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O.S. Isserson and L.I. Pelinovskaya

UNITED STATES AIR FORCE
SCHOOL of AEROSPACE MEDICINE
AEROSPACE MEDICAL DIVISION (AFSC)
BROOKS AIR FORCE BASE, TEXAS

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INDICES OF THE VENTILATION APPARATUS IN CASES OF CHRONIC PNEUMONIA, AND THEIR DEPENDENCE ON THE DEGREE OF RESPIRATORY FAILURE

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This report is devoted to an analysis of the results of a complicated and dynamic examination of the ventilation apparatus in eighty-five patients having chronic pneumonia. The patients were examined both in a state of rest (which is described in Report I), after performing an assigned physical task, and after inhaling ephedrine, (which will be described in Report II).

The table shows the distribution of patients by age and sex. The course of the disease, using the classification of I.K. Yesipova, was diagnosed as segmental in forty-two patients, diffuse in nine, and mixed in thirty-four. The examinees were divided into four groups according to the intensity of the clinical symptoms using the classification suggested by A.G. Dembo[1].

As can be seen from Table 1, the first degree of respiratory failure was diagnosed on thirty-four patients who manifested dyspnea at a quick walk, after climbing stairs or going uphill. In four of them, the pneumonia was diffuse, in the others it was segmental (bronchiectases were diagnosed in twenty, pulmonary abscesses in ten). In half of them, the ailment lasted more than five years. Exacerbations were observed annually in all patients and there was a flare-up of the pulmonary process. After physical and x-ray examinations, the initial symptoms of pulmonary emphysema were found in ten patients.

The second degree of respiratory failure was diagnosed in thirty-two patients. Dyspnea appeared after slight physical exertion, and after a moderate walk on a level surface. In four cases, the diffuse variant was diagnosed; one case was of the segmental type and twenty-seven patients

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1. By respiratory failure or insufficiency, Dembo understands "a condition of an organism in which the normal function of the external respiratory apparatus fails to provide the organism with the necessary amount of O_2 and fails to expel the necessary amount of CO_2.

had pneumonia of the mixed type. In the majority of the patients in this group, the ailment lasted more than five years, and in two thirds, it lasted more than ten years. In all patients the ailment was severe with frequent (2-3 times a year) exacerbations. All were admitted during the exacerbation period. For seven patients, the anamneses indicated attacks of suffocation. Eleven experienced periodic respiratory deterioration, twenty-nine showed symptoms of marked pulmonary emphysema and circulatory failure occurred in nine cases.

There were seven patients with the third degree of respiratory failure. They exhibited dyspnea at rest, and there was diffuse cyanosis. The course of the illness was long and continuously recurrent. In all patients, pulmonary emphysema and respiratory failure were found.

A separate group was made up of patients with no clinical signs of respiratory failure. They had pneumonia of the segmental type (five exhibited pulmonary abscesses, the others had bronchiectases); their chief complaint was a constant cough with sputum and frequent malaise. The illness lasted more than five years in six cases. There were no attacks of bronchial asthma or pulmonary emphysema.

The function of the ventilation apparatus was studied using the generally accepted methods. The forced vital capacity of the lungs (FVCL) and the respiratory coefficient time (RCT) (ratio of inspiration time to expiration time) were determined using the spirometabolograph manufactured in the Hungarian People's Republic, at a tape rate of 600 mm/sec. Other indices were determined using the spirograph from the Kiev Plant. The speed of the air stream in the case of forced respiration was determined using the pneumotachometer of B.Ye. Votchal. Changes in O_2 saturation of the arterial blood were studied using the Markin method with an oxyhemometer. The patients were examined twice: once during the exacerbation period of the pulmonary process (but after a drop in temperature and a reduction in intoxication), and again during the remission period. The control group consisted of eighteen healthy youths, all thirty-three years old. The data obtained were processed using variational statistics.

