THE ROLE OF IMPULSE OSCILLOMETRY IN THE EVALUATION OF SMALL AIRWAYS ABNORMALITIES IN ASTHMATIC CHILDREN

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ABSTRACT

Background: *Asthma has been considered a disease that predominantly involves the large airways. Today, this concept is being challenged, and increasing evidence has become available showing that abnormalities in the small airways also contribute to the clinical expression of asthma.*

Objectives: *To provide an overview of impulse oscillometry and its application to the evaluation of children with diseases of the airways and detection of bronchodilator response regarding the levels of asthma control in asthmatic children.*

Methods: *this study was done on 50 asthmatic patients diagnosed according to the clinical manifestations and pulmonary functions.* ***.*** *Children performed IOS and spirometry before and after 200 mcg salbutamol inhalation. Because of the possible effects of forced expiratory maneuvers on the bronchial motor tonus, first IOS, and then spirometry was performed. This study was carried out at Pediatric Chest Clinic, Children's Hospital, Ain Shams University. The asthmatic patients were recruited from both Al-Hussein and Ain shams pulmonology and allergy outpatient clinics, from December 2016 to November 2017.*

Results: *this study showed that the prevalence of small airways dysfunction when utilizing a spirometric cut-off value (i.e<60% in MEF25-75) was 64% and when employing IOS cut-off value (>0.1 kPa/L/s for R5-R20, >15 Hz for Fres) a prevalence of 82% and 78% were observed respectively and showed that the best index with +ve BDR was X5 which detected 63.6% of controlled , 52.6% of partly controlled and 66.7% of uncontrolled asthmatic patients compared with 40.9%, 63.2% and 66.7% for the same patients respectively when assessed by spirometry using Δ FEV1%. Statistical analysis was done by using IBM SPSS software package version 20.0.*

Conclusion: *IOS is a noninvasive, rapid and safe technique that may be used to diagnose, evaluate, and determine treatment response in those with asthma.*

Key words: *Impulse Osillometry System (IOS), Spirometry, Asthma, Small airways disease, respiratory function tests.*

INTRODUCTION

Asthma is reported to be the most common chronic respiratory disease in children, and its prevalence appears to be high worldwide. ***(Foliaki et al., 2007)*** Accordingly, significant efforts have been made to develop noninvasive techniques that accurately measure lung function in children.

Examples of such techniques include spirometry, plethysmography, tidal breathing measurements, multiple-breath inert gas washout technique, forced oscillation technique (FOT) and impulse oscillometry (IOS) ***(Gerald et al., 2007).***

The peripheral airway, commonly defined as small airways, are those with less than 2mm in internal diameter and may account up to 50-90 % of total airflow resistance in asthmatics ***(Perez et al., 2013).***

Although diseases frequently involve the small airways', the concept of small airways disease is one of which many pathologists lack a strong understanding. There are valid reasons for this lack of understanding. The definition of the term small airways disease varies based on the physician's perspective. Pulmonologists and other clinicians often consider small airways disease as a group of lung disorders involving the terminal airways often assessed for airflow obstruction or underlying etiology ***(Allen, 2010).***

In asthma, the small airways are thickened with a chronic inflammatory infiltrate affecting all layers of the airway ***(Hamid, 2012).***

The small airways may be more prone to pathology because of their size. Small inhaled particles and pathogens may be deposited there and pathological changes in airways disease make the small airways susceptible to occlusion. Therefore, small airways may require inhaled therapeutic aerosols of smaller size to be able to penetrate the airways tree and reach the distal lung region ***(Usmani et al., 2014).***

The forced oscillation technique (FOT) is the general name for airway mechanic measurements using the noninvasive super-imposition of pressure fluctuations on the airway over the subject's normal, quiet, tidal breathing. More than 50 years ago, FOT was first determined by ***Dubois et al.***

(1956) and has developed with regard to configuration, standardization, and application.

Impulse oscillometry (IOS) is one type of FOT. It delivers a regular square wave of pressure 5 times per second, which has the advantage of generating a larger sample during measurements and emitting a continuous spectrum of frequencies that may provide more detailed characterization of respiratory function ***(Smith et al., 2005)***

Impulse oscillometry (IOS) has been used in adults as well as in preschool children to identify lung dysfunction, such as in asthma ***(Neve et al., 2006)***

It is noninvasive, easy to perform, and requires only passive patients cooperation ***(Marotta et al., 2003)***.

