SURGERY FOR TRACHEOMALASIA AND TRACHEOBRONCHOMALACIA

TRAKEOMALAZİ VE TRAKEOBRONKOMALAZİ İÇİN CERRAHİ TEDAVİ

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Abstract

Severe tracheomalacia (TM) and tracheobronchomalacia (TBM) are associated with symptoms such as incessant coughing, dyspnea, retained secretion and repeated chest infections. In addition, respiratory failure requiring mechanical ventilation with continuous positive airway pressure is a life-threatening symptom of the disease. Therefore, most of patients with severe TM and TBM should be indicated for some sort of treatments. This chapter is intended focusing on surgical treatment for TM and TBM including the technique of tracheobronchoplasty in our institution, and the etiologic and diagnostic aspects of TM and TBM are briefly reviewed to gain a deeper understanding of the surgical treatment.

Keywords: Tracheomalacia, tracheobronchomalacia, surgery

Özet

Şiddetli trakeomalazi (TM) ve trakeobronkomalazi (TBM), aralıksız öksürük, nefes darlığı, sekresyon retansiyonu ve tekrarlayan akciğer enfeksiyonları gibi semptomlarla ilişkilidir. Bunlara ek olarak, sürekli pozitif hava yolu basınçlı mekanik ventilasyon gerektiren solunum yetmezliği de, bu hastalığın hayatı tehdit edici bir semptomudur. Bu nedenle, şiddetli TM ve TBM'li hastaların çoğunda tedavi endikasyonu vardır ve bir şekilde tedavi edilmelidir. Bu bölüm, kurumumuzda trakeobronkoplasti tekniği de dahil olmak üzere TM ve TBM'nin cerrahi tedavisine odaklanmayı amaçlamaktadır ve cerrahi tedaviyi daha iyi anlamak için TM ve TBM'nin etiyolojik ve tanısal yönleri kısaca gözden geçirilmiştir.

Anahtar kelimeler: Trakeomalazi, trakeobronkomalazi, cerrahi

INTRODUCTION

Malacia, from the Greek word malakos, means softness. The tracheobronchial tree is a dynamic conduit that changes lumen size with exposure to varying pressures experienced during different phases of respiration. Tracheomalacia (TM) refers to a weakness of the trachea, frequently due to reduction and/or atrophy of the longitudinal elastic fibers of the membranous wall, or impaired cartilage integrity, such that the airway is softer and more susceptible to collapse with changes in pressure. The majority of TM is intrathoracic disease in nature, such that excessive narrowing is most prominent when intrathoracic pressure is substantially greater than intraluminal pressure, as it is during a forced expiration or cough. Therefore, extrathoracic or cervical TM is seen less commonly. TM may be localized to one portion of the trachea or may involve the entire trachea. If the mainstems of the bronchi are also involved, the term tracheobronchomalacia (TBM) is appropriate. TM and TBM are disorders that are encountered in both pediatric and adult medicine. Despite increasing recognition of these disease processes, there remains some uncertainty regarding their identification, causes, and treatment (1).

This chapter mainly focuses on surgical treatment for TM and TBM in adult patients; however, a brief review of pediatric disease is also included.

Pediatric Tracheomalacia and Tracheobronchomalacia

TM is a common congenital anomaly of the trachea. It can be an isolated finding in healthy infants, but is more commonly seen in premature infants. It is believed to be a consequence of the inadequate maturity of tracheobronchial cartilage. Some associated diseases, which include polychondritis, chondromalacia, and mucopolysaccharidoses, result in dysmaturity of the collagen fibers and weakness in the tracheobronchial tissue. In the majority of healthy and premature infants, TM is a self-limiting disease. Most infants outgrow the condition by the age of 1 or 2 years. However, in those infants with connective tissue disease or congenital syndromes, the effects of TM often persist and may be fatal (1-2).

Regarding the treatment of pediatric TM and TBM, most mild disease can be treated non-surgically. However, severe TM and TBM with life-threatening symptoms or that are likely to represent a significant chronic health hazard may require surgical intervention. Options for surgical intervention of pediatric TM and TBM are as follows; aortopexy, tracheopexy, tracheal resection and reconstruction, or external stabilization. Surgical treatment must be specific for the type of TM and TBM in each patient, taking into account all the associated conditions such as cartilage deformity, regions of malacic airway, and abnormal anatomy of vessels and airways. The details of surgical treatment of pediatric TM and TBM are outside the scope of this chapter, however, they have been reviewed well by Fraga et al (3).

