

Pulmonary Surface Tension in Relation to Postoperative Pulmonary Complication

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An attempt was made experimentally to elucidate the sources of postoperative pulmonary complications closely related to an operative procedures in the field of thoracic surgery. The influential factors on postoperative pulmonary complications in dogs were evaluated on the basis of changes in lung surface activity.

The operative time of over 4 hours led to the high surface tension on the lung, while a continuous lung compression maneuver throughout the performance of thoractomy had a deteriorating effect on the surface tension. Intermittent lung expansion maneuver at 10 minute intervals each hour played a key role in minimizing a surface tension on the lung. In our view, an extended mediastinal lymph node dissection had a detrimental effect on pulmonary surface tension in dogs. It is strongly suggested that an extended lymph node dissection contributes to postoperative pulmonary complications due to an increase in the pulmonary surface tension.

INTRODUCTION

Postoperative pulmonary complications lead to serious and fatal complications. To improve surgical results, attention has been focused on particular problems in avoidance of postoperative pulmonary complications. When such a complication occurs in aged patients, an unfavorable outcome of death usually follows. Based on observation of the lung surface tension in dogs, this study was experimentally attempted to define the participating factors in the occurrence of postoperative pulmonary complication related to either the time duration of the performance of thorcotomy or the operative procedure of mediastinal dissection.

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MATERIAL AND METHODS

One hundred and forty-seven mongrel dogs of both sexes and weighing 15 to 20 kg were used for this study. The lung surface tension was measured by bronchial washing according to a modification of the Wilhelmy balance method. A KIMURAY' surfactometer at room temperature was used and the changing rate was 15% from 57.5cm² to 7cm² in surface area with two successive courses of 3 minutes' cycle time. The bronchial washing technique was performed with a successive three time pumping maneuver of 20ml saline, assuring over 70% recovery of the saline. The values of the γ max and γ min were demonstrated in two successive course of the hysteresis loop. Stability index was calculated as follows: $\frac{2(\gamma_{\max} - \gamma_{\min})}{\gamma_{\max} + \gamma_{\min}}$, where: γ max and γ min were obtained from the successive course of the KIMURAY' surfactometer. Right thoracotomy was made at the fifth intercostal space, the dog anesthetized with pentobarbital sodium (25mg/Kg) was under controlled respiration with Harvard respirator through the endotracheal tube. The 147 dogs were separated into three groups of 49, that is, thoracotomy alone, thoracotomy with continuous lung compression and thoracotomy with a repeated 10 minute' lung expansion maneuver (intermittent lung compression maneuver) every one hour during a period of 7 hours, respectively.

In each three group, 7 dogs were used to make clear of differences in a 7 hour duration. The merits and demerits of the mediastinal dissection as an operative procedure were also evaluated. Thirty dogs were separated into three groups according to the extent of the mediastinal dissection. The extent of dissection in group I was confined to the hilum of the lung, that in group II was extended to the bifurcation and that in group III was more extended to the paratrachea. The lung surface tension in each group was similarly measured one hour after completion of these procedures. A bronchial brushing method was used for the measurement of surface tension of the lung.

RESULT

The lung surface tension was expressed as the values of the γ max and γ min or stability index. As shown in Fig 1, the changes in lung surface activity during thoracotomy alone were demonstrated. The γ min values gradually increased with the elapse of time and was particularly pronounced over a period of 4 hours after the chest was opened. When the lung compression maneuver was added during the performance of thoracotomy, as presented in Fig 2, the γ min values soon increased. However, when intermittent lung expansion procedures were used, as presented in Fig 3, the increased γ min values were significantly reduced but remained all but unchanged, compared with the γ min during thoracotomy alone. Table I showed the γ min values in each group.

The changes in the γ min values in the performance of an intermittent lung compression maneuver were minimal even in comparison with the control. The continuous compression maneuver for the lung yielded the higher γ min values. In the case of mediast-

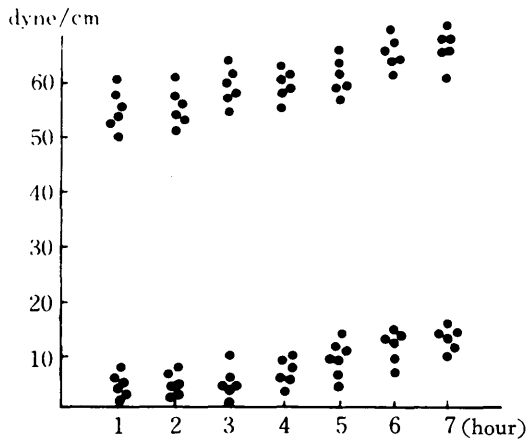


Fig 1. Changes of γ max and γ min in lung surface activity during a period of thoracotomy alone.

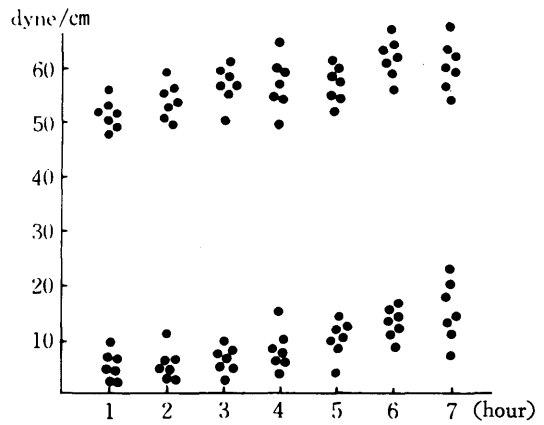


Fig 2. Changes of γ max and γ min in lung surface activity when added the compression maneuver to the lung in 7 hour duration.

inal dissection, the γ min values ranged from 4 dyne/cm to 24 dyne/cm. It was clear that the high γ min values were directly related to the extended mediastinal dissection procedures.

