The Degree of Relaxation
Obtained in Different Diameters of the Lung
By Pneumoperitoneum and Phrenic Paralysis,
When Used Either Singly or in Combination*

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Introduction

This subject is presented under three main headings:
A. Effect on Apico-Basal Diameter of the Diseased Lung.
B. Effect on the Differential Vertical Relaxation of the Upper and the Lower Lobes.
C. Effect on the Transverse Diameter of the Base of the Lung.


Banyai¹ (1946) reported on 40 patients. With pneumoperitoneum alone, the maximum elevation of the diaphragm on inspiration was 7.3 cm. on the right side and 6.4 cm. on the left side.

Thompson Evans² (1953) made a study of reduction of apico-basal diameter after pneumoperitoneum, and pneumoperitoneum plus phrenic crush.

<table>
<thead>
<tr>
<th>Form of Collapse</th>
<th>Rise of Right Dome Cm.</th>
<th>Reduction of A. B. Diameter Per Cent</th>
<th>Rise of Left Dome Cm.</th>
<th>Reduction Per Cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>On pneumoperitoneum alone</td>
<td>5.7</td>
<td>25</td>
<td>5.3</td>
<td>22</td>
</tr>
<tr>
<td>Pneumoperitoneum plus right phrenic crush</td>
<td>8.6</td>
<td>36</td>
<td>4.7</td>
<td>17</td>
</tr>
<tr>
<td>Pneumoperitoneum plus left phrenic crush</td>
<td>4.0</td>
<td>18</td>
<td>7.6</td>
<td>30</td>
</tr>
</tbody>
</table>

In order to avoid errors due to variation in the size of the thorax a reliable estimate of vertical relaxation of the lung in a given individual can be made by finding out the percentage of reduction in the apico-basal diameter as suggested by Banyai. (It will be called “Vertical Relaxation

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Index in the text hereafter). It is calculated easily by the following formula:

\[
\text{Vertical Relaxation Index} = \frac{\text{Decrease in apico-basal diameter}}{\text{Original apico-basal diameter}} \times 100
\]

For example, V.R.I. = \(\frac{4 \text{ cm.}}{20 \text{ cm.}} \times 100 = 20\)

In other words, there has been a reduction of 20 per cent in the apico-basal diameter of the lung in this case. It can also be expressed as vertical relaxation index being 20, in this case.

The apico-basal diameter is measured in centimeters from the highest point of the apex of the lung (the fixed point taken in these studies was the lower border of the transverse process of the first thoracic vertebra) to the highest point of the corresponding dome of the diaphragm.

I have made a study of vertical relaxation index of a group of 62 patients first on pneumoperitoneum alone, and later on the same patients when pneumoperitoneum was combined with phrenic paralysis. A total of about 280 roentgenograms were taken before and during treatment at the end of full inspiration from a distance of six feet, with the patient in the upright position about one to two hours before refills. A total of about 560 measurements were made. Apico-basal diameter was measured with a 30.5 cm. plastic transparent scale. Index of vertical relaxation was found after pneumoperitoneum alone and then compared with index of vertical relaxation (I.V.R.) after phrenic paralysis was added in those patients. That gave quite an accurate idea, as to how much additional relaxation of the lung one can expect after combining phrenic paralysis to an already existing pneumoperitoneum.

Patients were divided into two groups. Group “A” of 32 patients, received maximum of 1,000 cc. of air at seven to 10 days interval guided by fluoroscopy. Group “B” of 30 patients received a maximum of 600 cc. of air at weekly intervals.

