Journal Homepage: -www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI:10.21474/IJAR01/14456
DOI URL: http://dx.doi.org/10.21474/IJAR01/14456

RESEARCH ARTICLE

COMPARATIVE STUDY TO DETECT SITE OF OBSTRUCTION IN OBSTRUCTIVE AIRWAY DISEASES USING SPIROMETRY AND IMPULSE OSCILLOMETRY

Pundpal Gurudas S., Karpe Sonal P. and Meshram Priti L.

Manuscript Info

Manuscript History
Received: 22 January 2022
Final Accepted: 24 February 2022
Published: March 2022

Key words:-
COPD, Asthma, Site of Airway Obstruction, Spirometry, Impulse Oscillometry

Abstract

Introduction: Chronic Obstructive Pulmonary Disease [COPD] is associated with predominantly smaller airways and lung parenchyma involvement, whereas, Asthma involves predominantly smooth muscles located in the larger airway. Spirometry involves flow volume studies which are effort and coordination dependent and Impulse Oscillometry [IOS] is done during spontaneous respiration and hence effort independent. We studied the site of airway obstruction in COPD and Asthma patients using both Impulse Oscillometry and flow volume loop and whether both methods of pulmonary function testing are comparable with each other.

Aims: To study site of airway obstruction using Impulse Oscillometry and Flow volume loop in COPD and Asthma patients.

Methodology: The study was performed in 50 patients who were either COPD or Asthma. The patients underwent spirometry and impulse oscillometry. Both the modalities were analyzed for detecting the site of obstruction as per the diagnosis. Results and Conclusion: As per IOS, all the patients having large airway obstruction were asthmatics, all patients with mixed airway disease were COPD and 97.1% patients having small airway obstruction were COPD. Spirometry could not detect site of obstruction in 5 (10%) patients, on the other hand IOS could detect site of obstruction in all the 50 (100%) patients. Hence, Oscillometry is a better tool to know site of obstruction as compared to Spirometry in patients of Asthma and COPD.

Introduction:-

Obstructive Airway diseases comprises predominantly of Bronchial Asthma and Chronic Obstructive Pulmonary Disease (COPD). The major difference between COPD and Asthma is the clinical presentation and site of airway obstruction. COPD is associated with predominantly smaller airways and lung parenchyma [1] involvement, whereas, Asthma involves predominantly smooth muscles located in the larger airway. Both the conditions are diagnosed based on clinical history and Pulmonary function testing inclusive of conventional spirometry and flow volume loops. The Impulse oscillometryis a method in which respiratory impedance is measured simultaneously at various frequencies by complex oscillations superimposed at mouth during spontaneous breathing. The flow volume studies are effort and coordination dependent and Impulse Oscillometry is done during spontaneous respiration and hence effort independent. We studied the site of airway obstruction in COPD and Asthma patients using both Impulse Oscillometry and flow volume loop and whether both methods of pulmonary function testing are comparable with each other.

Corresponding Author:- Pundpal Gurudas S.

Aims and Objectives:-

To study site of airway obstruction using Impulse Oscillometry and Flow volume loop in COPD and Asthma patients.

Materials and Methods:-

This was a prospective study conducted in the Pulmonary Function Test laboratory of department of Pulmonary Medicine in a tertiary care facility. The study was performed by randomly selecting 50 patients who were diagnosed with either COPD or Asthma and who met the inclusion criteria. All the 50 patients who met the inclusion criteria were made to perform both spirometry and impulse oscillometry. The study recruited patients of both the genders. The patients who were unable to perform the test correctly or did not meet the inclusion criteria were excluded. The inclusion and exclusion criteria for the selection subjects were as below:

Inclusion criteria:

1. Adult above age of 18 years.
2. Patients diagnosed clinically to have COPD or Bronchial Asthma.

Exclusion criteria:

1. Patients with active or old tuberculosis.
2. Patients unable to perform either Spirometry or Impulse Oscillometry

Patients fitting into these criteria were selected and informed about the study. A well-valid written informed consent was taken from those patients who agreed to participate in the study.

