Certain pathological processes affecting the lung tissue or surgical operations on the lung interfere with external respiration. Under these circumstances the bodily functions are reorganized in accordance with the necessity of delivering oxygen to the tissues in order to maintain oxidative processes at the required level. In chronic pathological conditions of the lung (carcinoma, bronchiectasis) it is difficult to detect before operation the compensatory mechanisms which are gradually brought into play. Nevertheless the problem of the ways of compensation of the disorders of gas exchange in chronic pulmonary diseases, and also after major interference with the respiratory apparatus associated with operations on the lungs, is one of theoretical and practical interest.

P. K. Anokhin considers that the ordinary mechanisms of maintenance of the stability of the bodily functions in normal conditions have much in common with the mechanisms of compensation of these functions when disturbed [1].

One of the conditions causing reorganization of several bodily functions is physical effort. Much research has been done to study the changes in the bodily functions of healthy persons during effort in the course of athletic training, manual work and so on [5, 7, 11, 13, etc.]. Some interesting work has been done by Hemingway et al. [14], who investigated the changes in gas exchange with age, using physical effort for this purpose. Physical effort is widely used as a functional test nowadays in the examination of patients with diseases of the heart and lungs, since investigations at rest often fail to show certain defects of the respiratory and vascular systems [12, 15-19].

These authors, however, did not dwell on the special features of the adaptive reactions in different patients, which from our point of view is of definite interest in the problem of elucidating the compensatory mechanisms brought into play as the result of an increasing disability of the respiratory apparatus.

In this connection we examined 44 patients with pulmonary diseases at rest and after physical effort, before and after operation, in order to discover any individual peculiarities of the nervous regulation of respiration and the circulation of the blood in response to a raised level of the oxidative processes.

**EXPERIMENTAL METHOD**

We used the Douglas-Haldane method of investigation of the gas exchange and, in individual cases, Krogh’s method. The examinations were carried out in the morning, on fasting animals, in basal metabolic conditions. Measurements were made of the pulmonary ventilation (in liters per minute), the oxygen demand and the excretion of carbon dioxide (in ml per minute), the percentage utilization of oxygen in the lungs, the respiratory coefficient, and the basal metabolism (in calories and as a percentage of normal). At the same time
the pulse and respiration rate were counted. The patients then performed moderate physical exercise (going up and down steps 30 times in 1\frac{1}{2} minutes, or sitting down 20 times in 1\frac{1}{2} - 2 minutes). After the exercise the gas exchange was again investigated in the course of 7-8 minutes (see table).

Details of the Character of the Disease and the Number of Patients Examined

<table>
<thead>
<tr>
<th>Character of the disease</th>
<th>Total number of patients investigated</th>
<th>Number of patients examined before and after operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carcinoma of the lung</td>
<td>22</td>
<td>4</td>
</tr>
<tr>
<td>Bronchiectasis</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>Benign tumors, cysts, hydatid disease, etc.</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>44</strong></td>
<td><strong>12</strong></td>
</tr>
</tbody>
</table>

As we know, the increased oxygen demand of the tissues during and after effort is brought about by several interconnected functions taking part in the transport of oxygen. Under these circumstances increases take place in the pulmonary ventilation, the minute volume of the heart, the arteriovenous oxygen difference of the blood and so on.

In response to brief physical effort the pulmonary ventilation in all our patients examined increased 1\frac{1}{2} - 2 times, and in the course of 5-6 minutes after the exercise it decreased to approximately the initial value. The oxygen demand (in ml per minute) was 2-3 times greater than the original before the physical effort (measurements were made in individual cases) and twice as great as the initial value in the first 3 minutes of the recovery period, gradually decreasing with rest. The percentage utilization of oxygen in the lungs during brief physical effort increased by comparison with the resting state at the beginning of the recovery period and sometimes fell below the initial value at the end of this period, when the oxygen demand did not exceed its initial value. Only in a few cases was the percentage utilization of oxygen below the initial value in the first minutes of the recovery period.

On the basis of an analysis of the results obtained, it was found that the performance of physical exercises, which in all patients doubled the oxygen demand, was achieved by various forms of nervous regulation of respiration and the circulation of the blood. Four main types of reaction of respiration and the blood circulation to brief effort could be noted.

1. In 12 cases an increased delivery of oxygen to the tissues after effort took place as the result of deepening of the respiration and increased utilization of oxygen, as might be assumed, on account of an increase in the stroke volume of the heart. The pulse and respiration rates under these circumstances remained unchanged (Fig. 1).

2. In 17 cases the increased oxygen demand after physical effort was satisfied by an increase in the depth and the rate of respiration and an increase in the percentage utilization of oxygen. The heart rate was unchanged or even became slower, from which an increase in the stroke volume of the heart could be deduced (Fig. 2). The subjects forming the first and second groups had practiced sports in the past.

3. In 8 patients there was a considerable rise in the heart rate after effort, whereas the respiration rate remained unchanged or became slower. The increased oxygen demand was met by a deepening of the breathing and an increase in the minute volume of the heart, in this case mainly on account of an increased rate of contraction. The percentage utilization of oxygen in the lungs was unchanged.