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The interrupter technique: feasibility in children in acute asthma

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ABSTRACT

Background: *Asthma exacerbation's severity is difficult to evaluate, as it is mainly assessed by clinical parameters. Evaluation of lung function during the acute asthma might provide an objective assessment on the severity of respiratory function impairment.*

Objective: *To determine feasibility of interrupter technique in evaluating respiratory resistance (Rocc) on children with acute asthma*

Methods: *The study included 30 children aged 3 to 14 years, diagnosed with asthma, during an exacerbation; severity of acute asthma has been assessed according to the GINA classification 2007, evaluating individual parameters like intercostals retractions, wheezing, air entry intensity, as well as their association in a clinical score. For every patient spirometry, peakflowmetry and the interrupter technique was applied for assessing respiratory function. The feasibility rate for each method was calculated and compared with the clinical parameters.*

Results: *Out of the 30 children examined, the feasibility rate during the attack was 90% for the interrupter technique, 47% for peakflowmetry and only 27% for spirometry. Fifty-three percent of the exacerbations were classified as mild, 30% of moderate intensity and the remaining 37% being classified as severe exacerbations. The baseline Rocc has been correlated with clinical parameters and the clinical severity score. Best correlations were recorded between baseline Rocc and respiratory rate ($r=0.73$, $p<0.0001$), Rocc and heart rate ($r=0.5$, $p=0.0076$) and Rocc and the clinical score ($r= 0.78$, $p<0.0001$).*

Conclusion: *The study shows good feasibility of interrupter technique during asthma exacerbations, as well as strong correlation with clinical parameters assessing severity.*

Key words: interrupter technique, respiratory resistance, acute asthma, children

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INTRODUCTION

The severity of asthma exacerbations is assessed using only clinical parameters which do not always reflect the severity of respiratory dysfunction.(1, 2) An objective measure of ventilatory dysfunction is difficult to obtain in children, even outside an asthmatic exacerbation. The most used classification of asthma exacerbation severity is the one proposed by Global Initiative for Asthma (GINA) guideline; GINA classification is based on clinical parameters, but it is also using two objective measures: oxygen saturation, assessed by pulse oxymetry and peak expiratory flow (PEF), using the peakflowmetry. (3) Spirometry is the standard measurement technique for respiratory function, but it is limited in pediatric field, especially in young children and during asthmatic exacerbations, due to lack of cooperation on expiratory forced maneuvers. The association between the clinical score and the value of forced expiratory flow in the first second (FEV1) proved to have an important contribution on the evaluation of asthma severity and prognostic. (4)

The interrupter technique evaluating respiratory resistance (Rocc) is attractive to use in pediatric patients, because a minimal cooperation is required. Its usefulness was already proven in assessing lung function in preschool children, unable to perform a spirometry. Being such a simple and noninvasive method, it could be an important tool in assessing the lung function during an asthma exacerbation, where spirometry is limited besides age by the impossibility of cooperation to a forced expiration due to bronchial obstruction.

The objectives of this study were the evaluation of feasibility rate for interrupter technique in measuring lung function on children with an asthma exacerbation, when compared with spirometry and peakflowmetry and observing the correlation between Rocc and clinical parameters used to evaluate asthma severity. ❑

MATERIALS AND METHODS

We conducted a cross-sectional study on children aged 3 to 14 years, showing in either for pediatric consultation or for an emergency at the 3rd Pediatric Clinic of Cluj-Napoca, for a period of 6 months. The study was approved by the local Ethical Committee and the informed consent for participation in the study was obtained from parents or guardians.

Patients were eligible to participate if they had a diagnosis of an asthma exacerbation defined as: wheezing with or without respiratory distress in a patient with a previous diagnosis of asthma or 3 or more episodes of wheezing in the medical past history, necessitating an emergency consult and bronchodilator therapy.

The excluding criteria's were: chronic pulmonary diseases (cystic fibrosis, bronchopulmonary displasia, heart failure and neuromuscular diseases).

Every patient was included in the study only once, even when he/she suffered 2 exacerbations during the study.