<table>
<thead>
<tr>
<th>TABLE II—GROUP “A”</th>
<th>AVERAGE INDEX (PERCENTAGE) OF VERTICAL RELAXATION OF THE DISEASED LUNG IN GROUP “A” PATIENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group “A” Patients</td>
<td>Average Index of Vertical Relaxation In I.V.R. by Addition of Phrenic to P.P.*</td>
</tr>
<tr>
<td></td>
<td>On P.P.* Alone</td>
</tr>
<tr>
<td>16 Males</td>
<td>17.9</td>
</tr>
<tr>
<td>16 Females</td>
<td>14.08</td>
</tr>
<tr>
<td>In the whole group “A”</td>
<td>16.0</td>
</tr>
</tbody>
</table>

*P.P. = Pneumoperitoneum.

It will be seen from this table that the addition of phrenic paralysis to established pneumoperitoneum in males increased the index of vertical relaxation by 64 per cent on the average. In the female, the addition of
phrenic paralysis to established pneumoperitoneum gave an average increase of 97.7 per cent in the "Index of Vertical Relaxation."

Taking the group "A" as a whole it may be concluded that on the average, the addition of phrenic paralysis to established pneumoperitoneum increases the rise of the paralysed diaphragm by about 78 per cent.

**TABLE III—GROUP "B" PATIENTS**

**AVERAGE INDEX (PERCENTAGE) OF VERTICAL RELAXATION OF THE DISEASED LUNG IN GROUP "B" PATIENTS**

<table>
<thead>
<tr>
<th>Group &quot;B&quot; Patients</th>
<th>Average Index of Vertical Relaxation</th>
<th>Average Increase in I.V.R. by Addition of Phrenic to P.P.</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 Males</td>
<td>On P.P. Alone: 10.3 On P.P. Plus Phrenic: 22.4</td>
<td>117.4</td>
</tr>
<tr>
<td>10 Females</td>
<td>On P.P. Alone: 6.1 On P.P. Plus Phrenic: 25.3</td>
<td>Not measured reasons given in text</td>
</tr>
<tr>
<td>In the whole group &quot;B&quot;</td>
<td>On P.P. Alone: 8.4 On P.P. Plus Phrenic: 23.8</td>
<td>183.3</td>
</tr>
</tbody>
</table>

It will be seen from this table that in males addition of phrenic paralysis to pneumoperitoneum gave an average increase of 117.4 per cent in the Index of Vertical Relaxation. In females the average increase in the Index of Vertical Relaxation by addition of phrenic paralysis to pneumoperitoneum could not be calculated with any statistical justification; because out of seven patients in whom pneumoperitoneum was followed by phrenic paralysis, the amount of refills (about 500 cc. to 600 cc.) given were so small that x-ray films taken before instituting phrenic paralysis either showed only traces of air under the dome or no air at all.

**TABLE IV**

**COMPARATIVE FIGURES OF INDEX OF VERTICAL RELAXATION OF THE TWO GROUPS**

<table>
<thead>
<tr>
<th>Group of Patients</th>
<th>Average Index of Vertical Relaxation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>On Pneumoperitoneum Alone Per Cent</td>
</tr>
<tr>
<td>Group &quot;A&quot;</td>
<td>16.0</td>
</tr>
<tr>
<td>Group &quot;B&quot;</td>
<td>8.4</td>
</tr>
</tbody>
</table>

It will be noticed that in group "A," whereas Index of Vertical Relaxation with pneumoperitoneum alone, is 90 per cent more than that in group "B," the index of Vertical Relaxation with Pneumoperitoneum plus phrenic paralysis is only about 20 per cent more than that in the "B" group.

It is apparent that when pneumoperitoneum is used as a sole collapse measure 600 cc. refills at weekly intervals do not give adequate rise of
diaphragm. But when pneumoperitoneum is combined with phrenic paralysis it is seen that even 600 cc. refills at weekly intervals give significant rise of the paralysed dome and insignificant rise of non paralysed dome. As a result of this phenomenon, there occurs a unilateral selective pneumoperitoneum with much smaller degree of visceroptosis. We have found that this is the collapse measure of choice in unilateral lower and mid zone disease.

