Experimental Study on Tracheobronchial Plasty
-Changes in the Size of Anastomosis-

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Changes in the size of anastomosis were experimentally evaluated at oblique (O-group) and right angle (S-group) anastomoses of the bronchus to the lateral wall of the trachea. In addition, the resistance to air current was assessed by the measurement of the intraluminal pressure.

1) Difficulty in right angle anastomosis was assumed from the results of the survival time within 7 days after surgery and high incidence of respiratory failure and anastomosis insufficiency as causes of death.

2) Intratracheal pressure in S group was obviously higher than O-group although intrabronchial pressure did not indicate such a tendency.

3) The shapes and the sizes at anastomoses were also evaluated in accordance with respiratory cycle by the alternate addition of positive and negative pressures.

Shortness of the minor axis in S-group was manifest at negative pressure. In addition, the reduction rates in the minor axis of S group were more significant than those of O-group although reduction rates in the major axis were almost similar between the both groups.

Introduction

Bronchoplastic operation has become clinically prevalent with advances in surgery for the lung.

Needless to say, refinement of surgical technique extended the clinical indication and bronchoplastic operation enabled pulmonary function to preserve by leaving healthy pulmonary tissue as much as possible. This procedure has been indicated for hilar type of lung cancer, traumatic bronchial injury, stenosis of scar formation and benign tumors. In particular, availability and usefulness of this surgery has widely been recognized in clinical use for enhancing surgical radicality for malignant diseases and also for minimizing pulmonary function loss. Recent development of absorbable suture material had this procedures prevalent and safe in clinical application.

In contrast, postoperative complications such as anastomosis insufficiency and stenosis are ominous and lethal in relation to life threatening. It is of great value to know as to whether wound healing at anastomosis is satisfactory or not in relation to a fair long-term follow-up.

The purpose of this study is to histologically clarify wound healing at anastomosis and to functionally analyze the bronchus reconstructed lung.

Material and Method

a) Animals and preparation

Fifty-three adult mongrel dogs, weighing from 6.5 to 29kg with an average of 11kg were anesthetized with 20 to 30mg/kg of sodium pentobarbital, intubated with a cuffed endotracheal tube and ventilated with room air using a respirator (AIKA Co.) with tidal volume of 250ml.

Operative procedure: Thoracotomy was carried out via the right posterolateral approach at the 5th intercostal space. After dividing the azygos vein, the right main bronchus was exposed so as to prevent the vagal and phrenic nerves from surgical damage.

Fig. 1 showed the two different anastomosis types: One

![Fig. 1. Schema in sleeve anastomosis](image-url)
is a right angle anastomosis end to side to the trachea (S-group) after dividing the right main bronchus which is cut off at right angle to the tracheal axis, the other is an oblique anastomosis to the trachea (O-group) after dividing obliquely. After separating the right main bronchus from the trachea as shown in Fig. 1 the cut edge of the main bronchus was sutured with the use of 3-0 nylon of running sutures. The sleeve anastomosis to the trachea was achieved at the site 1cm proximal to the tracheal bifurcation, making a round window of at least 5mm in size on the lateral tracheal wall with an end to side fashion.

Anastomosis was completed by inverted suture on the posterior wall of the trachea and everted one on the anterior wall. Thus the thoracotomized wound was sutured layer to layer, leaving a drainage tube in place.

b) Measurement of the intraluminal pressures

Prior to and after anastomosis, the intraluminal pressures of the trachea and the bronchus were measured through 18G needle inserted 1cm proximal to 1cm distal to tracheal bifurcation and also at the time of sacrifice. The intraluminal pressures were measured with same manner as already described.

c) Measurement of anastomotic orifice

The major and minor axes of the cut edge of the bronchus were measured prior to anastomosis and also the measurement of the anastomotic orifice was conducted after performing anastomosis. At sacrifice, the trachea and anastomosed bronchus were taken out from the thoracic cage. A small amount of contrast was inserted into the No. 9 Nelaton tube. When pressed and depressed with air by using a syringe. Changes in the sizes of anastomotic orifices were carefully investigated.

Results

The survival times after tracheobronchial plasty were compared between S and O groups as shown in Table 1. The survivors over 7 days were seen in 12 dogs (37.5%) out of 32 in S-group and 13 dogs (61.9%) of 21v in O-group.