Adult Tracheomalacia and Tracheobronchomalacia

Epidemiology and Definition

The occurrence of TM and TBM in adult populations is not uncommon. Although several diseases such as tracheobronchomegaly and Mounier-Kuhn syndrome may have a genetic basis, the majority of adults with TM and TBM have the acquired or secondary form of the disease (1). There is increasing recognition of TM and TBM in patients with respiratory complaints, however the true incidence of the disease in adults is still unclear. Jokinen et al reported that TM and TBM were found in 23% of patients with chronic bronchitis (4). Jokinen et al also reported the diseases were found in 4.5% of the general population (5). Likewise, Ikeda et al showed that more than 13% of patients who underwent evaluation for respiratory complaints were found to have TM and TBM (6).

The main reason why the incidence of TM and TBM in the general population remains unclear is that the extent of airway collapse required to meet the threshold for pathologic collapse has not been well defined. The currently accepted definition for excessive airway collapse is a greater than 50% reduction in airway cross-sectional area with expiration (7). Under this definition, more than 13% of patients with emphysema were found to have TBM on examination. However, when the threshold was raised to greater than 70% of airway collapse, only 5% met the definition of TBM (8). A more recent report demonstrated a wide range of expiratory tracheal collapsibility observed in healthy volunteers, with many asymptomatic individuals frequently exceeding the current diagnostic threshold for TM and TBM (9-10). Currently, a greater than 90% collapse of the central airway has been regarded as a severe grade of TM and TBM among several leading institutes for complex airway diseases (11-13).

Severe TM and TBM are associated with symptoms such as incessant coughing, dyspnea, retained secretion, and repeated chest infections. In addition, respiratory failure requiring mechanical ventilation such as continuous positive airway pressure is a life-threatening symptom of the disease. Therefore, most patients with severe TM and TBM should be indicated for some type of treatment.

Classification and Diagnosis

TM and TBM can be classified according to the morphology of the airway into three different subtypes: saber sheath-type, circumferential-type, and crescent-type (14-15). Another classification according to the mechanism of airway collapse is more useful to understand the purpose of surgical treatment. Cartilaginous malacia consists of weak anterior tracheal cartilages and redundant posterior membranes, while membranous malacia is caused by excessive forward displacement of membranous walls (7,14-15).

Although it can be challenging to determine TM and TBM correctly in patients with concomitant chronic pulmonary diseases, the diagnosis of TM and TBM should be achieved with a dynamic chest CT and a dynamic bronchoscopy. A dynamic respiratory CT (Figure 1A, 1B) is a non-invasive and highly sensitive method for detecting severe airway malacia and has been shown to be concordant with a dynamic bronchoscopy (16). When severe malacic airway is revealed during the expiratory phase of the CT, a dynamic bronchoscopy is the next step in further evaluation of the airway. An awake bronchoscopy is an invasive diagnostic tool; however, it is still the gold standard for the diagnosis of TM and TBM because it can bring real-time and precise information of the airway including morphology, degree, and extent of malacia (Figure 2A, 2B). On the other hand, a pulmonary function test is less helpful in diagnosing the disease compared to previously mentioned diagnostic modalities.

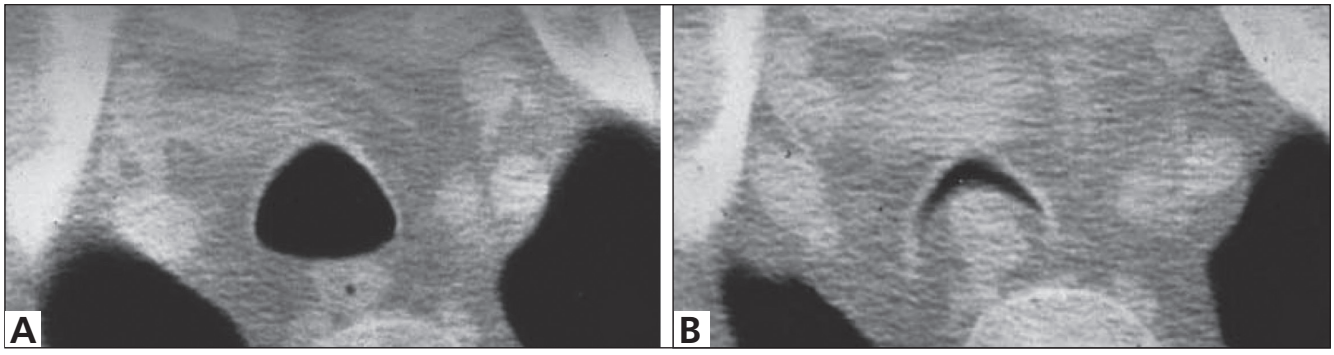

Figure 1. Findings of tracheomalacia in a dynamic respiratory CT. **A.** Inspiratory phase, **B.** Expiratory phase.

