Clinics in Surgery

Research Article
Published: 07 Mar, 2017

Tracheal Reconstruction with Radial Forearm Free Flap and Cartilage Graft: A Case Report

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Abstract

Introduction: Circumferential tracheal defects of less than 4-6 cm may be safely resected with primary anastomosis. Larger or irregular defects often require reconstructive surgery, which is often challenging. A successful tracheal reconstruction maximally preserves respiratory epithelium and local blood flow, and includes a rigid component to prevent inspiratory airway collapse. No consensus exists regarding an optimal solution to this problem. We present a case of tracheal reconstruction with a radial forearm free flap and costal cartilage graft as a method of restoring tracheal continuity and function.

Materials and Methods: The patient's tracheal adenoid cystic carcinoma was resected, leaving an irregular tracheal defect of about 5.5 cm in length. A costal cartilage graft of 7 cm was sutured to a 6 x 6 cm radial forearm fasciocutaneous flap. Microvascular anastomosis was performed and the cartilage-bolstered flap was sewn into the tracheal defect. Tracheostomy and nasogastric tubes were placed intraoperatively.

Results: The patient was able to swallow by postoperative day 7, allowing removal of the nasogastric tube. His tracheostomy tube was removed on postoperative day 14. Three years after surgery, the patient maintains a patent airway with good speech and swallowing functions and no respiratory complaints. He has had no major complications.

Conclusion: Radial forearm free flap with costal cartilage graft represents a safe way to repair large tracheal defects with preservation of speech and swallowing. Advantages of the procedure described include applicability to a wide variety of defects as well as ability to be carried out in a single stage.

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Received Date: *13 Jul 2016*
Accepted Date*: 27 Feb 2017*
Published Date*: 07 Mar 2017*

Citation:
Bertelsen C, O'Dell K, Kokot N. Tracheal Reconstruction with Radial Forearm Free Flap and Cartilage Graft: A Case Report. Clin Surg. 2017; 2: 1332.

Introduction

Management of tracheal defects differs based on size, shape and location. Defects less than 4-6 cm or 6 tracheal rings may be safely resected with primary anastomosis [1]. This is often technically difficult when laryngeal and hilar release procedures are required, which may interrupt tracheal innervation and blood supply and cause dysphagia. For large or irregular tracheal defects, airway reconstruction is frequently necessary and presents several challenges. A successful tracheal reconstruction preserves respiratory epithelium, maintains blood flow, and structurally resembles the native trachea. While a rigid component is desirable to prevent inspiratory airway collapse, intraluminal stent use for this purpose often leads to fibrosis or stent migration [2]. Disruption of tracheal blood supply during resection has also hindered reconstruction [3]. Recently, there has been increasing utilization of microvascular free tissue transfer to solve this problem. Free flaps are used frequently in reconstruction of the head, neck, and chest with good functional outcomes. Use of the radial forearm free flap (RFFF) for tracheal defects has been reported in several small series [4-8]. Adjuncts, including biodegradative mesh [9] or other non-resorbable material [6-8] as well as costal or auricular cartilage [5,10-12] or long bone [13,14] have been used to provide rigid support to a free soft tissue flap. While successful reconstructive outcomes have been reported, several patients in these series have experienced significant complications. There is currently no consensus regarding an optimal reconstructive procedure or combination of materials. We propose that tracheal reconstruction with a radial forearm free flap and costal cartilage graft represents a reliable method of airway reconstruction with preservation of speech and swallowing functions without need for long-term tracheotomy.

Materials and Methods

Under an IRB-approved protocol, the patient was identified retrospectively and his chart was

Figure 1: Preoperative CT scan showing tracheal tumor compressing esophagus.

