A novel approach to tracheal replacement: The use of an aortic graft

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Tracheal replacement remains one of the most important challenges in thoracic surgery. After tracheal resection of more than 5 to 6 cm, reconstruction by means of an end-to-end anastomosis is not possible. Several conduits have been proposed to confront this unsolved surgical problem, but they have been associated with multiple complications and surgical difficulties:

- Prostheses with the risk of chronic infection, obstruction due to granulated tissue, migration, and erosion into major blood vessels
- Tracheal allografts with the risk of necrosis and stenosis due to poor revascularization and with the need of immunosuppression
- Autologous tissues such as skin, esophagus, and bowel, which

are associated with similar problems in addition to being technically demanding procedures

As Grillo¹ suggested in 1990, we have to remain very imaginative. In our first series of experiments, we evaluated the use of an arterial tissue patch for repairing small tracheal defects. In an additional series, we replaced a 5-cm segment of the trachea with an autologous aortic graft supported by a stent.

Repair of Small Tracheal Defects With the Use of Arterial Tissue

An anterior half circumference of two tracheal rings was resected and replaced with an autologous arterial patch in 10 sheep. All animals received care in compliance with the "Guide for the Care and Use of Laboratory Animals" prepared by the Institute of Laboratory Animal Resources, National Research Council, and published by the National Academy Press, revised 1996. All animals survived the operation. Microscopic examinations after euthanasia at 1, 3, and 6 months showed progressive transformation of the arterial segment into tracheal tissue including a neoformation of cartilage and tracheal mucociliary epithelium. In addition, stenosis occurred in all cases, showing that a stent was necessary for the next experiments.

Tracheal Replacement With an Autologous Aortic Graft

Twenty-five sheep underwent tracheal replacement with an autologous aortic graft. Clinical, bronchoscopic, and histologic examinations were performed up to 1 year after implantation. Technically, through a left thoracotomy, a 5-cm segment of the descending thoracic aorta was harvested, and vascular reconstruction was performed with a Dacron graft. After this, a cervicotomy was performed, and a 5-cm segment of the trachea was resected and replaced with the aortic graft. Finally, an endotracheal stent was placed in the lumen of the new conduit to avoid collapse. We had no intraoperative mortality and one major complication related to the procedure (one stent displacement). More important, however, we observed no stenosis except in one animal that had an airway obstruction due to granulation formation. In addition, we observed progressive transformation of the aortic graft into tracheal tissue comprising a continuous epithelium and an amazing continuous cartilage neoformation in the anterior wall of the trachea (Figure 1) with an anatomically correct membranous posterior wall.

Comment

The more fascinating aspects of this study are the histologic findings, which revealed progressive transformation of the aortic graft into tracheal tissue with a continuous epithelium and a neoformation of organized cartilage. Numerous experimental studies have shown that after epithelial injury, migration of cells from the native trachea leads to regeneration of the destroyed area.² In contrast, mechanisms

Figure 1. A continuous neoformation of organized cartilage was observed in the anterior wall of the neotrachea at 1 year.

of cartilage neoformation remain unclear. Additional studies have to be conducted to explain this unexpected transformation.

Several solutions including prostheses,³ tracheal allografts wrapped in omentum or revascularized,⁴ and various autologous tissues⁵ have been proposed for tracheal replacement. Results have been affected by chronic infection and the formation of granulation tissue leading to airway obstruction for prostheses, by immunologic reactions, necrosis, and stenosis for tracheal allografts, and by necrosis and stenosis for autologous tissues. Some clinical trials using prostheses or tracheal allografts have been performed in human beings, but with poor results that did not permit a standardized clinical approach.

In conclusion, we believe that arterial tissue could be a valuable tracheal substitute. After tracheal replacement with an autologous aortic graft, we detected no stenosis, and we observed progressive transformation of the graft into tracheal tissue. These interesting findings encourage additional studies and offer new perspectives in tracheal replacement.

References

1. Grillo HC. Tracheal replacement. *Ann Thorac Surg.* 1990;49:864-5.
2. Lane BP, Gordon R. Regeneration of rat tracheal epithelium after mechanical injury. *Proc Soc Exp Biol Med.* 1974;145:1139-44.
3. Teramachi M, Okumura N, Nakamura T, Yamamoto Y, Kiyotani T, Takimoto Y, et al. Intrathoracic tracheal reconstruction with a collagen-conjugated prosthesis: evaluation of the efficacy of omental wrapping. *J Thorac Cardiovasc Surg.* 1997;113:701-11.
4. Macchiarini P, Mazmanian G-M, de Montpréville V, Dulmet E, Fattal M, Lenot B, et al. Experimental tracheal and tracheoesophageal allotransplantation. *J Thorac Cardiovasc Surg.* 1995;110:1037-46.
5. Letang E, Sanchez-Lloret J, Gimferrer JM, Ramirez J, Vicens A. Experimental reconstruction of the canine trachea with a free revascularized small bowel graft. *Ann Thorac Surg.* 1990;49:955-8.