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Experimental Assessment of Restoration of the Bronchial Artery in Sleeve Lobectomy Combined with Pulmonary Angioplasty

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The restoration of the bronchial artery after bronchoplasty combined with pulmonary angioplasty was studied in relation to the degree of stenosis of the pulmonary artery by means of the microangiographic technique. Thirty-three dogs were used in this study.

They were divided into Group A (15 dogs) with sleeve lobectomy alone, Group B (10 dogs) with sleeve lobectomy and a 50% stenosis of the left main pulmonary artery and Group C (8 dogs) with sleeve lobectomy and a 75% stenosis of the left main pulmonary artery.

The restoration of the bronchial artery was assessed by microangiography.

1) The restoration of th bronchial artery after bronchoplasty was completed on day 14. The trend toward a ready regeneration of the bronchial artery becomes apparent if some degree of stenosis of the pulmonary artery exists after a duration of seven days.
2) The interrupted bronchial artery starts to restore at the adventitial face and extends throughout the whole wall of the bronchus after the 7th day.
3) From these results, an operative procedure of sleeve lobectomy with pulmonary angioplasty is applicable even though stenosis of the pulmonary artery remains to some degree.

INTRODUCTION

With advances in surgery, it has become popular to use an operative procedure of bronchoplasty in the surgical treatment of hilar type of lung cancer.

Furthermore, the bronchoplastic procedures and their combinations with pulmonary

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angioplastic procedures are not infrequently indicated for those who have limited cancer invasion in the wall of the pulmonary artery.

The outcome of using this operative technique was satisfactory in the avoidance of postoperative cardiopulmonary crisis and subsequent cor pulmonale. The use of this operative technique offers the advantage of either preserving the postoperative cardiopulmonary function in older patients or enhancing the surgical curability.

Increasing attention has been given to the nutritional blood flow of the lung, which is interrupted by the bronchoplastic procedure. It is clear that the blood supply of the pulmonary artery plays an important role in maintaining the nutritional blood flow through the bronchial artery which is interrupted by the bronchoplastic procedure itself. On the basis of clinical results, the bronchoplastic procedure gives better pulmonary function following surgery without any nutritional deficency of the lung.

A stenosis of pulmonary artery to some extent following angioplasty inevitably ensue due to technical errors, distortion in the anastomotic site and compression by scar formation around the tissue and so on.

The aim of this study is to clarify the role of pulmonary arterial blood flow with respect to the nutritional aspect in the lung undergoing bronchoplasty combined with angioplasty.

METHOD

Mongrel dogs weighing from 7 to 15 Kg were anesthetized with 25 mg/Kg of sodium pentobarbital, intubated with a cuffed endotracheal tube and ventilated with room air using a Havard volume respirator with 200−300 ml of tidal volume.

Thirty-three dogs were divided into three grougs.

Group A consisted of 15 dogs with sleeve anastomosis between the left main bronchus and the left lower bronchus after a left upper lobectomy. Group B consisted of 10 dogs with a sleeve lobectomy and snaring of the left main pulmonary artery with the artificial dura mater (Silastic sheeling 501-1, Dow Corning Co.) 0.5-0.7 cm wide, to make a 50% stenosis which corresponds to two-third of the outside diameter of the pulmonary artery. Group C consisted of 8 dogs with a sleeve lobectomy and a 75% stenosis of the left main pulmonary artery.

These dogs underwent the pulmonary angiography by means of the right cardiac catherization using the Cournand 7F catheter to evaluate the degree of stenosis in the pulmonary artery and were sacrificed during a period of the first day to 7 months. At autopsy, the postmortem bronchial arteriography was performed to evaluate the vascular anastomosis between the bronchial artery and the pulmonary artery as shown in the following manner.

Left thoracotomy was made at the fifth intercosal space. The descending aorta was separated at both levels just distal to the origin of the left subclavian artery and proximal to the diaphragm. The No. 7 Nelaton catheter was introduced into the separated descending aorta, 500 ml of saline with heparin of 10 mg was infused and blood

in the aorta was washed out.

The cut-down tube (c-o type) was also inserted into the left main pulmonary artery and 500 ml of saline was infused with gravity drip of 60 cm high, keeping the wall of the left artium opened. Thirty to sixty ml of the radiopaque medium of 30% barium sulfate heated to 40°C was given through the No. 7 Nelaton catheter and introduced into the descending aorta. During this procedure the left thoracic cavity was cooled with ice slush filled in place.

