Autologous Tracheal Replacement
Surgical Technique and Outcomes

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KEYWORDS

• Forearm free flap • Tracheal replacement • Giant tracheal defect • Tracheal neoplasm

KEY POINTS

- The ideal tracheal substitute should be a well-vascularized autologous conduit with longitudinal flexibility, transverse rigidity, mucous clearance ability, and epithelial inner layer barrier.
- Cartilaginous-armed forearm free flap meets nearly all the criteria of ideal tracheal substitute but the mucous clearance ability.
- Cartilaginous-armed forearm free flap is a reliable, effective procedure to replace the trachea in case of extended destruction or neoplasm without the need of synthetic materials or immunosuppression.
- Further improvements are needed regarding the ability of mucous clearance for longer resection involving the bronchial bifurcation.

Video content accompanies this article at http://www.thoracic.theclinics.com.

INTRODUCTION

End-to-end anastomosis repair is the gold standard surgical repair technique after tracheal resection for benign or malignant diseases. However, it is generally agreed that, despite the use of laryngeal release maneuvers, the maximum length of tracheal resection that can be managed with direct anastomosis is 6 cm, representing the half of the tracheal length.[1] Hence, giant tracheal defects or extended tracheal neoplasms remain a surgical challenge needing entire tracheal replacement. Finding the ideal tracheal substitute has been the subject of intense research by thoracic surgeons for many decades.[2] Considering the ideal tracheal substitute requirements and long-term clinical results, autologous composite neo-trachea has been the best surgical solution for extended tracheal replacement so far. Indeed, synthetic prosthesis did not achieve satisfactory long-term outcomes with a high risk of vascular erosion and life-threatening airway hemorrhage.[3] Immunosuppression and technical issues made tracheal transplantation less attractive and problematic for the treatment of tracheal neoplasms.[4,5] Conduit allografts (aorta, small bowel, trachea) showed poor mechanical results needing prolonged stenting and controversial tissue regeneration.[6,7] At last, the attractive concept of bioengineered tracheal replacements holds promises but has not yielded a reliable solution yet.[8] Autologous composite tracheal substitute results

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in the use of reliable autologous free skin fascial flaps combined with autologous cartilaginous armature. These vascularized armed flaps meet the requirement of epithelial inner layer protection and transverse rigidity without the need of synthetic material or immunosuppression.[9,10] However, the lack of respiratory epithelial layer and the use of autologous cartilage require patient selection based on satisfactory pulmonary function tests, healthy cartilage, and a distal level of resection above tracheal bifurcation.

PREOPERATIVE PLANNING

Autologous tracheal replacement has been proposed to patients presenting with benign or malignant lesions involving more than the half of the length of the trachea. When lesions additionally involve the larynx, autologous neotrachea could be used to avoid mediastinal tracheostomy.

The lack of respiratory epithelial layer of the neotrachea induces reduction in mucous bronchial clearance and promotes bronchial obstruction, atelectasis, and infection. As a result, extended resection to the bronchial bifurcation should not be attempted, as well as resections for patients with impaired lung function. Preoperative workup includes pulmonary function test, coronary artery disease screening, as well as bronchoscopy and 3-dimensional reconstructed computed tomography (CT) scan. In case of tracheal neoplasm, preoperative screening rules out distant metastasis, lymph node involvement, or local extension, contraindicating surgery.

Of importance, CT scan should assess calcification and shape of cartilages to determine if the procedure is feasible and decide what is the optimal cartilage level and side to be harvested. Usually, the lateral portions of the sixth and, particularly, the seventh costal cartilages have the most acute curvature. In elderly patients, highly calcified cartilages may hamper the possibility of reliable and accurate neotrachea construction.

The forearm free flap, described in the early 1980s, is the second major component. It is a thin reliable and well-described flap with several small arteries vascularizing a large skin pad allowing tracheal size-matched conduit construction. Interestingly, forearm free flap could be bi-paddled if the anterior wall of the esophagus needs repair, which is useful in case of giant tracheoesophageal fistula.[11] As a prerequisite, noninvasive testing for patency and completeness of the palmar arch should be assessed by the Allen test and/or duplex assessment. Careful examination of the skin of the forearm rules out any scars or previous surgery within the harvesting zone. Tattoos do not contraindicate forearm flap harvesting.[12]

Neck vessel assessment (duplex scan, angio CT, or angiogram) is useful for vascular anastomoses of the flap's pedicle. Artery and vein anastomoses are preferentially performed at the level of the neck to avoid pedicle mediastinal compression or misplacement. The length of the pedicle and the thickness of the flap allow cervical connection.

Preparation and Patient Positioning

Autologous tracheal replacement by composite free flap is a 1-stage resection-reconstruction procedure requiring 1 patient's positioning. The patient is placed on a supine position, 1 arm at 90° on an arm table for flap harvesting and the other arm along the body (Fig. 1). A roll is positioned

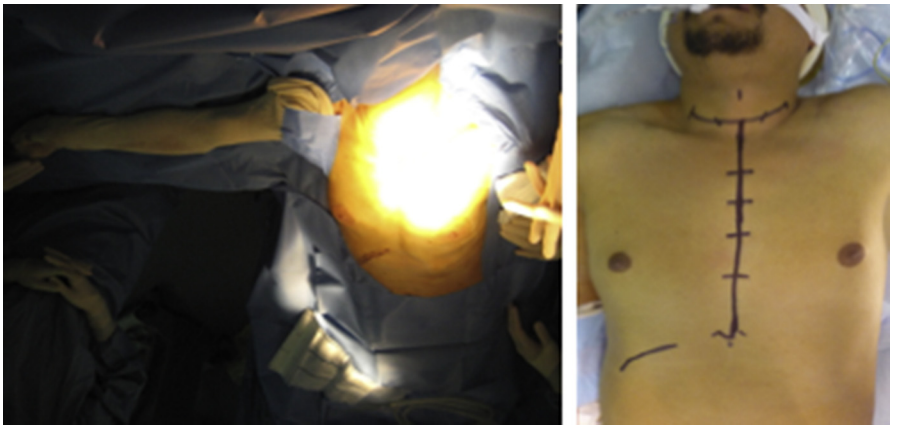

Fig. 1. Positioning and incisions. Patient is placed on a supine position, 1 arm at 90° on an arm table for flap harvesting and the other arm along the body. A roll is positioned behind the shoulders. Neck, chest, one arm, 1 groin, and 1 thigh are prepared. Tracheal resection is performed through a cervicosternotomy incision, cartilage harvesting through a lateral chest incision and forearm free flap using an incision along the radial pedicle.