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**Experimental Study of a New Porous Tracheal Prosthesis**

R. Guijarro Jorge, MD, A. Sanchez-Palencia Ramos, MD, A. Cueto Ladrón de Guevara, MD, F. Marti Huedo, MD, M. G. de Vega, MD, and F. Paris Romeu

Thoracic Surgery Unit, Hospital General Universitario, Valencia, Spain

We studied the efficacy of a new tracheal prosthesis made of expanded polytetrafluoroethylene reinforced with spiral silicone rings to repair circumferential tracheal defects in rabbits. Results showed an adequate consistency of prosthesis, adequate tolerance without producing tracheal stenoses, and impermeability to air, allowing a correct invasion by granulation tissue. This process was faster than any found in any other porous tracheal implant so far tested. We proved that epithelialization results from capillary invasion through the prosthetic pores and from growth from both tracheal ends. We conclude that this prosthetic material can be useful in repairing tracheal defects and may be the optimal tracheal graft for humans.

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Thoracic Surgery Unit, Hospital General Universitario, Valencia, Spain

Extensive tracheal defects after invasive medical care, trauma, or large resections of tumors remain a major challenge, not solved in general thoracic surgery [1]. When end-to-end anastomosis after extensive mobilization maneuvers is insufficient, a tracheal prosthesis is the solution. Many materials and techniques have been employed to this effect [2]. Such great diversity reflects the ongoing need to develop an ideal solution in this situation.

Research on prosthetic materials for tracheal replacement goes back more than 100 years. Previous studies with nonporous tracheal prosthesis like silicone rubber tubes, stainless steel, and a long list of other materials showed no incorporation of the implant because of developing granulation tissue at the anastomoses [3]. Research soon centered on porous materials, which permitted migration of cellularity and therefore internal growth of fibrous tissue, epithelialization, and bioincorporation of the implant.

Several conditions must be met by an ideal porous tracheal prosthesis. It must be easy to handle and cut to size. It must be also highly biohistocompatible, rigid enough to prevent it from collapsing, and impermeable to air. Several authors [4] have suggested that polytetrafluoroethylene could be an optimum material for such use.

In 1990 we reported an experimental study in rabbits using a new porous reinforced tracheal prosthesis made of expanded polytetrafluoroethylene [5]. In that article, we concluded that a necessary condition for full bioincorporation of the prosthesis was full epithelialization of its inner surface, because if this did not occur, granulation tissue from the surrounding tissues would grow and occlude the graft or cause a fatal tracheal stenosis. Since then, other experimental and clinical studies [2, 6] have concluded that the lack of epithelial lining on the luminal surfaces and inadequate biophysical properties and shapes of the prostheses were the main causes for failure of them.

Several surgical and experimental strategies have been thought of to solve this, like seeding isolated respiratory cells on the luminal surface [1], use of revascularized tracheal grafts [7], and omental wrapping [8]. We designed another experimental study [9] thinking that growth of epithelium in the tracheal prosthesis mainly was from resection edges, although is also possible microemboli from endothelial neoformed vessels surrounding the prosthesis can have a transmural invasion. This vascular invasion was closely dependent on the microporosity of the material (30 μm diameter in the prosthesis we use). This fact is very important in understanding why these implants are so well accepted. Bigger microporosity is not aerostatic, and smaller or no microporosity like in silicone tubes does not allow invasion from the surrounding tissues or allow fibroblasts to pass through the wall.

The epithelial growth from the resection edges is limited (and in most experimental models is never com-
plete), so trying to improve host tissue incorporation we used low-powered laser irradiation (904 nm). Preliminary studies of this have been published [9]. Granulation and epithelialization were found to be far better in the irradiated group than among the nonirradiated controls. Laser irradiation favors microcirculation and gets more speed in growth of epithelium from resection edges.

Results are encouraging from this and other studies that have used polytetrafluoroethylene as a prosthetic material to patch the trachea, although further experimental work must be undertaken before polytetrafluoroethylene can be applied in operations on the human trachea.

References