ORIGINAL ARTICLE

Role of IOS in Assessing the Improvement of Obstructive Component in Moderate to Severe Obstructive Sleep Apnea Hypopnea Syndrome

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ABSTRACT

Introduction: Impulse oscillometry (IOS), a simple, noninvasive method using the forced oscillation technique, requires minimal patient cooperation and is suitable for use in both children and adults. This method can be used to assess obstruction in the large and small peripheral airways.

Aim: To study impulse oscillometry measurements in cases of moderate to severe sleep apnea.

Materials and Methods: A study was performed in Department of Respiratory Medicine, Sri Aurobindo Institute of Medical Sciences. Thirty patients diagnosed with severe sleep apnea underwent home noninvasive ventilation therapy. Pre- and post treatment noninvasive ventilation (NIV) impulse oscillometry was given to these patients.

Results: The pre-NIV spirometry showed predominant mixed pattern of disease with Impulse oscillometry showing reduced R25 and R5 levels. Post 3 months of noninvasive ventilation therapy with >80% compliance demonstrated improvement in R25 parameters.

Conclusion: Respiratory resistance and reactance measured by Impulse oscillometryare abnormal in preobese and obese obstructive sleep apnea hypopnea syndrome (OSAHS) patients, and these parameters are closely correlated with OSAHS severity. Impulse oscillometrymight be a useful screening tool for detecting OSAHS in clinic based populations.

Keywords: IOS, NIV, OSAHS, Spirometry.

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INTRODUCTION

Obstructive sleep apnea (OSA) is a common disorder characterized by a repetitive collapse of the pharyngeal airway during sleep. It manifests as reduced (hypopnea) or absent (apnea) airflow, despite ongoing inspiratory efforts, which is terminated by a transient arousal from sleep and restoration of upper-airway patency.[1,2] Consequently, this pathophysiological process causes disturbances in blood gases and sleep structure and has also been associated with cardio-cerebrovascular complications.[3–5]

Nocturnal polysomnography (PSG) is a gold standard method for diagnosing OSA. However, in a country like India PSG is very expensive and time-consuming. There is a high prevalence of OSA and the associated syndrome (OSAHS) in obese populations, yet few centers can afford to perform the diagnostic procedure on all patients presenting with OSA. In this context, simpler and less expensive tests are needed, increased pharyngeal airway collapsibility during expiration plays an important role in these patients,[6,7] it is expected that the cycle of obstruction and restoration of upper-airway patency from arousal will be accompanied by large change in intrathoracic pressure and in the mechanical properties of the respiratory system.

The improvised technique that uses multiple sound frequencies at one time is called the IOS. The impulses generated by the loudspeaker travel superimposed upon the normal tidal breathing through the large and small airways. Higher frequencies (>35 Hz) travel shorter distances (generally up to the large airways), while lower frequencies (<15 Hz) travel deeper into the lung and reach the small airways and lung parenchyma.

The caliber of both pharyngeal airway and intrathoracic airways in OSA patients are commonly prone to collapse on the exhale, due primarily to decrease in lung volumes. The cross-sectional area of pharyngeal airway and peripheral airways are known to vary significantly with changes in lung volume. The lumen size in those structures are proved to a decrease when the end–expiratory lung volume (EELV) or FRC are artificially lowered, that either caused by negative expiratory pressure (NEP) or by positive extrathoracic pressure on exhalation, and

manifests as expiratory flow limitation (EFL) in the both structures as well as airflow resistance are markedly increased.[8–11] Such a change in lung volume may facilitate pharyngeal airway and intrathoracic airways to collapse or even closure, due to loss effects of caudal traction tension on both structures, and contribute to resistance increase in the airways.

We hypothesized some parameters of IOS measured in OSA patients, such as respiratory resistance at 25 Hz R25, R5, and reactance X at 5 Hz were significantly correlated with OSA severity as defined by AHI.[12]

The aim of this study was to develop a screening tool to see the improvement in obstructive component in moderate to severe OSAHS where polysomnography cannot be performed on a regular basis.