IOS systems are increasingly used in the clinical diagnostic testing of patients with airway hyper-reactivity and airway obstruction. Impulse oscillometry also may be used during challenge and provocation testing. The IOS apparatus generates small pressure oscillations that are applied at the mouth and transmitted into the lungs, to help determine the impedance (Zrs) of the respiratory system ***(Klug et al., 1997)*** pulmonary resistance and reactance are the key components of impedance ***(Beydon et al.,2007)*** and are measured and graphically displayed.

AIM OF THE WORK

The aim of this study was to determine the role of impulse oscillometry in comparison to the standard spirometry in the evaluation of small airways diseases and bronchodilator response regarding the levels of asthma control in asthmatic children.

PATIENTS AND METHODS

This is a cross sectional study which was conducted in the Pediatric Chest Clinic, Children's Hospital, Ain Shams University. It included 50 asthmatic patients recruited from both Al-Hussein and Ain shams pulmonology and allergy outpatient clinics during the period from December 2016 to November 2017.All fulfilled the diagnostic criteria of asthma ***(GINA, 2016).***

Inclusion Criteria: were:

- Asthmatics with different levels of asthma control and severity.
- Age 6-16 years of both sex.

Exclusion Criteria: were:

- Any child with upper respiratory tract illness, such as common cold, bronchitis, or pharyngitis, in the four weeks prior to the study ***(Shi et al., 2012)***.
- Other systemic diseases e.g. pulmonary, cardiac, collagen diseases and diabetes ***(Shi et al., 2012)***.
- Any child was not able to do standard spirometry.
- If the patient was received long acting beta 2 agonist (LABA) for the past 12hours or short acting beta 2 agonist (SABA) for the past 4 hours prior to the test.

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Ethical Consideration:

1. A written informed consent was obtained from patients or their legal guardians.
2. An approval by the local ethical committee was obtained before the study.
3. The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.
4. All the data of the patients and results of the study are confidential and the patients have the right to keep it.

All studied children were subjected to careful history taking stressing on demographic data including age, sex, and residency (rural, urban, slum areas), environmental tobacco smoking exposure, symptoms of asthma (cough, wheezing, shortness of breath, exercise intolerance) ,family history of atopy, age of onset and duration of illness ,asthma severity, medications used in the asthma and level of asthma control.

They were subjected to general examination to exclude other systemic illness from study laying stress on pallor, cyanosis and respiratory rate.

Anthropometric measures including weight in (kg), and the height in (cm) were measured.

Children performed IOS and spirometry before and after 200 mcg salbutamol inhalation (30 minutes apart). Because of the possible effects of forced expiratory maneuvers on the bronchial motor tonus, first IOS was done followed by spirometry ***(Batmaz et al., 2016)***.

Spirometry (JAEGER MS-IOS Digital) was performed with the child standing with nose clips in place. The child was encouraged to produce the greatest expiratory flow. FEV1 was reported from the best of three to six attempts. If the operator determined that the effort was suboptimal or expiration could not be maintained until close to residual volume, the test was discarded ***(Komarow et al., 2012).***

JAEGER MS-IOS Digital is fully integrated with an IOS system. IOS requires the subject to breath normally (tidal breathing) into a mouthpiece, while a loudspeaker generates an impulse shaped pressure signal into the respiratory system. The IOS system was calibrated each day prior to the measurements using a 3-liter syringe. IOS measurements were performed in the sitting position with participants wearing nose clips. Participants tidally breathed into the IOS mouthpiece for 30 seconds with the cheeks supported by the hands of trained technicians. The technicians evaluated the efforts and made sure each observation consisted of at least 3 reproducible maneuvers which did not have artifacts caused by coughing, swallowing, vocalization or breathe holding ***(Shi et al., 2012)***.

Statistical Analysis:

Data were collected, coded, revised and entered to the statistical package for social science (SPSS) version 20. Qualitative data were presented as number and percentages while quantitative data were presented as mean, standard deviation and range. The comparison between two groups with quantitative and parametric data was done by using independent t-test. The comparison between more than two groups with quantitative and parametric data was done by using one way analysis of variance (ANOVA) test. Spearman correlation coefficient were used to assess the relation between two parameters in the same group. P value below 0.05 was considered significant.

