PHILIPS
RESPIRONICS

BiPAP A40 EFL

Forced Oscillation Technique

The role of **forced oscillation technique** in ventilation

Author: Bob Romano, Biomedical Engineer, Philips, Monroeville, U.S.

The Forced Oscillation Technique (FOT) provides an objective, non-invasive measure of respiratory mechanics that does not require the performance of respiratory maneuvers and offers a simple and repeatable approach to investigating the mechanical properties of the respiratory system.

Since Dubois et al. first introduced FOT in 1956[1] numerous variants of the technology have been developed in terms of measurement configuration, oscillation frequencies and evaluation principles. FOT has been deployed in many commercial oscillatory diagnostics devices and has been utilised in ventilators to detect and treat upper airway obstruction in subjects with OSA.

FOT employs small-amplitude pressure oscillations (~2 cmH_2O) superimposed on normal tidal breathing (Figure 1) and therefore has the advantage over conventional lung function techniques in that it minimally interferes with the patient and can be measured at rest during tidal breathing. Moreover, in contrast with spirometry where a deep inspiration is needed, Forced Oscillation Technique does not artificially modify the smooth muscle tone of the airways, which could affect the measurement.

Another advantage of the Forced Oscillation Technique is that it can accurately determine hyperinflation without the need for invasive esophageal balloons, with the associated time-consuming, technically demanding analyses, and expensive bulky equipment.

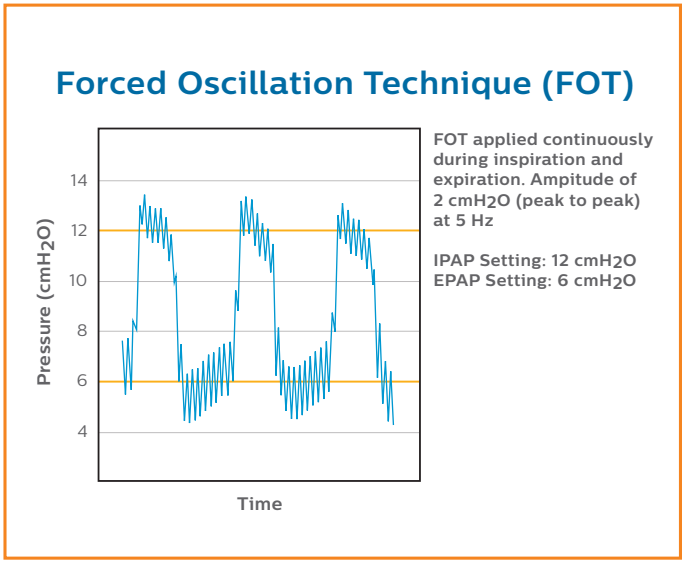

Figure 1

FOT data are sensitive to changes in the upper and lower airways and both obstructive and restrictive lung disorders; therefore, FOT is a valuable tool for quantitatively assessing bronchial disorders in adults and children. Forced Oscillation Technology works by comparing the phase shift of the small amplitude oscillations on the flow signal to the oscillations on the pressure signal. In a healthy unobstructed lung, these two signals arrive at the same time to the sensors. However, whenever there is a pulmonary obstruction or change in the inertial properties of the lung, there is an offset in the arrival time between these two signals.

Airway impedance is deduced by the mechanical response to these time-varying changes. The impedance can mathematically be further broken down into two components; resistance and reactance. The resistive component is dominant in patients who have airway restrictions, such as asthmatics, or those with upper airway obstructions.

Recent research by Dellaca et al.[2] has provided strong correlations of the changes in the expiratory reactance referred to as "DeltaXRS" to a person's degree of expiratory flow limitation (EFL), a condition when an increase in transpulmonary pressure causes no corresponding increase in expiratory flow due to "choke points" in the many bronchial branches (Figure 2), which is the hallmark of Chronic Obstructive Pulmonary Disease (COPD).

Additional studies have determined that a person's expiratory reactance, and therefore their EFL, can be minimised by the application of external Positive Expiratory Pressure (PEEP). Studies by Hart et al.[3] have shown that the application of an optimised level of PEEP during noninvasive ventilation can reduce a person's inspiratory muscle effort (elastic threshold load) by 30% - 40%.