MATERIALS AND METHODS

The study was done in Department of Pulmonary Medicine, Sri Aurobindo Institute of Medical Sciences, Indore. In total, 30 OSA patients with a body mass index (BMI) greater than $25 \, \text{kg/m}^2$ were included in our study. Exclusion criteria were a history of any ongoing cardiac, liver and renal disease, pulmonary hypertension, alcoholism and evidence of any neuromuscular disorder were also excluded.

Sleep Studies

Overnight sleep studies were performed in all participants, and consisted in full laboratory PSG including electroencephalography (C4-A1, C3-A2), right and left electrooculography, chin electromyography, oronasal airflow, thoracic and abdominal movements (inductive plethysmography bands) and oxygen saturation monitored via a finger probe. Respiratory events were defined as follows:[13] a nasal pressure drop to ≥ 30 % of baseline and associated with ≥ 3 % desaturation, lasting for at least 10 s was scored as hypopnea or associated with an EEG arousal was scored as respiratory effort-related arousals (RERAs). Absence of airflow on a nasal pressure transducer and $< 10\%$ baseline fluctuations on a thermistor signal lasting for > 10 sec, was scored as apnea. Respiratory disturbance index (RDI) was calculated by dividing the total apneas, hypopnea, RERAs by the total sleep time in hours, a RDI 15/h of sleep was used to define the presence of obstructive sleep apnea syndrome (OSAS)[13] and was used as the gold standard in the evaluation of the operating characteristics of the IOS parameters obtained to detect OSAS.

Spirometry and IOS

Three maximal flow-volume loops were obtained in the seated position using a MasterScreen pneumotachograph (Jaeger®, Germany), with the largest retained to calculate the first second of forced expiration (FEV_1)/forced vital capacity (FVC) ratio, FEV_1, FVC.

IOS (Jaeger®) measurements were made while a technician supported the cheeks of subjects who were wearing nose-clips in the sitting position, fulfilling standard recommendations.[14] Impulse signals originated from a generator at intervals of 0.2 sec, and the rectangular pressure impulses are superimposed on airflow, which are feed to the airway during tidal breathing via a mouthpiece after stable spontaneous volume and airflow were confirmed and a minimum of three consecutive measurements of > 30 sec were taken. As results of IOS measurement, we used the parameters of, mean whole-breath values of Rrs at 5 Hz, 25 Hz, and Xrs at 5 Hz (R5, R25 and X5).

Statistical Analysis

All analyses were performed using SPSS software. Differences of anthropometry (age, height, weight, BMI), lung volume and function were assessed by using one-way analysis of variance (ANOVA). Correlations between IOS measurements in both the positions and RDI and BMI were evaluated using Spearman's rank correlation coefficients. The sensitivity and specificity of possible cut-off points for the parameters of IOS obtained.

RESULTS

In total, 30 patients who had a BMI $> 25.1 \, \text{kg/m}^2$ were included in the study, Anthropometric characteristics, lung function and volume data, and PSG data of all patients are summarized in Table 1. Thirty subjects with a RDI 15 events/h were identified as OSAHS patients. No significant differences were found with respect to age, height, sex, FEV_1/FVC, and lung volume data. Spearman's rank correlation analysis was used to assess the association between IOS measurements and RDI, and BMI . After giving NIV therapy both investigations (IOS and PFT) were performed in all the patients, after comparing the results of investigations we concluded that IOS have shown significant improvement in obstructive component whereas PFT failed to demonstrate any improvement (Tables 2 and 3).

