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## MEASURING LUNG FUNCTION IN THE ELDERLY

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Lung function measurements have been performed for centuries: starting in 1679, when Giovanni Borelli inverted a bowl in water and blew into it through a tube to measure its elevation. They became more and more sophisticated and, nowadays, lung function measurement devices can produce such a number of parameters that one has the impression that everything is possible. However, reality shows that there may be difficulties, especially for the (very) young and old age groups. Presently, lung function measurements in elderly people are becoming more and more important. On one hand, people are living longer but on the other hand, people have become more wealthy in the post-war period and they, both males and females, can afford to smoke (more) cigarettes, which leads to an increasing amount of people forming a high-risk group for suffering from dyspnoea or chronic obstructive pulmonary disease (COPD).

### LUNG FUNCTION DIFFICULTIES

1. The test itself is more difficult at a higher age. Performing the vital capacity (VC) and forced expiratory volume in 1 s (FEV1) manoeuvres is exhausting. Problems may arise for several reasons, such as poorly fitting artificial teeth, inability to perform forceful manoeuvres or even inability to understand the test (*e.g.* due to dementia). It might be difficult to fulfil all three Fs: full inspiration, forceful expiration and full expiration. Additionally, travel to the pulmonary function lab might present a problem or be exhausting for the elderly patient.
2. The standard deviation of the measured values might be considerably higher. Is one good blow acceptable or should you stick to at least three reproducible values that are, for example, within 5% of each other.
3. Internationally accepted standardised normal values at high age are lacking or scarce. The 1993 normal values are defined up to 65 yrs of age, while the average age which people nowadays achieve in the Western world will be around 80–85 yrs.
4. Interpretation of results might often lead to misleading conclusions, especially when the Global Initiative for Chronic Obstructive Lung Disease (GOLD) criteria are used, which is most often the case. By these criteria, a person is defined as being obstructive if the Tiffeneau index (FEV1/VC) is <70. However, this Tiffeneau index is a function of age, due to the natural alteration of the lung tissue. At a young age (*e.g.* 25 yrs), it should normally be 83 with a lower limit (p5) of 71; so, a Tiffeneau index of <70 would be indicative of severe obstruction. However, at 80 yrs old, the normal value is 73 with a lower ►

limit of only 61, so many people with high age will be automatically classified as being obstructive, while they might have a “normal” lung function for their age. Additionally, the definition of reversibility may cause major problems. The European Respiratory Society (ERS) criteria is that the FEV1 % predicted should increase more than 12% after medication (and more than 200 mL); while the American Thoracic Society (ATS) criteria also uses the increase of 12% but as an increase of baseline. A simple example shows the striking difference when, especially at older age, the lung function is declined. For example, a normal FEV1 is 4.0 L, but a patient before medication only achieves 2.0 L (*i.e.* 50% of predicted). If, after medication, the FEV1 becomes 2.4 L (an increase of 400 mL), the absolute gain is  $2.4/2.0 = 1.2$  or a 20% increase. If the ERS criteria are used, the patient’s lung function has increased from 50% predicted before medication to 60% (2.4/4.0) after medication, so only a 10% increase. By the first criteria, the patient would be classified as having reversible bronchial obstruction (*e.g.* asthma or an asthmatic component) and might receive medication for that (*e.g.* a corticosteroid). By the second criteria, the patient would be classified as having a nonreversible bronchus obstruction (*e.g.* COPD) and would be treated accordingly.

Of course there are solutions for all these problems which might be more or less satisfactory in the individual case.

