Evaluation of the Reimplanted Lung by Lung Scanning in Dogs

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Eighteen dogs who survived left lung reimplantation were submitted to repeated lung scans at intervals up to six months postoperation. In five dogs the scans were normal or near normal. The reimplanted lungs in these animals appeared grossly normal and the pulmonary angiogram and microscopic appearance were also normal. The lung scans in eight dogs had diminished perfusion of the left upper lobe. In these lungs there was loss of volume of the upper lobe but the angiogram was otherwise normal. Histologic abnormalities were found in some of these upper lobes. Five dogs showed no perfusion of the left lung which emphasized that survival of the animal is not necessarily associated with function of the lung. Lung scans were helpful in evaluating the pulmonary vascular bed of reimplanted lungs and in some cases where the angiograms appeared normal abnormalities were demonstrated in lung scans. In the present study no attempt was made to compare the abnormalities of pulmonary function.

In the 17 years since Juvenelle and co-workers1 reported the first successful reimplantation of the lung in a dog, many aspects of the function of the transplanted lung have been studied.

Regeneration of the lymphatics,2 the bronchial arteries3 and nerves4 have been reported at varying intervals following reimplantation. Temporary, and in some cases permanent, pulmonary hypertension has been noted after transplantation in many of the surviving animals and this was accentuated by contralateral pneumonectomy or pulmonary artery ligation.5 The cause of this pulmonary hypertension has not been established but it was usually associated with a normal pulmonary angiogram.6

Lung scanning using macroaggregated serum albumin tagged with 131I has been undertaken in 18 dogs who survived left lung reimplantation to study the postoperative changes in the pulmonary vascular bed.

METHODS

Mongrel dogs weighing from 20 to 35 kg were used for this experiment. The technique which has been developed by others8 was used. The chest was opened through the left fifth interspace and the hilar dissection was followed by division of the pulmonary artery, the bronchus and the left atrial cuff, in that order. The left lung was removed and perfused with normal saline containing 25 mg of heparin in each 500 ml of perfusate. The lung was reimplanted using a continuous 5-0 silk suture for the atrial cuff and pulmonary artery and interrupted 3-0 silk for the bronchus. The chest was drained for two to three hours postoperatively and ampicillin 250 mg twice daily was injected for seven postoperative days. Systemic heparin was not used.

The lung scans were carried out under pentothal sodium anesthesia using 50 micrograms of macroaggregated radioactive serum albumin. The scans were undertaken at varying postoperative periods from ten days to six months and in most animals several scans were performed.

The animals were killed and after removal of the heart and both lungs en bloc, an angiogram using 50 percent hypaque was done. The lungs were inflated at this time. Histologic preparations were also made of the reimplanted lung.

RESULTS

Of the 18 dogs, five had normal or near normal lung scans (Fig 1). These scans were repeated at intervals up to six months postoperation.

In five dogs, the lung scan showed no perfusion of the left lung. Three of these were due to pulmonary vein thrombosis and it was of interest that this was

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FIGURE 1. A near normal lung scan, three months after left reimplantation. There is very slight reduction in perfusion of the left upper lobe.

compatible with good health in one of the dogs for a period of four months following operation, when the animal was killed. In the other two dogs complete bronchial occlusion at the suture line with normal, patent artery and veins, was found at autopsy.

In the remaining eight dogs, there was abnormality in perfusion of the left lung. The scan in these eight dogs had a similar appearance, with reduced perfusion of the left upper lobe but near normal perfusion of the left lower lobe (Fig 2). In these animals the appearance of the lung following sacrifice of the dog commonly showed diminished volume of the left upper lobe, a change which had been suggested on chest x-ray films of these animals. However, the angiograms performed at autopsy showed little difference between the group with normal scans and the group with reduced perfusion to the left upper lobe (Fig 4 and 5).

Histologic studies have shown the presence of focal areas of fibrosis with disruption of alveolar walls and atelectasis in some of these shrunken upper lobes. The microscopic appearance of the lower lobe has been close to normal.

DISCUSSION

In previous studies of reimplanted lungs, the oxygen consumption and ventilatory function was found to be decreased, pulmonary compliance was decreased, and pulmonary artery pressures were elevated.7-8 The exact changes in the vascular bed of the reimplanted lung leading to this pulmonary hypertension have not been identified, but selective angiography has shown good filling with no abnormality.9

133Xenon scans were used to study the autotransplanted lung in three dogs.10 These studies suggested that pulmonary hypertension of the autograft may be due to such factors as atelectasis or increased resistance to venous flow.

The histologic appearance of the reimplanted lung has been contradictory in previous studies. Some authors8 have recorded normal terminal respiratory units associated with sclerosis of the bronchial arteries and dilatation of the lymphatic ducts on microscopic examination of the reimplanted lung. Other workers11 have reported thickening of the al-

Figure 2. An abnormal scan with deficient perfusion of the left upper lobe, four months after left reimplantation.

Figure 3. A normal preoperative lung scan.
lobe has been less marked and the histologic differences between the upper and lower lobes have been less obvious. Nevertheless there has been no strict correlation between lung scan deficiencies and histologic abnormalities. There has been some minor variation in the lung scans performed at different times in the same animals which could not be explained.

It is of interest to speculate whether there may exist a relationship between the previously reported pulmonary hypertension associated with lung reimplantation and abnormal perfusion of part of the lung, but no attempt was made to confirm this hypothesis in these experiments.

In the past, it was felt that contralateral pneumonectomy or contralateral pulmonary artery ligation was the best method of determining whether a transplanted lung was functioning adequately.\textsuperscript{13} It was hoped that lung scanning would prove to be a simpler method of assessing the status of the vascular bed of the transplant.

The lung scans have been of value in differentiating the various degrees of structural abnormality as correlated with the gross autopsy findings. The relationship between the lung scans and other parameters of pulmonary function was not investigated in this study.

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**Figure 4.** A postmortem pulmonary angiogram of a dog showing deficient perfusion of the left upper lobe on scanning. Note the loss of volume of the left upper lobe, but with otherwise normal branches and distribution of the vessels.

**Figure 5.** A normal postmortem pulmonary angiogram in a dog which showed a normal scan.
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SYMPHONIES IN GRANITE AND MARBLE

Michelangelo Buonarroti (1475–1564) established himself as incomparably the greatest artist in the world in painting, in sculpture and in architecture. In addition to this, he was celebrated as an engineer and he also wrote some of the finest poems in the Italian language. He commanded an almost idolatrous veneration from practically all the younger artists of his day and his personal piety was such that it became a byword among his contemporaries; he was, for example, the friend of St. Ignatius Lovola, the founder of the Society of Jesus. Although he always claimed to be a sculptor and nothing else, he soon found himself compelled to paint the vast fresco cycle on the vault of the Sistine Chapel and, with the original designs for the projected monument to Julius II, he found himself involved in architectural activity. Michelangelo spent the last thirty years of his life in Rome where he began a number of architectural commissions. By far the most important was the work done at St. Peter's. When he died, he had nearly finished the drum of the dome, but the dome itself as it exists, although probably the most beautiful in the world, by no means corresponds to Michelangelo's intentions. It was built between 1585 and 1590 by Giacomo della Porta and Domenico Fontana.


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