourteen patients (median age, 62.5 years; 64.3% female). The two most prevalent comorbidities were hypertension (78.6%) and gastroesophageal reflux (85.7%). Two of the twelve (85.7%) patients had EDAC-TBM, 14.3% (Table). Breathlessness accounted for 71% of the most prevalent symptoms (Table). The average length of hospital stay was 5 days (5-7.75 days), the average intensive care unit stay was 1 day (1-2 days), and the average operation took 355 minutes (292-388 minutes). The two blinded pulmonologists concurred that postoperative dynamic bronchoscopy showed improvements in the left main bronchus by 50%, the distal trachea by 50%, and the median collapsibility of the mid trachea by 39.6%. There were differences of 38.2%, 37.9% in the right main bronchus, and 30.7% in the bronchus

intermediate (all $P < .001$; Figure 2). Between the two blindfolded physicians, the average intraclass correlation coefficient was 0.75 ($P < .001$). There was no discernible difference between the preoperative and postoperative PFT and 6MWT results (Supplemental Table). When preoperative and postoperative SGRQ and CSQLQ scores were compared, it was shown that the median SGRQ score had improved by 15.88 ($P = .013$) and the median CSQLQ score had improved by 22 ($P = .05$). Likewise, 12 individuals (85.7%) mentioned having symptoms. enhancement. No perioperative fatalities occurred. Within 30 days following surgery, only 1 patient (7.2%) experienced a Clavien-Dindo grade 3 complication. The patient's right middle lobe collapse got surgical correction. More than 30 days following surgery, three patients experienced problems. One patient experienced tracheal posterior wall ulceration, which improved with conservative therapy. One patient needed revisional TBP, while another needed to have one of the mesh strips removed because it was eroding into the wall of their airway a year later.

COMMENT

According to Damle and Mitchell³, the objective of TBP is to restore the trachea's D shape by approximating its cartilaginous margins. This is logical mechanically given crescent-type TBM, although it is structurally incoherent when paired with the saber-sheath, circumferential, and EDAC TBM subtypes (Figure 3). When coughing, these subtypes—which have a D shape at rest—are more likely to have a dynamic collapse of the lateral walls (saber-sheath), posterior membrane (EDAC), or both (circumferential).⁵ The majority of our patients had EDAC, which is similar to other reported series⁶, thus we concentrate on this subtype. The posterior membrane receives only a little amount of support from the flexible polypropylene mesh. It is anticipated that when the mesh stiffens the posterior membrane over time, collapse will improve secondary. A vascular graft with circular supporting rings is called ringed PTFE. A thin coating is used to secure the rings to the PTFE tube. Polypropylene is less flexible than ringed PTFE mesh, making it more effective in avoiding airway collapse. The largest body of writing on TBP has been written by Gangadharan and associates.^{2, 8, 9} The 5-year results of 61 patients who received traditional TBP were reported in 2023. The patients showed improved quality of life and 6MWT scores, as well as decreased collapsibility as determined by dynamic CT scan.⁸ Still, the first series and ceased to provide this parameter in later papers.³ The operative time reported by this group was 373 minutes with a further eight-day hospital stay. According to the Clavien-Dindo classification, respiratory failure accounted for 17% of the grade 3 problems that affected 23% of the patients.⁹ They experienced seven revision procedures and two in-hospital deaths.⁹ It was

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Lazzaro and colleagues¹ who initially described robotic TBP. A series of 42 patients with a median follow-up of 40 months was reported by them, showing gains in PFT and quality of life survey (SGRQ) outcomes. Not statistically significant was the change in the 6MWT distance. A 3-day hospital stay was required, with an operation lasting 249 minutes. There were eight (19%) patients with grade 3 problems. There were no fatalities and one patient underwent a revisional operation. Furthermore, 82% of respondents expressed satisfaction with the process. For TBP, evaluating postoperative changes in airway collapsibility is essential. A method for evaluating collapsibility changes is dynamic CT. Buitrago and associates⁹ showed that dynamic CT reduced the airway collapsibility from 70% to 36% ($P < .001$). However, intrinsic challenges in selecting the right moment for image capture can compromise the performance features of dynamic CT. Using preoperative and postoperative bronchoscopy, we demonstrated a notable improvement in dynamic collapse. The "gold standard" for diagnosing ECAC is dynamic bronchoscopy, and we show that bronchoscopy significantly reduces collapsibility. It was unexpected that the 6MWT distance did not improve, as this was inconsistent with the results of bronchoscopies and quality of life. Still, just eleven patients had 6MWT data from both preoperative and postoperative procedures, which reduced the observation's power. Less surprisingly, we also did not observe a substantial change in PFT values, given that preoperative PFT findings were generally normal. Compared to Buitrago, our operation and hospital stay took less time, although we stayed longer than Lazzaro. Of the 14 patients, 86% (12) reported a positive overall procedure satisfaction rate. This series outlines a few advantages and possible drawbacks of PTFE-TBP. The primary advantage is superior posterior membrane support, as evidenced by enhanced evaluation of collapsibility via bronchoscopy. Clinically speaking, this meant that all patients were extubated the day of the procedure, without the need for an ICU or reintubations/readmissions. On the down side, if ringed PTFE separates from the lateral edges, it returns to its cylindrical form. We now expand the PTFE past the boundary of the lateral wall and attach it to the tracheal cartilage. Two patients experienced erosion as a result of the PTFE strips curling into the posterior meniscus. One patient underwent a revision TBP at a different center after their crescent subtype of TBM did not improve. A polypropylene mesh or suture approach might be more suitable in certain circumstances. The other patient experienced mesh erosion as a long-term problem one year after a short-term one (right middle lobe collapse). This patient's breathing was still better, despite these setbacks. One patient (with crescent TBM, previously stated) and the other patient (with saber-sheath TBM) had worsened symptoms following TBP. For the sheath of swords. Furthermore, contrary to our expectations,

the ringed PTFE did not support and hold open the anterior cartilage's lateral edges. Our study's acknowledged limitations include the sample size and the 13-month median follow-up. Furthermore, it was frequently possible to distinguish between preoperative and postoperative bronchoscopy, even though all of the films were randomized and deidentified. In conclusion, the gold standard method of dynamic bronchoscopy showed that ringed PTFE for TBP greatly enhanced airway collapsibility. This method seems to be most effective for patients with TBM who have the EDAC subtype. Results are in good comparison to other published series.

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