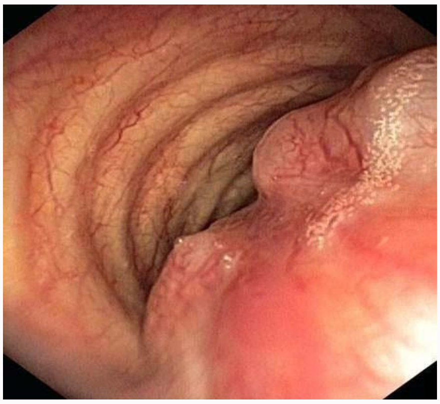

Figure 2: Bronchoscopic image showing tumor arising from posterior tracheal wall.

reviewed for pertinent details. The patient was an otherwise healthy man 50 year old man who presented in March 2012 with dysphagia. Barium swallow showed proximal esophageal compression, and Computed Tomography (CT) scan revealed a mass of apparent esophageal origin (Figure 1). Panendoscopy demonstrated a mass of the posterior tracheal wall (Figure 2). Fine-needle aspiration was diagnostic for adenoid cystic carcinoma, T4aN0M0, stage IVa. Reconstructive surgery of the trachea with laryngeal conservation was planned, as an alternative to total laryngectomy. The defect was anticipated to be too expensive to consider primary tracheal anastomosis.

Surgical technique

Reconstructive surgery was performed in June 2012. Intraoperative laryngoscopy identified tumor originating at the cricoid and terminating about 5 cm below. Resection included the entire posterior tracheal wall, approximately 75% of the diameter of the tracheal rings on the right, and the right thyroid lobe. The lumen of the esophagus was not entered, and the recurrent laryngeal nerves were identified and spared, although the right nerve was extensively dissected during resection. Resection spanned from the cricoid cartilage to 5 cm below, with additional margins taken from the cricoid cartilage until final frozen section margins were negative (Figure 3a), resulting in a defect approximately 5.5 cm in length. A 7 cm portion of cartilage was harvested from the right sixth rib and carved to assume a concave shape. A 6 x 6 cm fasciocutaneous flap centered over the radial artery was harvested from the left forearm. The distal ulnar side of the flap

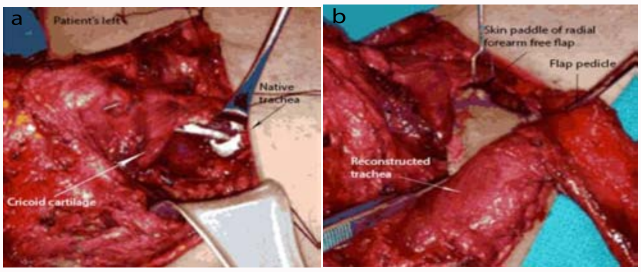

Figure 3: (A) Tracheal defect after tumor resection, spanning from cricoid cartilage to approximately 5.5 cm below. (B) Trachea after reconstruction with radial forearm free flap.

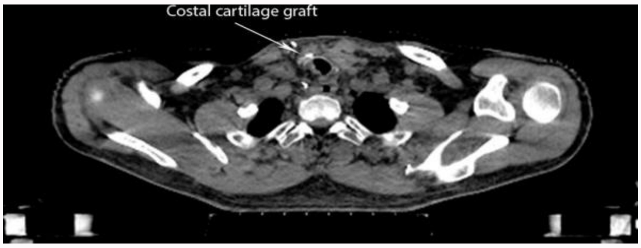

Figure 4: CT scan performed one month after surgery showing patent airway and costal cartilage graft *in situ*.

Figure 5: MRI performed 21 months after surgery demonstrating stability of the radial forearm free flap and costal cartilage construct with no evidence of recurrent disease.

was sutured along the left cricotracheal junction, with the remaining ulnar side of the flap sutured along the left lateral tracheal wall with interrupted 3-0 Vicryl sutures. Silk 2-0 sutures were used to anchor the cartilage to the flap with the concavity of the cartilage facing the tracheal lumen so that the flap would be pulled laterally to increase luminal size. Interrupted 2-0 Vicryl sutures were used to anchor the cartilage graft to the cricoid superiorly and to the native trachea inferiorly (Figure 3b). A low tracheotomy was performed and a size 6 cuffed Shiley tracheostomy tube was placed. A 9-0 running Nylon suture was used to anastomose the radial artery to the facial artery, and a 3.5 mm vein coupler was used to anastomose the cephalic vein and the common facial vein. The strap muscles were closed over the trachea and anchored to the sternocleidomastoid muscle on the left to ensure an airtight closure. A Penrose drain was placed in the right neck and a Jackson-Pratt drain was placed on the left. Postoperative CT images are shown in Figure 4.

