Ultrasonographic Evaluation of a Vascularized Tracheal Transplantation

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Tracheal stenosis is a frequent problem that in most cases is a complication of prolonged intubation. When the stenosis impairs more than half of the length of the trachea, it is not technically feasible to make a resection with a terminoterminal anastomosis. In this clinical context, tracheal transplantation is a therapeutic alternative. We report the case of a patient in whom a vascularized tracheal transplantation was performed successfully and emphasize the importance of an imaging evaluation, particularly with ultrasonography.

Case Report

An 18-year-old patient with a history of head trauma was admitted to the intensive care unit. Because he required prolonged intubation, a tracheostomy was performed. After 8 weeks, when we tried to decannulate, he had shortness of breath. Bronchoscopic and computed tomographic evaluations of the respiratory tract were performed and showed a total occlusion of the tracheal lumen impairing 70% of the tracheal length. Because resection and anastomosis were not possible, a tracheal transplantation (allograft) from a cadaveric donor was considered. The patient and his family accepted this option and gave their consent. The hospital’s Ethics Committee approved the procedure.

The transplantation was performed by anastomosing the donor’s trachea proximally from the first tracheal ring and distally 3 cm above the level of the carina. The trachea was transplanted in conjunction with the thyroid gland on the basis of a technique developed by the surgical team from previous experimental animal models. The arterial anastomosis was performed between the donor’s inferior thyroid arteries and the receptor com-

Abbreviations

DSA, digital subtraction angiography
common carotid arteries. Anastomosis between the right superior thyroid artery and the ipsilateral external carotid artery was also performed. The medium thyroid veins were anastomosed to the internal jugular veins, and the inferior thyroid veins were anastomosed to the innominate veins. Two months later, control catheter digital subtraction angiography (DSA) showed vascular (arterial) perfusion. The venous phase was not clearly shown in the examination. The postoperative evolution of the patient was uneventful, except for a chylothorax that resolved. The patient was extubated after surgery and had no respiratory difficulty; he received immunosuppression therapy to prevent rejection.

Six months after the transplantation, a neck ultrasonographic scan was performed with a high-resolution linear transducer (Voluson 730 PRO; GE Healthcare, Waukesha, WI) that showed the transplanted thyroid gland anterior and caudal to the native thyroid (Figure 1, A and B). Both glands were normal in echogenicity and size. Gray scale real-time ultrasonography showed a normal appearance of the inferior transplanted thyroid arteries. Color Doppler ultrasonography proved vascular perfusion and allowed visualization of the right superior thyroid artery. Power Doppler ultrasonography showed normal flow within the transplanted thyroid gland (Figure 1C). B-mode ultrasonography showed normal dilatation of the carotid artery at the site of the arterial anastomosis (Figure 2A); color Doppler ultrasonography showed reversal of flow at that point (Figure 2B). Spectral Doppler ultrasonography was performed at the origin of transplanted thyroid arteries and showed peak systolic speeds between 32 and 48 cm/s and end-diastolic velocities between 9 and 13 cm/s with high-resistance waveforms (Figure 3B). The evaluation of venous anastomoses was not possible because there were no changes in internal jugular veins allowing differentiation from native thyroid veins. Spectral analysis showed both arterial and venous flow within the transplanted thyroid gland, the latter being an indirect sign of patency of the venous anastomoses.

Discussion

Tracheal stenosis can be secondary to trauma, congenital malformations, inflammatory conditions, or neoplastic diseases. The most frequent cause is prolonged endotracheal intubation, as
was the case in our patient. The typical radiographic finding is a symmetrical narrowing with an hourglass deformity. Eccentric stenosis is less common. Computed tomography, especially with coronal reconstructions, reveals the severity and extension of the stenosis and its relationship with the glottis.

The incidence of tracheal stenosis induced by intubation is rising because of the availability of prolonged life support. Despite the existence of several surgical techniques for tracheal reconstruction, the success rate when damage is extensive (>50% of the length), remains low. In these cases, an alternative for a definite treatment is tracheal transplantation. Successful revascularizations of the larynx and trachea in experimental models have already been reported. A laryngeal or tracheal transplantation must be performed with arterial as well as venous vascularized segments to avoid stenosis or postsurgical malacia. This is why vascularized allografts are currently being used as one of the most reliable surgical methods to repair long tracheal defects.

