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Clinical experience with retrograde lung preservation

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Abstract Previous reports and our own experimental work suggest increased vascularity of the tracheobronchial wall when retrograde lung preservation is used. This principle was clinically applied in 21 consecutive lung transplant recipients (10 single and 11 bilateral). Lung preservation was achieved via the left atrial appendage and drainage was obtained through the pulmonary artery. Pneumoplegic preservation was achieved with modified Euro-Collins solution. Cardioplegia was induced by the standard method and the heart, harvested by different teams, did not exhibit left ventricular dilatation. Thirty-two bronchial anastomoses without wrapping were performed. No primary lung graft failure was documented. Cardiopulmonary bypass was instituted in three cases of pulmonary hypertension; however, this was deemed unnecessary in the remainder of the cases of bilateral transplantation while the second organ was being implanted. All bronchial anastomoses were followed between 2 and 28 months. A single instance of bronchial anastomosis dehiscence was observed on the 30th postoperative day. However, no stents were employed in this series, and no strictures or anastomotic granulomas have been reported so far. All the hearts could be used satisfactorily except for one primary graft failure. In conclusion, retrograde lung preservation is feasible in clinical lung transplantation, with simultaneous harvesting of the heart. The impact of retrograde lung preservation on the late clinical outcome remains to be seen.

Key words Retrograde lung · preservation · Left atrial appendage · Intraparenchymal bronchial circulation

Introduction

The success of clinical lung transplantation represents new prospects for the treatment of the increasing number of patients with end-stage lung disease. However, the number of such operations currently being done is limited, mainly due to the scarcity of donors. This shortage has led to the development of a variety of lung preservation techniques, which are of particular value when an organ must be transported from a distant donation site to the transplantation center [3, 5, 8].

Different techniques have been designed to provide adequate lung preservation by antegrade pulmonary artery flushing (PAF) with a preservation solution, generally modified Euro-Collins solution (EC) or University of Winconsin organ preservation (UW). Yet, despite these pharmacological advances, early allograft dysfunction remains a problem. An entirely new concepts is represented by the retrograde instillation of preservation solution through the left atrial appendage (RELA), using the pulmonary artery for outflow. The first report in three cases of human heart-lung transplantation was done by Sarsam [10].

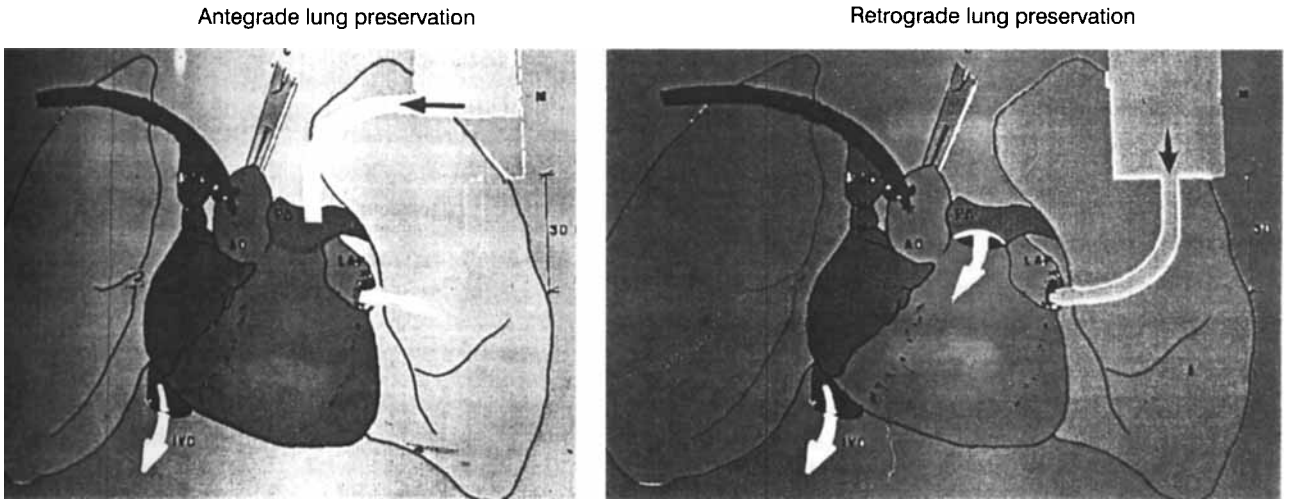

Fig. 1 **a** *PAF* Pulmonary artery flush. **b** *RELA* Retrograde left atrium flush

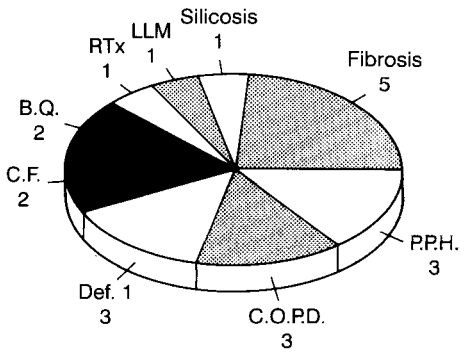

Fig. 2 Clinical experience with retrograde lung preservation. Diagnoses: *PPH* primary pulmonary hypertension, *COPD* chronic obstructive pulmonary disease, *DEFI* deficit and 1 antitrypsin, *CF* cystic fibrosis, *BQ* bronchiectasis, *RTx* retransplantation, *LLM* lymphangioleiomyomatosis

This original approach has been successfully employed in our laboratory and in 21 consecutive lung transplantation procedures. The observations and direct implications derived from this limited experience constitute the basis for the present report. The purpose of this analysis is to: (a) describe the advantages of RELA over PAF and (b) hypothesize on the role of intraparenchymal bronchial circulation in lung graft preservation.