*The Reduction in Apico-Basal Diameter in Patients in Whom Phrenic Paralysis Preceded Pneumoperitoneum.*—There were 11 patients in whom for one reason or the other phrenic paralysis was done before pneumoperitoneum. In such cases the first elevation of the diaphragm was solely due to phrenic paralysis.

Since significant difference was found in the right and left side figures, they were calculated separately and subjected to close scrutiny and analysis to arrive at the cause of such difference.

<table>
<thead>
<tr>
<th>TABLE V</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AVERAGE INDEX (PERCENTAGE) OF VERTICAL RELAXATION OF THE DISEASED LUNG ON PHRENIC ALONE FIRST AND LATER ON PHRENIC PLUS PNEUMOPERITONEUM IN BOTH GROUPS &quot;A&quot; AND &quot;B&quot;</strong></td>
</tr>
<tr>
<td>In Both Group of Patients</td>
</tr>
<tr>
<td>----------------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Left side</td>
</tr>
<tr>
<td>Right side</td>
</tr>
</tbody>
</table>

By phrenic paralysis alone on the left side the “Average Index of Vertical Relaxation” was 11.5 per cent and maximum was 23.3 per cent whereas on the right side the average was 9.3 per cent and maximum was 13.2 per cent.

When pneumoperitoneum was induced and established in such cases, it was found that it increased the “Index of Vertical Relaxation” by 172 per cent on the left side and 249.4 per cent on the right side.

An interesting fact which emerged from this study was, that the average index of vertical relaxation was greater with pneumoperitoneum alone (16 per cent usually equal on both sides unless atelectasis occurs) than with phrenic paralysis alone (9.3 per cent on the right side and 11.3 per cent on the left side). However when phrenic paralysis was later added to established pneumoperitoneum, the average index of Vertical Relaxation became 28.4 per cent. Similarly when pneumoperitoneum was later added to phrenic paralysis average Index of Vertical Relaxation became 31.9 per cent. This clearly shows that although the Index of Vertical Relaxation with phrenic operation alone was significantly less than with pneumoperitoneum alone, it increased ultimately to approximately the same degree when both operations were combined irrespective of the fact which precedes. If at all, the index of vertical relaxation is a little more when phrenic paralysis preceded pneumoperitoneum, probably by virtue of the
fact that longer period of paralysis leads to greater loss of tone of dia-
phragmatic musculature. Nevertheless, for other more important reasons,
it is logical that pneumoperitoneum should precede phrenic paralysis by
a few weeks. The advantage is that one can know whether diaphragm can
rise adequately or is bound down by adhesions or whether there are ex-
tensive intraperitoneal adhesions causing persistent abdominal pain to
warrant abandoning pneumoperitoneum.

B. The Effect of Pneumoperitoneum and Pneumoperitoneum Plus Phrenic
on the Differential Vertical Relaxation of the Upper and the Lower Lobes.

The opinion is divided among some workers on this subject. Rilance
and Warring, Trimble and Fowler, obtained better results and greater
incidence of closure of cavities situated in mid and lower zones than in
upper zones. On the contrary Keers, Anderson and Winn, Crow and
Welchel after an analysis of their work feel that there is no significant
difference in the healing response of any section of the lung with pneu-
moperitoneum or pneumoperitoneum plus phrenic paralysis. They further
add that the nature of the lesion appears to be more important than its
location in the lung from the point of view of its response to this form
of collapse.

Thompson Evans (1950) tried to measure the contraction of different
lobes on the right side in a few cases where the transverse fissure was
visible. He found that in the healthy right lung the relaxation induced
by pneumoperitoneum was taken up 78 per cent by the mid and lower
lobes and 22 per cent by the upper lobe. In a diseased lung the respective
figures with pneumoperitoneum were 59 per cent and 41 per cent and with
pneumoperitoneum plus phrenic paralysis 63 per cent and 37 per cent.
The influence of the site of the lesion on this differential relaxation was
not measured.

