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CLINICAL RESEARCH / KLİNİK ARAŞTIRMA

The Use of the Impulse Oscillometry Method in Evaluating the Respiratory Function of Children with Asthma

Astımlı Çocuklarda Solunum Fonksiyonlarının Değerlendirilmesinde İmpuls Ossilometri Yönteminin Kullanımı

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Abstract

Objective: Asthma is a chronic inflammatory lung disease. Classic spirometry is the gold standard in asthma follow-up. Howewer, the evaluation of asthma control can be difficult particularly in younger children due to limited cooperation and adaptability. Impulse oscillometry (IOS), shows the airway resistance and reactance with minimal patient cooperation and simple method of use. Our study aims to evaluate the use of IOS in monitoring asthma control.

Methods: The study included 80 newly diagnosed asthma and did not have asthma exacerbation patients between the ages of 6-17 who were asymptomatic, along with 34 healthy individuals as a control group. The sociodemographic features such as age, sex and height were noted. Classic spirometry obtained the forced expiratory volume (FEV1), FEV1/forced vital capacity (FVC), FVC, forced expiratory flow between 25-75% (FEF 25-75) and peak expiratory flow (PEF) values, whereas IOS acquired the R5, R10, R15 (resistance), X5, X10 and X15 (reactance) values.

Results: The mean age for children with asthma was 11.4±2.8 and 11.9±3.1 for the control group. When compared to the control group, the FEV1/FVC, FEF25/75 and PEF values of asthma patients were discovered to be significantly lower (p=0.040, p=0.007, p=0.02 respectively). At the same time, asthma patients R5 and R10 values reflecting the small airway resistance were found to be significantly higher compared to the control group (p=0.009, p=0.031 respectively). Moreover, the X5 value representing small airway compliance was found to be significantly smaller in asthma patients compared to the control group (p=0.014).

Conclusion: IOS is easy to use, requiring a scarce amount of patient cooperation in determining the respiratory functions in asthma patients, allowing for a safe method for monitoring asthma control at a young age.

Keywords: Asthma, children, spirometry, impulse oscillometry

Öz

Amaç: Astım, kronik enflamatuvar bir akciğer hastalığıdır. Klasik spirometri astım izleminde altın standarttır. Ancak, sınırlı iş birliği ve uyum yeteneği nedeniyle özellikle küçük çocuklarda astım kontrolünün değerlendirilmesi zor olabilir. İmpuls ossilometrisi (IOS), minimum hasta kooperasyonu ve basit kullanım yöntemi ile hava yolu direncini ve reaktansını gösterir. Çalışmamız, astım kontrolünün izlenmesinde IOS'nin kullanımını değerlendirmeyi amaçlamaktadır.

Yöntem: Çalışmaya astım tanısı ile yeni takibe alınan ve astım alevlenmesi olmayan, 6-17 yaş arası 80 hasta ile 34 sağlıklı kontrol alındı. Tüm olguların yaş, cins, boy gibi sosyodemografik özellikleri kaydedildi. Klasik spirometri yapılarak ekspirasyon hacim (FEV1), FEV1/zorlu vital kapasite (FVC), FVC, %25-75

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Öz

arasındaki zorlu ekspiratuar akım (FEF 25-75) ve ekspirasyon tepe akımı (PEF) değerleri, IOS ile R5, R10, R15 (rezistans), X5, X10 ve X15 (reaktans) değerleri elde edildi.

Bulgular: Astımlı çocukların ortalama yaşı 11,4±2,8 iken kontrollerin 11,9±3,1 olarak saptandı. Astımlı olgular kontroller ile karşılaştırıldığında astımlı grubun FEV1/FVC, FEF25/75 ve PEF değerleri kontrollere göre anlamlı olarak düşük saptandı (sırasıyla p=0,040, p=0,007, p=0,02). Aynı zamanda astımlı olguların küçük havayolu direncini gösteren R5 ve R10 değerleri sağlıklı kontrollere göre anlamlı olarak yüksek saptandı (sırasıyla p=0,009, p=0,031). Ayrıca küçük havayolu elastikiyetini gösteren X5 değeri astımlı hastalarda sağlıklı kontrollere göre anlamlı olarak düşük saptandı (p=0,014).

Sonuç: Astmlı çocuklarda solunum fonksiyonlarının değerlendirilmesinde çok az hasta kooperasyonu gerektiren ve kolay uygulanabilen IOS, güvenilir bir yöntem olarak küçük yaşlarda astım kontrolünün izleminde kullanılabilir.

