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SOME PRACTICAL APPLICATIONS OF PULMONARY FUNCTION STUDIES IN CHEST DISEASE

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The study of pulmonary physiology has become one of the most rapidly growing fields of investigation in recent years. For the practicing physician, an evaluation of the clinical usefulness of lung function tests has become increasingly difficult, owing to the continuing introduction of new methods and greater complexity. Two questions about such studies are commonly asked. These are, first, what is the single most useful test of lung function; and second, under what circumstances should functional evaluation of the lungs be undertaken?

To answer these important questions adequately will be impossible in this brief discussion. However, an understanding of a few general points will help to clarify the problem.

First, tests of pulmonary function in current use have certain clear-cut limitations. As in the case of measurements of liver or of renal function, they quantitate the ability of the organ to perform its physiologic task. They do not record anatomic changes; nor do they locate the *site* of a lesion within the lung. Similarly, they usually will not provide an etiologic diagnosis of the abnormalities found. They may show no significant alterations in localized lesions which produce little interference with either ventilation or perfusion of the lung. Thus, certain conditions of great clinical importance, such as carcinoma, lung abscess, or tuberculosis, may be undetected by physiologic studies. On the other hand, diseases with airway obstruction, and often relatively little abnormality on routine chest films, may produce marked alteration in function.

Pulmonary functions tests are concerned chiefly with the measurement of disability resulting from disease of the lungs, and of reserve available in times of stress. Thus, they are particularly useful in the evaluation of patients in whom major thoracic surgery is contemplated; in the quantitation of degree of impairment, and the determination of its physiologic cause, especially where medico-legal problems may be involved; and finally, in assessing response to therapy in chronic pulmonary disease, and in following its course by serial observations.

The multiplicity of current tests of lung function reflects the complexity of the work of the lungs, the primary function of which is to carry oxygen into the blood and excrete carbon dioxide. Many processes are integrated together to produce the end result; thus, no one determination can give a complete picture of the whole. Two relatively simple tests, however, will supply considerable information, and have been found in most instances to be well correlated with patient disability. These are the maximum breathing capacity—the maximum amount of air which can be moved in and out of the lungs in a given period of time—and the timed vital capacity, usually measured in a three second interval and calculated as percent of the total vital capacity. Using these baseline studies in conjunction with a careful history, physical examination, and chest fluoroscopy, a fairly accurate estimate of function can be made in the majority of cases. In addition, these tests often show certain patterns of abnormality

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which help, for instance, in the detection of pulmonary emphysema, and in its differentiation from various types of pulmonary fibroses, with which it is often confused.

Chronic obstructive pulmonary emphysema is perhaps the commonest, and also the most crippling of chronic chest diseases. It may exist by itself, but frequently complicates other chronic pulmonary disease. Detection of its presence, and accurate evaluation of its effects are essential for several reasons. The presence of obstructive emphysema is often the chief factor in disability. Patients with emphysema present a considerably increased risk for operative procedures; they tolerate anesthesia poorly, and have great difficulty raising secretions post-operatively. In addition, the dangers of over-sedation, and of therapy with high concentrations of oxygen in these patients are becoming increasingly well recognized.

Spirographic studies in these individuals reveal an abnormal pattern which is usually quite distinct from that generally found in pulmonary fibroses.

The following two cases demonstrate characteristic findings in such instances.

The first was a man of 50 with a typical story of moderately severe dyspnea on exertion, gradually increasing over several years. Cough and wheezing were also prominent symptoms at certain times. Chest films showed little abnormality in the parenchyma, although the hemi-diaphragms exhibited the flattened configuration usually seen in emphysema. Function studies revealed:

1. A prolongation of the vital capacity curve with a delayed return to the baseline.
2. Diminished vital capacity, with the ratio of the three second to the total capacity considerably decreased.
3. Greater decrease in maximum breathing capacity than in vital capacity, indicating inability to move air in and out rapidly.
4. Normal oxygenation of the blood at rest, as demonstrated by arterial blood studies; and the same during exercise, in spite of severe dyspnea—showing that the dyspnea was not secondary to hypoxia.

The figures obtained may be summarized as follows:

	Predicted	Determined	%
Total vital capacity	3850 cc.	3040 cc.	79
Three second vital capacity	95% of total	65% of total	—
Maximum breathing capacity	104.5 L/min.	36 L/min.	35

Thus we have the picture of diffuse airway obstruction as the outstanding abnormality, with no impairment of the blood oxygenating mechanism under the conditions of the test.

In sharp contrast to the foregoing were the findings in the next case. This patient was a man of 52, who also had noted gradually increasing exertional dyspnea over a period of several years. Serial chest films made as part of a routine yearly examination at his place of work over a ten year period revealed diffuse bilateral parenchymal densities which had become gradually more extensive during this time. During these years, the man had been employed in an industry manufacturing a cobalt alloy, but as far as could be determined no exposure to silica was present.

The most striking features on physical examination were marked clubbing of the fingers, and a pronounced tachypnea in response to exertion, without, however, the labor and discomfort of breathing observed in the previous patient. Function studies

differed distinctly from the preceding, and were, in general, representative of those found in other diffuse pulmonary fibroses of various types. The oustanding abnormalities were:

1. Marked decrease in vital capacity, as well as tidal air, indicating a restricted thorax.

2. Normal ratio of the three second vital capacity to the total—over 95%.

3. Maximum breathing capacity much less reduced than the vital capacity, indicating an absence of significant airway obstruction.

4. Studies with the oxyhemograph, or oximeter, revealed a marked fall of arterial oxygen saturation during exercise; however, no fall occurred during the same exercise while breathing 100% O_2, thus indicating the absence of any significant shunt of pulmonary blood from right to left.

The values obtained for vital capacity and maximum breathing capacity were as follows:

	Predicted	Determined	%
Total vital capacity	3620 cc.	1620 cc.	45
Three second vital capacity	95% of total	95% of total	
Maximum breathing capacity	99 L/min.	75 L/min.	76

The findings in this case are characteristic of those occurring in a patient whose primary problem is diffuse pulmonary fibrosis, resulting in a reduced lung volume, restricted ability to move the thoracic cage and lungs, and little or no airway obstruction. As in chronic emphysema, dyspnea or tachypnea is apparently unrelated to impaired oxygenation of the blood. In both these instances, relatively simple pulmonary function studies helped to delineate the character of the abnormalities present, and to quantitate the degree of impairment.

Careful studies of such specific alterations of function often have direct therapeutic implications. The management of the patient with chronic pulmonary emphysema may differ considerably from that of the patient with pulmonary fibrosis. Such matters as the proper use of O_2, the administration of bronchodilators, and the employment of steroid therapy, may be directly influenced by the primary type of underlying physiologic defect. Furthermore, the presence of a pulmonary fibrosis, in particular pneumoconiosis, does not necessarily imply a disability. When dyspnea supervenes, it is often an indication of the presence of a complicating emphysema, which is best measured by appropriate function studies.

More recent research in the field of pulmonary physiology involves studies of diffusion across the alveolar membrane and of ventilation-perfusion relationships within the lungs; measurements of the elasticity of the lungs; and determinations of the work involved in the mechanical act of respiration. All of these studies attempt to obtain fundamental information about the physiology of the lungs and to establish the nature of any defects which may be present. Like other basic studies, their usefulness to clinicians will depend on careful interpretation and understanding of the limitations of the methods involved. In any case, it is clear that judicious application of tests of pulmonary function will play a role of growing importance in the future management of clinical problems.