A clinical exam was performed for every child on the arrival, registering the following clinical parameters: intensity of air entry, heart rate (HR) and respiratory rate (RR). The retractions, the wheezing and the intensity of air entry were numerical quantified from 0 to 3, according to the intensity (Table 1). PASS (Pediatric Asthma Severity Score, Table 2), a validated clinical score was also used to evaluate the severity in children with acute asthma. We decided to use this score for its simplicity (only 3 parameters are needed: wheezing, prolonged expiration and work of breathing), its authors proving a good correlation with the exacerbation severity and an excellent interrater reliability among a large and diverse group of examiners. (5) The score is reported as a linear sum of individual values for each included parameter, with the limits being between 0 and 6. Using the GINA classification, the exacerbations were grouped as middles, moderate and

	Retractions	Wheezing	Air entry
0	None	None	Normal or mildly diminished
1	Mild	Only in expiration	Moderately diminished
2	Moderate	Inspiratory and expiratory wheezing	Severely diminished
3	Severe	Audible without stethoscope	Absent

TABEL 1. Quantification of individual clinical parameters

	Definition	0	1	2
Wheezing	High-pitched expiratory sound heard by auscultation	None or mild	Moderate	Severe wheezing or absent wheezing due to poor air exchange
Work of breathing	Observed used of accessory muscled, retractions or in-breathing	None or mild	Moderate	Severe
Prolongation of expiration	Ratio of duration of expiration to inspiration	Normal or mildly prolonged	Moderately prolonged	Severely prolonged

TABEL 2. The PASS Score (5)

sever. (3) The oxygen saturation measured by pulse oximetry was also recorded. All methods were applied on every patient, starting with interrupter technique, followed by spirometry and peakflowmetry, as the expiratory forced maneuvers could induce high respiratory resistance values.

For measuring FEV1 and Rocc we used the spirometer FLOWSCREEN PRO (Erich JAEGER GmbH, Wurzburg, Germany), which provides an additional device for Rocc measurement. For Rocc determination, the occlusion is applied during expiration for a short period of flow. At this moment equilibrium is established between mouth and alveolar pressure. By measuring pressure before and during interruption and reporting the difference to the flow measured before occlusion, we could have the value of respiratory resistance. Rocc is expressed as kPa/l/sec.

The respiratory resistance was measured in an upright position and when quietly breathing through the device via a mouthpiece with a nose clip, the lips firmly sealed around the mouthpiece, and the neck slightly extended. The cheeks and throat were supported by the hands of the investigator standing behind the child in order to decrease upper airway compliance. The average of five successive technically satisfactory readings was taken as a valid measurement.

Data were rejected according to the following criteria: if the pressure value was unusually small, indicating mask leakage or extremely high, indicating glottic closure, if irregular breathing, especially tachypnea.

We didn't analyze all the criteria for validation the spirometry, according to ATS/ERS.(6) Three spirometrical maneuvers were tried in every child, and we considered the spirometry as validated only if the children were able to obtain FEV1. We also considered as invalid measurements if the child coughs during the examination, if the spirometric curve has no peak or contrarily, has two peaks or it has a right deviation of the peak. The device used in our study couldn't allow the calculation of FEV 0.5. (Forced expiratory volume in the first half second).

PEF was obtained using a hand-held flow meter (manufactured by Vitalograph) and calculated as a percentage of the predicted value based on age, height, and gender-derived norms. The best of 3 attempts was recorded. For validating the measurement we followed the ability to perform PEF adequately, in order to obtain a PEF value for three consecutive times and the maximal difference between values not exceeding 40 l/min.

The statistical analysis was performed. Before and after stratifying for age, we then used proportions to describe the success rate with each technique. The relationship between Rocc and other indexes of asthma severity was described with the Pearson correlation coefficient. A value of $p<0.05$ was accepted as indicating statistical significance.

MedCalc, 8.1.1.0 version for Windows package for personal computers was used for all statistical analysis. ❑

RESULTS

Thirty children were included, 60% female and 40% male. Clinical parameters, oxygen saturation (SpO2) and values of respiratory resistance, FEV1 and PEF were recorded at the initial assessment. (Table 3)

The majority of exacerbations were mild (using GINA classification)(3) with only 17% being severe. When grouping the patients after age, we found severe exacerbations more frequent in children after 5 years of age. (Table 4)

Sex (%)	Boys 40% Girls 60%
Age (years)*	5.4 (4, 8.3)
Height (cm)*	116 (105, 130)
RR (respirations/min)**	32.43 (4.5)
HR (beats/min)**	113.86 (4.5)
PASS Score **	1.83 (1.6)
SpO2 (%)*	94 (93, 95)
Rocc (kPa/l/s)**	1.37(0.43)
FEV1 (l/s) **	1.42 (0.66)
PEF (l/min)*	135 (120, 170)