RESULTS

Table (1): Comparison Between R5 – R20 kPa/L/s and MEF25-75% regarding Detection of Small Airways Impairment Among Study Group:

IOS (R5 – R20 kPa/L/s)		spirometry (MEF%)		Total
		SAI	NSAI	
SAI	N	29	12	41
	%	58%	24%	82.0%
NSAI	N	3	6	9
	%	6%	12%	18.0%
Total	N	32	18	50
	%	64.0%	36.0%	100.0%
Chi-square	X^2	4.480		
	P-value	0.034*		

R5= Resistance of the respiratory system at 5Hz; **R20**= Resistance of the respiratory system at 20Hz; **MEF%**= mid expiratory flow between 25-75% of FVC; **R5 - R20=** Difference of Rrs5 minus Rrs20; X^2 = chi square test**; p** <0.05= statistically significant. **SAI**= Small Airway Impairment; **NSAI**= Non-Small Airway Impairment.

Table (1) showing that there is significant difference between **R5 – R20 kPa/L/s** and **MEF25-75%** regarding detection of SAI among studied asthmatics; $p<0.05$. Regarding the other parameters, we have shown that IOS does not match with spirometry in identifying asthmatics with small airway dysfunction.

Table (2): Frequency Distribution of Small Airways Impairment Recorded By Spirometry and Impulse Oscillometry Among Study Group:

Asthmatics with SAI patients	No	%
MEF25/75	32	64
R5%	18	36
R5 – R20 kPa/L/s	41	82
AX H2O/L/s	16	32
X5 kPa/L	27	54
Fres Hz	39	78

R5= Resistance of the respiratory system at 5Hz; **R20**= Resistance of the respiratory system at 20Hz; **MEF%**= mid expiratory flow between 25-75% of FVC; **R5 - R20=** Difference of Rrs5 minus Rrs20; X^2 = chi square test**; p** <0.05= statistically significant. **SAI**= Small Airway Impairment; **NSAI**= Non-Small Airway Impairment.

Table (2) and **Figure (1)** showing that the prevalence of small airways dysfunction in our study when utilizing aspirometric cut-off value <60% in MEF25-75 was 64% and when employing IOS cut-off value >0.1 kPa/L/s for **R5-R20**, >15 Hz for **Fres** a prevalence of 82% and 78% were observed respectively.

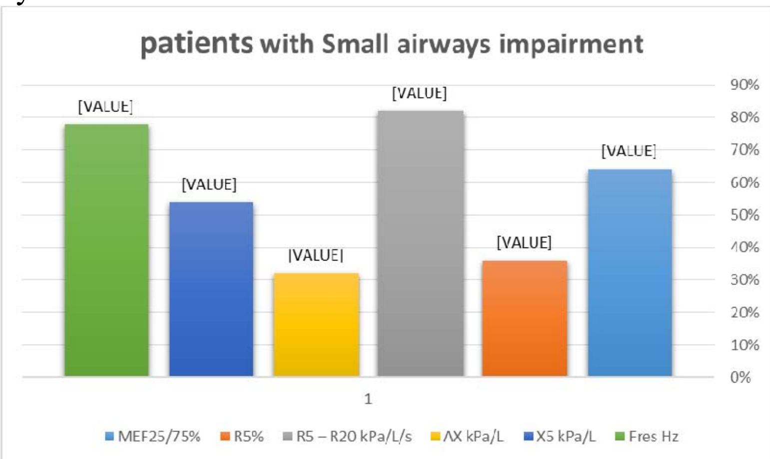

Figure (1): Frequency distribution of small airways impairment (SAI) recorded by spirometry and IOS among study group

Table (3): Frequency Distribution of +ve Bronchodilator Response (BDR) Among Asthmatic Subgroups:

BDR		Controlled (N=22)	Partly controlled (N=19)	Uncontrolled (N=9)	Total
ΔAX H2O/L/s %	N	9	10	6	25
	%	40.9%	52.6%	66.7%	50.0%
ΔFEV1 %	N	9	12	6	27
	%	40.9%	63.2%	66.7%	54.0%
ΔR5 kPa/L/s	N	1	3	3	7
	%	4.5%	15.8%	33.3%	14.0%
ΔFres Hz	N	4	2	2	8
	%	18.2%	10.5%	22.2%	16.0%
ΔX5 kPa/L	N	14	10	6	30
	%	63.6%	52.6%	66.7%	60.0%

Δ=the difference between pre and post bronchodilator; **AX**= area of reactance; **FEV1**= Forced expiratory volume in 1st second; **R5**= Resistance of the respiratory system at 5Hz; **Fres**= Resonant frequency in Hz; **X5**= Reactance of the respiratory system at 5Hz.