When the mediastinal dissection was confined to the hilum of the lung, there was a slight increase in lung surface tension as compared to findings during thoracotomy alone. An extension of this procedure resulted in an increase in the γ min values and the highest γ min values were obtained when extended to the paratrachea. There was not statistically significant difference.

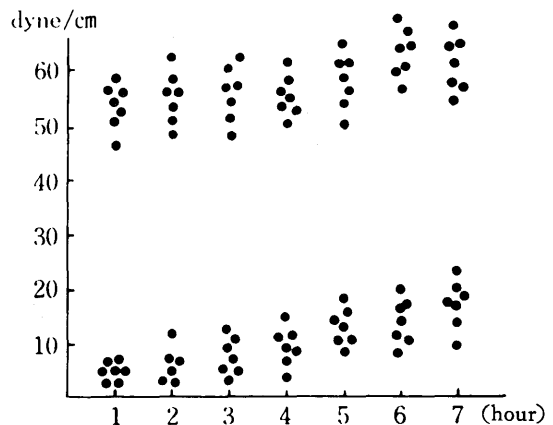


Fig 3. Changes of γ max and γ min in lung surface activity when added the compression maneuver to the lung intermittently with a repeated 10 minute relief every one hour.

Table 1. γ min values in accordance with elapsed time in three groups.

Thoracotomized time	group	thoracotomy alone	continuous lung compression maneuver	intermittent lung compression maneuver
1h		9 8 7 5 4 2 2	8 7 7 6 6 5 5	10 8 7 4 4 2 2
2h		9 6 7 5 5 3 2	11 8 7 5 3 2	9 8 6 5 4 4 3
3h		10 9 8 7 6 5 3	13 11 10 9 8 7 5	11 8 6 6 5 3 3
4h		13 11 5 10 9 7 5	15 13 12 10 10 9 5	11 10 9 8 7 4 5
5h		15 14 13 12 11 10 4	18 17 16 15 13 11 12	15 14 13 12 12 9 8
6h		18 17 18 17 15 12 11	22 18 18 15 14 13 11	15 14 14 13 12 10 9
7h		23 21 20 18 17 15 11	23 21 20 19 19 17 14	17 16 15 15 14 13 12

Table 2. Relationship between the levels of lung surface activity of γ min and stability index, and the extent of mediastinal dissection.

The extent of mediastinal dissection	lung surface activity	
	min dyne/cm (range)	stability index (range)
hilar region	5-13 (11)	1.0-2.0 (1.6)
hilar and the bilarcation regions	5-15 (11)	0.8-1.8 (1.5)
hilar bifurcation and paratracheal regions	9-24 (18)	0.5-1.3 (0.6)
thoracotomy alone	4-16 (8)	1.2-2.0 (1.7)

The stability index was indicated in a similar propensity as shown in Table 2. These ranged from 0.5 to 2.0 and the lowest values was observed in the case with an extended dissection.

DISCUSSION

Postoperative pulmonary complications are caused by various factors and the incidence associated with thoracic surgery is considerably higher than that with other surgery⁶⁾. Our present study was undertaken to elucidate the influence on pulmonary complications of opening the chest or performing mediastinal dissection on the basis of the results of changes in lung surface tension. The changes in lung surface tension were evaluated with time during the thoracotomy. Direct exposure of the lung to dryness and coldness of the air had led to a decrease in lung surface tension. Such was greatly influenced during thoracotomy and it became detrimental with over 4 hours' duration.

The application of lung compression maneuver as an operative procedure was experimentally contemplated in this study to produce a similar situation to the clinical one. There were significant differences in the types of added compression to the lung between the continuous and intermittent maneuvers. In the situation with continuous lung compression it showed a maximum of the deterioration as to lung surface tension level. On the contrary in the intermittent one it revealed a less deterioration. It is our conviction that postoperative pulmonary complication is largely attributed to an incidental patchy or massive atelectasis caused by lung compression maneuver during thoracotomy. There is no doubt that the increase in lung surface tension should be a causative factor of postoperative atelectasis, which is one of the main causes of postoperative pulmonary complication. Attention to this aspect of operative maneuver can diminish the risk of developing pulmonary complication in maintaining an appropriate lung surface tension level, not so severely compromised.

Furthermore, an insult caused by mediastinal dissection of the operative procedure was tested in different extents to dissect. Our results obtained from this study clearly

indicate that an operative procedure of lung compression itself intends to offer an increase in lung surface tension level and also its intensity corresponds to the dissected extent. The procedure of mediastinal dissection extended from the mediastinum to the lung hilum interferes with lung surface tension.

The question arises whether an operative procedure of an extended mediastinal dissection which is necessary for enhancing surgical radicality allows its prognosis to improve fairly. The fundamental consideration in the aspect of operative insults is whether the risk of cancer recurrence associated with incomplete mediastinal dissection outweigh the risk of postoperative complications derived from enhancing surgical radicality. Issue of debate about the efficacy of enhancing operative radicality with the ensuing risk of postoperative pulmonary complication remains still obscure.

In the older and debilitated patients, it is not advisable either to make operation time unnecessarily prolonged or mediastinal dissection inadvertently extended in order to avoid occurring the postoperative complications.

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