The survival time in O-group was superior to that in S-group without statistically significant difference. The dogs with the survival time of less than 7 days included 25 dogs (47%) out of 53 dogs except for three sacrified dogs in S-group. The causes of death were respiratory failure in 10 dogs (76.9%) in whom 10 dogs (76.9%) were in S-group as shown in Table 2. And also anastomosis insufficiency related to death was seen in 10 dogs (40%) in whom 7 dogs (70%) were in S-group.

Changes in the size of anastomosis prior to anastomosis, the major and the minor axes of the cut edge of the bronchus were measured. As a result, the sizes of anastomosis were 15.4 X 10.4mm in S-group and 16.0 X 14.1mm in O-group. The anastomotic orifice in O-group was layer that in S-group. The sizes of postoperative anastomotic orifice were 10.8 X 7.5 in S-group and 13.1 X 11.8mm in O-group.

The difference between two major axes was 4.6mm and that between two minor axes was 2.9mm in S-group. On the other hand, the difference between the major axes was 2.9mm and that between two minor axes was 2.3mm in O-group.

The difference between two major axes in S-group was larger than that in 0-group. And also there was no remarkable change in the minor axis between the two groups.

Alterations of the anastomotic orifice were observed in the both states when air was pressed and depressed through a small tube with a small amount of contrast medium.

There was a 26% change in the major axis of S group between positive and negative pressures. In contrast, a 23% change was shown in the major axis of O-group without statistically significant difference as shown in Fig. 2. On the other hand, there was a 51.8% reduction in the minor axis of S-group and a 20.0% decrease in the minor axis of O-group with a statistic difference (p < 0.05). Table 3 showed a result of changes in the anastomotic orifices of five cases in S-group and four cases in O-group.

![Fig. 2. Changes in the diameter of anastomotic orifice](image-url)
Table 3. Changes in the diameters of anastomotic orifice (positive and negative pressure)

<table>
<thead>
<tr>
<th></th>
<th>major axis</th>
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<th>minor axis</th>
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<tbody>
<tr>
<td></td>
<td>positive pressure (mm)</td>
<td>negative pressure (mm)</td>
<td>(reduction rate)</td>
<td>positive pressure (mm)</td>
<td>negative pressure (mm)</td>
<td>(reduction rate)</td>
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<td>S-group</td>
<td>N1 (on day 2)</td>
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<td>3</td>
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<td></td>
<td>N2 (on day 6)</td>
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<td>8</td>
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<td>4</td>
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<td></td>
<td>N3 (on day 18)</td>
<td>19</td>
<td>15</td>
<td>−21%</td>
<td>17</td>
<td>8</td>
</tr>
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<td></td>
<td>N4 (on day 30)</td>
<td>16</td>
<td>12</td>
<td>−25%</td>
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<td></td>
<td>N5 (on day 40)</td>
<td>13</td>
<td>10</td>
<td>−24%</td>
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O-Group

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<tr>
<td></td>
<td>positive pressure (mm)</td>
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<td>(reduction rate)</td>
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<td>N1 (on day 8)</td>
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<td>11</td>
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<td>−25%</td>
<td>11</td>
<td>9</td>
<td>−18%</td>
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<tr>
<td>N3 (on day 21)</td>
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<td>12</td>
<td>−20%</td>
<td>10</td>
<td>8</td>
<td>−20%</td>
</tr>
<tr>
<td>N4 (on day 30)</td>
<td>13</td>
<td>10</td>
<td>−23%</td>
<td>9</td>
<td>7</td>
<td>−22%</td>
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Fig. 3a showed changes in anastomotic orifice in anterolateral and lateral view of S-group between positive and negative pressures. And also Fig. 3b shows changes in anastomotic orifice in anterolateral and lateral view of O-group between positive and negative pressures.

Measurement of intraluminal pressure of the trachea and the bronchus.

Under controlled respiration, the intraluminal pressures were measured at the sites proximal and distal to the bifurcation through 18G needle by using a pressure transducer (Nihonkoden Co.). The results are shown in Fig. 4. The mean intraluminal pressures of the trachea were 12.4 ± 2.7cmH2O prior to surgery and 12.9 ± 2.5cmH2O after surgery in O-group without a significant difference. On the other hand, the mean intraluminal pressures of the bronchus were 12.7 ± 3.1 and 13.1 ± 2.5cmH2O prior to and after surgery without any significant difference, respectively. In contrast, the intraluminal pressures of the trachea in S-group were 12.9 ± 2.9 prior to surgery and 14.1 ± 3.2cmH2O after surgery with a significant difference (p < 0.05), respectively.

