RESTECH
As simple as breathing

FOT (Forced Oscillation Technique) - Oscillometry
LITERATURE, PUBLICATIONS SUMMARY

REV0 - October 2023

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Alessandro Gobbi, Marie K. Breyer, Sylvia Hartl, Otto C. Burghuber, Robab Breyer-Kohansal
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ERS 2022 Poster Presentation (Session 227 - PA1753) :
EFFECT OF DIFFERENT STIMULATING WAVEFORMS ON THE DERIVATION OF OSCILLOMETRY SPECTRAL PARAMETERS IN ASTHMATIC CHILDREN
P.P. Pompilio, G. Ferrante, A.Gobbi, L Venditto, M. Piazza, R. Dellaca', G. Piacentini
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L. Reyes, W. De Jesus-Rojas
American Journal of Respiratory and Critical Care Medicine, ATS Meeting Abstracts, 2022 – A65
PULMONARY CLINICAL CASES II / Thematic Poster Session / Sunday, May 15/09:30 AM-03:45 PM

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ASSESSMENT OF BRONCHIECTASIS BY IMPULSE OSCILLOMETRY IN PRIMARY CILIARY DYSKINESIA
P. M. Quiles Ruiz De Porras1, W. De Jesus-Rojas2
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PHYSIOLOGIC STUDIES OF LUNG FUNCTION / Thematic Poster Session / Sunday, May 15/09:30 AM-03:45 PM

Esther S. Veldhoen,, Johan H. Roos, Rolien Bekkema, W. Ludo van der Pol, Marcel H.B. Tinnevelt, Laura P. Verweij-van den Oudenrijn, Roelie M. Wösten-van Asperen, Erik H.J. Hulzebos, Camiel A. Wijngaarde, C. Kors van der Ent,
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Neeraj Gupta
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F Lucca, M Piazza, L Tenero, E Bonetti, S Cesaro, G Piacentini

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Francine M. Ducharme, Anna Smyrnova, Christiane C. Lawson, Laura May Miles

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GUIDELINES, STANDARDS AND SUGGESTED READING

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European Respiratory Journal, 2020; 55: 1900753

"The main changes in this update, compared with the 2003 ERS task force document are 1) new quality control procedures which reflect use of "within-breath" analysis, and methods of handling artefacts;
2) recommendation to disclose signal processing, quality control, artefact handling and breathing protocols (e.g. number and duration of acquisitions) in reports and publications to allow comparability and replication between devices and laboratories;
3) a summary review of new data to support threshold values for bronchodilator and bronchial challenge tests; and
4) updated list of predicted impedance values in adults and children."

"The recommended thresholds for positive bronchodilator responses in both children and adults is−40% in Rrs5, +50% in Xrs5 and−80% in AX. z-scores are recommended for future definition of a significant response, which will require data of bronchodilator responses in healthypopulations."

"Oscillometry testing should precede tests requiring deep breaths (e.g. exhaled nitric oxide, spirometry, diffusing capacity) and allow a standardised length of time during which deep breaths are withheld, before performing oscillometry."

"Modern analysis tools allow removal of entire breaths affected by artefact, so that an acquisition may remain technically acceptable, as long as there are at least three breaths remaining in that acquisition"

"The ideal forcing frequency when applied to spontaneous breathing is⩾4Hz (changed from⩾2Hz)
Not using coherence function for quality control and use of CoV⩽10% in adults and⩽15% in children."

"*it is recommended to use at least three replicates, which are deemed acceptable after application of specified quality criteria: visual inspection, within-session coefficient of variability (CoV) and automated signal processing.*".

Oostveen, E., MacLeod, D., Lorino, H., Farre, R., Hantos, Z., Desager, K., & Marchal, on behalf of the ERS Task Force on Respiratory Impedance Measurements
THE FORCED OSCILLATION TECHNIQUE IN CLINICAL PRACTICE: METHODOLOGY, RECOMMENDATIONS AND FUTURE DEVELOPMENTS.
European Respiratory Journal, 2003, 22(6), 1026–1041.