Methodology: -

All the participants were explained about the study and the procedure. Spirometry and IOS studies were performed in the Pulmonary Function laboratory of the department of Pulmonary Medicine between 9am and 12 noon.

The tests selected for the assessment of the Pulmonary Function were:

1. Forced vital capacity (FVC) and Forced expiratory volume in first second (FEV_1)
2. Percentage of ratio between FEV_1 and FVC (FEV_1 / FVC %)
3. FEF 25-75% (Forced Expiratory Flow 25-75%)
4. Impulse Oscillometry.

Results:-

The average age the study population was 49.7 years with the youngest subject being 18 years old and the oldest being 80 years old. There were 34 (68%) males and 16 (32%) females in the study population. Out of total 50 patients,10 (20%) were Asthma patients and 40 (80%) were COPD.

As per the Spirometry, 5 [10%] patients had normal lung functions and remaining 45[90%] had obstruction either in small, large or both airways.

Amongst patientsubset with obstruction in large airways, 2 [40%] were Asthmatic and 3 [60%] had COPD. Amongst patients having peripheral obstruction by spirometry, 1 [50%] had Asthma and 1 [50%] had COPD. 33 (66%) patients had both small and large airway obstruction, out of which 4 [12.1%] had Asthma and 29 [87.9%] had COPD. Thus as per spirometry majority of COPD and Asthma patients, 33 [66%] had both small and large airway obstruction.

Table I:- Correlation between site of obstruction in COPD and Asthma by Spirometry.

Site of Obstruction by Spirometry	Disease				
			Asthma	COPD	Total
	Normal	Count	2	3	5
		%	40.0	60.0	100.0
	Central Obstruction [Large airway]	Count	1	1	2
		%	50.0	50.0	100.0

	Peripheral Obstruction [Small Airway]	Count	3	7	10
		%	30.0	70.0	100.0
	Both Small and Large airway obstruction.	Count	4	29	33
		%	12.1	87.9	100.0
Chi-Square Tests					
	Value	df	P-value		
Pearson Chi-Square	4.28	3	0.233		

Table II:- Correlation between site of obstruction in COPD and Asthma by Oscillometry.

Site Of Obstruction by Oscillometry	Disease				
			Asthma	COPD	Total
	Central Obstruction [Large airway]	Count	9	0	9
		%	100.0	0.0	100.0
	Peripheral Obstruction [Small Airway]	Count	1	33	34
		%	2.9	97.1	100.0
	Both Small and Large airway obstruction.	Count	0	7	7
		%	0	100	100
Chi-Square Tests					
	Value	df	P-value		
Pearson Chi-Square	43.94	2	< 0.001		

As per our study, in patients with obstruction in large airways as per IOS, all 9 [100%] were diagnosed with Asthma and none had COPD. Amongst patients having peripheral obstruction, 1 [2.9%] had Asthma and 33 [97.1%] had COPD. Amongst patients both small and large airway obstruction all 7 [100%] patients had COPD.

As per IOS, all the patients having large airway obstruction were asthmatics, all patients with mixed airway disease were COPD and 97.1% patients having small airway obstruction were COPD. Spirometry could not detect site of obstruction in 5 (10%) patients, on the other hand IOS could detect site of obstruction in all the 50 (100%) patients. Hence, Oscillometry is a better tool to know site of obstruction as compared to Spirometry in patients of Asthma and COPD.

