SOME TECHNIQUES FOR INCREASING THE ACCURACY OF DETERMINING AND EVALUATING THE INDICES OF PULMONARY CAPACITIES

A. M. Marin

A number of methods, including those based on mixing gases, have been proposed for determining the residual volume (RV) and functional residual capacity (FRC). The literature of the past decade [1-6] indicates the diagnostic value of determining the RV in emphysema, chronic bronchitis, bronchial asthma, pneumoconiosis, and other diseases.

Thanks to the organization of the lot production of POOL-1 instruments for measuring pulmonary capacities, the method of mixing with helium is being used more extensively in clinical practice. Of importance in connection with this is the correct methodological approach to determination of the indices of pulmonary capacities and their evaluation.

Investigations performed by A. A. Cherkasova [7] indicate noticeable errors of the POOL-1 instrument due to errors of the gas analyzer for helium. The error, which depends on the behavior of the patient and skill of the investigator, was not taken into account in this case. In the present study we attempted to find the possibilities of a more accurate determination of the RV by reducing the errors not associated with the technical capabilities of the instrument.

Investigation of the RV by means of the POOL-1 instrument is based on the principle of a decrease of helium concentration in the air-helium mixture when the latter is diluted with air contained in the FRC of the lungs. The instrument consists of a SG-1M spiograph and a TP-1120 gas analyzer attachment for continuous recording of the helium concentration in the gas mixture during the investigation. The apparatus is connected to the examinee for breathing the air-helium mixture after a gentle expiration.

The magnitude of the RV is determined from the difference between the FRC calculated by formula and the expiratory reserve volume (ERV). To determine the latter the instrument instructions indicate that the testee exhale completely at the end of the investigation, after which he is switched over to breathing atmospheric air.

On the basis of the fact that the magnitude of the ERV depends in many respects on the quality of performing tests, which is governed by many factors (the emotional factor at the time of investigation, the degree of training for the task set up, etc.), we suggest to our testees a threefold recording of the vital capacity of the lungs (VC) at the 6-7th min of breathing the air-helium mixture instead of a single deep inspiration at the end of the recording.

In a study of the RV of more than 250 persons the use of the threefold recording of the VC enabled us to determine more accurately the ERV, which applies equally to the RV. The magnitudes of the ERV in the first recording of the VC were sometimes 200-400 ml less than in the subsequent ones. In addition, in the case of pronounced pulmonary pathology (emphysema, pneumoconiosis, etc.) when there are numerous portions of the lungs not being ventilated, a deep inspiration when determining the VC possibly promotes an increase of the effectiveness of mixing in some cases.
Patient K., age 56 years. Diagnosis: chronic diffuse bronchitis, stage II of emphysema of the lungs. During determination of the RV based on the minute drop of helium concentration, we noted a slowing of intrapulmonary mixing. Equalization of the gas concentration in the spirometer-lungs system occurred only at the 6th min* (see Fig. 1). At the clear-cut drop of helium concentration, owing to the pulmonary air with which the helium during quiet breathing possibly did not mix. With the use of the data obtained before and after measuring the VC, the difference in the residual volume amounted to 250 ml.

The magnitude of the RV is determined on the basis of absolute indices and its percentage ratio to the total capacity of the lungs (TC), which represents the arithmetic sum of the RV and VC of the testee. The simultaneous recording of the VC when determining the RV eliminates the need for additional finding of this index.

The method of evaluation based on the absolute index does not give a sufficiently complete idea about the magnitude of the RV (on comparing it with the mean normal values described in the literature), since in this case it is impossible to take into account individual peculiarities of the examinee (height, weight, age) which have a considerable effect on the magnitude of pulmonary capacities. Therefore, to evaluate the RV in each specific case we more often use the percentage ratio of the absolute values of the RV and TC. This index, however, also has its shortcomings.

Our investigations of patients with chronic bronchitis and pneumoconiosis showed that when the TC does not correspond to the rightful values the ratio is distorted: there can be an increase of the percentage for an unchanged RV but lowered VC (the TC is reduced) or the ratio can be underestimated with an appreciable increase of the RV (leading to an increase of TC with a little-changed VC).

Taking into account that for pronounced forms of pathology the relationship of pulmonary capacities, including the TC, is most often disturbed [2, 6], to eliminate the indicated distortions when evaluating the RV of such patients we propose to use the ratio RV/RTC \( \times 100 \) (RTC is the rightful total capacity of the lungs) instead of the ratio RV/TC \( \times 100 \).

In calculating the RTC we proceeded from the values of the rightful VC (RVC) obtained from A. O. Navakatlyan's tables [8] compiled for physical laborers. The indices were obtained on the basis that the RVC is 72% of the RTC, since in healthy persons at an age of 20-50 years for whom the VC corresponds to the RVC and the RV does not change, the ratio of the last to the TC is on the average 28%, according to the literature and our data. In this case the RTC of the testee in each specific case corresponds to his RVC multiplied by the coefficient 1.39, which is obtained from the calculation.

\[
\text{RTC (unknown)} = 100\% \\
\text{RVC of testee} = 72\% \text{ of RTC} \\
\text{RTC} = \frac{\text{RVC}}{0.72} = \text{RVC} \times 1.39
\]

Investigations of healthy persons engaged in physical labor at an age of 30-49 years showed that the RTC obtained by the described method of the average corresponded to the actual TC.

In our investigations by means of this index we more fully revealed the interrelation of changes in the functions of external respiration in certain occupational diseases. No less important is the use of the ratio of the RV to the RTC for diagnostic purposes (emphysema, pneumoconiosis, etc.).

We will consider two examples with the use of the ratios RV/TC and RV/RTC for evaluating the RV.

---

*0.02% decrease of concentration per minute occurs owing to solution of helium in the blood. It is accounted for by drawing a straight line up to the intersection with the line denoting the start of the investigation. The point of intersection indicates the end concentration.