In this work an effort has been made to study the problem of differential
relaxation in greater detail and to determine the influence of the site of the
disease on the degree of relaxation which different lobes undergo with
pneumoperitoneum and phrenic paralysis.

There is almost a consensus of opinion among most authorities that
other factors being equal the therapeutic result of pneumoperitoneum or
pneumoperitoneum plus phrenic are in direct proportion to the degree of
rise of the diaphragm and the degree of vertical relaxation of the lung. In
order to get some objective evidence, we decided to measure the “differential
relaxation” of the upper lobe on the one hand, and of the lower and middle
lobe on the other, in those cases where the transverse fissure was visible.

Observations and measurements were made in two cases where right
lung was healthy, in eight cases of upper lobe lesions, in one of lower lobe
lesions and in two where the entire right lung was diseased.

Measurements were taken on roentgenograms from apex to the mid
point of the transverse fissure and then from the latter to the highest
point of the dome. Roentgenograms were taken on the same fixed criteria
as described earlier.
Results and Discussions

1. In the healthy right lung (Table VI) the vertical relaxation which occurs with pneumoperitoneum is taken up 66.5 per cent by the lower and middle lobes and 33.5 per cent by the upper lobe.

TABLE VI
DIFFERENTIAL RELAXATION IN UPPER AND LOWER LOBES OF RIGHT LUNG (WHEN RIGHT LUNG WAS HEALTHY)

<table>
<thead>
<tr>
<th>Nature of Collapsing Therapy</th>
<th>Number of Cases</th>
<th>Total Reduction in Apep-Basal Diameter</th>
<th>Reduction in Apex to Transverse Fissure Diameter</th>
<th>Index of Vertical Relaxation of Upper Lobe</th>
<th>Reduction in Transverse Fissure to Dome Diameter</th>
<th>Index of Vertical Relaxation of Lower &amp; Middle Lobes</th>
</tr>
</thead>
<tbody>
<tr>
<td>With P.P.* alone</td>
<td>1</td>
<td>2.3</td>
<td>1</td>
<td>43</td>
<td>1.3</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2.5</td>
<td>0.6</td>
<td>24</td>
<td>1.9</td>
<td>76</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>33.5 66.5</td>
</tr>
</tbody>
</table>

P.P. = Pneumoperitoneum.

2. In the case of lower lobe disease with cavity (Table VII), the relaxation on pneumoperitoneum alone was 14.3 per cent in the upper lobe and 85.7 per cent in the lower and the middle lobe. When phrenic was added, the respective figures were zero per cent and 100 per cent due to segmental atelectasis in the lower lobe.

TABLE VII
DIFFERENTIAL RELAXATION IN UPPER AND LOWER LOBES OF RIGHT LUNG (IN LOWER LOBE DISEASE WITH CAVITY)

<table>
<thead>
<tr>
<th>Nature of Collapsing Therapy</th>
<th>Total Reduction in Apep-Basal Diameter</th>
<th>Reduction in Apex to Transverse Fissure Diameter</th>
<th>Index of Vertical Relaxation of Upper Lobe</th>
<th>Reduction in Transverse Fissure to Dome Diameter</th>
<th>Index of Vertical Relaxation of Lower &amp; Middle Lobes</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>With P.P. alone</td>
<td>3.5</td>
<td>0.5</td>
<td>14.3</td>
<td>8</td>
<td>85.7</td>
<td></td>
</tr>
<tr>
<td>With P.P. plus phrenic</td>
<td>5.5</td>
<td>0.0</td>
<td>0.0</td>
<td>5.5</td>
<td>100 Whole of the relaxation taken up by L.L. no manifest, gross atelectasis. Segmental atelectasis probable</td>
<td></td>
</tr>
</tbody>
</table>
3. Where the whole of the right lung was diseased (the lower lobe had bigger cavity) (Table VIII) the proportion of vertical relaxation with pneumoperitoneum plus phrenic was 73.7 per cent for lower and middle and 26.3 per cent for the upper lobe.