Table 1: Anthropometric Data

Parameter	Male	Female
Number	22	8
Age (years)	48 (+/-15)	45 (+/-9)
Height (cm)	166 (+/-9)	155 (+/-5)
Weight (kg)	94 (+/-18)	88 (+/-12)
BMI (kg/m²)	34.94 (+/-9)	32.1(+/-9)
Smokers	11	2
Osahs mild	15	5
Osahs moderate	13	4
Osahs severe	9	4

Table 2: Moderate to severe OSA–IOS

	Pre NIV	Post NIV	Significance
"R' Resistance (kPa/ (L/s)) R5	104.9+/-11	76.1+/-6	p <0.5
R25	168.6+/-18	158.6+/-18	p <0.01
"X" Reactance (kPa/L/s) X5	4260.2+/-523	3210.2+/-523	p <0.01
X25	29+/-54	29+/-54	p <0.3
"AX" Area of Reactance (kPa/L)	1.24+/-2.3	1.24+/-2.3	p <0.6

Table 3: Moderate to severe OSA–PFT

Spirometry	Pre NIV	Post NIV	p value
No. of subjects	30	30	
FVC, percent predicted	74.5±3.6	71.5±3.6	<0.6
FEV	69.6±0.9	73.9±0.9	<0.8
FEF25-75%, percent predicted	61.6±4.7	71.6±4.7	<0.8
PEF, percent	75±6.0	85±6.0	<0.6

DISCUSSION

In this study, we systematically appraised the ability of IOS parameter in assessing the improvement of the obstructive component of OSA in moderate to severe OSAHS compared with full polysomnography, for the detection of OSAHS. These associations were stronger when the IOS parameters were obtained, and a highly significant association was found between R25 and RDI ($p < 0.01$).

We demonstrated that central-airway parameter measurements by IOS in pre- and post-NIV patients were significantly and moderately correlated with the severity of OSAHS as defined by RDI (Table 2). These associations strongly found that significant resistance R25 value decrease after NIV therapy.

Obesity has been proven to be the most common risk factor for OSAHS. Obese subjects usually respire with a lower compliance of the lung and chest wall.[15,16] Breathing with such a respiratory system determines larger changes in intrathoracic pressure, and even generates positive intrathoracic pressure surrounding the lung while relaxed at the FRC level. Concomitantly, the high pleural pressure would cause tidal breathing to be initiated from low EELV where the lungs are less compliant and airways are prone to close on exhalation.[17] Breathing at lower end-expiration volumes has been demonstrated to significantly influence upper-airway patency, through loss of tension of caudal traction in the pharyngeal-airway, making it more folded and leading to increased pharyngeal collapsibility.

In this study, the reactance (Xrs) at 5 Hz oscillatory-frequencies measured and found to be significantly decreased in the obese OSAHS group and was found to strongly correlate with the severity of OSAS as defined by RDI and shows good predictive value for the diagnosis of OSAHS in obese snorers and also evident the usefulness of NIV. The X5 is a component of the out-of-phase air flow and pressure signal and is numerically a negative value that reflects the sum elastance or compliance of the respiratory system. X5 values that are more negative indicate reduced respiratory system compliance or increased lung elasticity recoil pressure.[9-11] Our findings thus lead us to a conclusion that a narrowing of the upper airway due to obesity causes inspiratory resistive breathing, and leads to respiratory compliance reduction in OSAHS patients.

OSAS patients were optimally detected using the cut-off points of -0.23 kPa.s.L^{-1} for X5 with a good sensitivity 77.7% and specificity of 79. 4% and with a highly diagnostically accurate of 0.811 (95% CI: 0.682–0.813). Among the predictors, R25 showed good PPV (76.9%) and NPV (80%) for the polysomnography screening of OSAHS.

CONCLUSION

In conclusion, IOS significantly correlate with the severity of OSAHS as defined by RDI. This study appears to indicate that the upper airway, or central airway may experience obstruction or collapse. Thus, reactance (X5) and resistance R25 measurements are related to the degree of airflow obstruction, which had a moderate sensitivity and specificity for screening OSAHS. Therefore, IOS measurements might be useful as a screening test for OSAHS during wakefulness.

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