In patients who indicated latent respiratory failure, many indices were near the lower limit of the normal value or slightly depressed. The ventilation indices did not differ from those of healthy persons. In only one subject was there hyperventilation (minute volume of respiration - MVR = 191%). Bronchial permeability was disturbed in eight persons. Thus, the FVCL was reduced in comparison with the normal VCL to 79.3 ± 18.1%, while in only one case was the one-second FVCL equal to 75%; and in the others it was reduced (34% - 65%): for three seconds, three patients exhaled 74% - 82%, whereas the others showed 100% VCL. The deceleration of the expiration rate for the one-second FVCL in comparison with the three-second one is worthy of attention. The velocity of the air stream in the case of forced inspiration was 5.0 ± 1.0 l/sec, and in the case

of forced expiration, it was 4.3 ± 0.67 l/sec (as against 6.4 l/sec for both in healthy persons). The RCT varied within broad limits (from 1:1.1 to 1:1.8), i.e. in many patients the expiration time was considerably prolonged. The MVL (minute ventilation of the lungs) for the group was 89 ± 20.6% of the normal value, and the VCL was 88.4 ± 11% of the normal value. The O_2 saturation of the arterial blood was normal according to the data from the oxyhemometer. In four patients, the desaturation time exceeded four minutes, which confirmed the unevenness of the pulmonary ventilation (Ye.A. Markin, B.Ye. Votchal and N.A. Magazanik).

Thus, even in the given group it was possible to notice disturbances in bronchial permeability; in one third of the patients there were signs of unevenness in ventilation, i.e. in patients in this group there was latent respiratory failure.

In patients who exhibited a clinically diagnosed degree of respiratory failure, the mean MVR was 7.9 ± 2.8 l or 143 ± 45.3% of the normal value. In eight patients marked hyperventilation was noted at rest (MVR 186% - 267%). In all patients, with the exclusion of one, the hyperventilation was caused either by a deepening of respiration, or also by its accelerated rate. In two patients, there was hypoventilation (MVR 83% - 91%). The respiratory volume was 472 ± 158 ml on an average; the respiratory rate was 17 ± 4.2 per minute. Reduction in the coefficient of O_2 utilization was noted (34 ± 6.3 ml), while in nine patients it was very low, and did not exceed 15 - 28.2 ml. The lowest coefficient of O_2 utilization were found in cases of hypoventilation.

VCL in this group averaged 69.3 ± 11.7% of the normal value, and the FVCL was 70.4 ± 12.9% of the VCL: after 1 second 58.1 ± 19.0% was exhaled, and after three seconds, 97 ± 5.4%. The MVL was reduced to 65.6 ± 19.9%. The ratio of the inspiration time to the expiration time was 1:1.1 - 1:1.5, while in four cases it was 1:1.7, i.e. the expiration time was increased considerably. The power of the forced inspiration was 3.9 ± 1.0 l/sec, while the power of expiration was 3.3 ± 0.84 l/sec. There was no hypoxemia in patients of this group, and unevenness of the pulmonary ventilation was observed in sixteen patients.

Consequently, in this group of patients, the indices studied were changed. Both hyper- and hypoventilation were encountered and the coefficient of O_2 utilization was reduced. Signs of disturbances in the bronchial permeability came to the fore, independently of the clinical symptoms of dyspnea. In half of the patients, unevenness of the pulmonary ventilation was detected.

Among patients exhibiting the second degree of respiratory insufficiency, hyperventilation was noted in seven cases at rest, and there was hypoventilation (MVR 79 - 96%) in three cases. In the remaining twenty-two cases, the MVR varied between 100% - 150% of the normal value, the average being 6.9 ± 1.3 l or 135.1 ± 27.8%. The mean respiratory

volume was 413 ± 111 ml; the respiration rate was 18 ± 3.2. The coefficient of O_2 utilization was reduced in two thirds of the patients (17.5 - 38.9 ml), i.e. in patients in this group, it was not dependent on the ventilation volume.

The VCL (to 55.7 ± 17.5%), the MVL (to 42.2 ± 13.8%) and the velocity of the air stream in the case of forced respiration (for inspiration 2.5 ± 0.99 l/sec, for expiration 1.7 ± 0.83 l/sec) were considerably reduced. The FVCL was 51.6 ± 15.5% of the VCL; after one second, the patients exhaled 50 ± 17.5%, after three seconds, 88 ± 14.2%. The RCT for the group averaged 1:1.3 ± 0.22 and in individual cases, it was 1:1.7 - 1.8.

In half of the patients, hypoxemia was detected from the oxyhemometric data (the increase in O_2 saturation of the arterial blood after 5 minute O_2 respiration equalled 4.5 - 8%). The desaturation time after transition to air occurred within 3.6 minutes in only six patients. In others it was increased (from 4.5 in two patients, to 5.5 - 10 minutes in the others).