4. In cases with upper lobe disease with or without cavity, (Table IX) the proportion of vertical relaxation on pneumoperitoneum alone was 53.3 per cent in the upper and 46.7 per cent in the lower and middle lobes. In this series of six patients, there was one case in which due to massive atelectases of the upper lobe all the vertical relaxation (100 per cent) was taken up by it and proportion for lower and middle lobe was recorded as (0 per cent). If this case is excluded from the series the figure will be 44 per cent for the upper lobe and 56 per cent for lower and middle lobes.

<table>
<thead>
<tr>
<th>TABLE VIII</th>
<th>IN DISEASE OF THE WHOLE OF THE RIGHT LUNG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Cases</td>
<td>Total Reduction in Apex-Base Diameter</td>
</tr>
<tr>
<td>With P.P. alone only 2 refills of 100 cc. and 150 cc.</td>
<td></td>
</tr>
<tr>
<td>With P.P. and phrenic one month after</td>
<td>5.0</td>
</tr>
<tr>
<td>Five months after</td>
<td>5.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TABLE IX</th>
<th>DIFFERENTIAL RELAXATION IN THE UPPER AND LOWER LOBES OF RIGHT SIDE IN UPPER LOBE DISEASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of Collapse Therapy</td>
<td>Reduction in Apex-Base Diameter</td>
</tr>
<tr>
<td>After P.P. alone average of 6 cases</td>
<td>2.4</td>
</tr>
<tr>
<td>After phrenic alone average of 2 cases</td>
<td>2.25</td>
</tr>
<tr>
<td>After P.P. plus phrenic average of 4 cases</td>
<td>5.16</td>
</tr>
</tbody>
</table>
With phrenic alone in upper lobe disease the relaxation is 35 per cent in upper lobe and 65 per cent in the lower and middle lobes.

In other words the vertical relaxation induced by pneumoperitoneum or pneumoperitoneum plus phrenic paralysis is chiefly taken up by the lower and middle lobes except when the upper lobe is predominantly diseased. Then the latter also takes up nearly half the vertical relaxation. In short the vertical relaxation induced is distributed between the various lobes, in this proportion.

1. In a healthy lung about two-thirds in the lower and middle and about one-third in the upper lobe.
2. In upper lobe disease, a little less than half in the lower and middle and a little more than half in the upper lobe.
3. In lower lobe disease about four-fifths in the lower and middle, and one-fifth in the upper lobe.
4. In disease of the whole of the right lung, the proportion will depend on, which lobe is more diseased and also which one undergoes segmental or lobar atelectasis.

C. The Effect of Mediastinal Shift and Compensatory Rib Movement on the Transverse Diameter of the Lower Lung Fields Following Pneumoperitoneum Combined with Phrenic Paralysis.

Fox* (1950) advanced a modified concept of the effect of pneumoperitoneum plus phrenic nerve paralysis on the transverse diameter of the lung base. He stated that the vertical relaxation induced by the combined procedure is to some extent off set by the broadening of the lung field at the base on the paralysed side, due to two factors:

1. Partly due to mediastinal shift away from the paralysed side.
2. Partly due to the increased compensatory movement of the lower ribs which follows the operation of phrenic paralysis.

Of these two factors, he studied the effect of mediastinal shift in 80 cases, and found that average reduction of the width of the opposite lower hemithorax due to mediastinal shift was 11.4 per cent. He has not mentioned the average increase in the transverse diameter of the base of the lung on the paralysed side, nor has he measured the increase in this transverse diameter due to compensatory rib movement.

**Mediastinal Shift**—The horizontal distance between the side of the vertebral bodies and the point of maximum bulge in the cardiac outline on the non-paralysed side was measured before the beginning and after the full establishment of treatment. The difference between these two distances was taken to be the measurement of mediastinal shift. Corrections were made in the measurements of mediastinal shift for any clavicular tilt present.