"As a tool for the investigation of respiratory mechanics in clinical practice, the forced oscillation technique (FOT) is well supported theoretically."

"The most attractive feature of FOT is that the forced oscillations are superimposed on the normal breathing, avoiding the need for any special breathing manoeuvre or any noticeable interference with respiration."

"WESSELING and WOUTERS [61] found abnormal Zrs data in 70% of the subjects with chronic bronchitis in the presence of normal spirometry."

"FOT has proven to be at least as sensitive as spirometry to detect impairment of lung function due to exposure to cigarette smoke or occupational hazards. The sensitivity to detect mild airway disease and the minimal requirements for subjects cooperation make FOT a very suitable lung function test for epidemiological and field studies."

"A significant correlation between the changes in Rrs and FEV1 following bronchoconstriction has been reported by several investigators. "
"The deep inspiration that precedes forced expiration may modify airway smooth muscle tone, and, therefore, may influ- ence the result of the BHR test. FOT has the considerable advantage that it measures airway properties during quiet breathing. This may be the reason why FOT has proved more sensitive than FEV1 to detect changes in BHR in asthmatics after corticosteroid treatment [101]."

"There is evidence that FOT and plethysmography provide comparable information on bronchial sensitivity and responsiveness and may be superior to spirometry"

Navajas, D., & Farré, R.
FORCED OSCILLATION TECHNIQUE: FROM THEORY TO CLINICAL APPLICATIONS,
Monaldi Archives for Chest Disease = Archivio Monaldi per Le Malattie Del Torace / Fondazione Clinica Del Lavoro, IRCCS [and] Istituto Di Clinica Tisiologica E Malattie Apparato Respiratorio, Università Di Napoli, Secondo Ateneo,
2001, 56(6), 555–62. 555–562.

"It has been suggested that FOT is adequate for assessing the increase in airway obstruction induced by bronchial challenge… Similarly, FOT has been used to assess the decrease in airway resistance induced by bronchodilation agents… Another interesting feature of FOT is that its time resolution allows the easy measurement of the dose-response effect"

"According to the currently available data, FOT has a sensitivity and specificity similar to that of conventional spirometric indices [65, 69]."

"In recent years, FOT has been employed to assess upper airway obstruction in patients with the sleep apnea/hypopnea syndrome (SAHS).""The technique has enough time resolution to track the obstructive

events undergone by the upper airway during the different phases of the breathing cycles."

Bates, J. H. T., Irvin, C. G., Farré, R., & Hantos, Z..
OSCILLATION MECHANICS OF THE RESPIRATORY SYSTEM.
Comprehensive Physiology, 2011, 1(3), 1233–72.

"The reproducibility of Zrs in healthy humans is similar to that observed in other parameters of respiratory mechanics such as those provided by body plethysmography or the flow interrupter technique;"

"The FOT has been shown to reveal differences in baseline lung mechanics in patient both with asthma and COPD who had abnormal spirometry (52). Also, the frequency dependence of Rrs has been shown to change in patients with asthma or other obstructive diseases (37, 52, 112, 192, 212), likely due to the presence of ventilation inhomogeneities (37, 212). Furthermore, patients with different types of obstructive lung disease (emphysema, chronic bronchitis and asthma) have been reported to show different patterns of abnormality by the FOT with similar abnormalities in spirometry (282)."

"The FOT has also been shown to provide indices related to the severity of asthma (50), and can be used to detect central airway obstruction due to either tracheal stenosis or vocal cord dysfunction (137), which can be confused with asthma."

"several recent studies have used the FOT to follow the temporal variations in lung function associated with asthma (72, 110, 233). Indeed, home monitoring via the FOT may become an important means of following asthmatic patients in the future (66)."

"Another characteristic feature of COPD is that Zrs is often very different between inspiration and expiration in contrast to the situation in normal subjects (65). In particular, the magnitude of Zrs is abnormally elevated in expiration due to the presence of expiratory flow limitation (68), which prevents the FOT from being able to probe the lung beyond the choke point where flow limitation occurs. Accordingly, bronchodilation produces a particularly marked reduction in the magni- tude of Xrs when flow limitation is relieved (67)."

