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Assessment of impulse oscillometry findings in obstructive lung disease patients in Eastern part of Uttar Pradesh: An observational study

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ABSTRACT

Background: Lung oscillometry is a simple, non-invasive lung function test where multiple frequency pressure waves are forced into the respiratory tract superimposed over normal tidal breathing. It is predicted to be a useful diagnostic tool with a bright future for diagnosing various respiratory disorders. **Methodology**: An observational study was conducted in eastern part of Uttar Pradesh. All participants (80) who were diagnosed as obstructive lung disease on the basis of clinical history, examination and PFT findings were selected and oscillometry was performed. All parameters of oscillometry are then analysed. **Result**: Z score R5, the sensitivity is 76%, specificity is 83.33%, PPV is 88.37%, NPV is 67.57%, and AUC is 0.240. Z score R5-20 exhibits a sensitivity of 80%, specificity of 63.33%, PPV of 78.43%, NPV of 5.52%, and AUC of 0.152. Z score AX shows a sensitivity of 72%, specificity of 56.67%, PPV of 73.47%, NPV of 54.84%, and AUC of 0.241. **Conclusion**: Impulse oscillometry is a useful tool in the diagnosis and evaluation of adult patients with obstructive airway disease. Z scores can be used to define OAD in oscillometry and can give more accurate results.

Keywords: IOS (Impulse oscillometry),OAD (Obstructive lung disease), R(Resistance), R5 (Resistance at 5 Hz), R20 (Resistance at 20 Hz), R5-R20 (Heterogeneity of resistance), X (Reactance), Z (Impedance), AUC (Area under graph)

Introduction

Impulse oscillometry (IOS) is a newer diagnostic modality and advanced spirometry technique. It is simple, non-invasive lung function test based on measurement of sound waves reflected by airway resistance. The important aspect regarding the IOS is that it has much higher sensitivity than FEV1 and peak expiratory flow. It is done during normal tidal breathing, so it requires much less patient effort and cooperation[1].

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The basis of oscillometry is to use external forcing signals of sound waves applied either continuously or in a time-discrete manner. IOS machine produces and transmits small pressure pulses down the trachea-bronchial tree and records pressure and flow changes at the mouth.

Asthma is defined as a chronic inflammatory disorder of the airways which manifests itself as recurrent episodes of wheezing, breathlessness, chest tightness and cough. It is characterized by bronchial hyper-responsiveness and variable airflow obstruction that is often reversible either spontaneously or with treatment. The prevalence of asthma in India is big and is responsible for significant morbidity. Patients with asthma need to be monitored regularly. There are many methods including subjective and objective measures. Subjective measures usually consist of a series of questions based on clinical assessment and quality-of-life questionnaires. Spirometry, peak flow measurement and broncho provocation testing constitute the traditional objective means of measuring asthma.[2]

Global Initiative for Chronic Obstructive Lung Disease (GOLD), defined COPD as "It is a common, preventable, and treatable disease that is characterized by persistent respiratory symptoms and airflow limitation that is due to airway and/or alveolar abnormalities usually caused by significant exposure to noxious particles or gases and influenced by host factors including abnormal lung development. It is diagnosed as post bronchodilator cut-off point of FEV /FVC ratio <0.7. COPD is a leading cause of mortality and morbidity, as WHO declared it as 3rd leading cause of death and disability by the year 2020. COPD is a multifaceted condition that manifests in different parts of the lungs, central vs. peripheral and that can have several causes that can lead to different manifestations.

Summary of Oscillometric parameters:

Parameters	Physiological interpretation[4]
Z	Respiratory system impedance, reflecting the total forces related to resistance, elastance and inertance that must be overcome to drive airflow into and out of the lung. Z is represented by its components, respiratory system resistance (R) and reactance (X).
R	Resistance of the respiratory system, reflecting frictional losses both in gases as they flow along airways and in tissues of the lung and chest wall as they are stretched and deformed. R at individual frequencies is denoted R5, R8, etc.
R5–20	The frequency dependence of R is commonly quantified as the difference R5–20. This is thought to primarily be sensitive to heterogeneous narrowing in the peripheral airways, but it may also arise from substantial heterogeneity in narrowing of more central airways, heterogeneity of time constants reflecting airway versus parenchymal disease, and upper airway shunt flow (compliant regions proximal to resistance).
X	Expresses the energy stored and dissipated by the respiratory system in response to pressure waves. Reactance (X) becomes more negative in diseases characterized by an increase in elastance.
AX	The area of reactance, which is the total area of capacitance (between Xcurve and zero axis from X5 till Fres) reflecting the elastic properties of the respiratory system being sensitive to peripheral lungs pathology (parenchyma and airways).

