CLINICAL SIGNIFICANCE OF PULMONARY FUNCTION TESTS

Disability or Disinclination?*  
Impairment or Importuning?  

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The use of the terms, disability and impairment, as though they were interchangeable has been and is a source of confusion that should be avoided at all costs. Disability or disablement is present when the affected subject is either incapable of performing a certain job or activity or, if he is capable, can do so only at the expense of undue distress. It therefore follows that disability may be partial or complete. In contrast, an impairment or functional deficit is a deviation from normal function. While some impairments may be severe and disabling, others may be so mild as to be asymptomatic; moreover, it is possible for two persons to have the same impairment and for one to be completely disabled while the other is relatively unaffected. Thus, the loss of a leg would be totally disabling for a ballet dancer but would certainly not be so for a government civil servant; indeed, since the latter has been trained to do "nothing in particular and do it very well," he might find himself promoted and in for a merit increase. The extent of any impairment can and should be determined by a physician, but the decision as to whether a particular impairment is likely to lead to disability should take into account several other factors, some of which are social and some educational. Because of these considerations, many persons believe that determination of disability should not depend solely upon a physician's opinion.

The most common symptom in those claiming respiratory disability is shortness of breath; however, it must be borne in mind that with a certain level of exertion, some breathlessness is experienced even in the healthy subject, and only if the dyspnea is excessive for a particular task does it suggest that impairment may be present. Moreover, shortness of breath, like pain, is an unpleasant and distressing sensation and, also like pain, is tolerated well by some and badly by others. With these provisos in mind, let us now consider in more detail some of the factors that determine whether a particular impairment is likely to lead to disability.

EDUCATIONAL STATE AND MOTIVATION

The development of shortness of breath sufficient to put a man at a disadvantage for a particular job need not always be disabling, since in some instances, he can be moved to a less arduous job. The elderly foundry worker with obstruction of the airways may be quite capable of carrying out the duties of a storekeeper or night watchman, but such a happy and simple solution is not always available. Thus, the coal miner who is unable to continue working in the mines might have sufficient respiratory reserve remaining to work as a bank teller or as a salesman but may have neither the education nor the intellectual attainments for these positions, even if they should be available. If suitable alternative employment is not available, the miner must be regarded as disabled, despite his having sufficient respiratory reserve to enable him to perform to a less arduous job.

In a similar vein, it has been clearly established that the likelihood of a man with a particular impairment continuing to work depends on his educational background. The better educated the subject, the less likely he is to stop working. LeRoy-Ladurie and colleagues have shown that about 20 percent of laborers return to work following a pneumonectomy, while in contrast, 70 to 80 percent of those with a profession return to their jobs. In the case of children undergoing pneumonectomy, all go on to obtain a job. While the loss of earnings is usually greater in the disabled professional and this obviously provides some stimulus to return to work, it is not the only factor, and there is little doubt that if a man finds his job interesting and stimulating, he has less desire to stop working and claim compensation.

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With increasing age, there is decreasing adaptability, and older persons find it more difficult to acquire new skills. In addition, pulmonary function and pulmonary reserve decline with age, and these changes have an effect on working capacity and will be alluded to again later.

SUBJECTIVE COMPLAINTS

The most common complaint in the subject who has respiratory impairment is shortness of breath. Breathlessness can be graded according to its severity, and in this context, one of the first reliable questionnaires was introduced by Fletcher. He was able to show that it had limited variation between observers and that it correlated reasonably well with studies of pulmonary function. Nonetheless, it has become apparent that the degree of breathlessness claimed by any particular subject is related to the reason why he or she is consulting the physician. Should the subject be claiming compensation, then he tends to exaggerate his symptoms. This was first quantified by Cotes when he related the degree of breathlessness in two groups of subjects, one of which was claiming compensation while the other had consulted the physician on account of respiratory symptoms. For the same level of breathlessness, those claiming compensation had a mean forced expiratory volume in one second (FEV₁) which was appreciably better than those who consulted the physician for other reasons. These effects are shown in Figure 1. Similarly, subjects who are overweight and who lead sedentary lives are also likely to complain of more severe shortness of breath in the presence of minor respiratory impairments.

ENERGY REQUIREMENTS

Clearly, the energy necessary to carry out a specific task is important, since in some instances a subject's respiratory reserve may be insufficient for a particular job. While the resting requirements for oxygen in a normal person are around 250 to 300 ml/min, housework and clerical duties require an intake of oxygen of around 900 ml/min. A face worker in a coal mine who is operating a continuous miner uses around 1.2 L/min, while farming is somewhat harder and more demanding, and the requirement for oxygen in this occupation is around 1.5 L/min but may be appreciably more under certain circumstances. Heavy labor in many iron and steel foundries necessitates an oxygen consumption of around 2.1 L/min. By the same token, sustained moderate effort is tolerated less well in the subject with respiratory impairment than are short bursts of high output of energy followed by a prolonged low expenditure of energy. In deciding whether a man is capable of carrying out a task, it is therefore essential to know the physical demands of the job and also his exercise tolerance.

PULMONARY IMPAIRMENT

The assessment of functional deficits in relation to disability is most often required in occupational pulmonary disease. In subjects being examined for occupationally related disability, one has to bear in mind that naturally occurring diseases, such as asthma and emphysema, occur frequently. It then becomes important to separate the effects of occupation from those of naturally acquired disease. To achieve this requires a knowledge of the type and site of the impairment produced by the hazard. Thus, while byssinosis is purely a response of the airways, silicosis and asbestosis affect the pulmonary parenchyma. Tests that enable one to diagnose and quantify the degree of impairment in a cotton worker with byssinosis are inappropriate for characterizing the respiratory defects in subjects with asbestosis or silicosis.