**The Transverse Basal Diameter**—The horizontal distance between the sides of the vertebral body and the inner margin of the periphery of the bony thorax was measured by a line passing through the highest point of the diaphragm before the beginning and after the full establishment of treatment. The point which needs emphasis is, that after the base of the
lung has been lifted up in the thorax by the rise of the paralysed diaphragm with pneumoperitoneum, the transverse diameter should now be taken at the level of the highest point of the diaphragmatic contour, and not at the original level of the diaphragm, for the base of the lung has moved up considerably in the thorax which is roughly cone-like. Our results were as follows:

### Table X

<table>
<thead>
<tr>
<th></th>
<th>Reduction in Apico-Basal Diameter</th>
<th>Increase in Basal Transverse Diameter</th>
<th>Total Increase in Basal Transverse Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per Cent</td>
<td>Per Cent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Due to Mediastinal Shift</td>
<td>Due to Rib Movement</td>
<td></td>
</tr>
<tr>
<td>1. P.P. plus right phrenic crush, average of 8 cases</td>
<td>27.8</td>
<td>6.5</td>
<td>5 per cent in half the cases. But in the other half 5 per cent diminution occurred</td>
</tr>
<tr>
<td>2. P.P. plus left phrenic crush, average of 4 cases</td>
<td>23.8</td>
<td>2.5</td>
<td>2.2 per cent in ¼ the cases. But in the ¾ the cases. 1 per cent diminution occurred</td>
</tr>
</tbody>
</table>

### Results and Discussion

**A. On the right side:** (eight cases of pneumoperitoneum plus right phrenic crush were studied). The average reduction in apico-basal diameter was 27.8 per cent. The average increase, on the paralysed side, in the transverse diameter at the base of the lung due to mediastinal shift was 6.5 per cent, whereas the effects of compensatory rib movements increased the transverse diameter of the base by 5 per cent in half the cases. In the other half the transverse diameter at the base was diminished by 5 per cent, thereby showing that the effect of the lifting of lung base in the cone-like thorax diminished its transverse diameter more than the compensatory rib movements could increase it at that level.

Taking the effect of both mediastinal shift and compensatory rib movement together, we find that the transverse diameter of the lung base was increased by 11.5 per cent in half the cases and by 1.5 per cent in the other half.

**B. On the left side:** (four cases of pneumoperitoneum plus left phrenic crush were studied). The apico-basal diameter was diminished by 23.8 per cent and the transverse basal diameter was increased by 2.5 per cent due to mediastinal shift. Compensatory movements increased the transverse diameter in one-quarter of the cases only by 2.25 per cent. The combined effect of mediastinal shift and the compensatory rib movement was to increase the basal transverse diameter in one-quarter of the cases by 5 per cent and in the remaining three-fourths cases by 1.5 per cent. We are aware the number of the cases studied with left side treatment
was only four and, therefore, too small for statistical analysis.

This small increase in transverse diameter was only present in those cases where the mediastinum was mobile and further that it did not materially neutralize or offset the benefits resulting from reduction of apico-basal diameter.

Acknowledgements: The author is deeply grateful to Dr. R. N. Tandon, Head of the Department of Tuberculosis, Lucknow University, India for his guidance and criticism in this work.

SUMMARY

1. A comparative study of the reduction in apico-basal diameter has been made on 62 patients, first on pneumoperitoneum alone, and later on the same patients when pneumoperitoneum was combined with phrenic crush.

2. In “group A” of 32 patients who received 1000 cc. of air at seven to 10 day intervals, the average reduction in apico-basal diameter was 16 per cent with pneumoperitoneum alone, and 28.5 per cent after addition of phrenic crush; that is, phrenic crush caused a further increase in vertical relaxation by about 78 per cent.