Discussion:-

The respiratory tract dichotomous branching dividing it into 23 generations by airways starting from the trachea and culminating into the acinar sacs. The diameter of the daughter airways reduces by a factor of 0.79 compared to the parent airway till atleast the respiratory bronchiole as per the Hess and Murray law.[2,3] The conducting airways are formed by first 15 generations and take no part in gas exchange. Beyond conducting airways there are the respiratory bronchioles which have occasional alveoli budding from them. These continue to divide until they reach the alveolar sacs. These airways are called acinar airways and they take part in gas exchange. The small airways refer to those airways that are less than 2 mm in diameter. [4]

Assessment of function of small airway obstruction is difficult which may be seen in early COPD. Although Forced expiratory flow during mid expiration (FEF25-75%) does reflect resistance in small airways, it is estimated that 75% of small airway obstruction is required before significant airflow limitation can be detected by routine PFT. Thus these spirometric values for assessment of function of small airways have their own limitation and need to be interpreted with caution. [5]

In emphysema the morphological basis of predominantly irreversible airflow limitation with varying combinations of inflammatory and fibrotic narrowing of peripheral airways [6]and loss of elastic lung recoil with enhanced

collapsibility of central airways [7,8] Studies suggest that the major site of airflow limitation in emphysema is peripheral airways.[6]

The variable airflow limitation in asthmatics is due to multiple pathophysiological changes of central airwayleading to bronchoconstriction, airway edema, mucus secretion, airway hyper-responsiveness and leading to airway remodeling. [9] Remodeling of the airway is due to multiple pathologic changes such as increased airway smooth muscle mass, basement membrane thickening, and mucus gland hyperplasia.[10, 11]These are common features of asthma that contribute to airflow obstruction primarily involving central airway both by luminal encroachment and by enhancing constrictor hyperresponsiveness.

Spirometry is conventionally used measure of lung function and is a measure of volume against time. The patients are asked to take a maximal inspiration and then to forcefully expel air for as long and as quickly as possible. Measurements that are made includeForced expiratory volume in one second (FEV1), Forced vital capacity (FVC), ratio of the two volumes (FEV1/FVC) and Maximum Mid-Expiratory.Spirometry can determine central or large airway obstruction by assessment of Forced Expiratory Volume during the 1st sec [FEV1] and also the Peak Expiratory Flow Rate.

The peripheral airways do not have cartilaginous support to maintain their patency. Their patency primarily depends upon the elastic recoil. During expiration as the lung volume decreases the recoil pressure also starts diminishing, thus the resistance of small airway increases relative to that of central airways in the terminal part of the forced expiration. Therefore, peripheral airway disease can be suspected if the FEV_1 and PEF are normal, whereas measurements obtained at low lung volumes are abnormally reduced and give 'slow tail'. The $FEF_{25–75\%}$ has been recommended as a good way to identify small airway disease. [12]

