Bronchial Healing at Anastomosis with Special Reference to Omentopexy and Immunosuppressive Drugs

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Bronchial healing at anastomosis was experimentally evaluated in terms of restoration of bronchial collateral circulation, the tensile strength in association with mobilization of surgical procedure and omentopexy. It is defined that the tensile strength of over 1200 g reduces bronchial collateral circulation. In contrast, mobilization of the surgical procedure contributes to reduce the tensile strength, which reduces the blood flow in the inner layer of the bronchial wall.

In addition, the bronchial collateral circulation differs from selection of immunosuppressive drugs in the lung allografts. Azathioprine (Aza) revealed inhibition of the development of bronchial arterial regeneration. In contrast, Cyclosporin A (CyA) showed facilitation of wound healing at anastomosis.

Introduction

It is well known that many approaches have been designed to measure the blood flow. With respect to the measurement of trancheobronchial blood flow, the hydrogen clearance\(^6\) and the laser doppler methods\(^7\) have been applied. However, a laser doppler method is superior to other methods with regard to continuous monitoring, the consumed time for measurement and the technical simplicity.

Blood flow in the trancheobronchial wall comprised of two parts, the adventitial and the submucosal routes. We have already reported in 1980\(^8\) the changes in the blood flow of the tracheal wall with surgical procedure of mobilization maneuver.

Needless to say, rich blood flow of the tracheal wall is indispensable for wound healing at anastomosis. Recently, thoracic surgeons, attention is focused on the validity of omentopexy to facilitate wound healing. It is now accepted that bronchial healing without complication is a great concern about a key of successful lung transplantation and tracheobronchial plasty.

It is necessary to know an accurate state of bronchial blood flow in order to obtain an excellent healing at bronchial anastomosis. In this study, the blood flow at anastomosis were experimentally analyzed on the surgical conditions.

Material and Method

The days required for completion of recannalization were evaluated by microangiography in which yellow rubber contrast were infused from the thoracic aorta which was clamped at the both ends directly below the attachment of the subclavian artery and just above the diaphragma and red rubber contrast were introduced from pulmonary artery. Every day after performing bronchial anastomosis was examined as to whether the vessels stained by contrast medium extend across the anastomotic site.

Fig. 1 showed the stained bronchial arteries at anastomosis. Immediately after performing anastomosis, no bronchial arteries were seen beyond the anastomotic line, extending to the graft. In contrast, 10 days or more after transplantation, the stained vessels were obviously visible, extending across the anastomotic line to the graft as shown in Fig. 2.
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(RBF-1) by a principle of ionization on the condition of biochemical current of 10 A and its time duration of 60 sec and polars voltage of 600 mD as shown in Fig. 4 in order to measure the influence on changes in blood flow by mobilization and tension for the trachea.

![Fig. 2. Bronchial arteriography on day 10, showing regeneration of the bronchial artery across the anastomotic line.](image)

In this method, recanalization of the bronchial arteries was evaluated with the lapse of time after transplantation in comparison with omental wrapping. And also microangiography was performed to confirmed the completion of recanalization as shown in Fig. 3.

![Fig. 3. Microangiography, demonstrating regeneration of the bronchial artery beyond the anastomotic line.](image)

In addition, the measurement of the blood flow of the tracheal wall was made with the use of the flow meter (RBF-1) by a principle of ionization on the condition of biochemical current of 10 A and its time duration of 60 sec and polars voltage of 600 mD as shown in Fig. 4 in order to measure the influence on changes in blood flow by mobilization and tension for the trachea.

Moreover, the blood flow of the wall of the trachea were measured after transplantation to identify the difference in blood flow between the immunosuppressive drugs used. Left lung allotransplantation was performed according to the ordinary procedure. The immunosuppressive drugs of 20 mg/kg of cyclosporine A (CyA) and 50 mg/body of azathioprine (Aza) were used every day.

To certify the influence of the immunosuppressive drugs on the recanalization after lung allotransplantation, the measurement of the blood flow on the lung allotransplantation was performed at the site of carina, proximal site of anastomosis, distal site of anastomosis and the left side of first bifurcation, respectively.

**Results**

Recanalization of the interrupted bronchial artery was observed with the lapse of time as shown in Table 1. Regeneration of the bronchial artery with omental or pericardial wrapping was compared with the control as shown in Fig. 4. Regeneration in the control initiated on day 7 and it was completed on day 10 to 14. In contrast, recanalization by omental wrapping was faster. It started on day 3 to 4 and accomplished on day 7. Contrary to expectation, pericardial wrapping failed to facilitate recanalization as compared with the control. No effect of pericardial wrapping was recognized with respect to recanalization of the interrupted bronchial artery.

The influence of the surgical procedure of mobilization was evaluated. Fig. 5 shows the correlation between the tensile strength and the resected number of cartilaginous rings with or without mobilization. Mobilization allowed...
the tensile strength to eliminate effectively. In particular, over 1200 g of the tensile strength was remarkably weak-
ed by mobilization, which was induced by defect of 4 cartilaginous rings or more.

On the other hand, a decrease in the blood flow was seen in the case of over 1200 g of the tensile strength. A significant reduction of the blood flow in the inner layer of the tracheal wall was prominent rather than that in the outer layer as shown in Fig. 6. The reduction of blood flow took place first and was apparent in the inner layer of the tracheal wall. After lung allotransplantation, the blood flow of the carina, proximal, distal sites of anastomosis and left the 1st bifurcation were independently measured in comparison with the immunosuppressive drugs as summerized in Table 1.