3. In “group B” of 30 patients who received a maximum of 600 cc. of air at weekly intervals, the average reduction in apico-basal diameter was 8.4 per cent with pneumoperitoneum alone, and 23.8 per cent after addition of phrenic crush.

4. When pneumoperitoneum was used as a sole collapse measure, 600 cc. refills at weekly intervals did not give adequate rise of the diaphragm. When phrenic crush was added, it was seen that even 600 cc. refills at weekly intervals gave adequate rise of paralysed dome, and either no rise or insignificant rise of non-paralysed dome.

5. In eleven patients, phrenic paralysis on one side was performed first and pneumoperitoneum was added later. It was noticed that with phrenic paralysis alone on the left side, the average reduction in apico-basal diameter was 11.5 per cent and maximum was 23.3 per cent. Whereas on the right side, the average reduction was 9.3 per cent and maximum was 13.2 per cent. With the addition of pneumoperitoneum the average reduction was 31.3 per cent on left side and 32.5 per cent on the right side.

6. The vertical relaxation induced by pneumoperitoneum or pneumoperitoneum plus phrenic paralysis is distributed between different lobes, in different proportions depending on the site of the major lesions.

7. Pneumoperitoneum combined with phrenic paralysis slightly increases the transverse diameter of the base of the lung due to the shift of a mobile mediastinum and compensatory rib movements. This insignificant increase in transverse basal diameter was only present in those cases where the mediastinum was mobile and it did not materially neutralize or offset the benefits resulting from reduction in apico-basal diameter.

RESUMEN

1. Un estudio comparativo de la reducción del diámetro apico-basal se ha hecho en 62 enfermos, primero con neumoperitoneo solo y después en el caso de los enfermos con neumoperitoneo combinado con frenopraxis.
2. En el grupo “A” de 32 enfermos a quienes se insuflaron 1000 cc. cada siete a diez días, la reducción del diámetro apicobasal por término medio fue de 16 por ciento con neumoperitoneo solo y 28.5 por ciento después de agregar el machacamiento del frénico o sea que el machacamiento causó un aumento de la relajación vertical de cerca de 78 por ciento.

3. En el grupo “B” de 30 enfermos que recibieron un máximo de 600 cc. cada semana la reducción apicobasal media fue de 8.4 por ciento con neumoperitoneo solo y 23.8 por ciento después de frenopraxis.

4. Cuando se usó el neumoperitoneo como único recurso el inyectar 600 cc. cada semana no produjo una elevación suficiente del diafragma. Cuando se agregó la frenopraxis se vio que aún 600 cc. semanarios proporcionaban suficiente elevación de la cúpula diafragmática paralizada sin que hubiese del lado no paralizado elevación alguna o era insignificante.

5. En once de los enfermos la parálisis del frénico de un lado fue realizada primero y el neumoperitoneo usado después. Se notó que con la parálisis frénica sola en el lado izquierdo la reducción media del diámetro apicobasal fue de 11.5 por ciento y la máxima de 23.3 por ciento. En tanto que en el lado derecho la reducción media fue de 9.3 por ciento y al máximo llegó a 13.3 por ciento. Agregando el neumoperitoneo la reducción media fue de 31.3 en el izquierdo y 32.5 por ciento en el derecho.

6. La relajación vertical producida por el neumoperitoneo o el mismo más la frenicoparálisis se distribuye entre diferentes lóbulos en diferentes proporciones dependiendo del lugar de las lesiones más grandes.

7. El neumoperitoneo combinado con frenicoparálisis aumenta ligeramente el diámetro transversal de la base del pulmón debido a desplazamiento del mediastino móvil y a los movimientos costales de compensación. Este aumento insignificante transversal de base sólo se notó cuando el mediastino era móvil y no neutralizó o perturbó los beneficios de la reducción del diámetro vertical.

RESUME

1. Une étude comparative de la réduction du diamètre apico-basal a été faite chez 62 malades, d’abord par le pneumopéri tone, et ensuite sur les mêmes malades après qu’un écrasement du phrénique eût été associé au pneumopéritoine.

