MORPHOLOGY OF NON-VENTILATED TRANSPLANTED RAT LUNGS

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Morphological changes in lung tissue of heterotopic heart-lung transplants have been studied 28 days following transplantation in 20 rats. Lung tissue showed disperse haemorrhagic necrosis often sparing bronchi and branches of pulmonary artery and conspicuous accumulation of bronchial secretion. Partial disappearance of cardiac muscle cells from the walls of pulmonary veins has been ascribed to tissue hypoxia.

INTRODUCTION

The weight of hearts of adult mammals is determined, to a major part, by the haemodynamic workload that depends on the vascular impedance and the functional needs of the organism. The increased haemodynamic load results in higher functional demands leading to hypertrophy. In contrary, decreased work of the heart is followed by its atrophy. We have used heterotopic transplantation of the rat heart as an experimental model for the study of cardiac effects of decreased workload. One of the modifications of this procedure[1] preserves a part of the pulmonary circulation through a part of the right lung that is transplanted together with the heart.

The primary goal of our experiment was to follow functional and morphological changes of the transplanted hearts. These show rapid decrease in weight during several days after transplantation[2]. Non- ventilated transplanted pulmonary lobes deprived of bronchial circulation also undergo profound changes, as illustrated in this short communication.

MATERIAL AND METHODS

Twenty adult inbred male Lewis rats were used in the experiment. Hearts from donors of the same body weight were transplanted as described previously[2]. Briefly: Following anaesthesia and heparinization, thoracic cavity of a donor rat was opened and the heart was arrested by cold saline and ice. The aorta was connected to a cannula and the heart was perfused with 20 ml of cardioplegic solution (Plegisol, Abbott Laboratories, Chicago, USA). Both the superior and inferior vena cava were ligated and the left lung together with the upper lobe of the right lung were removed.

The abdominal aorta of the recipient rat was isolated in the infrarenal region and occluded with a special clamp. The ascending aorta of the donor heart was connected to the abdominal aorta of the recipient in an end-to-side anastomosis.

Following the release of the clamp, the heart was perfused with blood and resumed its pulsation. The circulation in this heart-lung preparation is illustrated in Fig. 1. The myocardium is perfused through coronary arteries. The effluent from the sinus venosus enters pulmonary artery and perfuses the lung from which blood returns to the left atrium and left ventricle. From the left ventricle, blood is expelled to the abdominal aorta and mixes with blood coming from the abdominal aorta of the recipient rat.

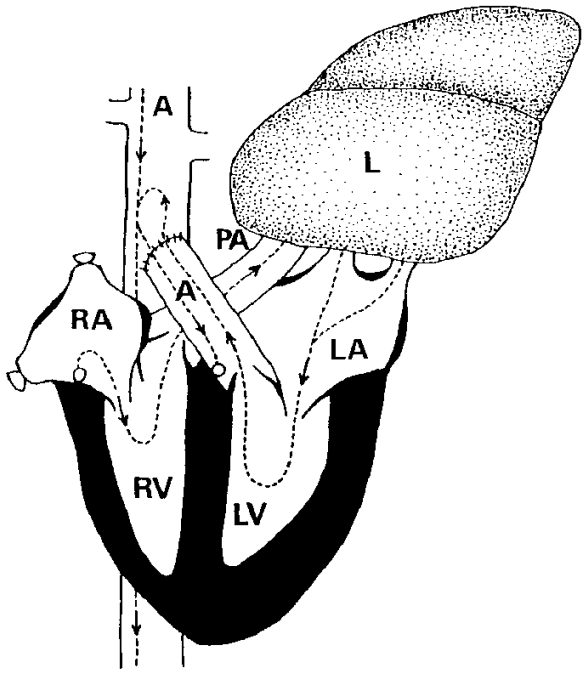

Fig. 1. Schematic drawing of blood circulation through the heart-lung transplant (A-aorta, L-lung, PA-pulmonary artery, RA-right atrium, RV-right ventricle, LA-left atrium, LV-left ventricle).

RESULTS

Histological changes in the atrophic hearts are described elsewhere[3].

Lungs of recipient rats were used as controls. They showed normal structure except for occasional foci of peribronchial lymphocytic infiltrate.

Parenchyma of most of the transplanted lungs did not collapse despite the absence of ventilation. Ten lungs showed extensive hemorrhage, often with appearance of haemorrhagic infarct usually sparing branches of pulmonary artery and bronchi. The non-haemorrhagic parenchyma frequently contained haemosiderin, mostly intracellular in mononuclear macrophages and in multinuleated giant cells. Some of the branches of pulmonary artery appeared contracted (Fig. 2), occasionally there was focal hypocellularity of the media indicative of segmental necrosis of the arterial wall. There were no major changes in the branches of bronchial arteries. Large bronchi were dilated, sometimes cystic, filled with mucinous secretion and scattered polymorphonuclear leucocytes. Small bronchi did not show any remarkable abnormalities except for mucostasis and an increased number of goblet cells in their epithelium. Occasionally bronchial mucus expanded the surrounding alveoli (Fig. 3).