Anahtar Kelimeler: Astım, çocuk, spirometri, impuls ossilometri

Introduction

Asthma is a chronic inflammatory respiratory disease with reversible airway obstruction. This inflammatory process leads the airways to become increasingly sensitive to airway allergens or irritants, causing symptoms such as coughing and shortness of breath[1]. In children, diagnosis of asthma and its intensity is more dependent on symptoms. This is because of the lack of reliability of respiratory function tests measurements in primarily the preschool era[2]. During asthma diagnosis and follow-up, the most commonly used spirometry value is the forced flow volume measurements. The accuracy and repeatability of this technique is dependent on the patient's cognitive level and effort, as it requires expiratory manoeuvres[3]. Impulse oscillometry (IOS) is non-invasive, requires minimum patient cooperation and is an easy to use method in preschool children. IOS gives various frequency pressure waves into the airway providing a method to measure lung reactance and resistance and show the respiratory functions of the lungs[4]. The latest studies indicate that it can be useful in small and large airway obstructions, monitoring airway mechanics and the control of asthma[5]. Additional studies highlight its practicality in diagnoses of asthma, reversibility assessment, evaluating the control level of asthma when exacerbated and long term follow-up[6]. A study comparing IOS use between preschool and adolescent individuals discovered that IOS is able to successfully predict peripheral airways diseases and foresee the obstructive spirometry values[7]. Although the use of IOS is an appealing method as an add on to the conventional spirometry, there is not sufficient data for its sensitivity when it is applied on its own.

The purpose of our study was to evaluate the use of IOS in monitoring asthma control in children.

Materials and Methods

Study Population

This study included 80 asymptomatic asthma patients above the age of 6 who accepted entrance into this study and applied to the Celal Bayar University Pediatric Allergy outpatient clinic. Children with newly diagnosed asthma without clinical signs of acute asthma exacerbation and without signs of acute upper respiratory tract infection were included. Patients for the control group were chosen from the Celal Bayar University General Pediatric Outpatient Clinic. Thirty-four patients who had no signs of acute infection, no respiratory symptoms such as runny nose, cough, and no chronic disease were included.

Study Design and Ethics Approval

This case-control study was approved on 11.09.2013 by the Celal Bayar University Clinical Studies Ethics Committee (decision no: 20.478.486.225.)

Data Collection

The age, sex, height, weight and date of asthma diagnoses were noted in this study. A classic spirometry was performed at a period when there was no exacerbation of symptoms. Classic spirometry obtained the forced expiratory volume (FEV1), FEV1/forced vital capacity (FVC), FVC, forced expiratory flow between 25-75% (FEF 25/75) and peak expiratory flow (PEF) values, whereas IOS acquired the R5, R10, R15 (resistance), X5, X10 and X15 (reactance) values. Patients who had acute asthma inflammation symptoms, congenital and secondary heart diseases were excluded.

Classic Spirometry Measurement

Spirometry was conducted with a Jager master screen (MS)-IOS (carefusion/Germany) brand device. The respiratory

manoeuvres, FVC and forced expiratory volumes (FEV1, PEF, FEF25/75) were measured. After multiple measurements, the measurement with the best cooperation and best results for the patient was chosen[8].

Impulse Oscillometry Measurement

A Jager MS-IOS (carefusion/Germany) brand device was used for Impulse oscillometry. In accordance with the American thoracic society/ European respiratory society rules, IOS measurements were repeated at least three times at each step, in order to provide the best possible result with the least artefact (threshold at 5Hz >0.6 and at 10Hz >0.9). During measurement, from the mouthpiece of the pneumatograph, various pressure waves between the frequency of 5-30Hz can be applied to a patient who is breathing in and out normally. As a result, airway resistance (R/resistance) and capacity of compliance (X/reactance) can be acquired from the reflected pulses. The main parameter of the respiratory system Resistance (R) shows the airway obstructive resistance, and Reactance (X) expresses the capacitive-compliance capacity from the airway and surrounding tissues. Without requiring patient effort, this method obtained resistance (R5, R10, R15) and reactance (X5, X10, X15) values at frequency levels of 5, 10 and 20 Hz[9].

Statistical Analysis

Assessment of the obtained data was done by the Statistical Package for the Social Sciences (SPSS) 16.0 (SPSS Inc., Chicago, IL, USA) statistics package program, categorical variables were given as a number and percentages (%). Student's t-test was used to compare normal distribution data and a Mann-Whitney U test was used to compare abnormal data distribution. P<0.050 was classified as statistically meaningful.