Spirometry is used to diagnose obstructive airway disease (asthma & chronic obstructive pulmonary disease (COPD)). Impulse oscillometry (IOS) is an innovative method for diagnosing respiratory mechanics, although relatively little is known about its use in patients with asthma and COPD. So, we are interested in doing this study to evaluate the potential of oscillometry in the diagnosis of chronic lung diseases.

Aims and Objectives

1. To evaluate the role of IOS in obstructive airway disease.
2. To co-relate different IOS parameters in asthma and COPD patients .

Methodology

Study setting: The study was conducted in the Sir Sunderlal Hospital, Banaras Hindu University, Varanasi.

Study Population: Includesadultmore than 18 years of age diagnosed as obstructive lung disease (asthma and COPD) based on clinical history, examination and PFT findings.

Inclusion Criteria: All patients more than 18 years of age who were diagnosed as obstructive lung disease (asthma and COPD) based on clinical history, examination and PFT findings, who are willing to give consent for the study.

Exclusion Criteria: Adults who were unable to provide written informed consent were excluded.

Sample Size: A sample size of 80adults was determined based on inclusion criteria.

Study Design: Observational study.

Study Methodology: IOS can be performed in an inpatient or outpatient setting. The device should be calibrated daily as directed by the manufacturer. It is typically performed with the patient sitting and breathing at tidal volume, the head held in neutral position, a nose clip in place, and the cheeks firmly supported by either the patient or another individual such as the examiner or caregiver.

Ethical Considerations: Ethical approval was obtained, and written informed consent was obtained from all participants. Participation was voluntary, and participants were informed of their right to withdraw at any time. Participant information sheets were provided.

Statistical Analysis: Data were compiled and cleaned using MS Excel and analysed using SPSS software (version 26.0). Descriptive statistics and the Chi-square test were employed to analyse the data, assessing associations between IOS and obstructive airway disease.

Result

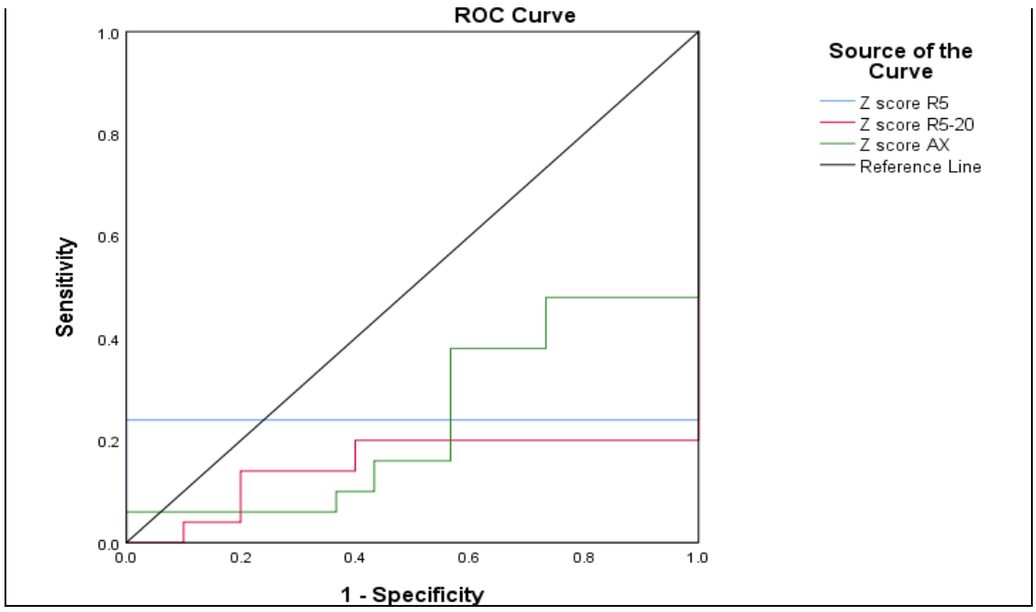
An observational study was conducted to assess the role of IOS in OAD in the eastern area of Uttar Pradesh.80 patients were enrolled in study for obstructive lung disease. On further evaluation 30 of them were diagnosed as asthma and 50 as COPD.