Impulse Oscillometry

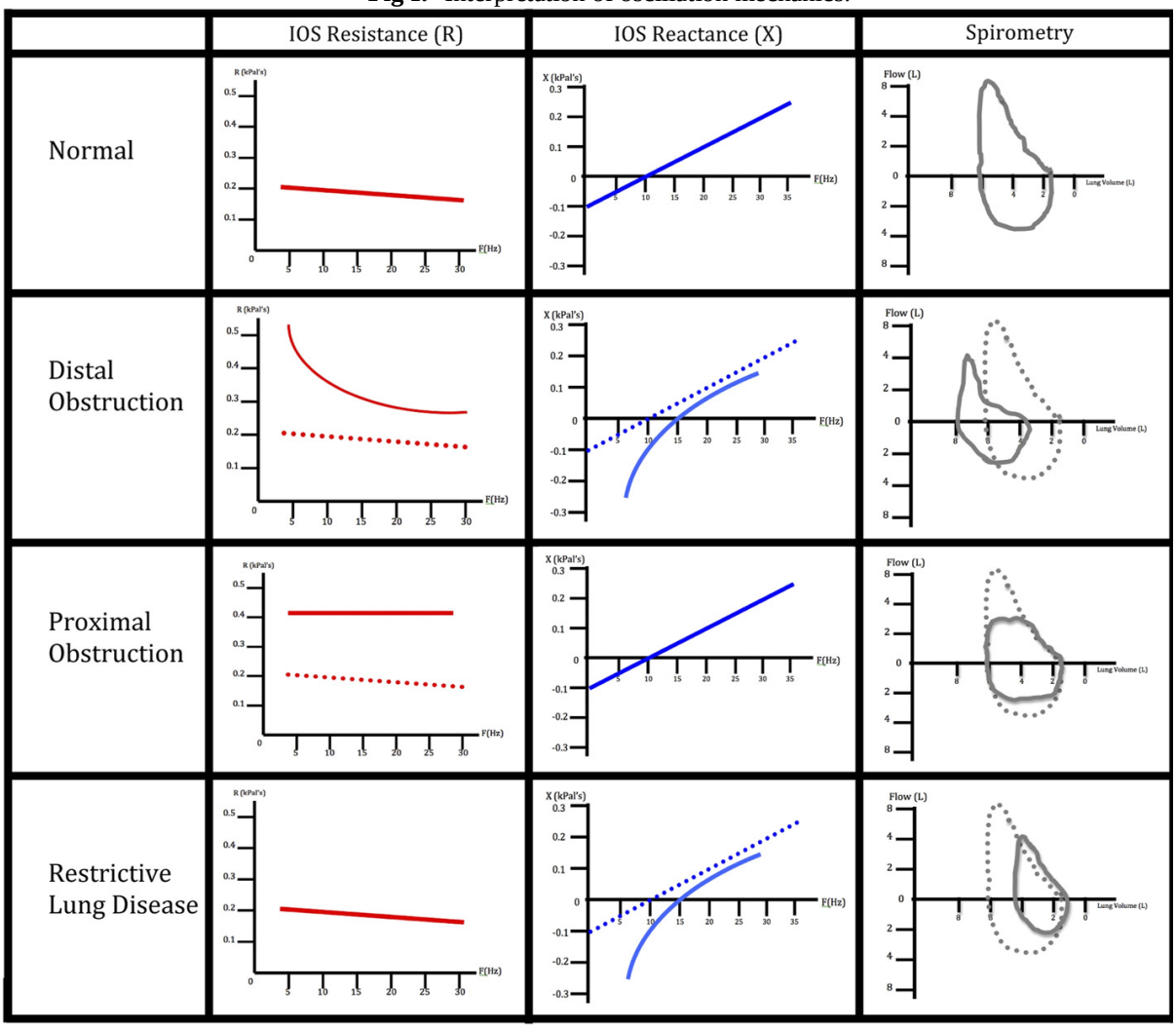
It is a noninvasive method of lung function testing described by Dubois about 60 years ago. It is a variant of forced oscillation technique. Sound waves are superimposed on normal tidal breathing in this technique. The disturbances in flow and pressure caused by external waves are used to calculate IOS parameters such as respiratory Resistance (R) and Reactance (X). [13]

Advantages of the IOS/FOT are, IOS being passive method of lung function testing and requires minimal cooperation it can be easily performed by children and elderly subjects. It measures resistance and reactance at different frequencies in lung and offers important information about regional inhomogeneity and lung.IOS is a very useful tool in measuring the mechanical properties of lung, and also help in diagnosis and monitoring the progress of chronic lung diseases. IOS parameters may be less variable than commonly measured spirometry parameterssuch as FEV1, $FEF_{25\%-75\%)}$. Also, IOS is more sensitive than spirometry in detecting airway abnormalities. It is considered better tool to predict asthma control and exacerbations. [14]Interpretation of IOS [Fig I]

1. Respiratory resistance (Rrs)

The resistive component of respiratory impedance, Rrs, includes proximal and distal airways (central and peripheral), lung tissue and chest wall resistance. In healthy subjects, Rrs is almost independent of oscillation frequency, but may increase slightly at higher frequencies due to the upper airways shunt effect. Proximal airways obstruction elevates Rrs evenly independent of oscillation frequency. In distal airways obstruction, Rrs is highest at low oscillation frequencies and falls with increasing frequency. Peripheral resistance increases, Rrs becomes more frequency dependent.