Results

A nasogastric tube was placed intraoperatively and removed on postoperative day 7. By the first office visit on postoperative day 14 the patient was tolerating regular diet without complications; his tracheostomy tube was removed at this time. He has had no respiratory complaints, and there have been no flap-related complications. The patient began radiation treatment six weeks postoperatively, receiving a total of 60Gy between August and October 2012. Surveillance MRI 21 months postoperatively (Figure 5) showed an intact flap, patent trachea, and no evidence of recurrent disease. Three years after his operation, the patient is alive with good respiratory function. Recent CT scans have demonstrated multiple bilateral subcentimeter pulmonary lesions consistent with metastatic disease, for which he is being observed. He has intermittently experienced mild dysphagia as a result of radiation treatment, however has been able to tolerate a normal diet and maintain his weight. He also reported slight dysphonia approximately two years postoperatively and was found to have a mild paresis as well as some atrophy of the right true vocal fold. For this he underwent a right TVF injection augmentation with good result, and has had no recurrent voice complaints. He is able to carry out his daily activities normally with good exercise tolerance.

Discussion

Early attempts at tracheal reconstruction employed synthetic intraluminal stents, with the rationale that restoring airway patency and continuity would be functionally sufficient. These approaches frequently failed due to granuloma or scar tissue formation, stent migration, restenosis, and infection [15]. Cadaver allografts were used as tracheal replacements to combat complications seen with synthetic materials, but resulted in similar complications [16]. This experience, combined with the relative failure of pericardial and periosteal autografts [17], suggested that preserving tracheal vascularity was critical for long-term viability of the construct. The use of microvascular free flaps has been somewhat more successful than the aforementioned approaches. Here, we describe a successful case of tracheal reconstruction with RFFF and costal cartilage graft, an approach that has several advantages over others described in the literature. Free tissue transfer uses vascularized tissue which allows for reconstruction of larger areas of reconstruction than would be possible with free grafts. The use of autologous cartilage or bone as rigid support precludes the need for synthetic scaffolds, avoiding potential foreign-body related complications. Our patient's early and sustained decannulation of his tracheostomy demonstrates ability of the construct to recreate a functional airway. Additionally, the operation was carried out in a single stage, in contrast with various two-stage approaches reported by others [5,9,10,12,13]. This aspect is particularly advantageous for patients who cannot tolerate a second surgical procedure due to comorbidity or to healing impairment from factors such as prior chemoradiation treatment or concurrent corticosteroid administration. It also provides the benefit of earlier completion of oncologic and reconstructive surgery allowing for more prompt initiation of adjuvant radiotherapy. An alternative reconstruction could have used an osteocutaneous RFFF, but we chose our method for this young, active patient to avoid the potential fracture risk at the donor site seen with the osteocutaneous RFFF [14]. We also circumvent the requirement for a temporary tracheal stent as seen with the prefabricated and double folded RFFF previously described [5], averting any potential stent-related complications. Finally, our follow-up length of three years has enabled us to demonstrate durability of the reconstructed trachea through postoperative radiation treatment and beyond. In the future, tracheal replacement through the use of either allotransplantation or tissue engineering may be possible. Delaere et al. [18] reported a case of a tracheal allotransplant via orthotopic revascularization in the recipient's forearm and stability of the construct after withdrawal of immunosuppression [19]. In cases of malignancy allotransplantation has historically been considered contraindicated, and the use of this approach without immunosuppression requires further validation. Others [20] have performed successful bronchial reconstruction through the use of autologous stem cells combined with a decellularized tracheal cadaver allograft. These methods require further investigation before use as alternatives to current standards of care.

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