Material and methods

Twenty-one consecutive lung transplantation procedures (10 unilateral and 11 bilateral) were carried out after lung preservation by the "retrograde technique" (Figs. 1, 2). This was accomplished using a short-tipped William Harvey cannula (Bard and William Harvey, Santa Ana, California, USA) for instillation of the pneumoplegic solution with modified EC (Laboratorios Esteve, Barcelona, Spain) through the left atrial appendage (retrograde), with outflow through the pulmonary artery (RELA).

Cardioplegia was induced previously with 1 l of a crystalloid solution instilled into the aortic root. A 14–16 cannula was positioned in the left atrial appendage for retropneumoplegia. A single bolus of prostaglandin E1 (500 mg) was injected into the pulmonary artery prior to pulmonary flushing with normothermic (1000 ml) and later cold (3000 ml, 4 °C) pneumoplegic solution. The effort was made to keep the solution 30 cm above table level to prevent pulmonary edema. The time taken for this technique is usually about 5 min. Left ventricular distension was prevented by venting the pneumoplegic solution through the anterior aspect of the pulmonary artery. Both pleural cavities were opened and irrigated with continuous cold saline slush to further enhance graft preservation. The heart was removed and the double-lung block excised adequately and immersed in a cold solution for transport.

The procedure in the recipient was performed via lateral thoracotomy for unilateral lung transplants or the "clam-shell" incision for bilateral lung transplants with or without cardiopulmonary bypass. The native lung(s) was (were) excised and the appropriate stumps created for the bronchial airway and vascular pedicles.

The airway anastomoses were done with a running 4-0 PDS (posterior row) and single-interrupted stitches (anterior row). The telescope technique was only employed when obvious disparity existed between donor and recipient bronchi. Otherwise, no attempts were made to wrap the anastomoses.

Results

No primary graft failure was detected in this limited series. Gas exchange was satisfactory in all cases, and extubation was carried out within the first 48 h in most patients. Chest X-rays were mostly within normal limits.

No strictures nor granulomas have been observed to date during a mean follow-up period of 2–28 months. One case of airway dehiscence was observed 30 days af-

ter the operation, and this was the only case requiring retransplantation in our experience.

All the hearts harvested in the above manner could be used immediately. Graft failure (hyperacute rejection?) occurred in only one case.

Discussion

Clinical lung transplantation has been impeded by inadequate graft preservation and subsequent allograft dysfunction, thus limiting the number and quality of procedures worldwide. Initially, lungs were harvested in situ and transplanted immediately in an effort to minimize organ injury [1]. Different protocols were subsequently established to preserve lung allograft function, including donor-core cooling [6, 13] and PAF with either modified EC [11] or UW [4]. Both gained wide acceptance when associated with a single intravenous prostaglandin bolus for pulmonary vasodilation. This resulted in superior lung preservation but, as a preservation strategy, it ignores the bronchial circulation. RELA flushing of the preservation solution was introduced to address this problem.

The pulmonary venous circulation is a low-resistance high-capacity system. Flushing of preservation fluid through this system is straightforward and results in rapid and uniform distribution of the solution [9]. Timing for administration of the pneumoplegic solution does not hamper delivery of the cardioplegia, and both can be flushed at the same time or once the heart is arrested, since most RELA drainage exits through the anterior aspect of the pulmonary artery.

Furthermore, it has been shown in three cases of heart-lung transplantation that no left ventricular dilatation occurs despite transatrial cannulation for preservation [10]. Part of the solution exits through the aortic valve as in antegrade flushing, returning via the coronary aorta and coronary sinus to the right atrium, from where it is expelled via the venae cavae when these are transected prior to heart removal. Neither EC nor UW solution alters in any way the coronary artery endothelium [12].

The bronchial circulation is also known as the pulmonary systemic network and supplies not only the extra/intrapulmonary airway system, but the neurovascular bundles, lymphoid structures, and visceral pleura, as well [2]. Bronchial veins from the upper airway (especially the extrapulmonary veins) drain into the right heart chambers via the venae cavae, while those arising from the intrapulmonary airway and parenchymal systems drain into the left heart via the pulmonary veins. The latter constitutes the so-called "pulmonary collateral", "bronchopulmonary anastomotic," or "bronchial-pulmonary systemic" blood flow, the role of which has been well defined by Lo Cicero et al. [7]. They demonstrated the architecture of the bronchial circulation, in a rather complex but conclusive manner, by perfusing a closed segment of the mid descending thoracic aorta and collecting the resultant solution in the left atrial appendage. However, the real implications of bronchial-pulmonary preservation are still unclear and remain to be elucidated. Another point that deserves further discussion is that of the revascularization of the bronchial circulation and its impact on medium-term function of the graft, as well as the development of bronchiolitis obliterans.

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