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An Experimental Evaluation of Tracheal Blood Flow with Special Referrence to Operative Procedure of Tracheal Mobilization

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ABSTRACT

Based on the study with special referrence to blood flow in the trachea, the factors influential on the operative procedure of tracheal mobilization were carefully evaluated to ensure optimal surgical results. It has already been assumed with an aid of microangiographic technique that the main trancheal blood flow comprise two routes, namely, adventitial and submucosal layers. The amount of blood flow in the trachea divided into individual two layers were measured by hydrogen clearance test with wire electrodes placed in either adventitial or submucosal layer.

When employed the procedure of extensive mobilization of the trachea, the level of tracheal blood flow reduced in adventitial layer rather than in submucosal layer. Blood flow in submucosal layer, however, remain closely near the normal level, which is thought to compensate a decreased blood supply in the tracheal adventitia.

Meanwhile, when proposed an excessive tension of more than 800g at the site of anastomosis, a decrease in submucosal blood flow has become manifest despite of a slight decrease in adventitial blood flow simultaneously. Greater emphasis has been focused upon

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a limitation of tension imposed on approximation of bronchial stump after segmental resection of the trachea.

It seems worthwhile to document from this study that the degree of inherent tension to anastomosis should be eliminated as low as 800g to allow minimal risk of catastrophic complications related to anastomosis technique.

The procedure of tracheal mobilization, whenever feasible, is considered best suited for management of a regularly and safely operative method of tracheobronchial reconstruction to allow the satisfactory anastomotic healing and to permit more extensively segmental resection of the trachea without a hiderance of blood supply into the trachea.

INTRODUCTION

The tracheobronchial reconstructive procedures were widely accepted and were attempted to the enlargement of its indication to relieve the respiratory distress with advances of safety respiratory care perioperatively and the improvement of surgical techniques. It, however, has some limitations with regard to the resectable extent of the trachea and the bronchus. Since no ideal tracheal substitute is reported to date, it is difficult to determine as large an extent to be resected as possible recostructed without further troubles. It is considered to be 6.6 cm in length with the technique of end to end anastomosis combined with a procedure of tracheal mobilization[1]. Even after an extended resection of 6.6 cm, the tracheal reconstruction requires the meticulous and complicated maneuver which is necessitating either end to end or end to side anastomosis. Needless to say, it has restrict to its safety clinical application.

The surgical procedures of mobilization of throughout the trachea permit as long an extended resection of the trachea as possible. The safe limitation for the extent of tracheal resection is reported as a 60 % of tracheal length[2] or 58 %[3]. The injury of bronchial artery which is draining into lateral wall of the trachea, furthermore, should be avoided[4] and gentle manarement for the trachea is needed in prevention from surgical insult of trancheal membranous portion[5].

A trial of enlarged surgical indication for tracheal resection requires an extended tracheal mobilization, whereas, it is better not to violate tracheal wall in anastomotic site. The aim of this study is to certify the operative efficacy of tracheal mobilization to enlarge the extent of tracheal resection concerning about blood flow in the tracheal wall.

MATERIAL AND METHOD

Thirty six mongorel dogs weighing from 10kg to 15 kg body weight were subjected to this study. Each animals were anesthetized and systemic blood pressuse were measused with cannula placed ino the femoral artery to exclude an influence of hypotension below 100 mmHg. The right thoracotomy was carried out at fourth intercostal space and the entire trachea was exposed under division of the azygos vein.

The blood flow in either outer (the adventitia) or inner (the submucosa) layer of the trachea were measured by means of hydrogen clearance method with UH meter, PHG 201, Unique Medical Co., LTD. Inspiratory hyrogen concentration is adjusted into as low as 5 % and hydrogen clearance curve are delineated under successive 3 minutes inhalation. Tissue blood flow of the trachea was calculated as following formula, $F=\frac{69.3}{T^{1/2}}$, where, F: Blood flow in ml/min/100g, T: Time in minute from initial hydrogen concentration level to half of it by hydrogen clearance, which equals in every intervals.

A consecutive 36 dogs were submitted to evaluate an influenced factors on blood flow of the trachea, especially concerning either the procedure of tracheal mobilization or the degree of tension imposed on the trachea. The measurement of blood flow was made after completion of this procedure for the entire trachea. The modality of this procedure comprise a separation of the pulmonary ligament and an opening the pericardium surrounding the pulmonary hilus and also a dissection of the trachea at inside of tracheal sheath quoted by Sarrazin.

In addition, the changes of blood flow were evaluated in terms of the degree of tension on the tracheal wall after segmental resection of the trachea. The degree of tension at edges of the trachea vary from 400g to 1200g, which are measured with use of spring scale by means of jointing together the separated edges of the trachea after resection of the trachea from 3 cartilages to 8 cartilages in length.