Table (3) showing that the best index with +ve bronchodilator response (BDR) was **X5** which detected 63.6% of controlled , 52.6% of partly controlled and 66.7% of uncontrolled asthmatic patients compared with 40.9%, 63.2% and 66.7% for the same patients respectively when assessed by spirometry using Δ **FEV1%**

Table (4): Correlations Between Different Studied Quantitative Parameters of Spirometry and IOS Among Total Patients of Study:

	R5%		R5 – R20 kPa/L/s		Fres HZ		AX H2O/L/s		X5 kPa/L	
	r.	p	r.	p	r.	p	r.	p	r.	p
FEV1%	- 0.302	0.033*	- 0.181	0.071	- 0.371	0.001*	- 0.120	0.407	0.203	0.043*
FEV1/FVC%	- 0.456	0.001*	- 0.244	0.014*	- 0.295	0.003*	- 0.230	0.109	0.184	0.067
MEF%	- 0.505	0.001*	- 0.179	0.076	- 0.171	0.088	- 0.326	0.021*	0.039	0.699

p >0.05= statistically insignificant; **p**<0.05=statistically significant; **p**<0.01=statistically highly significant; **FEV1**= Forced expiratory volume in 1st second; **FEV1/FVC%=** Ratio between FEV1 and FVC; **MEF%**= Mid expiratory flow between 25-75% of FVC.

There was a statistically significant negative correlation between all spirometry parameters and **R5%**. **FEV1%** with **R5%** and **Fres HZ**. **FEV1/FVC%** with **R5%**, **R5 – R20 kPa/L/s** and **Fres HZ**. **MEF%** with **R5%** and **AX H2O/L/s**, and significant positive correlation between **FEV1%** and **X5 kPa/L/s**, while other studied quantitative parameters showed insignificant correlations; **Table(4)**

Table (5): Frequency Distribution of Small Airways Impairment (SAI) Among Asthmatic Subgroups:

SAI		Controlled (N=22)	Partly controlled (N=19)	Uncontrolled (N=9)	Total (50)
MEF25/75	**N**	8	15	9	32
	%	36.4%	78.9%	100.0%	64.0%
R5%	**N**	3	10	5	18
	%	13.6%	52.6%	55.6%	36.0%
R5 - R20 kPa/L/s	**N**	14	18	9	41
	%	63.6%	94.7%	100.0%	82.0%
Fres Hz	**N**	12	18	9	39
	%	54.5%	94.7%	100.0%	78.0%
AX H2O/L/s	**N**	6	7	3	16
	%	27.3%	36.8%	33.3%	32.0%
X5 kPa/L	**N**	9	10	8	27
	%	40.9%	52.6%	88.9%	54.0%

SAI= Small Airway Impairment; **MEF%**= mid expiratory flow between 25-75% of FVC; **R5**= Resistance of the respiratory system at 5Hz; **R5 - R20=** Difference of Rrs5 minus Rrs20; **Fres**= Resonant frequency in Hz; **AX**= area of reactance; **X5**= Reactance of the respiratory system at 5Hz.

For the patients with small airways impairment as assessed by spirometry **MEF25-75** (n=32), we found that 62.5% showed +ve BDR when assessed by **ΔFEV1%,** which is equal to the same number of patients detected by **ΔX5kPa/L/s** compared to 53.1%, 15.6%, 15.6% detected by **ΔAX H2O/L/s**, **ΔR5 kPa/L/s** and **ΔFres Hz** respectively; **Table (5)**

DISCUSSION

This is across- sectional study aimed to assess the small airway impairment in asthmatic children and to correlate them to the level of disease control and bronchodilator response comparing the spirometry and IOS parameters pre and post bronchodilator

To fulfill the aim of the current study, 50 children with clinical definite asthma were recruited from Pediatric Chest Clinic, Children's Hospital, Ain Shams University during the period from December 2016 to November 2017.