It took about 30 minutes until the infused contrast medium became stiff.

Thus, the trachea and the bilateral lung were removed together. In the resected specimens, the trachea and bronchus, including the anastomotic site, were longitudinally opened and fixed in 10% formalin during a period of 7 days. A roentogenological examination with soft ray was conducted using Softex Type EMB (Softex Co.).

The regeneration of the bronchial artery was evaluated on the basis of findings on the microangiography by the following grading. The microangiographic findings of Grade 0 corresponds to unregenerated bronchial artery extending across the anastomotic site which is shown by the arrows.

Grade I indicates a few regenerated bronchial artery in the adventitia extending across the anastomotic site.

Grade II reveals a moderately developed bronchial artery in both the adventitia and the mucosa. Grade III demonstrates a markedly developed bronchial artery throughout the bronchial wall. These findings were shown in Fig. 1a to 1d.

Dogs with evidence of atelectasis, pneumonia, intraparenchymal bleeding and abscess formation at autopsy were excluded from this study.

RESULTS

The degree of stenosis on the pulmonay artery was adjusted by snaring it with artificial dura mater into 50% and 75% in diameter. Postmortem examination in the site of created stenosis on the pulmonary artery revealed that stenosis resulted from development of fibrogranulomatous tissue around the artificial dura mater had increased with time. In group B, complete obstruction was achieved on day of 13, whereas in Group C, it was within 7 days' duration.

On the basis of these results, it was determined that the degree of stenosis of the pulmonary artery became gradually manifest and exceeded the predicted degrees with the elapse of time and occlusion of the pulmonary artery finally developed. The restoration of the bronchial artery was evaluated according to grading on the microangiographic findings.

Fig. 2 showed the rate of regeneration of the bronchial artery extending beyond the anastomotic site with time in relation to the stenosis of the pulmonary artery. The restoration of the bronchial artery is initiated in the adventitial face on Day 7 as shown in grade I, and it is completed on Day 14 or after as shown in grade II or III.

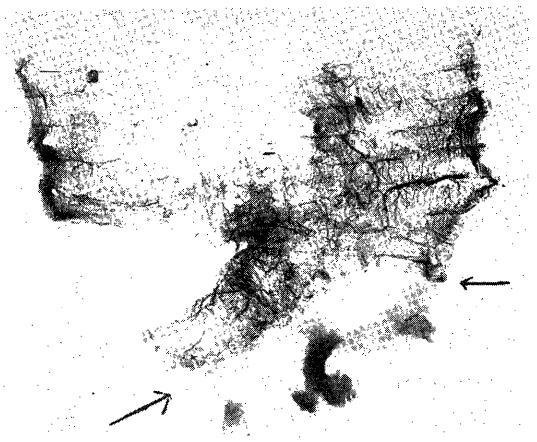

Fig. 1a

Fig. 1b

Fig. 1c

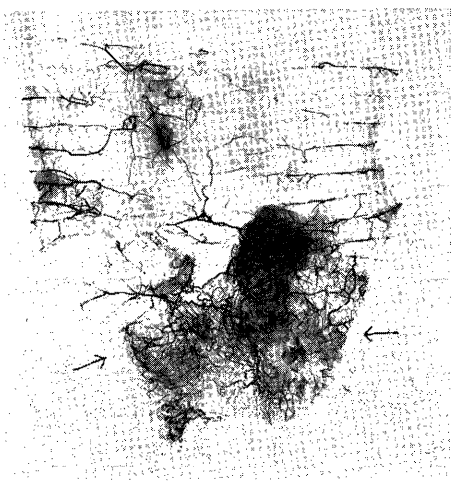

Fig. 1d

Fig. 1a Grade 0 microangiogram: The anastomotic site of the bronchus was shown by the arrows
Fig. 1b Grade I microangiogram
Fig. 1c Grade II microangiogram
Fig. 1d Grade III microangiogram

Group B revealed the tendency for the restoration of the bronchial artery to be enhanced compared to those in Group A, whereas in Group C, the development of the bronchial artery was significantly depressed.

The existence of stenosis in the pulmonary artery seems to contribute to early restoration of the interrupted bronchial blood flow. The ready regeneration of the bronchial artery may as well require the stenosis of the pulmonary artery, not exceeding a 50% stenosis.