RESULT

Blood flow in inner and outer layer of tracheal wall were respectively calculated as an average of 68 ml/min/100g and 83 ml/min/100g by hydrogen clearance method. In normal trachea, the blood flow in outer layer is pronounced rather than that in inner layer as indicated in Fig. 1. By the procedure of tracheal mobilization, the values of blood flow on tracheal wall more or less decreased, mainly from 83 ml/min/100g to 44 ml/min/100g with an average of decrease of 48.2 % in outer layer and from 68 ml/min/100g to 52.2 ml/min/100g with an average of decrease of 22.7 % in inner layer respectively. The blood flow in inner layer of the trachea was dominant rather than in outer layer after completion of tracheal mobilization.

In attempt to certify whether blood supply may be well enough to permit an excellent healing in tracheal anastomosis after this procedure, the blood flow was measured in outer and inner layers of tracheal wall respectively. It showed 43 ml/min/100g in outer layer and 49.4 ml/min/100g in inner layer as shown in Fig 2, in contrast to 68 ml/min/100g in outer layer and 60 ml/min/100g in inner layer respectively prior to procedure of tracheal mobilization. It is of interest to note that the level of blood flow in submucosal layer was not responsible for procedure of tracheal mobilization whereas there was notably reduction of blood flow in adventitial layer.

The relationship between tensile strength against tracheal wall and blood flow in

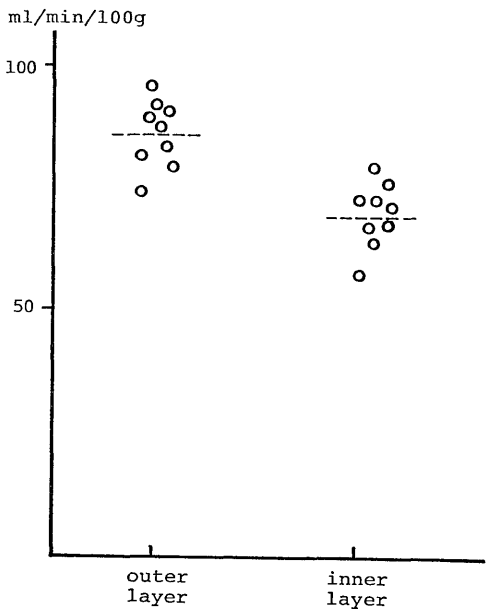

Fig 1. Blood flow in outer and inner layer of the tracheal wall

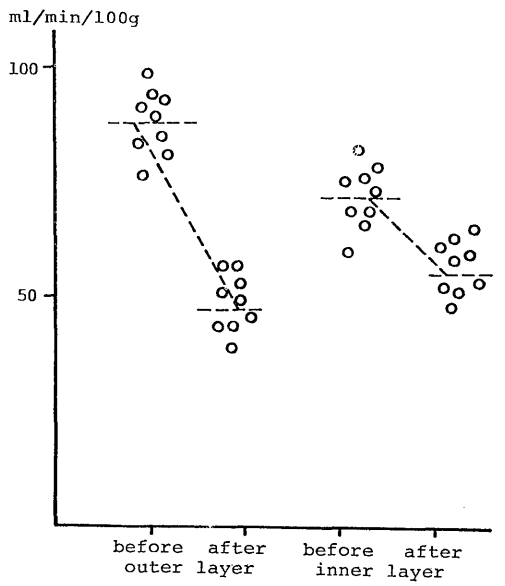

Fig 2. Changes of blood flow caused by tracheal mobilization

tracheal wall, furthermore, were experimentally evaluated. The tensile strength of the trachea was measured with use of spring scales placed on both proximal or distal edges of the trachea after segmental resection of the trachea as jointed together each other.

The changes of blood flow in trancheal wall for tension added the tracheal edges were almost the same in either proximal or distal trachea within as much as 800g of tensile strength. Meanwhile, the values of tracheal blood flow decreased when an additional tension to the tracheal edge exceeded 800g as shown in Fig 3. The decreased patterns of blood flow in submucosal layer, moreover, had become manifest rather than those in adventitial layer. When the level of tension on tracheal edge reached as much as 1200g, blood flow in adventitial layer showed an average of 41.2 ml/min/100g as compared to those in adventitial layer which revealed a significant reduction with an average of 32.6 ml/min/100g as indicated in Fig 3.

In order to assess definitely whether a procedure of tracheal mobilization was strongly responsible for changes of blood flow in the site of anastomosis, the measurement of blood flow after procedure of tracheal mobilization was scheduled at 1 cm apart from anastomotic site as compared to those of anastomosis alone.

As indicated in Fig 4, a procedure of tracheal mobilization leads to reduced blood flow in adventitia of the trachea. whereas the level of blood flow in the tracheal submucosa remains almost constancy. From this observation, it has been proved that blood flow in the trachea does not changed obviously by a procedure of tracheal mobilization in the face of a decrease of blood flow in outer layer of the trachea and it would seem wise to recommend that this procedure should be applied to relieve tension at the

