Variability of peripheral airway resistance through impulse oscillometry in asthmatic children and adolescents

Variabilidade da resistência das vias aéreas periféricas através da oscilometria de impulso em crianças e adolescentes asmáticos

DOI:10.34117/bjdv8n4-228

Recebimento dos originais: 21/02/2022
Aceitação para publicação: 31/03/2022

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ABSTRACT

Introduction. The assessment of lung function in asthmatic patients is a procedure used for the diagnosis and monitoring of diseases. The impulse oscillometry system, a minimally invasive and collaborative method, allows the measurement through changes in resistance and reactance. The analysis of variability allows the identification of the quality and reproducibility of this method. Goal. To describe the behavior of the variability of impulse oscillometry parameters in asthmatic children and adolescents. Method. A quantitative descriptive cross-sectional study was carried out in the Allergy and Immunology sector of the Hospital das Clínicas of the Federal University of Pernambuco. The sample consisted of children and adolescents, of both sexes, diagnosed with asthma and rhinitis. Three measurements were taken and for each parameter the mean of the resistance values at the frequencies of 5Hz and 20Hz was calculated, and from these data the resistance of the peripheral pathways (R5-R20Hz), in addition to the elastance at 5Hz and the reactance area (AX).. Results. Seventy children and adolescents, with 62% (43) male, and for the whole group, mean age of 11.22±3.23 years, mean weight of 44.21±16.15 kilograms and mean height of 150.28 ±17.07 centimeters. There was no significant variation in measurements between times. The measure of the intraclass correlation coefficient was 0.949, demonstrating a high correlation between the analyzed moments. Conclusion. The total airway resistance is one of the most used parameters to measure alterations in the tracheobronchial tree and the verification of the variability must remain equal to or less than 15%.

Keywords: asthma, oscillometry, respiratory function test.

RESUMO

Introdução. A avaliação da função pulmonar em doentes asmáticos é um procedimento utilizado para o diagnóstico e monitorização de doenças. O sistema de oscilometria de impulso, um método minimamente invasivo e colaborativo, permite a medição através de alterações na resistência e na reactância. A análise da variabilidade permite a identificação da qualidade e reprodutibilidade deste método. Objectivo. Descrever o comportamento da variabilidade dos parâmetros da oscilometria de impulso em crianças e adolescentes asmáticos. Método. Foi realizado um estudo descritivo quantitativo transversal no sector da Alergia e Imunologia do Hospital das Clínicas da Universidade Federal de Pernambuco. A amostra consistiu em crianças e adolescentes, de ambos os sexos, diagnosticados com asma e rinite. Foram efectuadas três medições e para cada parâmetro foi calculada a média dos valores de resistência nas frequências de 5Hz e 20Hz, e a partir destes dados foi calculada a resistência das vias periféricas (R5-R20Hz), para além da elastância a 5Hz e a área de reactância (AX). Resultados. Setenta crianças e adolescentes, com 62% (43) do sexo masculino, e para todo o grupo, idade média de 11,22±3,23 anos, peso médio de 44,21±16,15 quilogramas e altura média de 150,28±17,07 centímetros. Não houve variação significativa nas medidas entre os tempos. A medida do coeficiente de correlação intraclasse foi de 0,949, demonstrando uma alta correlação entre os momentos analisados. Conclusão. A resistência total das vias aéreas é um dos parâmetros mais utilizados para medir as alterações na árvore traqueobrônquica e a verificação da variabilidade deve permanecer igual ou inferior a 15%.

Palavras-chave: asma, oscilometria, teste de função respiratória.

1 INTRODUCTION

Asthma is a chronic inflammatory disease characterized by hyperresponsiveness of the lower airways and by variable airflow limitation, reversible spontaneously or with specific treatment, clinically manifested by recurrent episodes of wheezing, dyspnea and cough, usually at night or at dawn[1]. It results from the interaction between genetics and environmental exposure to allergens and irritants leading to the development and maintenance of symptoms[2].

Among asthmatics, exercise-induced bronchospasm (EIB) is a temporary bronchoconstrictor phenomenon present in 40 to 90% of them, being also found in non-asthmatic individuals in a lower percentage value2,3. Due to its relationship with the pathophysiology of asthma and its possible consequences, an accurate diagnosis is necessary for the correct treatment as well as for the establishment of preventive measures[3]. Screening is performed through the correlation between the clinic and the pulmonary function assessment[4].