Results

Demographic Characteristics

The mean age for children with asthma was 11.4±2.8 and 11.9±3.1 for the control group. 40% were female. The mean age for diagnosis of asthma was 8.3±2.9.

Respiratory Function Test Findings

Classical Spirometry Results

When compared to the control group, the FEV1/FVC, FEF25/75 and PEF values of asthma patients were found to be significantly lower (p=0.04, p=0.007, p=0.02 respectively) (Table 1).

Impulse Oscillometry Results

Asthma patients R5 and R10 values reflecting the small airway resistance were found to be significantly higher compared to the control group (p=0.009, p=0.031 respectively). Moreover, the X5 value representing small airway compliance was found to be significantly lower in asthma patients compared to the control group (p=0.014) (Table 2).

Discussion

In our study, respiratory functions were compared with the control group using classical spirometry and impulse oscillometry. FEV1/FVC, FEF25/75 and PEF values in spirometry were found to be lower in asymptomatic asthma patients compared to the control group. In addition, R5 and

Table 1. Comparison of spirometry values of individuals with asthma and those who are healthy

	Patient (mean±SD)	Control (mean±SD)	p*
FEV1	2.45±0.88	2.58±0.70	0.493
FEV1 (%)	103.83±18.00	111.44±14.06	**0.046**
FVC	2.87±1.08	2.92±0.86	0.833
FVC (%)	108.40±18.74	107.26±16.12	0.775
FEV1/ FVC	82.90±10.34	89.36±8.52	**0.004**
FEV1/ FVC (%)	98.66±17.99	105.63±10.03	**0.055**
FEF 25/75	2.36±0.98	2.96±0.95	**0.007**
FEF 25/75%	84.80±25.69	102.85±27.81	**0.002**
PEF	3.80±1.41	4.53±1.22	**0.01**
PEF%	75.61±19.38	84.23±18.77	**0.04**

*Student's t-test.
SD: Standard deviation, FEV1: Forced expiratory volume, FVC: Forced vital capacity, FEF 25/75: Forced expiratory flow between 25-75%, PEF: Peak expiratory flow

R10 values, which reflect small airway resistance in asthmatic patients, were higher than the control group, and X5 values, which represent small airway elasticity in asthmatic patients, were found to be lower than the control group.

In children with asthma, monitoring of respiratory functions gives information about the course of the disease. Classical spirometry is a reliable method used in the diagnosis and long-term follow-up of respiratory diseases over the age of 6 years[1,3]. IOS is now an alternative noninvasive method used to evaluate airway mechanics, requiring minimal patient cooperation[10,11]. Pressure pulses applied to the mouth provide information about airway resistance (resistance) and airway capacitance (reactance)[11,12]. Low frequency pulses (5Hz) are conveyed to the distal areas of the lung, whereas high frequency pulses (20Hz) convey them to the central large airways. This allows the assessment of the tracheobronchial tree[5].

Reports have indicated that children who have recurring bronchiolitis during early childhood are more prone to develop respiratory functions similar to that of chronic obstructive pulmonary disease at adulthood[13]. Close monitoring is vital in cases where the child cannot adapt to the spirometry from a young age. Numerous studies have attempted to evaluate respiratory function with an IOS. A prospective study of 84 children with recurrent wheezing, gathered IOS parameter information from the whole bronchial tree, including the peripheral airways. Thus, our results can be applied to predict preschool IOS parameters of peripheral airway deterioration when they reach puberty[7]. In a study evaluating whether or not a modified IOS can be used in asthma predictive index (API) of children with recurrent wheezing, 115 children between the ages of 3-6, R5-R20% values of individuals with mAPI positivity, compared to negative mAPI, were found to be significantly higher and it concluded that it may help physicians to identify patients with a high risk of asthma in the preschool era with wheezing[14].

There is no concrete evidence regarding preschool era wheezing caused by rhinovirus (RV) having an effect on respiratory functions during childhood. A study followed-up 238 children after birth for 8 years, and RV related wheezing was compared with healthy children. Although asthma diagnosed individuals were reported to have meaningfully lower FEF 25/75 values in comparison to those without asthma, IOS parameters showed no significant differences. However, when comparing the respiratory functions in cases with wheezing history during the first 3 years of life caused by RV at school age, they had significantly lower FEV1, FEF 25/75 values and a high R5-10 and more negative X5 value with an IOS[15].