Thus, in patients with second degree respiratory failure, marked disturbances of the function of the ventilation apparatus were observed: reduction of the coefficient of O_2 utilization, considerable disturbance of bronchial permeability, hypoxemia in half the patients, unevenness of pulmonary ventilation in two thirds of the cases.

For patients with third degree respiratory insufficiency, very low indices were characteristic. The MVR was 143 ± 20.3% of the normal value. All patients exhibited dyspnea (respiration rate 23 ± 5.2) and the respiratory volume was low (330 ± 125 ml). The VCL did not exceed 34 ± 7.8%. The FVCL was 28 ± 5.3% of the VCL; after one second the patients exhaled 48.2 ± 18.8%, and after three seconds 79 ± 18.1%. The MVL dropped to 23 ± 3.2%; the power of forced inspiration dropped to 1.33 ± 0.53 l/sec, and that of expiration to 0.85 ± 0.36 l/sec. The length of inspiration in proportion to that of expiration was 1:1.4 - 1.6. Oxyhemometry indicated marked hypoxemia and unevenness of pulmonary ventilation.

Consequently, the increase in the degree of respiratory failure is reflected by a progressive reduction of the following indices: MVL, pneumotachometric data, VCL and FVCL. Along with the degree of respiratory failure, the respiration rate increases and its depth decreases. In the group with latent respiratory failure, and first degree respiratory failure, arterial hypoxemia was not noted. The latter was observed in half of the patients with the second degree and usually in those with the third degree.

No relationship exists between the change in MVR and the degree of respiratory failure. Thus, hyperventilation is encountered with the same frequency in patients with first and second degree respiratory failure (in 27% of the cases) along with hypoventilation in some of the patients, while in

others, the MVR is normal. The data in the pertinent literature are not in agreement on this question (A.G. Dembo; A.I. Borokhov; B.V. Veselov; L.I. Fogel'son et al.; I.I. Likhnitskaya). At the same time, even in a state of rest and during the initial phases of the development of respiratory insufficiency, a disturbance in bronchial permeability is detected. Reduction of the FVCL, pneumotachometric indices and MVL was already noticed in the group with latent respiratory failure. Disturbance in bronchial permeability was present both in the case of the diffuse and the segmental pulmonary process. There are no substantial changes in the reduction of the indices examined (within one group) in patients with bronchial asthma (excluding an attack) compared with those in whom this ailment was not listed in the anamneses. Even in the second group, in which marked pulmonary emphysema was diagnosed in twenty-nine out of thirty patients, all indices changed rather considerably. Consequently, in the early stages of chronic pneumonia, the disturbances in the ventilation apparatus are conditioned to a large extent by functional changes and primarily by a disturbance in bronchial permeability. Later, the clinical picture of respiratory failure and the functional disturbance of the ventilation apparatus becomes more profound with respect to the morphological changes (pulmonary emphysema, pneumosclerosis, etc.).

Conclusions

1. There is a relatioship between the functional condition of the ventilation apparatus and the clinically determined severity of respiratory failure: definite functional disturbances in a series of indices (MVL, VCL, pneumotachometric data, FVCL, frequency and depth of respiration) correspond to the degree of respiratory failure.

2. In chronic pneumonia, even during the early stages of development, there are disturbances of the bronchial permeability. The association of pulmonary emphysema makes these changes more profound.

3. Dyspnea is not the first sign of respiratory failure. Even before it occurs, some functional disorders of the ventilation apparatus become manifest in chronic pneumonia patients (reduction of MVL, reduction of velocity of air stream in forced respiration, VCL and unevenness of ventilation).

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2 Возраст (в годах)	3 Число больных	1 Степень дыхательной недостаточности							
		4 латентная		I		II		III	
		М.	Ж.	М.	Ж.	М.	Ж.	М.	Ж.
5 До 20	7	—	—	3	1	3	—	—	—
21—30	20	7	—	6	1	2	2	1	1
31—40	24	5	—	13	1	3	1	1	—
41—50	21	—	—	6	1	10	2	2	—
51—60	11	—	—	1	—	9	—	1	—
61—70	2	—	—	1	—	—	—	1	—
6 Всего	85	12	—	30	4	27	5	6	1

Table 1: Classification of Patients by Age and Sex

1. Degree of respiratory failure
2. Age (in years)
3. Number of patients
4. Latent
5. Up to
6. Total

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