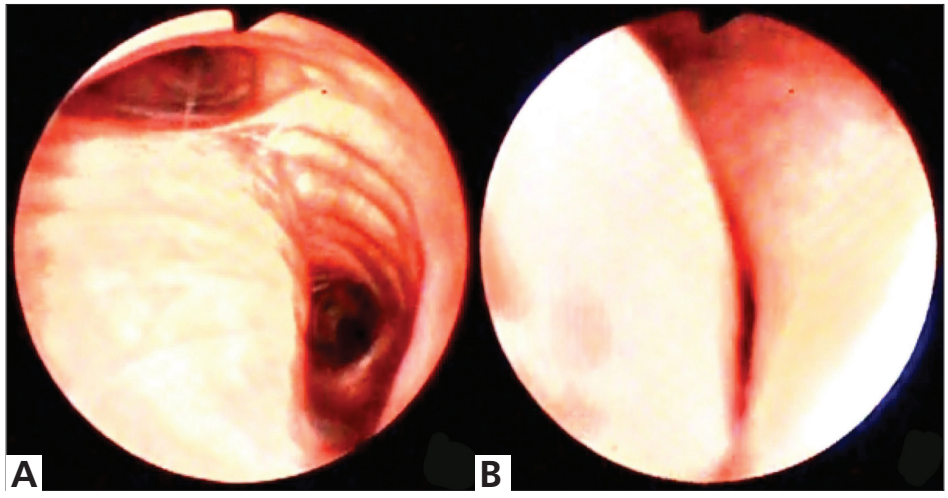

Figure 2. Findings of tracheobronchomalacia in a dynamic bronchoscopy. **A.** Inspiratory phase, **B.** Expiratory phase.

If a patient exhibits both clear symptoms of severe airway malacia and the corresponding findings of severe disease on a dynamic chest CT and a dynamic bronchoscopy, they should be considered for surgical treatment after screening for general status and comorbidities. A 2-week trial of a silicon Y-shaped stent has been proposed to predict the effects of surgical treatment (12-13,17), however it may be controversial. Airway stenting for severe TM and TBM can be problematic with a high occurrence of stent-related complications, even with short-term insertion (18). Some patients who had a history of airway stenting were referred to our hospital due to failure of the procedure; the surgical intervention mentioned in the following section could achieve an excellent result in such patients. For this reason, the stent trial is not performed routinely in our institution.

Concept of Surgical Treatment and the Technique:

The surgical treatment for TM and TBM was historically described by Nissen and Herzog as a span plasty, which was a type of posterior splinting tracheobronchoplasty (TBP) using autologous ribs (19-20). The posterior splinting TBP has continued to evolve; recently TBP with a polypropylene mesh has been reported with satisfactory perioperative and long-term results (21-22).

The concept of TBP is to reconstitute the D-shape central airway; that is, to reform well-curved cartilage and to stabilize the redundant membranous wall in cases of cartilaginous malacia. For membranous malacia, the main purpose is to add rigidity to the excessively flexible membranous wall since the cartilage is generally normal. A schema of this concept is shown in Figure 3.

The posterior splinting TBP surgical technique used in our institution is described below. Patients are placed in the left lateral decubitus position under general anesthesia with an epidural catheter. Single-lung ventilation is established using a normal endotracheal tube with a COOPDECH bronchial blocker tube (Daiken Medical Co., Ltd., Osaka, Japan). A double-lumen endobronchial tube is not our preference, because the thick tube complicates the surgical procedure that includes suturing to the membranous wall, especially in the left main bronchus. The approach is a standard posterolateral thoracotomy in the 4th intercostal space. The upper mediastinum should be opened widely by dividing the azygos