"The FOT has been used in patients with sarcoidosis, providing parameters that correlate significantly with those of spirometry. In particular, the magnitude of Zrs at 4Hz appears to be clinically useful in this disease (78)."

"Routinely measured lung volumes (total lung capacity and vital capacity) have been shown to correlate well with aver- age Xrs and with the slopes of Xrs and Rrs versus frequency in patients that have ILDs but no sign of airway obstruction (281)".
FOT has been applied in occupational respiratory diseases such as silicosis in which the pattern of Rrs is similar to that seen in COPD; Rrs is elevated and has an increased negative dependence on frequency (59).

"The FOT can also be useful in assessing possible side effects of therapies in nonpulmonary diseases, such as the treat- ment of spinal cord injury with neostigmine and glycopyrrolate which have been implicated in increased airway secretions and bronchospasm (235)."

"Recent preliminary data suggest that the FOT could be useful for assessing the evolution of respiratory function soon after lung transplantation when spirometry is not feasible (119). "

"In a study of patients with extra-thoracic upper airway obstruction, mostly due to carcinoma, Rrs and Xrs were correlat- ed with airway resistance measured by body plethysmography. Moreover, Rrs tended to be higher in patients with upper airway obstruction compared to patients with COPD (284)."

"Tracheal stenosis is another extrapulmonary disease where the FOT has been employed to characterize respiratory resis- tance, and a strong correlation between indices derived from Rrs and the diameter of tracheostenosis has been reported (137). Patients with tracheal stenosis also tend to have a marked flow dependence of Rrs measured by FOT which has been found to be correlated with conventional upper airway obstruction indices derived from spirometry (288)."

PEDIATRICS

Beydon, N., Davis, S. D., Lombardi, E., Allen, J. L., Arets, H. G. M., Aurora, P., Wilson, N. M.
AN OFFICIAL AMERICAN THORACIC SOCIETY/EUROPEAN RESPIRATORY SOCIETY STATEMENT: PULMONARY FUNCTION TESTING IN PRESCHOOL CHILDREN.
American Journal of Respiratory and Critical Care Medicine, 2007, 175(12), 1304–45

"Lack of cooperation and noninvasiveness are key features of the FOT, which is therefore increasingly used in young children."

"The feasibility of the FOT in the acutely ill, untrained preschool children measured in the emergency room ranged from 20% in 3 years old to more than 80% in 5 years old. In laboratory or field settings, higher values of 80 to 100% have been obtained in healthy preschool children or stable preschool patients."

"The single frequency sinusoid has optimal signal-to-noise ratio; allows the descriptions of Zrs variations with time, within- and between-breath and in relation to flow and volume; "

"FOT assessment of response to bronchodilator was found to be in agreement with FEV1 and airway resistance with plethysmography"

"The FOT was probably one of the first techniques applied to preschool children to estimate the airway response to metacholine and histamine. … In wheezy preschool children, changes in FOT paralleled those observed with plethysmog- raphy, interrupter resistance, or spirometry.

Frey, U..
FORCED OSCILLATION TECHNIQUE IN INFANTS AND YOUNG CHILDREN.
Paediatric Respiratory Reviews, 2005, 6(4), 246–54.

"In stable ASTHMA, higher respiratory resistance at various frequencies were found in the mid range in comparison with healthy subjects. These changes in Rrs were consistent with decreased FEV1 values in asthmatic group"

"Reversible airway obstruction and bronchial hyperresponsiveness (BHR) are significant components contributing to the diagnosis of bronchial asthma in infants and young children. Changes in mid-frequency Zin were related to changes in FEV1 or clinical signs after a challenge with bronchodilators. Similarly, BHR showed changes from baseline comparable or better than other lung function tests. The increased Rrs was accompanied by a decrease in Xrs in most studies after challenge."

"One study assessed the feasibility of FOT in the emergency department in the untrained child with respiratory distress.
…. These success rates were higher than those for spirometry"