Large branches of pulmonary veins of the control recipient lungs regularly contained striated muscle cells resembling cardiac muscle cells. The number of these muscle cells appeared markedly decreased in the walls of pulmonary veins of donor lungs (Fig. 4).

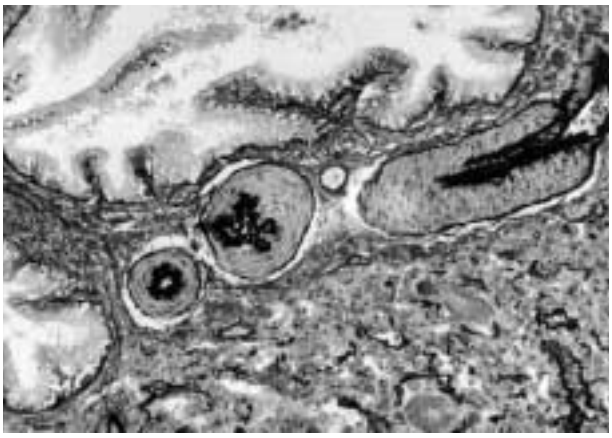

Fig. 2. Contraction of branches of the pulmonary artery in a haem rrhagic lung. Electica-van Gieson, x 220.

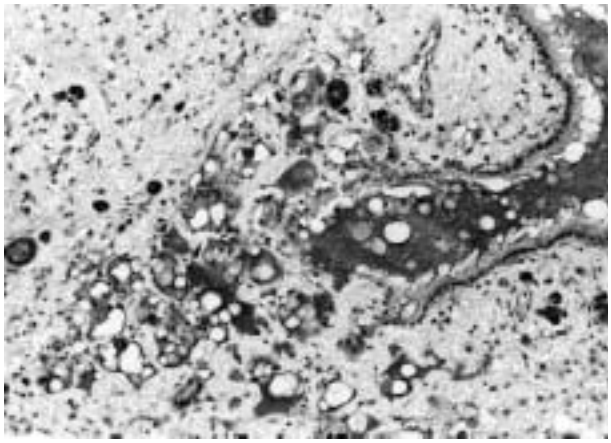

Fig. 3. Mucostasis in a small bronchus and the neighbouring alveoli. x 220.

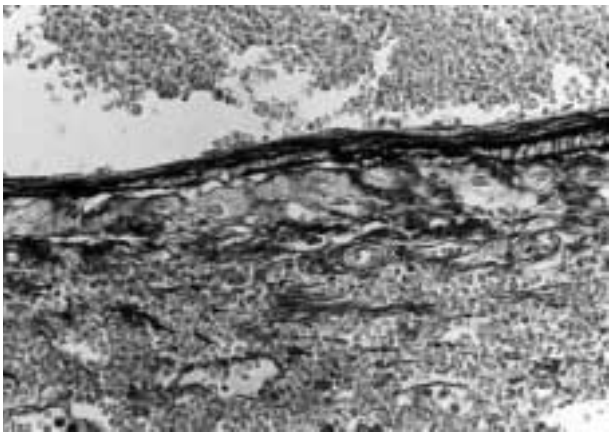

Fig. 4. The wall of a pulmonary vein of a donor lung showing reduction in number of the striated muscle cells. Elastica-van Gieson, x 440.

DISCUSSION

Except for a remote resemblance to human extralobar pulmonary sequestration[4], it would be difficult to find, in human pathology, a situation that would resemble the result of this experimental procedure. In extralobar pulmonary sequestration, the ectopic lung tissue is supplied by fully oxygenated blood flowing under systemic pressure through branches of the pulmonary artery. In our experiment the oxygen tension in the lung must have been decreased. Contrary to the situation of human pathology, blood pressure in the donor lung of our experiment was low, determined by a relatively small blood flow through the coronary circulation of the transplanted heart. We therefore could not see hypertensive pulmonary angiopathy observed in experimental hypobaric hypoxia[5,6] or plexogenic angiopathy reported in human intralobar bronchopulmonary sequestration[7]. The reduced workload was reflected in an atrophy of the right ventricle. The degree of atrophy was comparable with that of the left ventricle. Blood supply through the bronchial arteries was totally interrupted in the transplanted lungs. Preservation of branches of pulmonary artery and of bronchi in haemorrhagic areas may have been caused by the proximity of the life-preserving blood supply and by lesser metabolic demands compared with the rest of the pulmonary parenchyma. The only close similarity of our experiment with pulmonary sequestration in human was an absence of drainage of occluded bronchi, leading to a massive stasis of bronchial secretion. The duration of the experiment was too short for further development of morphological changes similar to those seen in human cases of pulmonary sequestration[8].

Striated muscle cells resembling cardiac muscle cells are normal constituents of the walls of pulmonary veins in laboratory rats. Previous study has shown extension of the „pulmonary myocardium“ in rats exposed to high-altitude hypoxia[9]. Reduced presence of cardiac muscle cells in transplanted lungs of this experiment could have been caused by severe acute post-transplant hypoxia.

According to the experimental design, all rats were sacrificed 28 days after transplantation. We therefore could not follow morhogenesis and further development of the abnormalities observed in the donor lungs.

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