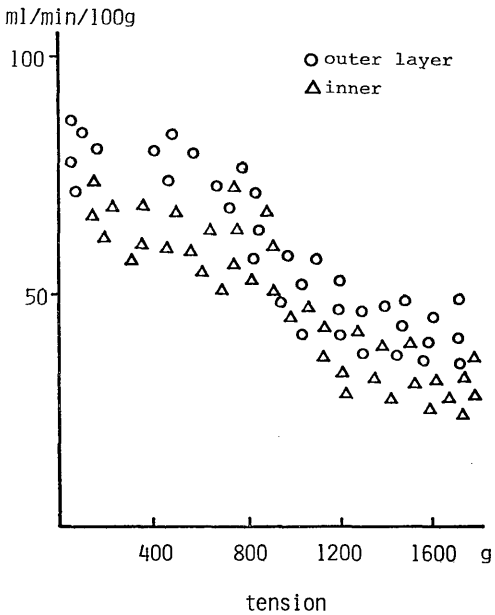

Fig 3. Changes of blood flow for tracheal tension against approximation of distal and proximal tracheal ends

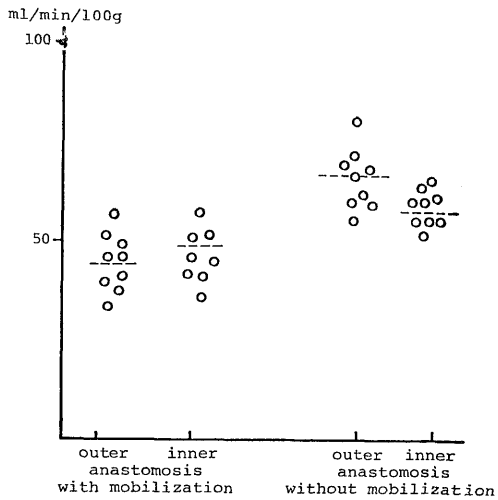

Fig 4. Blood flow measurement at 1cm apart from anastomotic site either with or without mobilization

site of anastomois aside from a fear of slightly induced impairement of blood supply. It is proved that potential hazard caused by tension after an extensive resection of the trachea can be minimized with a procedure of tracheal mobilization.

It must be assumed that tension in tracheal anastomosis tends to restrict to an appropriate healing while it leads to considerably decline of blood flow. A resection of the trachea within 3 cartilages in length showed a minimal tension of less than 600 g in anastomotic site, whereas resection of the trachea beyond 5 cartilages in length results in an excessive tension of more than 1200g which may be not well enough to allow satisfactory healing in anastomosis as shown in Fig 5.

It is also confirmed that when employed the operative procedure of tracheal mobilization, it is able to afford the resection of 6 cartilages of the trachea

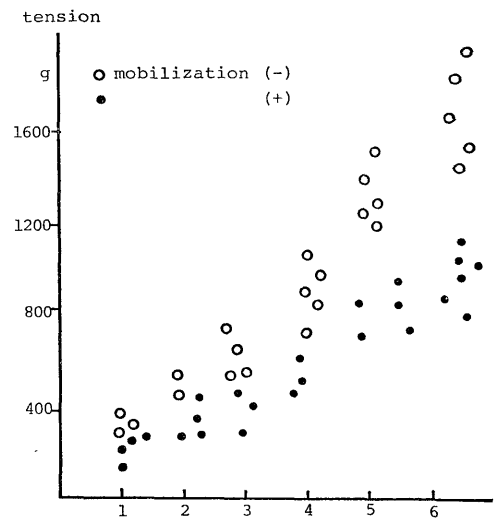

Fig 5. Relationship between the degree of tracheal defect and tension in anastomotic site with or without tracheal mobilization

within 800g tension.

DISCUSSION

Most of techical problems in regard to tracheal and bronchial reconstruction have not infrequently been reported to date. It is no doubt that serious complications subsequent to tracheobronchial anastomosis contribute to operative death following surgery. An excellent blood supply in anastomosis is undoubtedly neccessary for preventive step from serious complication[6)7)]. In order to maintain a preservation of blood flow in the trachea, it is essential in avoidance of interruption of the bronchial artery and in relief of tension in anastomosis to achieve a successful tracheobronchial recostruction. It is, accordingly, stressed that the preservation of some [of major bronchial artery is of importance to be capable of significantly lowering the incidence of its complication.

In fact, a tracheal mobilization as one of routine procedures, however, is neccessary for a gain of tension-free anastomosis when more extended resection is attempted. In this study the changes of blood supply in the tracheal wall were evaluated as a parameter of tissue blood flow. As a results of our observation, it is appearent that tracheal mobilization provoked an eventual reduction of adventitial blood despite of no remartable change in submucosal blood flow. A relationship between the degree of tension in anastomotic site and the changes of blood flow in the tracheal wall was also carefully estimated. Needless to say, the tension in anastomotic site rendered blood flow drained into the trachea diminish. When strained tension in anastomotic site is within as much as 800g, the changes of blood flow are definitively pronounced in neither adventitial nor submucosal layer, whereas significantly reduced blood flow is observed by tension overload more than 800g in anastomotic site.

This study was mainly attemted to allow a better appraisal as to whether a procedure of tracheal mobilization is beneficial to diminish tension in anastomotic site without serious complication despite of an interruption of blood supply. It is concluded that operative management of tracheal mobilization play an important role in favor of relief of excessive tension in tracheal anastomosis and that its procedure enable the resectable extent for tracheal lesion to enlarge with a less risk of postoperative complication when tension in anastomotic site exceeds more than 800g.

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