Thirty patients (60%) were males and twenty (40%) were females with a male to female ratio of 3:2. Many studies reported a gender difference with male preponderance in pre-pubertal asthmatics. Such gender difference may be related to a greater degree of bronchial liability in males, increased levels of serum IgE in young males, and sociocultural factors that have been suggested to lead to under-diagnosis of asthma in younger girls ***(Osman, 2003; Jain et al., 2010; Rao et al., 2011).***

Regarding the enrolled asthmatics 22 (44%) were controlled, 19 (38%) were partly controlled and 9 (18%) were uncontrolled assessed by asthma control questionnaire of ***GINA 2016***

Positive history of second hand smoking (SHS) exposure was recorded in 62 % of enrolled asthmatics. Such link between asthma and exposure to SHS was explained by both ***Feng et al., (2001)*** and ***Hogan et al., (2011)***

Conventional spirometry is regarded as the gold standard assessment of airflow obstruction; however, it has a limited capacity to distinguish between distal and proximal airways involvement. For example, the most frequently used measurement, **FEV1**, mainly reflects the large airways ***(Annesi et al., 1992)*** and forced expiratory flow at 25% to 75% of forced vital capacity **(FEF25-75)**, which is believed to be a marker of the small airways has poor reproducibility ***(Marseglia et al., 2007)***

It has also been stated that for subjects with non-asthmatic allergic disease (atopy) early manifestation prior to asthma could be early Small Airway Disease (SAD) also known as Small Airway Impairment and then if inflammation persists, asthma would appear ***(Pesola and ahmed., 2005)***

Asthmatic patients present a progressive deterioration of lung function, and this deterioration seems to be more evident in younger asthmatics whose disease is not well controlled. Therefore, early evaluation and therapy for small airways may be even more effective when started earlier in the course of the disease ***(Gary, 2005)***

The prevalence of small airways dysfunction among our patients when utilizing aspirometric cut-off value <60% in **MEF25-75** was 64% and when employing IOS cut-off value >0.1 kPa/L/s for **R5-R20**, >15 Hz for **Fres**, a prevalence of 82% and 78% respectively.

This discrepancy in diagnostic methodologies highlights a potential for missing patients with small airway dysfunction when using spirometry.

Regarding the other parameters we have shown that IOS does not concur precisely with spirometry in identifying asthmatics with small airways dysfunction, this is similar to results got by ***Price et al., (2016)***

The resistance is the in-phase component of lung impedance. Because low oscillation frequencies (<15 Hz) can be transmitted more distally in the lungs compared with higher frequencies***, (Goldman et al., 2005)*** **R5** reflects obstruction in both the small and large airways, **R20** reflects the large airways only, and the difference of **R5** and **R20** (R5-20) is an index of the small airways only ***(Grimby et al., 1968)***.

AX is the total reactance (area under the curve [AUC] at all frequencies between 5 Hz and **Fres**. Thus **X5**, **Fres**, and **AX** all reflect changes in the degree of obstruction in the peripheral airways ***(Goldman et al., 2005)***.

Airway resistance and reactance are likely coupled because, at equivalent airway pressures, a stiffer small airway will have a smaller caliber, which would increase the resistance to flow. In either case, the increase in resistance and reactance of the small airways results in a larger pressure during inspiration to inflate the lungs. A larger pressure requires more exertion by the respiratory muscles and is thus the probable mechanism underlying the relationship between the IOS parameters and asthma control. ***(Shi et al., 2012)***

Previous investigators have shown that peripheral- or small airway function evaluated based on IOS correlates with healthy status and asthma symptoms in children and adults, ***Nielsen et al., (2001), Takeda et al., (2010) and Hozawa et al., (2011***) which is consistent with our results in children. We compared the utility of 5 peripheral airway variables **(R5%, R5-20, Fres, X5,** and **AX)** from IOS, which characterize both airways resistance and reactance, in distinguishing asthma control. The results suggested that increased indices representing resistance and reactance, (**R5-20**) 63.6% and 94.7% in patient with controlled and partly controlled asthma respectively and (**Fres**) 54.5% and 94.7% in patient with controlled and partly controlled asthma respectively when compared with the changes detected by (**MEF 25-75**) 36.4% and 78.9% for controlled or partly controlled asthmatics respectively, being considered as indicators of loss of asthma control. Regarding the uncontrolled patients all of them showed elevated (**R5-20**), (**Fres**) and (**MEF 25-75**)

This suggests that both a decrease in small-airway caliber and an increase in airway wall tone contribute to asthmatic symptoms in children. The resistance to flow through a tube is inversely related to the radius of the tube to the fourth power ***(Pfitzner and Poiseuille law. 1976)*** thus a larger pressure is required to force air through a tube of smaller diameter.