The most useful tests in the assessment of respiratory disability are those which are objective and are not influenced by the behavior of the subject. Simple and reproducible tests which, although partly dependent upon effort, reveal whether or not the patient is cooperating are the most useful. In this regard the FEV₁ and the other indices derived from the maneuver to determine forced expiratory volume are more useful than the maximal voluntary

![Figure 1. Relationship of FEV₁ to grade of breathlessness in group of 150 coal miners claiming disability, as compared to 60 consecutive hospitalized patients. Breathlessness was graded as follows: 0, none; 1, more breathless than persons of same age while climbing hill or hurrying; 2, breathless while performing ordinary tasks at work or while walking on level and 3, short of breath at rest or while undressing.](image-url)
ventilation (MVV), since in the latter a submaximal effort is more difficult to detect. Nonetheless, since multiplying the FEV₁ by 40 gives a reasonably accurate prediction of the MVV, measurement of the latter gives an added check on the claimant’s effort.

Although it is often maintained that there is a poor relationship between pulmonary impairment and dyspnea, such a pronouncement is a quarter truth. Granting that there are some individuals in whom this is true and provided one makes allowances for personality, educational status, and whether or not the subject is claiming disability, an acceptable correlation exists in the majority of cases. Faute de mieux, in determinations of disability, we have to rely on the degree of impairment to indicate how short of breath a person is likely to be. Although among the simplest tests to perform, it is still true that the vital capacity, the FEV₁ and the diffusing capacity remain the most useful. In contrast, the relationship of deranged blood gas levels to respiratory symptoms is far less reliable. The comprehensive review in which Gaensler and Wright⁶ related symptoms to various grades and types of pulmonary impairment is still the standard reference, despite the advent of a plethora of so-called sensitive tests for the detection of the function of the small airways, none of which has any usefulness in assessing disability.

Whether exercise testing is necessary for the determination of disability remains one of the most discussed and frequently asked questions. The answer must remain that it depends on the circumstances. The subject who has normal spirometric data and a normal diffusing capacity is most unlikely to be disabled by pulmonary disease, and occupationally related pulmonary impairment would be excluded, to all intents and purposes. Nonetheless, an occasional subject with a rare condition affecting the pulmonary vasculature might escape detection with these tests, and in this instance, exercise testing might well be helpful. In contrast, an appreciable number of subjects with impairment due to heart disease will have normal results on studies of pulmonary function, and exercise tests will bring a significant proportion of these to light. Whether this can be used as a justification for recommending exercise tests in the Department of Labor Disability Program for coal miners is debatable, since it has been shown that coal mining does not lead to cor pulmonale in the absence of progressive massive fibrosis, and the latter can be reliably and simply diagnosed from the chest roentgenogram. Moreover, progressive massive fibrosis is usually associated with abnormalities on the more simple tests of pulmonary function.

Although the diffusing capacity is an excellent index of gas transfer from the alveolus to the capillary, measurement of oxygen consumption gives additional information in that it is an index of the availability of oxygen to the metabolic sites throughout the body. If exercise tests are to be performed, they are best carried out in a steady state and on a treadmill, rather than on a bicycle ergometer, because many adults these days are unfamiliar with bicycling. In addition, exercise on the treadmill utilizes large groups of muscles. Maximal exercise is best avoided, especially in elderly subjects who may have coronary arterial disease. Thus, it has been shown that it is possible to extrapolate from a submaximal level of exercise to the subject’s predicted maximal level.⁶ The most useful tests which may be used to predict maximal aerobic working capacity in subjects with respiratory impairment are the FEV₁ and MVV.⁶ Wright⁶ also showed that if he used the MVV and ventilation oxygen consumption ratios as independent variables, he could with reasonable accuracy predict the maximal oxygen consumption. He was able, by using the ventilation oxygen consumption ratio in submaximal steady-state exercise, to predict maximal aerobic working capacity. This work was subsequently confirmed and extended by Armstrong et al.⁷ The methods described by both Wright⁶ and Armstrong and colleagues⁷ are useful in predicting and evaluating a man’s capacity to work and have been utilized by the Social Security Administration in formulating criteria for disability in coal miners. Thus, Roemich et al.⁸ showed that for coal miners taller than 165.1 cm (5 ft 5 in.), provided the FEV₁ was over 50 percent of the predicted figure, the miner was capable of sustaining a level of work requiring 1.7 L of oxygen per minute. As indicated earlier, this level is relatively strenuous and is in excess of the usual energy demands made on coal miners.⁸

Turning now to grading the severity of impairment, in general the patient’s or claimant’s value is expressed as the percentage of the predicted value for a person of the same age, height, and sex. That this is less than ideal and discriminates against the older worker is not apparent at first sight. Since pulmonary function declines with age, for a given percentage of decrement to reflect the same disability in an elderly man as it does in a young man would require that the ventilatory cost of performing a certain task would decline with age. The reverse is true, and in reality the young man who has an MVV which is 30 percent of his predicted figure utilizes a lot less of his respiratory reserve to carry out certain work load than does a 60-year-old man. The regulations devised by the Bureau of Disability of Social
Security take this into account and award disability on the basis of certain absolute reduction of pulmonary function, such a reduction being related only to the subject's height and sex, with age being ignored. The justification for the decision is apparent from a perusal of Cotes' discussion of disablement in occupational pulmonary disease.

In conclusion, the determination of disability is complex, and many factors have to be taken into consideration. For the most part, simple reproducible and noninvasive tests are the most useful. Nonetheless, additional tests are needed to identify the effects of a lack of cooperation, although for the most part the obvious malingerer can be identified with currently available tests.

**REFERENCES**

6 Wright GW: Maximum oxygen consumption for work periods of six minutes duration in normal and pathological subjects. Science 112:423-424, 1950