In the control of autotransplantation, the blood flow in the distal site of anastomosis was obviously reduced on day 0 and increased on day 3 to 5. In contrast with the control in allotransplantation treated with Aza, the blood flow of the tracheal wall was significantly diminished day 0 and

### Table 1. Changes in blood flow at the sites of the carina, proximal and distal to anastomotic sites in accordance with the immunosuppressive drugs.

<table>
<thead>
<tr>
<th>Group</th>
<th>pre ope</th>
<th>post ope</th>
<th>p. o. 3</th>
<th>p. o. 5</th>
<th>p. o. 7</th>
<th>p. o. 10</th>
<th>p. o. 14</th>
<th>p. o. 21</th>
<th>p. o. 28</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carina</td>
<td>72.1 ± 13.21</td>
<td>71.6 ± 17.21</td>
<td>68.2 ± 1.40</td>
<td>102.0 ± 27.13</td>
<td>105.7 ± 30.02</td>
<td>81.8 ± 7.80</td>
<td>81.3 ± 19.50</td>
<td>89.2 ± 17.52</td>
<td></td>
</tr>
<tr>
<td>proximal site of ana.</td>
<td>72.1 ± 13.21</td>
<td>71.6 ± 17.21</td>
<td>68.2 ± 1.40</td>
<td>102.0 ± 27.13</td>
<td>105.7 ± 30.02</td>
<td>81.8 ± 7.80</td>
<td>81.3 ± 19.50</td>
<td>89.2 ± 17.52</td>
<td></td>
</tr>
<tr>
<td>distal site of ana.</td>
<td>33.4 ± 10.99</td>
<td>57.1 ± 8.50</td>
<td>70.0 ± 24.84</td>
<td>86.7 ± 21.23</td>
<td>97.8 ± 18.51</td>
<td>98.0 ± 14.91</td>
<td>79.6 ± 14.70</td>
<td>74.4 ± 9.03</td>
<td></td>
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<tr>
<td>left the Ist. bifr.</td>
<td>66.5 ± 11.65</td>
<td>62.6 ± 14.28</td>
<td>63.3 ± 6.74</td>
<td>67.5 ± 5.06</td>
<td>87.9 ± 14.41</td>
<td>78.0 ± 9.75</td>
<td>83.2 ± 8.11</td>
<td>68.8 ± 4.01</td>
<td></td>
</tr>
</tbody>
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F = m ± S. D. : ml/min/100g

* (* p < 0.05, ** p < 0.01)
The use of CyA is expedient to adapt and heal the anastomosis. In fact, it is a consistent observation that completion of bronchial circulation is seen in 3 weeks after lung transplantation. As for lung transplantation, Morgan\textsuperscript{10} emphasized that the use of the omentum is of great value to prevent the major complication of impairment of bronchial healing for irradiated bronchial ischemia as well as to promote good healing without granulation formation, helping to hold excellent patency at anastomosis.

Discussion

It is well known that circulation of the trachea mainly comprises of the bronchial artery. In contrast, the main bronchus is supplied by the pulmonary and the bronchial arteries.\textsuperscript{5} It is accepted that the anastomosis between the bronchial artery is completed in 2 weeks after lung transplantation. For lung transplantation, Morgan\textsuperscript{10} reported that regeneration of the bronchial artery develops within 6 weeks after interruption by means of bronchial arteriography, and Pearson\textsuperscript{9} also confirmed that it took 4 weeks to establish recanalization of the bronchial artery by selective bronchial arteriography and observation of latex infusion to the bronchial artery. Kawahara\textsuperscript{11} reported that bronchial arterial circulation restores within 14 days after lung transplantation. As for lung transplantation, Rabinovich\textsuperscript{11} reported that interrupted bronchial artery is reestablished from on day 15 after autotransplantation. On the other hand, Kawahara\textsuperscript{11} confirmed that recirculation of the bronchial artery is completed in 2 weeks after lung allotransplantation treated with CyA. Akamine\textsuperscript{16} confirmed that completion of bronchial circulation is seen in 3 weeks with the use of FK-506. It is apparent that selective use of immunosuppressive drugs influences the development of bronchial collateral circulation and relates to wound healing at anastomosis. Aza impairs development of a bronchial collateral circulation, whereas CyA facilitates regeneration of the bronchial artery to achieve good wound healing at anastomosis as reported by Goldberg M\textsuperscript{16} and Hashimoto T. et al.\textsuperscript{13}

Needless to say, an excess of the tensile strength is a hazard of breaking down the suture line. Prediction of satisfactory wound healing is also attributable to good blood perfusion which needs reestablishment of bronchial collateral circulation as early as possible. It is defined in this study that the tensile strength as large as over 1200 g makes the bronchial blood flow reduced remarkably and the surgical procedure of mobilization contributes to elimination of the tensile strength. As a result, it helps to increase the bronchial blood flow. Availability of omental flap comes to widely accept in order to facilitate blood perfusion and promote good wound healing even in the infected field such as bronchial fistula.

Fig. 6. Relation between blood flow and tensile strength. Right: Relationship between the degree of tracheal defect and tension in anastomotic site with or without tracheal mobilization. Left: Changes of blood flow against tracheal tension continued at least on day 5. On the other hand, a decrease in the tracheal blood flow in the allotransplantation treated with CyA remained on day 3, thereafter, it reverted to the increment on day 5. It was obvious that recovery from the reduced blood flow was the earliest when CyA was used. The use of CyA is expedient to adapt and heal the anastomotic wound satisfactorily.

References