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Forced expiratory decay in asthmatic preschool children — Is it adult type?

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Summary
Background: The forced expiratory decay in healthy preschool children portrays a convex shape that differs from the linear decay in the older healthy population. The "adult-type" expiratory decay during airway obstruction is concave. The study objective was to determine if the expiratory decay in young asthmatic children is "adult-type".
Methods: Among 245 children (age 3—7 yrs), 178 had asthma (asthmatics) and 67 were non-asthmatic (controls). The expiratory flow decay was inspected by FEF25-75/FVC ratio (=1.0 when linear). Values were compared to those of our formerly studied (n = 108) healthy children. A meaningful obstruction in FEF25-75/FVC ratio was defined as 2-zScores from healthy. A meaningful response to bronchodilators was related to non-asthmatics.
Results: In healthy subjects FEF25-75/FVC ratio declined with age from 1.73 ± 0.17 to 1.28 ± 0.11. Non-asthmatics portrayed ratio values similar to those of healthy subjects. In asthmatics, 118/178 displayed a convex to linear expiratory decay (FEF25-75/FVC = 1.33 ± 0.22). Sixty/178 asthmatics portrayed concavity (FEF25-75/FVC-0.79 ± 0.16) that appeared when FEF50 was 43.4 ± 12%healthy. Concavity appearance was also age-dependent (30.4% of 3—4 y old and 59.1% of 6—7 y). Vital-Capacity decreased in either decays, forming a visually petit curve. Most asthmatic children respond to bronchodilators by a meaningful elevation in FEF25-75/FVC values and by a visual change in the shape of the curve. Other common spirometry indices also increased meaningfully.
Conclusion: Most asthmatic preschool children portray convex to linear expiratory decay with diminished vital-capacity, resulting in a visually smaller than healthy curve, with seemingly

Abbreviation list: FVC, forced vital capacity; FEVt, forced expiratory volume at t seconds; PEF, peak expiratory flow; FEF25-75, forced expiratory flow at 25—75%FVC; FEF50, forced expiratory flow at 50%FVC.

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normal expiratory decay. These curves may be misinterpreted as "normal" or as "no-cooperation" and may lead to misinterpretation. In response to bronchodilators, FEF25-75/FVC value increases in asthmatics and the curve changes from concave to linear or from linear to convex contour.

Introduction

Spirometry is a simple technique that describes airway obstruction in relation to lung volume and is a basic tool used for the diagnosis, classification, and management of a variety of pulmonary diseases in the general population (age >6 years). Despite recent advances in techniques, suitable adaptations for age, and the existence of reference values in the preschool age,[1–3] the clinical significance of spirometry has often been questioned. Poor cooperation on the child's part and lack of recommendations for identifying airway obstruction or response to bronchodilators by the common guidelines have often been raised as probable reasons for the limited use of spirometry.[4]

Airway anatomical and physiological differences between the younger and older populations may also contribute to difficulties in interpreting spirometry in the preschool age. In the general healthy population, the expiratory decay of the flow/volume is linear ("adult type").[5,6] In healthy preschool children the expiratory decay portrays a convex shape.[7,8] The convex shape is caused by the high flow derived from fully developed airways relative to small lung volumes caused by incomplete alveolization in those young children.[9–14] During airway obstruction in adults the expiratory decay becomes concave.[5,6] This concavity is a reflection of the proportionally greater reduction in mid-vital capacity flows than reduction of the FVC.[5,6] The importance of detecting concavity was underlined by the ATS/ERS guidelines.[15] FEF25-75/FVC ratio can be used as a surrogate measure of airway size relative to lung size.[6] When FEF25-75/FVC equals ~1.0 the decay is linear, as found in the healthy general population.[6] During airway obstruction when the curve becomes concave, the FEF25-75/FVC ratio decreases below 1.0.[14,16] The study aims to define if the expiratory decay contour in asthmatic preschool children is concave by assessing FEF25-75/FVC ratio.

Subjects and methods

The study was approved by the local ethics committee of the Rambam Health Care Campus (Institutional Review Board 0304-11-RambamMC). Children participating in the study were 3.0–7.0-years-old and included asthmatic and non-asthmatic children. Data were collected retrospectively during 2011.

Children with known Asthma (Asthmatics) included children who were defined as asthmatics according to GINA guidelines,[17] who suffered from frequent episodes of wheezing, activity-induced cough/wheeze, nocturnal cough without viral infections, and absence of seasonal variations. All these children had a previous positive methacholine/exercise challenge test or response to bronchodilators.[18,19]

Non-Asthmatics – included children who were referred to the Pediatric Pulmonary Unit at Meyer Children's Hospital because of non-organic cough or sigh to exclude asthma. This group included children who had no previous treatment for asthma, no family history of asthma, and no hospitalization due to asthma attack. On previous visits these children had negative methacholine or exercise challenge tests, with no response to bronchodilators.

Exclusion criteria for all children were the inability to comply with repetitive reliable simple spirometry or any chronic respiratory illness except for asthma.

Spirometry measurements

Spirometry maneuvers were performed using a commercial spirometer (KoKo-Dosimeter, nSpire Healthcare Inc, Longmont, CO, USA). Tests were performed by a highly trained technician, aided by incentives that included targets for peak flow and vital capacity, and were performed in the standing position without a nose clip. Each test included at least three technically acceptable curves.[1] The technical acceptance of spirometry data was inspected in relation to recommendations for the preschool age.[1] The single best FVC + FEV_1 (or FVC + FEV0.5) curves were stored for further analysis, where common spirometric indices values were inspected. Reproducibility was assessed as the difference between the best and the second best curve values.

Initial FEF25-75/FVC ratios were calculated, where values above 1.0 were considered convex and below 1.0 as concave. FEF25-75/FVC ratio data from healthy preschool children formerly studied[8] were evaluated in relation to the annual age. The significance of the deviation of FEF25-75/FVC ratio and other common spirometry indices from healthy were calculated by unpaired-t test. Correlations were sought between several spirometry indices (%healthy) and FEF25-75/FVC ratio.

We also wanted to assess the change in the curve contour in response to bronchodilators; therefore flow/volume maneuvers were repeated 15 min after inhalation of 2 puffs of 100 mg Albuterol via a volumetric spacer. Changes in expiratory decay contour in response to bronchodilators in the asthmatic and non-asthmatic children were analyzed by comparing the baseline values of FEF25-75/FVC ratio to the post-bronchodilator values by paired t-tests. A meaningful change in FEF25-75/FVC ratio was defined as a change of >2-zScores (in relation to non-asthmatics). Data are presented as mean ± standard deviation (SD) unless otherwise indicated. $p < 0.05$ was considered significant.