Considering that asthma is known to increase resistance of peripheral airways, IOS can be a suitable tool to determine peripheral airway resistance. Therefore, a rise in R5 resistance along with a negative reduction in X5 reactance is expected[16]. A study including 142 asthmatic (acute attack and stable) and 102 healthy children compared spirometry and IOS parameters, all resistance and reactance parameters of IOS were reported to have a correlation with at least one spirometry parameter and it was noted that IOS can be

Table 2. Comparison of impulse oscillometry values of individuals with asthma and those who are healthy

	Patient (mean±SD)	Control (mean±SD)	p*
R5	2.22±13.14	0.68±0.15	0.613
R5 %	104.61±35.87	130.17±40.90	0.009
R10	2.17±13.6	0.54±0.100	0.605
R10 %	100.42±38.4	122.20±38.94	0.031
R15	2.05±13.16	0.48±0.07	0.604
R15 %	96.39±34.60	114.05±34.72	0.051
X5	1.33±12.32	-0.19±0.84	0.590
X5 %	84.31±77.90	134.55±77.94	0.032
X10	3.64±31.55	-0.13±0.08	0.605
X10 %	148.28±232.94	283.32±550.66	0.108
X20	-2.69±15.60	-0.06±0.07	0.466
X20 %	66.05±252.41	12.25±147.22	0.377

*Student's t-test.
SD: Standard deviation

utilized in children who cannot cooperate with expiratory manoeuvres[17]. When asthma patients with a normal FEV1 were evaluated for small respiratory airway resistance and their response to a bronchodilator, a significant correlation was found in cases with normal FEV1 between the small airway indicators of the spirometry and R5-R20 values. Nevertheless, there was no significant relationship between IOS and spirometry values in bronchodilator response (BRD) [18]. Moreover, a study of 442 asthma patients who compared spirometry and IOS values after a year discovered that spirometry and IOS measurements are equally beneficial in use as a potential marker in patients with persistent asthma[19]. Our studies uncovered similar results in asthma patients in regard to small airway involvement, by showing an increase in R5 R10 values with the IOS.

In another study comparing spirometry and IOS data of healthy controls (n=57) and patients with uncontrolled asthma (n=44), small airway indicators such as R5, X5 and FEV1 and BDR were found to be significantly different in uncontrolled asthma compared to healthy subjects. It was emphasized that IOS can be used as a safe method in the evaluation of asthma control[20]. Similarly, a retrospective study of 139 patients with medium to severe asthma aged 4-18 compared control levels of asthma and peripheral airway involvement; poorly controlled asthma patients had deteriorating levels of FEV 1 and FEF25/75, an increase in resistance (R5, R10) and a lower lung compliance (negativity in X5) with an IOS were reported[21]. Our asthma patients also had a significant increased negativity with X5 which represents lung compliance capacity. In a study in which children aged 4-7 years with recurrent wheezing were followed prospectively for 10 years, annual simultaneous spirometry and IOS were performed; after 10 years, FEF25/75 decreased significantly with spirometry and an increase in IOS and R5 resistance was reported, thus it was concluded that IOS and spirometry could be used together in the follow-up of asthma[22].

Study Limitations

Our study protocol has some limitations. First, the cross-sectional design prevented us to use particular statistical methods. Second, using this methodology we couldn't show the cause-effect relationship between the variables. Despite these shortcomings, the study showed the use of IOS as a reliable tool for monitoring asthma control in children with asthma.

Conclusion

As a result, as shown in the data of our study, since IOS can provide information about the entire bronchial tree, it can show respiratory tract involvement, especially in the period when pre-school spirometry cannot be performed. Therefore, it can be used safely in the follow-up of patients with recurrent respiratory symptoms starting from the pre-school period and in the adult period.

Ethics

Ethics Committee Approval: This case-control study was approved on 11.09.2013 by the Celal Bayar University Clinical Studies Ethics Committee (decision no: 20.478.486.225, date: 11.09.2013).

Informed Consent: Retrospective study.

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Authorship Contributions

Surgical and Medical Practices: E.T.K., Y.Ş., Concept: Ö.Y., H.Y., Design: E.T.K., Ö.Y., Data Collection or Processing: E.T.K., Analysis or Interpretation: Ö.Y., Literature Search: E.T.K., Ö.Y., Y.Ş., Writing: E.T.K., H.Y.

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