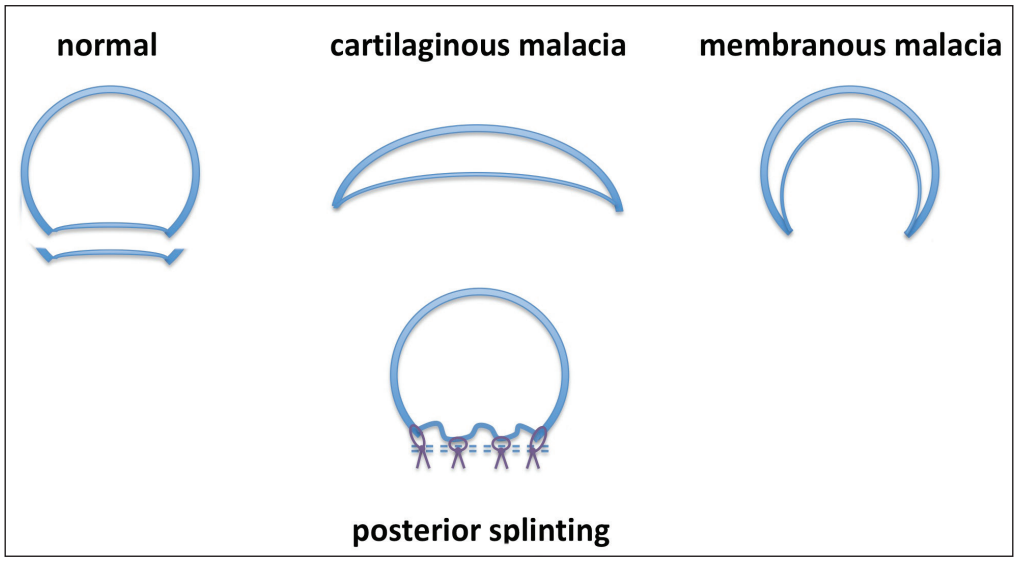

Figure 3. Schema of the concept of posterior splinting tracheobronchoplasty.

vein, and the posterior airway membrane is fully exposed from the thoracic inlet to the bilateral main bronchi including the bronchus intermedius on the right side. The right vagus nerve is isolated during the procedure and it should be preserved as much as possible including all small branches. Dissection of the lateral and anterior aspects of the airway is not necessary; this avoids injury to the laryngeal nerve, and also avoids ischemia of the airway.

After full exposure of the posterior airway, the splinting materials are prepared to the appropriate size and shape according to intraoperative measurement of the patient's posterior airway. The width of splinting material should be 60–80% of the width of the patient's posterior membrane for cartilaginous malacia, and 90–100% of the width for membranous malacia. In all cases, including cases of isolated TM, total splinting of the posterior airway from trachea to the bilateral main bronchi is our policy during surgical intervention. Polypropylene mesh (Product ID 0112680, Bard Mesh, C. R. Bard, Inc., Murray Hill, NJ, USA) is used in our institution as the splinting material in common with most other centers. The technique, using a piece of Y-shaped mesh, is reported by other institutions (11-13); however, we prefer to use the mesh in a separated fashion because that way it can be easily adjusted for size, shape, and angle of the mesh to the patient's airway. Recently, the use of an acellular dermis as an alternative splinting material, has been reported (11).

We always start from the tracheal fixation, and then move to the splinting of the left main bronchus. Our TBP finishes with the plasty of the right main bronchus (Figure 4). Suturing is started from the proximal edge of the posterior wall of the trachea. Although there is no clear answer regarding the best suture for this procedure, our preference is a 4-0 absorbable monofilament suture. Normally four sutures are placed in a row on the membranous wall of the trachea. From a technical point, placing the suture from the left to the right side is easier. Lateral stitches should be through the junction of the cartilage and membranous wall, and partial-thickness suture should be used for the middle stitches. After four sutures on the first row, further sutures are placed distally as the second row in the same fashion. The distance between each row is 5–7 mm. We normally make 3–4 rows of sutures on the membranous wall, passing through the prepared mesh with a terminal tie-off (Figure 5A, 5B). The sutures on the most distal row are not tied before suturing on the next row except for the last row of a mesh. After splinting of the trachea, plasty for the left main bronchus is started. On the main bronchi, we standardly use three sutures on a row, this is usually two lateral stitches and a middle stitch. Although the direction of the procedure of the main bronchus is opposite to the procedure of the trachea, each element of the procedure such as suturing and fixing should be the same. Splinting of the right main bronchus is the last step of the surgical intervention and is generally easier than on the left. Trimming of overlapped mesh and extra sutures on them are sometimes required on the carina; TBP is then complete (Figure 6A, 6B). After irrigation of the chest cavity and placement of a drainage tube, the thoracotomy is closed.