Figure 2. A, B-mode ultrasonographic longitudinal section showing normal dilatation of the carotid artery at the site of the arterial anastomosis in an 18-year-old man who underwent tracheal transplantation. B, Color Doppler longitudinal view image. The blue area (arrow) at the arterial patch represents reversal of flow.

Figure 3. A, Color Doppler cross-sectional image showing the left inferior transplanted thyroid artery with a loop configuration (black arrow) originating from the left common carotid artery (white arrow) in an 18-year-old man who underwent tracheal transplantation. B, Spectral Doppler image at the origin of a transplanted thyroid artery showing a high-resistance waveform.
The vascular territories of the larynx and trachea depend basically on the superior and inferior thyroid arteries. Revascularization of these organs was shown at the beginning of the last century in a canine model for laryngeal transplantation; however, it was not until the end of the century that it was determined that the superior thyroid artery nourishes up to 13 tracheal rings. The wide anastomoses between these vascular territories allow the revascularization of long tracheal segments. Vascular perfusion is crucial for maintaining the viability of the graft.

We have used different methods for the imaging evaluation of the vascular supply of the graft. In the postsurgical stage, DSA showed the patency of the transplanted thyroid arteries. The spatial resolution of DSA allows a thorough evaluation of the morphologic characteristics of these vessels; however, the well-known complications of this invasive method with the use of potentially nephrotoxic contrast media, especially in patients who receive immunosuppressive drugs with deleterious effects on renal function, makes this a less than ideal imaging modality. In addition, we have used other noninvasive techniques such as magnetic resonance imaging and Doppler ultrasonography to evaluate our patients. Magnetic resonance imaging allows a detailed observation of the venous and arterial systems of the graft. Its drawbacks are its high cost and the lack of compatibility with some supporting elements in the early postoperative stage. Ultrasonography is a low-cost modality that can even be performed as a bedside examination in the intensive care unit, avoiding transportation of the patient to the angiography suite.

Transplantation of the thyroid gland has already been reported as part of a larynx transplant; however, the ultrasonographic appearance of the transplanted gland has not been described. In our patient, real-time B-mode ultrasonography clearly depicted both the native and transplanted thyroid glands, and their anatomic relationships, with homogenous echogenicity. In the evaluation with color Doppler ultrasonography, the maximum systolic speeds on both glands were similar to those reported previously. There were no technical difficulties for the evaluation of the thyroid arteries, in agreement with a previous report. The duplication of thyroid arteries made the evaluation of our patient more complex. It is important to differentiate between the native and transplanted vessels. Two factors can help differentiate the arteries of the native and transplanted trachea: first, the thyroid arteries of the graft originate from the common carotid arteries (Figure 3), which normally do not show branches; second, the presence of dilatation of the carotid arteries is indicative of the site of the vascular patch (Figure 2).

The major complications of tracheal transplantation are vascular in origin. Vascular patch thrombosis is the most serious complication during the immediate postoperative period. An important possible complication of tracheal transplantation is rejection manifested as absent or decreased vascular flow. Later on, endothelial hyperplasia of the nutritious vessels could diminish perfusion to the trachea. Ultrasonography could play a primary role in the detection of vascular complications. Pulsed and color Doppler imaging could show absent flow within the transplanted thyroid arteries and within the transplanted thyroid gland parenchyma. Gray scale ultrasonography could show abnormal transplanted thyroid gland echogenicity as a sign of rejection. It could also detect changes in the wall of transplanted vessels, allowing recognition of intimal thickening as a sign of endothelial hyperplasia.

Although DSA is the standard technique for the evaluation of arteries, we believe that, in the future, Doppler ultrasonography could be an alternative noninvasive method to evaluate the perfusion of the graft, which is one of the most critical predictors of the success of the transplantation. Whether the presence of edema can pose technical difficulties in the evaluation of the neck in the early postoperative stage is not clear. New studies will be necessary to compare the different radiologic techniques in the early postsurgical follow-up of these patients.

In conclusion, ultrasonography can show in detail some of the anatomic changes subsequent to tracheal transplantation (presence of 2 thyroid glands and vascular branches of the graft). Doppler ultrasonography allows the verification of the patency of the arterial branches and the flow in the transplanted thyroid gland, which is one of the useful variables for anticipating the success of the transplantation.
References