Additionally ***Shi et al., (2012)*** found that dysfunction of the small, but not the large, airways was associated with worse asthma control. They found that the **R5-R20** and reactance area **AX** values were the only small airways parameters that could discriminate between patients with controlled and uncontrolled asthma, with a high sensitivity and specificity of 84% and 86%, respectively.

These findings suggest that IOS indices of peripheral airway function are useful in identifying asthmatic patients who are at risk of losing control, and may be able to assist clinical decisions and treatment plans.

Similarly ***Song et al., (2008)*** have shown that the parameters which reflect small airways function were statistically different between children with controlled, partly controlled and uncontrolled asthma.

Regarding the recorded IOS parameters, only mean values of **R5%** and **Fres Hz** were significantly higher in studied asthmatics prior to bronchodilator administration (P= 0.007, and

0.001 respectively) signifying higher small airway resistance in enrolled asthmatics while there was statistically insignificant difference regarding **R5-R20** and **AX** (p=0.155 and 0.486 respectively). This is similar to findings got by ***Nielsen et al., (2001), Takeda et al., (2010), Hozawa et al., (2011),*** and ***Shi et al., (2012).***

Measurements that have traditionally been considered to represent small airway obstruction, such as, **R5-R20** and **AX**, do not appear to be associated with impaired asthma control or quality of life cross-sectionally, although the long-term significance of these parameters requires further investigation ***(Gonem et al., 2013)***

These findings suggest that IOS indices of peripheral airway function are useful in identifying asthmatic patients who are at risk of losing control, and may be able to assist clinical decisions and treatment plans.

In all patients **R5%** values are significantly negatively correlated to all recorded spirometry indices **FEV1** (r =- 0.302; p=0.033) **FEF25–75** (r =- 0.505; p=0.001) and **FVC/FVC**(r =- 0.456; p=0.001), While **R5 – R20 kPa/L/s** values are significantly negatively correlated to **FVC/FVC** only (r = - 0.244; p=0.014), **Fres Hz** values were significantly negatively correlated to **FEV1** (r =- 0.371; p=0.001) and **FVC/FVC**(r = - 0.295; p=0.003), **AX H2O/L/s** values were significantly negatively correlated to FEF25–75(r = - 0.326; p=0.021) only, and **X5 kPa/L** values were significantly positively correlated to **FEV1** only (r =0.203; p=0.043)

Pisi et al. (2014) reported that in all patients, **R5–R20** values, but not **X5**, values were significantly and inversely correlated to **FEF25–75** and **FVC/FVC**

Bronchodilator response:

In our study, we used IOS to assess bronchodilator response compared with traditional BDR (percentage change in **FEV1**), detecting the percentage of change in (**X5, AX, Fres** and **R5**) variables from IOS which showed that positive BDR in 60%, 50%, 16% and 14% respectively compared to 54% of patients detected by percentage change in **FEV1**.

Our results showed that the best index with +ve BDR was **X5** which detected 63.6% of controlled, 52.6% of partly controlled and 66.7% of uncontrolled asthmatics compared with 40.9%, 63.2% and 66.7% for the same patients respectively when assessed by spirometry using Δ **FEV1%**

For the patients with small airways impairment as assessed by spirometry **MEF25-75** (n=32) we found that 62.5% showed +ve BDR when assessed by Δ**FEV1%** which is equal to the same number of patients detected by Δ**X5kPa/L/s** compared to 53.1%, 15.6%, 15.6% detected by Δ**AX H2O/L/s**, Δ**R5 kPa/L/s** and Δ**Fres Hz** respectively. This is similar to results got by (***Nieslsen et al., 2001; Song et al., 2008; Jee et al., 2010).***

CONCLUSION

From this study, we can conclude that impulse oscillometry is a non-invasive, rapid, safe and validated technique that measures respiratory impedance that is used as an indicator of lung function. It requires minimal cooperation from the subject and is therefore of great utility in preschool children, as well as in older children and adults. IOS can be used to diagnose, evaluate, and determine treatment response in those with asthma or other pulmonary disease states, with an accuracy and reproducibility comparable to spirometry and other lung function tests. IOS provides objective measurements of the patients performance, whereas spirometry requires subjective judgments of patient effort and cooperation. Thus, impulse oscillometry is an excellent choice for the evaluation of lung disease in children. Further studies investigating the roles of small-airway parameters to predict future risks of asthma exacerbations will be of merit.