For the assessment of pulmonary function, the instrument considered the gold standard is spirometry, but it requires the active collaboration of the individual and can

lead to changes in bronchial tone in the search for better reproducibility[5]. The Impulse Oscillometry System (IOS), in turn, is a technique of forced oscillations (TOF) differing from this one by obtaining resistance and reactance measurements at multiple frequencies, consisting of the application of small mechanical waves of mono pressure. or multifrequency, applied to the interior of the respiratory system and that overlaps the basal breathing, allowing the collection of information in a minimally collaborative way using the tidal volume[6,7]

Among the OSI parameters, resistance (R) is the energy required for the propagation of a pressure wave through the airways, which passes through the bronchi and bronchioles, and involves distention of the lung parenchyma[8]. It can be expressed as resistance at 5 Hz (R5), called total resistance, and at 20 Hz (R20), called central resistance, and R5-R20 when inferring the representativeness of small airway resistance9. The IOS also measures the elastance at 5Hz, the area under the curve (AX) and the resonance frequency (Fres)[9]. The analysis of resistance variability at 5Hz makes it possible to identify baseline changes in relation to those predicted, as well as to verify the learning curve in relation to the repeatability of the procedure before performing bronchoprovocation tests[10,11].

To ensure the quality of the measurement and maintain the resistance at acceptable levels, the measurement of the coefficient of variability (CoV) is currently indicated in place of coherence. According to the European Respiratory Society (ERS, 2020), this value should be equal to or less than 10% in adults and equal to or less than 15% in children. The aim of this study was to describe the behavior of the variability of the airway parameters through impulse oscillometer in children and adolescents with asthma.

2 METHOD

A descriptive, cross-sectional quantitative study was carried out from January to March 2021, in the Allergy and Immunology sector of the Hospital das Clínicas of the Federal University of Pernambuco, after authorization by the Research Ethics Committee of the Hospital das Clínicas of the Federal University of Pernambuco. of Pernambuco under opinion nº 2.947.744.

The sample consisted of children and adolescents, of both sexes, diagnosed with asthma and rhinitis. As an eligibility criterion, those with a clinical diagnosis of asthma confirmed by the criteria of the Brazilian Society of Pulmonology and Tisiology (SBPT, 2012), aged between 7 and 18 years were included, and those who had respiratory

infection in a period of less than 18 years were excluded. 30 days or cognitive deficit that led to the inability to respond to questions or to respond to the commands requested.

After signing the terms of agreement, anthropometric measurements were taken and sociodemographic data were collected. Impulse oscillometry was performed using equipment with a MasterScreen VIASYS HealthCare GnbH pneumotachograph (Germany), calibrated daily using a 1 (one) liter syringe Medical-West (São Paulo – Brazil).

Participants were instructed to remain seated, with the hip and knee at 90 degrees of flexion, in a chair with a backrest, feet on the floor, breathing calmly through a plastic mouthpiece, for a period of 30 seconds. A clip was used to prevent nasal airflow, with the hands pressing both cheeks to minimize the loss of oscillatory pressure, resulting from their high compliance.

Three measurements were performed and for each parameter, the average of the resistance values at the frequencies of 5Hz and 20Hz was calculated, and from these data the resistance of the peripheral pathways (R5-R20Hz), in addition to the elastance at 5Hz and the reactance area (AX). During data acquisition, pressure and flow curves were graphically monitored in real time, and maneuvers in which the tracings showed uninterrupted breathing with coherence values for R5Hz > 0.8 (for children under 10 years old) and between 0.8 and 1.0 for R5hz and R20Hz (for children over 10 years of age and adolescents), maintaining an intertest variability of ≤ 15% and redone if they presented events such as coughing, apnea, swallowing or vocalization. The examination was repeated at three times: zero, fifteen minutes and thirty minutes after the beginning of the procedure.

A descriptive analysis of the categorical variables was performed and, for the quantitative variables, measures of central tendency and dispersion were calculated, where the non-parametric Mann-Whitney test was used to compare the groups. Spreadsheets for data storage and analysis were prepared in Excell MS-Office 2010, where data were entered by two different people and subsequently compared to minimize bias. In all tests, a significance level of $p < 0.05$ was adopted, and the statistical analysis was performed using SPSS version 10 software.