1. Should a clinician always want to have a spirometric value for a very old patient with complaints of dyspnoea? Too often, respiratory technicians need to measure patients who are unable to perform the standard (forceful) spirometry test. If objective

numbers are needed to evaluate if a patient is obstructive or shows reversibility on medication, another lung function test could be performed. For example, the respiratory impedance measurement, by the forced oscillation technique, might be a promising technique since the patient only needs to be able to breathe normally. Moreover, in contrast with spirometry, in which a deep inspiration is needed, the forced oscillation technique does not modify the airway smooth muscle tone. Therefore, if both measurements are taken from the same patient, the respiratory impedance measurement should always be the first performed. The forced oscillation technique has been shown to be as sensitive as spirometry in detecting impairments of lung function due to smoking or exposure to occupational hazards [1]. However, this technique also has drawbacks. Normal values are less standardised than those of classic spirometry. Standard deviation of measured values in general will be higher. It measures a parameter other than the classic FEV1 and (F)VC, namely the impedance of the respiratory system. It should, therefore, never be seen as a replacement of classic spirometry but as a complementary measurement. Of course, if classic spirometry is not possible, it might be the only solution and, therefore, the best option.

2. How to proceed in the event of a patient who is only able to perform one “good” blow is dependent on the quality of the blow and the expertise of the respiratory technician supervising the test. If the technician is certain that this one blow was good and fulfilled most or all of the quality criteria, they could mention this in the comments of the test. However, even sub-optimal tests might still contain useful information, as ►

- long as what went “wrong” is well documented. The person interpreting the measured results can then see that there is no indication of restriction (*e.g.* VC >80% of the normal predicted value), no clear obstruction (Tiffeneau index higher than the lower limit of normal) or no flow limitation (based on the form of the flow–volume curve). It is important that all curves should be recorded and reported along with the comments of the technician. This issue becomes even more important when reversibility should be evaluated. One good blow, before or after medication, might otherwise easily end up in misleading conclusions about reversibility.
3. The lack of internationally accepted normal values at older age is problematic. In the ideal situation, each pulmonary function lab has measured, with their own equipment, all types of patients of all age groups with all kinds of disease, from perfectly healthy to severely disabled for both sexes and all heights, age and races, which are representative for the population of that area. Of course, this is, in almost all cases, unrealistic and perfectly healthy elderly people will be especially hard to find; so most times, internationally accepted standards are instead used. In Europe, the ERS normal values of QUANJER *et al.* [2] from 1993 are often still used as the gold standard, but their data were based on measurements in the decades before and have an upper age limit of 65 yrs. If people are older, extrapolation is often used, but results may be highly unrealistic. For instance, older woman will, in reality, have a 15–20% higher FEV1 and VC predicted by the normal values. An elderly woman with a normal lung function of only 90% of predicted (by the 1993 guidelines) might, in reality, have a lung function which is around 30% less than it should be. There are, however, several studies which did produce numbers for older people but there is not yet a consensus on the correct values or equations. Recently, an international task force has been initiated to study how up-to-date normal values can be composed from existing data including, especially, for the older age group. Of course, the reference values are limited not only to FEV1 and FVC but also to lung volumes like residual volume, functional residual capacity and total lung capacity [3].
  4. To overcome possible misinterpretation and/or misclassification, one should avoid working with the GOLD criteria for the Tiffeneau index but instead stick to the lower limit of normal which is substantially lower than 70% at high age. Of course, one should not only rely on the exact numbers but also try to incorporate, objectively, the complaints of the patient in order to come to the correct clinical decision. More detailed information can be found in the number 5 of the series on standardisation of lung function testing published in the *European Respiratory Journal* [4]. Additionally, it may become debatable if, especially for the elderly or the severe COPD patient, whether the Tiffeneau index should be considered as the best/gold standard parameter. It might be, that in a decade it is replaced by the FEV1/FEV6 parameter, *i.e.* to replace the forced vital capacity with the forced expiratory volume in 6 seconds. This measurement is not only much more patient friendly than the FVC (especially for the elderly patient) but also has a smaller coefficient of variance, due to the fact that one person can and will still exhale as deep as possible while others will stop after they feel exhausted (which might be long before the FVC is reached). Of course, clinical ►

decisions based on this new parameter should be re-evaluated and may not necessarily adhere to the same numbers as those for the Tiffeneau index.