Postoperative Management and Complications

Airway surveillance is performed by bronchoscopy just after TBP in the operating room. Normal bronchoscopy can

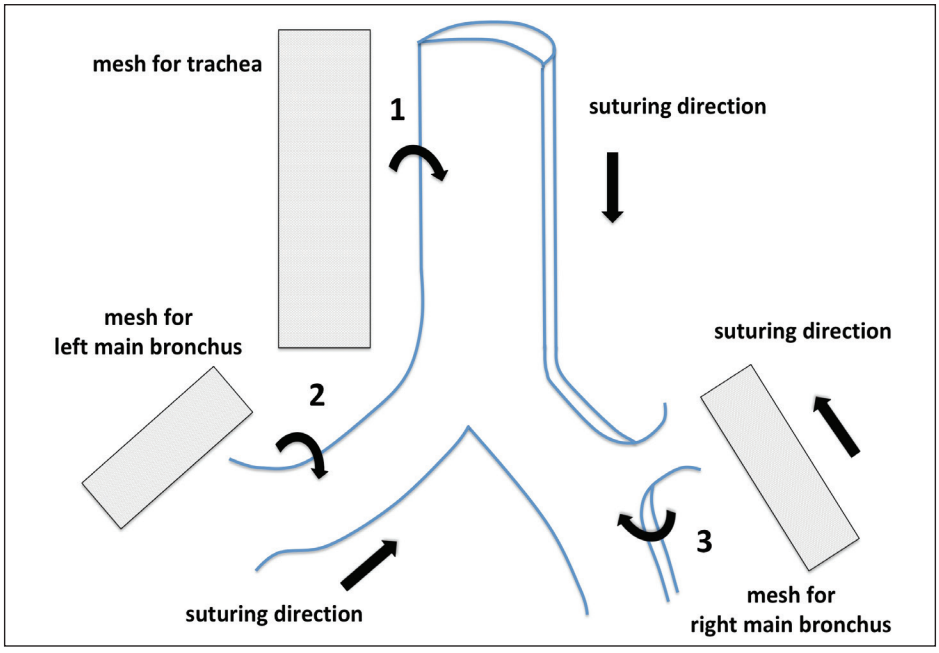

Figure 4. Schema of the procedure of our tracheobronchoplasty.