3 RESULTS AND DISCUSSION

The sample consisted of 70 children and adolescents, of both sexes, aged between 7 and 18 years, with a clinical diagnosis of asthma and rhinitis. Sixty-two percent (43)

were male, and for the entire group, mean age of 11.22±3.23 years, mean weight of 44.21±16.15 kilograms and mean height of 150.28± 17.07 centimeters. Fifty-five percent (39) of the patients had bronchospasm after performing a bronchoprovocative test (**Table 1**).

Table 1. Clinical and anthropometric characterization of children and adolescents undergoing pulmonary function assessment (n = 70), Recife, Brazil**.**

Variables	**N**	**%**
Sex		
Male	43	62,0
BIE		
Positive	39	55,0
Negative	31	45,0
Comorbities		
Asthma	8	12,0
Asthma and Rinhits	62	88,0
	Média	**Desvio-padrão**
Age	11,22	3,23
Peso (Kg)	44,21	16,15
Altura (cm)	150,28	17,07
Índice de massa corpórea (IMC)	19,69	4,67
Asthma control test (ACT)	20,12	2,60

Table 2 describes the variability of R5 at times zero, fifteen and thirty minutes pre-bronchoprovocative test. There was no significant variation (greater than 15%) between times. The measure of the intraclass correlation coefficient was 0.949, demonstrating a high correlation between the analyzed moments.

Table 2. Variability of R5 at 0, 15 and 30 minutes before voluntary eucapnic hyperventilation in children and adolescents (n=70), Recife, Brazil.

Variáveis	**Momento da Variação**		**p-valor**
	Momento 0 a 1 n (%)	**Momento 1 a 2 n (%)**	
Variação ≥ 15% entre os tempos			
Alterada	13 (18,6)	11 (15,7)	0,654 *
Normal	57 (81,4)	59 (84,3)	
	Mediana (Q1; Q3)	**Mediana (Q1; Q3)**	0,655 **
Variação Percentual	-0,96 (-7,04; 10,26)	-1,60 (-6,08; 5,21)	

Q1: 1º intervalo quartílico; Q2: 2º intervalo quartílico; Q3: 3º intervalo quartílico

The resistance value is generally associated with the airway caliber; Longer, narrower airways have greater resistance because of the greater frictional pressure loss as air passes through them. Resistance is a parameter affected by heterogeneity in the distribution of resistances and reactances throughout the tracheobronchial tree

(ASSUMPÇÃO et al., 2014). According to the updates implemented by the European Respiratory Society (ERS), the acceptable variability is equal to or less than 15% between the evaluated times (KING et al., 2020). This degree of variability indicates that obtaining similar repeated measurements is not difficult, and that the IOS is reproducible, making its identification a predictive factor of exam quality (KING et al., 2020).

The variability between repetitions performed before the bronchoprovocative test in the R5Hz parameter was not different between the evaluated moments. Komarow et al, used IOS in 117 asthmatic and non-asthmatic children and adolescents (ages 3 to 18 years), before and after bronchodilator administration. In their results, the authors showed that asthmatics showed greater variation in R5Hz compared to healthy children, with R5Hz being the most representative variable in terms of the analyzed effects (KOMAROW et al, 2012).

Brindz et al, used the IOS in 89 children and adolescents (between 7 and 16 years old) before and after the bronchial provocation test. Resistance and reactance measurements were taken at 5Hz, as well as area under the curve (AX). Forty-five percent of the participants showed variation in R5, but without significance during the measurement of repeatability between times zero and thirty minutes pre-test. The coefficient of variation (CoV) was 13.22%. A similar result was found in the study by Cameron et al, but the CoV was 14.88%, being considered very close to the value equal to or less than 15%.

The intraclass correlation coefficient (ICC) was also verified, with values above 0.9 considered excellent. The value found in our study was 0.949. Ribeiro et al carried out a study with 57 measurements to compare non-invasive techniques in newborns. The correlation coefficient found between the plethysmography and oscillometry techniques was 0.89. The difference for our study is that here we evaluated the variability of R5 and in the aforementioned study, the parameter evaluated was the reactance and resistance of the central pathways.

4 CONCLUSION

Total airway resistance is one of the most used parameters to measure changes in the tracheobronchial tree and the verification of variability must be kept below 15%.

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