TABLE 3. Characteristics of the 30 patients

*values expressed as median (25th, 75th percentile)
**values expressed as mean (standard deviation)

	Mild exacerbation	Moderate exacerbation	Severe exacerbation
3-5 years	10	4	1
>5 years	6	5	4
Total	**16/30(53%)**	**9/30(30%)**	**5/30(17%)**

TABLE 4. The severity of exacerbations according to age

	Rocc	FEV1	PEF
3-5 years	80%	0	27%
>5 years	100%	53%	67%

TABLE 5. Feasibility of methods according to age

	Rocc	FEV1	PEF
Mild exacerbation	14/16 (87%)	4/16 (25%)	8/16 (50%)
Moderate exacerbation	9/9 (100%)	4/9 (44%)	6/9 (67%)
Severe exacerbation	2/5 (40%)	0/5	2/5 (40%)

TABLE 6. Feasibility of methods according to exacerbation's severity

The success rate for the 3 techniques was different when reported according to age and severity of the asthma attack (Tables 5 and 6). For all participants in the study, feasibility was 90% for the interrupter technique, 54 % for the peakflowmetry and only 27 % for spirometry.

Obtaining FEV1 in young children was limited due the lack of cooperation, specific to this age, but 54 % of children were capable to perform peakflowmetry during asthma exacerbation. The respiratory resistance was optimally measured in 80% of children aged 3 to 5 years.

The results showed a strong correlation between Rocc and RR ($r=0.73$, $p<0.0001$), Rocc and HR ($r=0.5$, $p=0.0076$) and Rocc and the PASS score ($r=0.78$, $p<0.0001$). (Figure 1, Table 7)

No correlation was proven between Rocc and SpO2 ($r=-0.19$, $p=0.33$). ❑

DISCUSSION

The study proves the interrupter technique can be successfully used to measure respiratory resistance in previously untrained preschool children, aged 3 years and older, with an asthma exacerbation. All of children older than 5 years were capable to perform the technique and it was also possible in 80% of the younger children (3-5 years). Different studies showed that peakflowmetry and even spirometry is feasible in children of young ages (7-9), so we also studied children from 3 years of age in order to assess the success rate of these methods in asthma exacerbation. Regarding the interrupter technique we expected a good cooperation in young ages, based on previous results from literature, but the studies were performed outside an asthma exacerbation.

The low success rate for spirometry was also influenced by the young ages where, even outside an exacerbation, the cooperation for

	RR	HR	Wheezing	Retractions	PASS score
Rocc (absolute values)	r=0.73 p<0.0001	r=0.50 p=0.0076	r=0.53 p=0.0039	r=0.54 p=0.0032	r=0.62 p=0.0005
Rocc (%)*	r=0.68 p=0.0001	r=0.54 p=0.003	r=0.56 p=0.0019	r=0.63 p=0.0004	r=0.78 p<0.0001

TABLE 7. Correlation between Rocc and clinical parameters

*Rocc (%) is calculated as a percent of the absolute value from the predictive value corresponding to the age and height

