Beyond Spirometry
Why measuring FEV$_1$ and FVC may no longer be enough.
Leslie Gold, M.Sc., and Lennart Lundblad, PhD & Associate Professor, 2018

Background
For many decades, requiring patients to make forced, maximal exhalations to measure their expiratory volumes and flows, has been the standard of care for pulmonary function testing (PFT).

However, despite its wide acceptance and abundant clinical use, Spirometry suffers from several shortcomings and limitations for patient assessment and diagnosis. This document discusses the strengths and weaknesses of Spirometry and contrasts them with oscillometry, a novel and complementary technique to assess pulmonary function during quiet, tidal breathing that requires minimal patient effort and coordination.

The Basics: Spirometry vs. Oscillometry

**Spirometry** requires patients to take a deep breath and then to exhale maximally for at least six seconds. A skilled health care professional is needed to properly coach the patient throughout the manoeuvre, and to judge from the resulting flow-volume loops whether the patient indeed expired hard enough to reach expiratory flow limitation throughout the entire forced expiration. If so, the best of three repetitions is used to calculate the Forced Expired Volume in one second (FEV$_1$) and the Forced Vital Capacity (FVC).

**Oscillometry** measurements, on the other hand, are obtained during tidal breathing with minimal patient cooperation. The tremoflo$^\text{®}$ Airwave Oscillometry System (AOS) superimposes a gentle oscillatory waveform over the patient’s natural, quiet breathing. The resulting pressure and flow waveforms are recorded and analyzed by a computer to provide measurements of the mechanical properties of the large central and smaller peripheral airways. Oscillometry can easily be used in preschool children and elderly patients alike, and it provides unique information that is clinically valuable and complementary to Spirometry.$^1$
Early Detection of Peripheral Airway Impairment

Obstructive pulmonary diseases including asthma and COPD are increasingly recognized to originate in the "small airways" (i.e., those airways with a diameter of less than 2 mm).

Early obstructions in these peripheral airways are often not measurable by spirometry and therefore risk going undetected. ²

In contrast, oscillometry has been shown to be sensitive to changes in the small airways. ¹ Consequently, oscillometry provides unique and valuable information regarding peripheral lung function over and above Spirometry, which translates into better patient outcomes. ¹

Diagrammatic representation of the airways ¹₄

Personalized Abnormality Threshold

In conventional PFT, it is common practice to consider an FEV₁ (the forced expiratory volume in 1 second) of less than 80% predicted as abnormal. This practice stems from both its ease of use and long tradition. ³ In actual fact, however, the statistical lower limit of normal (LLN) varies considerably with age and drops well below 80% predicted in both pediatric and senior populations. ⁴

Therefore the blanket use of 80% as a wellness threshold can result in misclassification of patients ⁵, is without rational basis, and was shown to be inappropriate by numerous authors. ³ Nonetheless, this practice is only slowly changing in Spirometry.

In contrast, common practice in oscillometry is to report the deviation of the patient’s value from given normative data based on the patient’s particular demographic information.

The tremoflo software, in particular, plots patient values on clearly labelled green-yellow-red gauge scales that visually indicate the patient’s deviation from normal, or z-score.
Contraindications

There are at least 29 contraindications to spirometry due to the high pressures that result when forcibly exhaling, potentially causing injury, the risk of spreading infection from contagious patients, and inability to participate for some patient populations. Some of the documented contraindications are highly pertinent in patient populations most in need of testing; dementia, for example, is a contraindication for spirometry, and it is known that COPD sufferers are at higher risk for dementia than the general population.

Since oscillometry is performed during quiet breathing with no patient effort required there are no known contraindications to this type of testing. Oscillometry can therefore be a useful testing and assessment tool in those patients for whom spirometry is contraindicated.

Problem Groups: Children and the Elderly

Anecdotal evidence from numerous clinicians reveals that even for COPD patients for whom spirometry is not explicitly contraindicated, the test is stressful and exhausting. A typical geriatric spirometry test can last 30 minutes. Moreover, there is a risk of false positives due to a change in underlying bronchomotor tone after repeated forced expirations.

Successful spirometry depends on patient cooperation and maximal effort, therefore the success of a test is severely jeopardized in patients who have difficulty in understanding and following instructions, including young children, and those with language barriers or mental impairments.

In contrast, oscillometry was shown in a study to be successful in nearly 100% of school aged children and in 70-80% of older pre-schoolers.

In another study comparing oscillometry and spirometry in patients 65 and older, all were capable of producing a valid oscillometry test whereas valid spirometry was completed in only 33.4% of the participants.
Reproducibility of Data

A recent study assessed the quality of both spirometers and spirograms in primary care settings. It was found that less than 6% of the spirometers assessed in the study met the ATS criteria for accuracy and precision. In addition, just 60% of the spirograms produced by the participating clinics were deemed to be clinically acceptable with the other 40% failing various quality control measures.

As oscillometry is performed in quietly breathing patients, neither skilled coaching by the operator nor patient effort is required to obtain a successful test. In addition, the tremoflo in particular employs a very fast and easy daily calibration to ensure that the device is always accurate.

In conclusion: Reasons to Look Beyond Spirometry

The requirement for operator skill and patient effort to conduct a successful spirometry test, combined with the numerous contraindications and limited sensitivity to small airway disease, present limitations to the clinical utility of spirometry that are not yet widely recognized. Due to its operating principles and ease of use, oscillometry addresses many of the shortcomings associated with spirometry and may add valuable information related to small airways function in clinical practice. Furthermore oscillometry can be easily integrated in your everyday practice with the portable tremoflo to help you in the detection and monitoring of the pulmonary status of your patient.
References