Another aspect, which often causes misinterpretation is the height of the patient. Especially for elderly people the self-reported height is severely overestimated by the patient, since they will report the height that was in their passport when they were a young adult.

However, they do not realize that people really do shrink. The solution is, of course, simple: the respiratory technician should always measure the height of the elderly patient and never rely on self-reported height [5].

Occasionally, a subject is unable to perform a satisfactory inspiratory limb immediately following a maximal forced expiratory manoeuvre. This is particularly common in the elderly and the infirm. In these circumstances, it may be necessary for the subject to record an inspiratory manoeuvre separately from the expiratory manoeuvre. Equipment should be able to perform these separately and then present three or more loops together on a graphical display or output [6].

That respiratory impedance might be a more useful tool than spirometry in elderly is also shown in an article by CARVALHAES-NETO *et al.* [7]. In that study, 208 institutionalised patients with various degrees of cognitive function impairment, measured by respiratory impedance (the forced oscillation technique) and by normal spirometry, were compared. Of the 208 patients, 162 had severe or mild cognitive impairment (measured by the mini-mental state examination) (MMSE), while 46 had no impairment. In only 85 cases, spirometry was possible, while respiratory impedance measurements were successful in 159 patients. Among

the 84 patients able to complete both tests, significant correlations were found between the spirometric and respiratory impedance measurements indicating that the forced oscillation technique might be a worthwhile substitute when spirometry is no longer possible.

It might of course be possible that in the (near) future lung function measurement systems (e.g. pneumotach systems) would have an incorporated respiratory impedance measurement system. In such a case respiratory impedance measurements could automatically be done while the subject is still normal breathing, for instance just before the classic spirometric manoeuvres like the FEV1 and VC,

Another difficulty is that the standard reference values for spirometry are limited to 65 yrs of age, and respiratory impedance values at high age groups might be even more scarce. However, in a recent article [8] lung function normal values of healthy people clearly over 65 yrs old were given. In a prospective study, the respiratory impedance of 223 healthy nonsmoking subjects of  $83 \pm 8$  yrs of age was measured. The Zrs parameters, which include average resistance between 4–16 Hz, average resistance between 4–30 Hz, resonant frequency, capacitance and inertance, were measured along with forced expiratory manoeuvres. Not only did this show that the standard reference values for classic spirometry underestimate the real values (FEV1 110% pred, FVC 114% pred and FEV1/FVC 112% pred) but also provided resistance, compliance and inertance values for healthy adults in this high age group. The article showed that, at this high age, height was the most influential predictor for the respiratory impedance values. Reference values for spirometry for 65–85-yr-old adults have,

amongst others, now been established by ENRIGHT *et al.* [9].

In an article of BELIA *et al.* [10], another aspect of lung function in the elderly is mentioned. When measuring peak expiratory flow (PEF) in two groups with the same degree of asthma, a “young age” group of 14–47 yrs and a “high age” group of 53–74 yrs, it became clear that both PEF amplitude and “morning dip” were greater in the older patients, indicating that they might have an increased variability of airway calibre in asthma. Together with the fact that they will have a poor subjective awareness, extensive PEF monitoring might be recommended for older asthmatics.

Finally, questionnaires are the most used tool in respiratory epidemiology. Standardisation of these questionnaires should limit bias. In a Union project BIOMEDI1, a compendium of respiratory standard questionnaires (CORSQ) was developed for adults, covering 18 topics, from general information to early life events, through environmental risk factors and respiratory symptoms and diseases[11].

## CONCLUSION

Measuring lung function in the elderly is not only increasing but has more difficulties than one would like. Not only do technical difficulties and increased variability of measured values play a role, but also misinterpretation of measured results is easily possible. Respiratory impedance measurements might provide a tool to overcome the ability of the mentally or physically disabled patient. Careful consideration of the appropriate measurement tool and the correct interpretation of the results with the appropriate normal values might help to correctly measure the lung function and lead to a correct clinical interpretation. ■

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