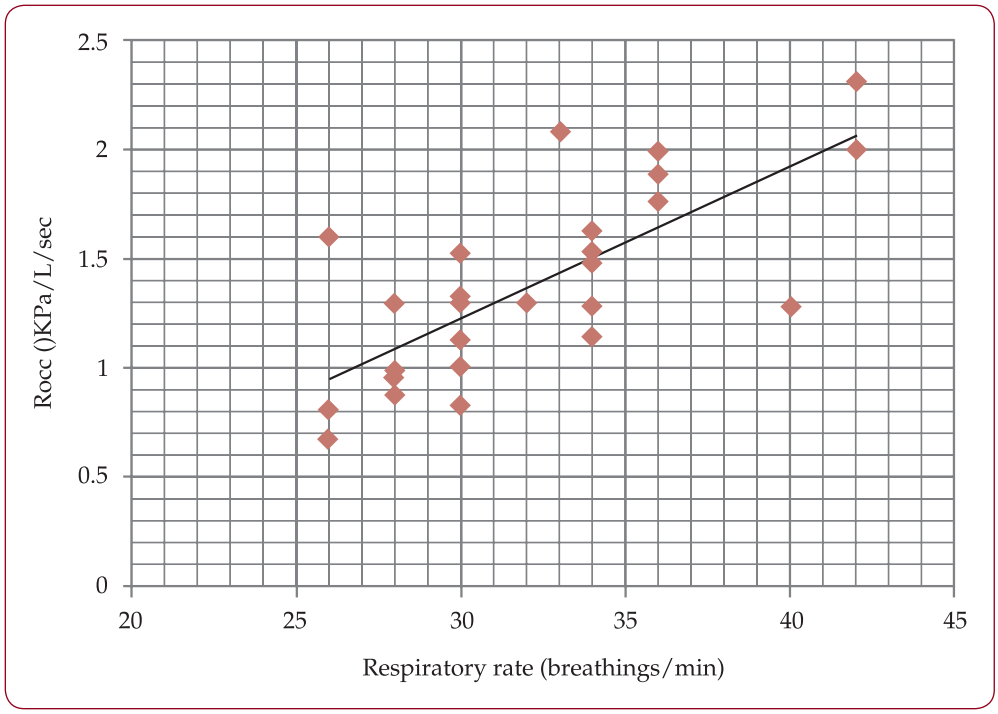

FIGURE 1. Correlation between Rocc and respiratory rate (RR)

obtaining FEV1 is low. (10) But, even in older children, we obtained only a 54% for the feasibility rate of spirometry with a little higher percent registered for peakflowmetry (66%).

The interrupter technique is not yet standardized as a method of exploring lung function in children, but it gains more and more interest for the pediatric patients. The interrupter technique requires minimal cooperation from the child, as a regular pattern of breathing with a constant tidal volume is required for the measurements. The basic assumption underlying the interrupter technique is that, following an instantaneous interruption of airflow at the airway opening (by closing a valve or shutter), there is an instantaneous equilibration of pressure between the alveoli and the airway opening (behind the occlusion). Dividing this pressure change by the flow occurring immediately before the occlusion allows the calculation of resistance.

There are reference values published for preschool children, (11-13) but they are not comparable, because of differences in using the method. Also, there are studies proving a good correlation between the interrupter technique and spirometry or pletismography. (14)

The interest for using this method on children was mainly focused on promoting the interrupter technique as a good alternative to spirometry for measuring lung function in young ages. Its features, like as the minimal cooperation required and the lack of invasiveness are also promoting this technique as a candidate for evaluating respiratory function in acute asthma in any age. The spirometry is difficult to perform during an exacerbation, even in older children, due to the bronchial obstruction present. There are no studies yet using this technique in acute asthma in children, but similar techniques, such as forced oscillation technique was proven as a feasible and reproducible method for evaluating lung function in acute asthma in children aged 3 to 17 years.(15, 16)

The most used parameters for evaluating severity and prognosis of an asthma exacerbation are the clinical ones, but the quantification of the severity of bronchial obstruction using a measure of lung function could provide important and objective information about the severity of ventilatory dysfunction (4,17,18) and in monitoring the therapeutic response.(19)

PEF is a parameter which is also easy to obtain, being included as a functional parameter in evaluation of the severity of asthma exacerbation in the GINA classification.(3) In children however it was not proven as a valid and reproducible measure, especially in young ages and a poor correlation was proven when compared with the standardized methods.(20, 21)

In parallel with the GINA classification, we choose in our study a validated clinical score – Pediatric Asthma Severity Score (5), as it is simple to use and to correlate with Rocc values.

We proved a very good feasibility of the interrupter technique during an asthma exacerbation, superior to the other two techniques used, spirometry and peakflometry. The study proved also a good correlation between Rocc values and the clinical parameters (respiratory rate, heart rate, retractions, wheezing and PASS Score), suggesting the inclusion of Rocc values in the evaluation of asthma exacerbation could add important information on the severity of ventilatory dysfunction. We couldn't find a good correlation between Rocc and oxygen saturation, proven in the other studies where the forced oscillation technique was used for determining respiratory resistance.(16) It is possible that a higher degree of obstruction is necessary to induce changes in SpO2 than in Rocc.

The limitations of the study consist in the small number of participants (only 30 patients) which could influence the power of the study. The cooperation rate with spirometry is likely to be influenced by the proportion of children who have performed the technique previously, a variable not documented in our patients. Future studies are needed to clarify the role this technique and if it could play as a measure of lung function during asthma exacerbation. ❑

CONCLUSION

The interrupter technique for assessing respiratory resistance is a feasible method in asthma exacerbations in children, even on younger ones, and its results proved a good correlation with the clinical parameters used in evaluation of acute asthma. ❑

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