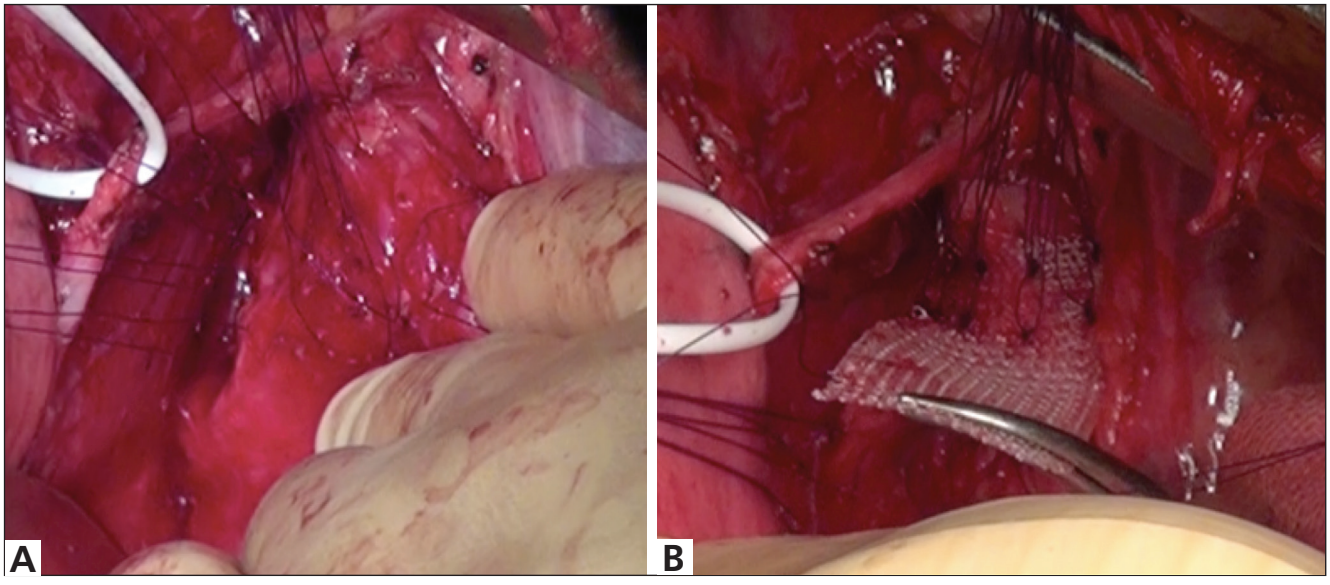

Figure 5. A. Intraoperative view of the suturing on the tracheal membranous wall. **B.** Intraoperative view of the fixing mesh on the tracheal membranous wall.

be performed by removing the bronchial blocker tube. The effect of TBP should be seen in spontaneous breathing, and that the airway is rigid without collapse during expiration. Normally, patients are extubated in the operating room. Bronchoscopy in the intensive care unit is occasionally recommended to evaluate the airway status and to remove secretions. Otherwise, postoperative care of TBP is the same as in other major chest surgeries.

Regarding postoperative complications, mortality following TBP is quite rare, and most morbidities are pulmonary-related (21-22). Specific complications such as injury of the membranous wall and dislocation of the splinting material may occur; however we have not experienced this in our institution.

The outcome of TBP should be evaluated through the improvement of symptoms and quality of life. Most patients show improvement just after surgery, and usually express satisfaction with the results of TBP even at long-term follow up (22). Proper selection of TBP candidates is the most important aspect in achieving satisfactory results after TBP.

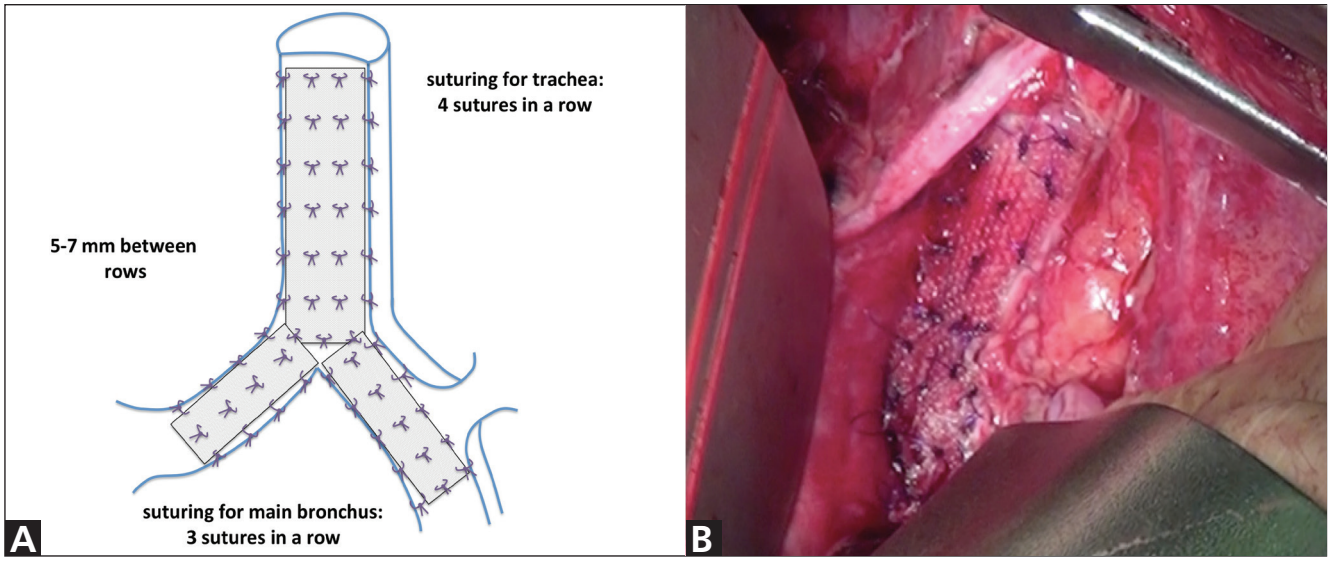

Figure 6. A. Schema of the completed tracheobronchoplasty. **B.** Intraoperative view of the completed tracheobronchoplasty.

Though this is not easy, as previously mentioned, it must be emphasized at the end of this chapter.

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DISCLOSURE STATEMENT

We have no conflicts of interest or financial ties to disclose.

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