2. Dans le groupe A comprenant 32 malades qui reçurent 1.000 cc d’air à intervalles de 7 à 10 jours, la réduction moyenne du diamètre apico-basal fut de 16% avec le pneumopéritoine seulement, et de 28,5% après addition de paralysie phrénique; c'est-à-dire que la paralysie phrénique créa une augmentation ultérieure de la détente verticale d'environ 78%.

3. Dans le groupe B de 30 malades qui reçurent un maximum de 600 cc d’air à intervalles d’une semaine, la réduction moyenne du diamètre apico-basal fut de 8,4% avec le pneumopéritoine seul, et 23,8% après association de la paralysie phrénique.

4. Lorsque le pneumopéritoine fut utilisé comme seul moyen de colllapsus, des insufflations de 600 cc. chaque semaine ne donnèrent pas une élévation suffisante du diaphragme. Lorsque la paralysie phrénique fut associée, on constata que des insufflations de 600 cc. chaque semaine pro-
voquait une élévation convenable de l'hémi diaphragme paralysé et pas d'élévation presque insignifiante du côté où la paralysie phrénique n'avait pas été réalisée.

5. En onze de les malades où la paralysie du phrénique d'un seul côté fut d'abord pratiquée, et le pneumopéritoine associé ultérieurement, on nota que la paralysie phrénique seule, du côté gauche, amena une réduction moyenne du diamètre apico-basal de 11,5% et une réduction maximum de 28,3%. Du côté droit, la réduction moyenne fut de 9,3% et la réduction maximum de 13,2%. Avec l'association du pneumopéritoine, la réduction moyenne fut de 31,3% du côté gauche, et de 32,5% du côté droit.

6. La détente verticale imposée par le pneumopéritoine ou le pneumopéritoine associé à la paralysie phrénique frappe les différents lobes d'une façon différente, selon la situation des lésions principales.

7. Le pneumopéritoine associé à la paralysie phrénique augmente légèrement le diamètre transversal de la base du poumon, augmentation due au déplacement de un médiastin mobile et aux mouvements costaux compensateurs. Cette augmentation insignifiante du diamètre basal transversal n'existe que dans les cas où le médiastin est mobile, et il ne peut ni neutraliser ni diminuer les avantages résultant de la réduction du diamètre apico-basal.

ZUSAMMENFASSUNG

1. Es erfolgte eine vergleichende Untersuchung der Verminderung des apico-basalen Durchmessers an 62 Patienten, zuerst mit Pneumoperitoneum allein und später an denselben Patienten, nachdem das Pneumoperitoneum kombiniert worden war mit einer Phrenicus-Quetschung.

2. Bei der „Gruppe A“ von 32 Patienten, die 1000 ccm Luft in 7-10-tägigen Intervallen erhielten, betrug die durchschnittliche Verminderung des apico-basalen Durchmessers 16% bei Pneumoperitoneum allein und 28,5% nach Hinzufügung der Phrenicus-Quetschung; das heisst, die Phrenicus-Quetschung verursachte eine weitere Zunahme der verticaler Entspannung um ungefährr 78%.


5. Bei elf Patienten wurde die Phrenicus-Lähmung auf einer Seite zuerst durchgeführt und das Pneumoperitoneum wurde später hinzugefügt. Es war zu bemerken, dass bei einer alleinigen Phrenicus-Lähmung auf der linken Seite die durchschnittliche Verminderung im apico-basalen Durchmessers 11,5% betrug und im Maximum 23,3%. Während auf der
rechten Seite die durchschnittliche Verminderung 9,3% betrug und im Maximum 13,2%. Mit der Hinzufügung des Pneumoperitoneums betrug die durchschnittliche Herabsetzung 31,3% auf der linken Seite und 32,5% auf der rechten Seite.


REFERENCES