Fig I:- Interpretation of oscillation mechanics:



The purpose of this study was to access the site of obstruction in patients with COPD and Asthma using Impulse Oscillometry and flow volume loop studies.

In our study it is observed that Oscillometry is better tool to know site of obstruction as compared to Spirometry in patients of Asthma and COPD using Pearson correlation (p value <0.001). The results have been shown to be comparable with an earlier study conducted by H.S. Hira, JitenderMunjal, Sanjay Zachariah, M.R. Chauhan, Anshu Singh in 2008. [15] They showed that IOS had proven to be advantageous over FV loop studies as it could identify central and peripheral airway obstruction separately and established the predominant site of obstruction.

Conclusion:-

As we venture into the world of target specific pharmacotherapies it becomes necessary that we are able to pin point the site of obstruction for better understanding and guidance of treatment. Newer modalities such as impedance oscillometry need further studies as they have an advantage of being effort independent have advantage over FV loop studies to identify central and peripheral airway obstruction separately and establish the predominant site of obstruction in patients of obstructive airway disease. Since our study had limited number of patients larger studies would be required for concluding the same.

Bibliography:-

1. Hogg JC, Thurlbeck WM. Site and nature of airway obstruction in chronic obstructive lung disease. N Engl J Med. 1968;278:1355–60. Jun 20.
2. Hess WR. Das Prinzip des kleinstenKraftverbrauchesimDienstehämodynamischerForschung. Arch Anat Physiol. 1914;2:1–62.
3. Murray CD. The physiological principle of minimum work. I. The vascular system and the cost of blood. Proc Nat AcadSci USA. 1926;12:207–14
4. Usmani OS. Small airways dysfunction in asthma: Evaluation and management to improve asthma control. Allergy Asthma Immunol Res. 2014;6:376–88.
5. McNulty W, Usmani OS. Techniques of assessing small airways dysfunction. EurClinRespir J. 2014;1:25898.
6. 6. Hogg JC, Thurlbeck WM. Site and nature of airway obstruction in chronic obstructive lung disease. N Engl J Med. 1968;278:1355–60. Jun 20.
7. Leaver CG, Tatters field, Pride NB. Contributions of loss of lung recoil and of enhanced airway collapsibility to the airflow obstruction of chronic bronchitis and emphysema. J Clin Invest. 1973;52:2117–28.
8. Colebatch HJH, Finucane KE, Smith MM. Pulmonary conductance and elastic recoil relationship in asthma and emphysema. J Appl Physiol. 1973;34:143–53
9. Lemanske RF Jr, Busse WW. 6. Asthma. J Allergy ClinImmunol. (2003). 111(2 Suppl):S502–19. doi: 10.1067/mai.2003.94
10. Al-Muhsen S, Johnson JR, Hamid Q. Remodeling in asthma. J Allergy ClinImmunol 128: 451–464, 2011.
11. James AL, Maxwell PS, Pearce-Pinto G, Elliot JG, Carroll NG. The relationship of reticular basement membrane thickness to airway wall remodeling in asthma. Am J RespirCrit Care Med 166: 1590–1595, 2002.
12. McFadden ER, Jr, Linden DA. A reduction in maximum mid-expiratory flow rate. A spirographic manifestation of small airway disease. Am j Me. 1972;52:725–737.
13. Desiraju K, Agrawal A. Impulse oscillometry: The state-of-art for lung function testing. Lung India 2016;33:410-6.
14. H.J. Smith, P. Reinhold#, M.D. Goldman. Forced oscillation technique and impulse oscillometry. EurRespir Mon, 2005, 31, 72–105.
15. H.S. Hira, JitenderMunjal, Sanjay Zachariah M.R. Chauhan, Anshu Singh. THE SITE OF AIRWAY OBSTRUCTION AMONG PATIENTS OF EMPHYSEMA: ROLE OF IMPULSE OSCILLOMETRY. Lung India 2008; 25 : 8-13.