The bronchial pressured were 13.7 ± 4.2 prior to surgery and 13.9 ± 4.0 after surgery without significant difference. It is confirmed that the tracheal pressures in S-group were higher than those in O-group in contrast to no difference in intraluminal pressures of the bronchus.
Fig. 3a. Changes in anastomotic orifice in anterolateral view and lateral view of S group between positive and negative pressures
Fig. 3b. Changes in anastomotic orifice in anterolateral view and lateral view of O group between positive and negative pressures
Discussion

The techniques of tracheal and bronchial anastomosis have been far advanced by development of absorbable suture material. In general, whole layer and intramucosal stitches have been used for the suture technique. It is accepted that nonabsorbable sutures disclosed a 14 percent incidence of suture granulation formation and reduced the incidence of postoperative stenosis at anastomosis by granulation formation. Thompson reported that the use of chromic suture prevents occurrence of suture granuloma.

Recently, the newer synthetic absorbable suture have been developed and reported to demonstrate superiority to chromic suture in uniformity of the rate of absorption, an excellent tensile strength for comparable size, knot security and diminished that advances in tracheobronchial plasty is based on development of absorbable suture material. And also it is widely accepted that the problem of suture granuloma follows the use of a variety of nonabsorbable sutures regardless stitch technique.

Therefore, development of suture material makes tracheobronchial plasty far advanced in clinical use. However, impaired bronchial healing following lung transplantation remains a major problem to ensure clinical security of this operative procedure. Since 1960, this procedure has been in great necessity for tuberculous stenosis and carcinoma in Japan.

 Needless to say, changes in the shape and the form at anastomosis are influenced by tension and blood flow around anastomotic sites. It is assumed that the main cause is granulomatous changes which demonstrate transmural dense fibrosis.

On the contrary, recent studies demonstrate that stenosis at anastomosis no longer is an invariably lethal lesion because of development of meticulous management such as cryotherapy, steroid injection laser resection and dila-

In this series, the types of bronchial anastomosis are functionally evaluated. Knowledge of pulmonary function related to a bronchial anastomosis is scant and discussion regarding anastomosis techniques has sporadically been seen hitherto.

In particular, it is contemplated that this procedure is indispensable for lung cancer of hilar type to enhance surgical radicality and to preserve healthy lung tissues as much possible.

The tracheobronchial plastic operation has become a popular operation of choice for pulmonary surgery. However, changes in shapes and sizes at anastomosis remains major problem to solve and to maintain satisfactory function.

In this study, sleeve anastomosis between the trachea and bronchus was experimentally investigated and the superiority was compared between oblique and right angle anastomoses to the trachea in terms of alteration of the shape and the size anastomotic orifice.

The intraluminal pressure was compared in end to side sleeve anastomosis between right angle and oblique anastomosis. Increased intratracheal pressure in S-group was manifested and compared with that in O-group in contrast to no remarkable changes in intrabronchial pressure in both groups. The diameters of anastomotic orifices were also compared in accordance with respiratory cycles of inflation and deflation, it was confirmed that the area of cross section of anastomosis in S-group had become smaller with time in addition to shortness of the major axis, and 4.6 cm shortness of the major axis was clarified in S-group in addition to the fact that anastomosis was confined in area.

In dynamic observation according to respiratory cycle, changes in cross-sectional areas of the major and the minor axis were carefully observed. There was no significant difference in the major axis between S-and O-groups.

In contrast, a 51.8 percent reduction in S-group and a 20.0 percent reduction in O-group were represented in the minor axis between positive and negative pressures, assuming lung inflation and deflation clinically. From the above result of this study with respect to air flow resistance, the right angle anastomosis of the bronchus to the trachea is superior to the oblique anastomosis. Tsuji et al reported that oblique anastomosis caused unfitness of cartilaginous tissues to have tension to the membranous portion which becomes a weak point for wound healing. They emphasized that support of the tracheal cartilage and membranous portion is most important to predict satisfactory wound healing. Ishihara insisted that approximation of the both edges of anastomosed bronchi is required for good healing of anastomosis, cutting to make.

From the result of this study, oblique anastomosis is beneficial in maintaining the size of anastomosis, lessening tension and ensuring physical air current. However, surgeons are aware of slipping down cartilaginous ring at the
time of oblique anastomosis.

Takada also reported that oblique anastomosis of the bronchus to the trachea is superior to right angle anastomosis on the basis of the result of hemodynamic evaluation two to four weeks after surgery.

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References