Philips Respironics has taken the knowledge of the aforementioned science and advances in technology to simplify the previous complex technological solution used by Dubois and others to develop an eloquent noninvasive ventilator with the internal ability to deliver precision FOT. A newly designed ventilator is able to continually assess a person's pulmonary mechanics and automatically apply an appropriate setting of PEEP that is able to counterbalance intrinsic PEEP and treat a person's EFL on a breath-by-breath basis. This therapy can be delivered in either the seated or supine positions, allowing for accurate assessments of expiratory flow limitation under different postural conditions, useful for stratifying patients by the severity of their COPD and disease progression. This optimised and individualised therapy leads to improvements in respiratory muscle effort, comfort during sleep and improved patient-ventilator synchrony.

In a current clinical overnight comparative observational trial conducted by M. Vitacca et al., preliminary results reflect that a Philips Respironics non-invasive ventilator with FOT, indicate clinically significant physiological improvements in decreases in arterial pCO_2 and decreased variability of SpO_2 during therapy at lower levels of inspiratory pressures that can lead to improved efficacy of therapy and increased patient comfort.[4]

Expiratory Flow Limitation Choke Points in COPD

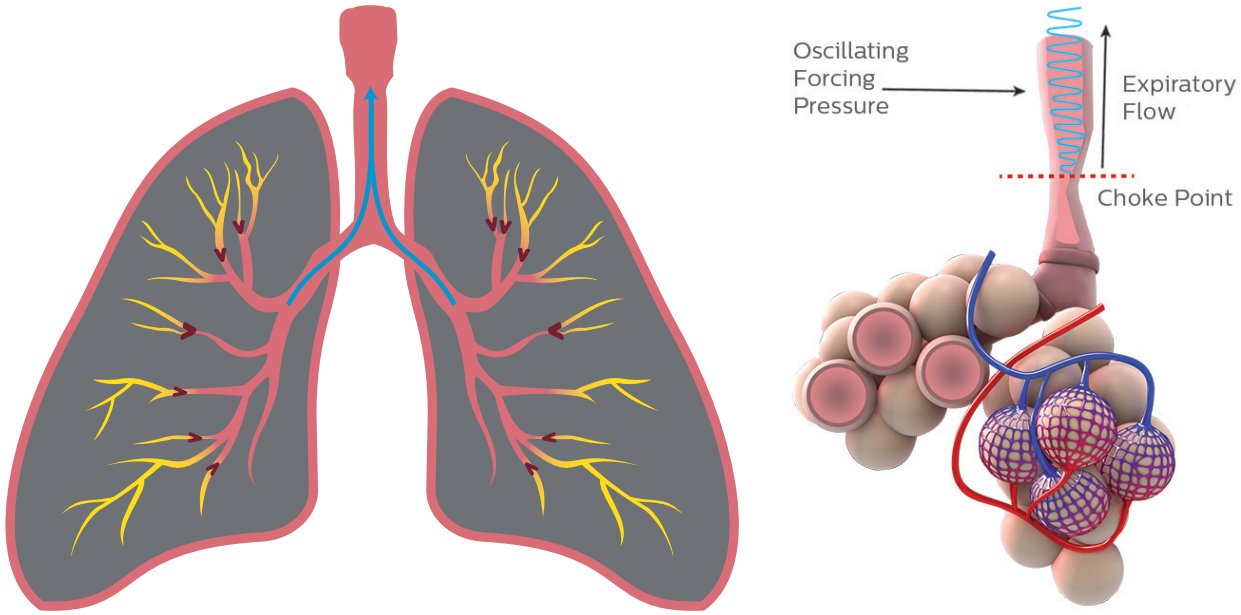

Figure 2

References

1. DuBois AB, Brody AW, Lewis DH, Burgess BF. *Oscillation mechanics of lungs and chest in man*. J Appl Physiol 1956; 8: 587–594.

2. R.L. Dellaca`, M. Rotger, A. Aliverti, D. Navajas, A. Pedotti and R. Farre. *Noninvasive detection of expiratory flow limitation in COPD patients during nasal CPAP*, Eur Respir J 2006; 27: 983–991

3. ES Suh, P Pomplio, S Mandal, P Hill, R Romano, RL Dellaca, N Hart. *Abolition of expiratory flow limitation in severe COPD using auto-titrating CPAP based on the measurement of within-breath airway reactance determined by the forced oscillation technique*, ATS 2014 Abstract

4. Milesi, R. Dellacà, R. Porta, S. Cacciatore, L. Barbano, M. Vitacca - *Preliminary Comparative overnight clinical study utilizing FOT in the study of Expiratory Flow Limitation*, estimated complete June 2019