The data compares COPD (N=50) and asthma (N=30) patients. Significant differences emerge in age (COPD: 54.44 ± 8.92 vs. Asthma: 31.20 ± 10.22, $p<0.001$), gender distribution ($p=0.001$), and various pulmonary function parameters. Notably, Pre R_5 ($p=0.016$), Pre R_{20} ($p=0.024$), and Pre R_{5-20} ($p<0.001$) demonstrate significant disparities. Percentage differences in R_5, R_{20}, R_{5-20}, X_5, and A_X are also notable (all $p<0.001$). Z scores for R_5, R_{5-20}, and A_X significantly differ between groups (all $p<0.001$). These findings suggest distinct physiological profiles between COPD and asthma, highlighting potential diagnostic and therapeutic implications. Further investigation could elucidate underlying mechanisms contributing to these disparities and inform tailored management strategies for each condition.[6, 7]

Table-1: Comparison of various parameter between COPD and Asthma

		COPD (N=50)		Asthma (N=30)		P value
Gender	Male	42	84.0	15	50.0	0.001
	Female	8	16.0	15	50.0	
Age		54.44 ± 8.92		31.20 ± 10.22		<0.001
Height (in cm)		165.78 ± 10.02		159.40 ± 13.98		0.020
PreR$_5$(cm H2O/L/s)		5.29 ± 0.89		6.17 ± 2.24		0.016
PreR$_{20}$(cmH2O/L/s)		3.67±0.66		4.03±0.73		0.024
PreR$_{5-20}$(cmH2O/L/s)		1.48 ± 0.59		2.18 ± 0.86		<0.001
PreX$_5$(cm H2O/L/s)		-2.16± 1.67		-2.71± 1.45975		0.140
PreA$_X$(cm H2O/L)		49.25 ± 5.91		52.89 ± 9.41		0.037
R$_5$ %		-7.58± 6.36		-33.43± 8.19		<0.001
R$_{20}$%		-8.58± 5.61		-29.13± 3.82		<0.001
R$_{5-20}$%		-22.30± 11.19		-53.37± 19.95		<0.001
X$_5$%		-14.10± 7.65		42.50 ± 13.34		<0.001
A$_X$%		-21.78± 10.54		-59.10± 10.23		<0.001
ZscoreR$_5$		1.27 ± 0.80		2.01 ± 0.07		<0.001
ZscoreR$_{5-20}$		2.32±2.13		5.03±2.50		<0.001
ZscoreA$_X$		2.05 ± 1.13		3.06 ± 0.76		<0.001

Figure-1: ROC analysis of predictive validity of Z score R_5, R_{5-20} and A_X in predicting OAD



	TP	FP	FN	TN	AUC	Cut off	Sensitivity %	Specificity %	PPV %	NPV %	P value
Zscore R5	38	5	12	25	0.240	≤1.92	76.0	83.33	88.37	67.57	<0.001
Zscore R5- 20	40	11	10	19	0.152	≤3.90	80.0	63.33	78.43	5.52	<0.001
Zscore AX	36	13	14	17	0.241	≤3.03	72.0	56.67	73.47	54.84	<0.001

This data presents diagnostic performance metrics for three variables: Z score R_5, Z score R_{5-20}, and Z score A_X. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and area under the curve (AUC) are provided. For Z score R_5, the sensitivity is 76%, specificity is 83.33%, PPV is 88.37%, NPV is 67.57%, and AUC is 0.240. Z score R_{5-20} exhibits a sensitivity of 80%, specificity of 63.33%, PPV of 78.43%, NPV of 5.52%, and AUC of 0.152. Z score A_X shows a sensitivity of 72%, specificity of 56.67%, PPV of 73.47%, NPV of 54.84%, and AUC of 0.241. All variables demonstrate significant differences ($p<0.001$). These findings suggest varying diagnostic accuracies and highlight the importance of considering multiple parameters in clinical decision-making.[5]

Table-1: Cut-off value for significant bronchodilator reversibility

Cut of Value	Percent
R_5%	17.0
R_{20}%	20.0
R_{5-20}%	35.0
A_X%	36.0

Conclusion

Impulse oscillometry is a useful tool in the diagnosis and evaluation of adult patients with obstructive airway disease.[8] The role of oscillometry is relevant in predicting bronchial asthma with the help of significant bronchodilator reversibility. It can replace spirometry as it is easy to perform and effort independent. Z scores can be used to define OAD in oscillometry and can give more accurate results.[9]

Furthermore, studies are essential to make oscillometry a potential tool in evaluating and diagnosing respiratory diseases.[10]

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