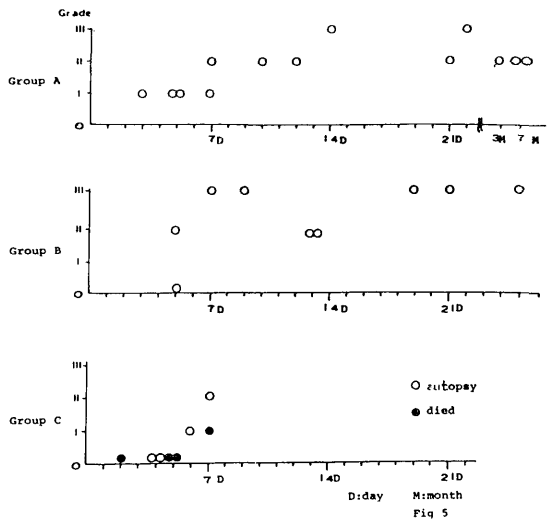

Fig. 2 The degree of the regenerated bronchial artery was shown with grading classified by microangisgraphic findings according to a classification of group A, B and C in relation to the elapsed time.

DISCUSSION

It is well known that the bronchial artery plays an important role in the nutrition of the lung.

It, however, increases in patients with chronic pulmonary diseases and congenital heart diseases, which cause decrease in pulmonary blood flow.

It is clear that the bronchoplastic procedure compels the bronchial artery to be interrupted and subsequently a reduction of the nutritional blood flow ensues. It is possible that the pulmonary blood flow may exert as being the nutritional blood. There are scattered reports concerning the regeneration of the bronchial artery in experiments of autotransplantation or hilar stripping.[1)-3)]

PEARSON[2)] reported that regeneration of the bronchial artery was completed within four weeks after the performance of radical hilar stripping and anastomosis following division of the right main bronchus. ARON[1)] also identified that restoration of the bronchial artery was initiated at the sixteenth day following the procedure of left hilar stripping, and anastomosis following division of the left main bronchus.

RABINOVICH[4)] described that a 15-day duration of time was required in the autotransplanted lung until restoration of the interrupted bronchial artery occurs. The bronchial artery seems to run on the adventitial layer and to form a network at the hilum of the lung.

It's distribution is divided into the intrapulmonary and extrapulmonary bronchial artery, and it enters the muscular and mucosal layers, including the bronchial glands in the lobar bronchus, constructing the fine vascular network.[5)6)]

In this study, we assume that restoration of the bronchial artery begins at the adventitial face and is allows facilitated by granulation tissues accompanying the development of the bronchial artery. At the site of anastomosis, the vascular communication to the distal bronchus is completed. The slight degree of stenosis of the pulmonary artery results in the ready recanalization of the intrapulmonary bronchial artery.

The complete obstruction of the pulmonary artery prior to sufficient recanalization of the bronchial artery brings the detrimental findings of intraparenchymal bleeding, degeneration and necrosis in the bronchus-reconstructed lung.

When the pulmonary artery is occluded, the bronchial arterial flow increases, a finding supported by many investigators.[7)-9)] ELLIS[10)] emphasized that the bronchial blood flow in necessary to the nutrition of the main and lobar bronchus, but it is not indispensable for the nutrition of the lung parenchyma.

Although sleeve lebectomy brings an interruption to the bronchial artery, lung necrosis due to nutritional deficiency, is rarely encountered.

Care being taken to avoid the ensuing pulmonary stenosis following bronchoplastic procedure combined with angioplasty, however, is required in preservation of well-functioning lung tissue, providing an adequate pulmonary vascular beds without any nutritional deficiency on bronchus-reconstructed lung. As far as anastomosis of the pulmonary artery is concerned, pulmonary stenosis to some extent ensues due to torsion by inflation and deflation of the lung in accordance with respiration even though satisfactory anastomosis is technically performed. Surgeon should be aware of its possibility.

In this study the degree of pulmonary stenosis affecting restoration of the bronchial artery was experimentally evaluated and it was established that pulmonary stenosis of less than 50% was not full of concern about nutritional deterioration of the lung. Even if existed, slowly developed stenosis exceeding 7 days following surgery was not detrimental to subsequent restoration of the bronchial artery.

The operative procedures of sleeve lobectomy with segmental resection of the pulmonary artery are warranted while leaving stenosis of less than 50% at the anastomotic sites of the pulmonary artery on the basis of the results with respect to recover of the bronchial arterial flow.

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