Experimental Study on Angioplastic Procedures of the Pulmonary Artery

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To solve problems arising during angioplastic procedures of the pulmonary artery, experimental studies using canine lungs were performed. Since the lung has dual adjacent components, i.e. pulmonary arteries and bronchi, sleeve resection of the pulmonary artery should be limited in length when not combined with bronchoplastic procedures. In such cases we used Gore-Tex as an artificial graft for replacement of the resected pulmonary artery and obtained good results.

During the angioplastic procedures the main pulmonary artery and/or bronchus may be completely occluded, hence the risk of acute pulmonary edema in the remaining lung increases with long operations. From the results of this experiment it appears that the time required for operation with interruption for both perfusion and ventilation is about 2 hours.

(Key Words: Angioplastic Procedure, Pulmonary Artery, Gore-Tex, Pulmonary Edema)

INTRODUCTION

Angioplastic procedures, similar to bronchoplastic procedures, are useful operative methods to preserve normal lung tissues, particularly in patients of advanced age and/or limited respiratory reserves. We reported eight patients with lung cancer who underwent angioplastic procedures on the pulmonary artery and emphasized the clinical usefulness of these methods in another paper (5).

However, some problems accompany such methods. Since the lung has dual adjacent components, i.e. pulmonary arteries and bronchi, sleeve resection of the pulmonary artery is limited in length for end-to-end anastomosis. In cases of combined resection of both the pulmonary artery and bronchus, we performed sleeve resections of the pulmonary artery by as much as 4.7 cm length followed by end-to-end anastomosis because the residual lung could easily be moved. However, in case of angioplasty only, we could not resect the pulmonary artery by more than 3 cm, which appeared to be the maximum length for end-to-end anastomosis.

The other problem involved in angioplasty is harmful effects on the lung tissue by occlusion of the pulmonary blood flow during the operative procedure. If chronic occlusion of the pulmonary blood flow occurs, the bronchial artery develops in compensation for the pulmonary artery, but if acute occlusion of the pulmonary blood flow takes place for several hours, it has been reported in canine lungs that biochemical and structural deterio-
rations are observed even though the bronchial artery remains and ventilation is maintained (3,4).

Recently we have used one lung anesthesia to facilitate the operative maneuver (1). Under this anesthesia both perfusion and ventilation in the residual lung are completely interrupted, and it can be assumed that lung injury occurs because of such interruptions.

To solve these problems we have performed the following experiments using canine lungs.

MATERIALS AND METHODS

EXPERIMENT 1

Six mongrel dogs were used. Under anesthesia with sodium pentobarbital, each dog was intubated with a cuffed endotracheal tube and ventilated with a respirator. After left thoracotomy, left upper lobectomy was performed and the left pulmonary arteries were occluded with vascular clamps. Sleeve resection of the pulmonary artery was done, leaving apart necessary for suture. This was followed by replacement with Gore-Tex as an artificial graft. Two kinds of Gore-Tex, 4mm and 6mm in diameter, were used and end-to-end anastomosis was performed with prolene 6-0. After pulmonary angiography was performed 3 weeks to 8 months after the replacement, the animals were sacrificed and Gore-Tex was extracted for macroscopic observations from the interior.

EXPERIMENT 2

Ten mongrel dogs were used. Anesthesia and ventilation were the same as in the above experiment. Left thoracotomy was performed in each dog and then the left main bronchus and pulmonary arteries were occluded simultaneously for 2, 3, 5, and 24 hours. After the occlusion was stopped, the left lung was reexpanded and examined for damage by macroscopic and chest X-ray findings. To determine whether the lung injury induced by occlusion of both the perfusion and ventilation was reversible, the chest wall was closed and then reopened 7 days later, and the difference between the left and the right lung was examined.

RESULTS

When Gore-Tex 4mm in diameter was used, marked stenosis of the anastomosis was observed. However, when Gore-Tex 6mm in diameter was used, almost satisfactory results were obtained. Fig. 1 shows a pulmonary angiogram and specimens obtained after the replacement. There was no particular stenosis in the suture line and the inside of the Gore-Tex was generally covered with uniform and thin neointima.

Other than in the above mentioned experiment, we used Gore-Tex as patches for covering defects made after partial resection of the wall of the pulmonary artery. In this experiment good results were also obtained and it was felt that Gore-Tex was useful in cases where the pericardium or pleura were too thin to be used as patches.

When both perfusion and ventilation were interrupted for 5 and 24 hours, rapid and severe pulmonary edema occurred with bloody and foamy
Fig. 1  Pulmonary angiogram and resected specimen 5 months after replacement by Gore-Tex in the canine lung.
There is no particular stenosis in the suture line (Arrow) and the inside of the Gore-Tex is covered with uniform and thin neointima.
sputum just after the release of the pulmonary artery and bronchus (Fig. 2). When interrupted for 3 hours, the left lung appeared reddish in the macroscopic examination after reexpansion, but this was not so severe as in the former cases. However, chest X-ray film 7 days later showed persistence of pulmonary edema when compared with the right lung (Fig. 3B). When interrupted for 2 hours, the left lung showed no abnormal findings in the macroscopic examination or chest X-ray film just after the release or 7 days later (Fig. 3A).

DISCUSSION

Gore-Tex has a good antithrombotic effect and is superior to Teflon and Dacron since it causes less late occlusion by intimal thickening. This artificial graft has been used widely for construction of the peripheral arteries or superior vena cava, but few cases of its use in pulmonary artery reconstruction have been reported (2). Although it is not completely free from problems in long term observations, good results were obtained in an 8 month experiment in canine lungs. Gore-Tex is naturally a foreign body and its clinical use should be confined to limited cases such as when end-to-end anastomosis can not be performed for long sleeve resection of the pulmonary artery. We believe that sleeve resection with replacement by Gore-Tex will become a useful method in the future.

From the results of experiment 2, it appears that the time limit for
Fig. 3  Chest X-ray films on 7th day after 2 hours (3A) and 3 hours (3B) of interruption of both perfusion and ventilation. 3A shows no abnormal findings but 3B shows pulmonary edema in the left lung.
operations with interruption of both perfusion and ventilation is about 2 hours. Experimental studies on preservation of canine lungs have also shown that 3 hours of interruption of both perfusion and ventilation causes histological changes such as bleeding, congestion and edema in the lung (6). These results agree with our results.

Clinically pulmonary angioplastic procedures can almost all be completed within 2 hours, but when combined with bronchoplastic procedures, the time needed for the operation may be more than 2 hours. In these cases we must take proper measures such as inflation of the operated lung.

REFERENCES