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دور جهاز قياس التذبذب في تقييم اضطرابات الشعب الهوائية الصغيرة في الأطفال الذين يعانون من الربو الشعبي

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الهدف: الهدف من هذه الدراسة هو تحديد دور جهاز قياس التذبذب (IOS) في تقييم اضطرابات الشعب الهوائية الصغيرة في الأطفال الذين يعانون من الربو الشعبي بالمقارنة مع جهاز قياس التنفس القياسي (Spirometry).

المنهجية: تم إجراء هذه الدراسة على 50 طفلا ممن يعانون من الربو والذين تم تشخيصهم وفقا للمبادئ الإرشادية لـ(GINA 2016) ، وتم اختيار الحالات من عيادات الحساسية والمناعة في كل من مستشفى الحسين ومستشفى عين شمس الجامعي ، تم خضوع كل حالة للاختبار بجهاز قياس التذبذب يليه استخدام جهاز قياس التنفس قبل وبعد استنشاق عقار السالبيوتامول باستخدام بخاخة الفم تم الحصول على موافقة كتابية لكل حالة قيد الدراسة وتمت الموافقة على إجراء الدراسة بواسطة لجنة الأخلاقيات بكلية الطب، جامعة الازهر وتم تقسيم المرضى حسب مدى الاستجابة لعلاج الربو إلى ثلاث مجموعات وتم خضوع كل طفل لكل مجموعة للاختبار بجهاز قياس التذبذب وجهاز الـspirometry وذالك لتحديد الاطفال الذين يعانون من اضطرابات الشعب الهوائية الصغيرة ومدى ارتباطها بمستوى التحكم في الربو.

النتائج: بعد قياس وظائف التنفس لكل طفل باستخدام الجهازين تبين قدرة جهاز قياس التذبذب في اكتشاف عدد حالات أكثر من جهاز الـ spiometry فيما يخص وجود اضطرابات في الشعب الهوائية الصغيرة بنسبة 82%, 78%بمؤشري R5-R20 و Fres لجهز التذبذب في مقابل 64% بمؤشر MEF25/75 لجهاز ال spirometry

وفيما يتعلق باكتشاف الاستجابة لموسعات الشعب الهوائية كان مؤشر X5 لجهاز التذبذب اكثر المؤشرات اكتشافا لمدى الاستجابة للموسعات القصبية بالمقارنة بباقي

مؤشرات نفس الجهاز ومؤشر ال FEV1 في جهاز الـ spirometry مما يدل على قدرة جهاز قياس التذبذب في تشخيص الربو الشعبي , وتقييم مدى السيطرة عليها , وفـي وجـود اضطرابات في الشعب الهوائية الصغيرة في اوقت قد تكون النتائج ذات دلائل طبيعية فـي حالة استخدام جهاز spirometry.

الاستنتاجات والتوصيات: إن نظـام قيـاس التذبـذب هـو أسـلوب موسـع، والـذي يسـتخدم الموجات الصوتية لقياس ميكانيكـا الجهـاز التنفسـي . لأنـه يقـوم علـى مبـدأ تقنيـة التذبـذب القسري(FOT) والذي تم اكتشافه لأول مرة بواسطة (Dubois) وآخرون في عام 1956 واهم المزايا الرئيسية لاستخدام جهاز قياس التذبذب هي :-

- إن إجراء الاختبار سهل نسبيا حيث انه يتطلب الحد الأدنى من تعاون المريض.
- أنـه يقـيس مقاومـة ومفاعلـة الرئـة للتـرددات المختلفـة ممـا يقـدم معلومـات هامـة عـن التغييرات التي تصيب الرئة في مناطق مختلفة بما فيها الاجزاء الطرفية منها.
- قدرة جهاز قياس التذبذب في تشخيص الربو الشعبي , وتقييم مدى السيطرة عليها , وفـي وجود اضطرابات في الشعب الهوائية الصغيرة بينما قد تكون النتائج ذات دلائل طبيعية في حالة استخدام جهاز spirometry.
- هنـاك حاجـة لمزيـد مـن الدراسـات علـى نطـاق واسـع لاكتشـاف القـيم المرجعيـة لكـل مؤشرات جهاز قياس التذبـذب فـي الأطفـال المصـريين وذالـك للاسـتفادة القصـوى مـن الجهاز مستقبلا.