Official Case Reports Journal of the Asian Pacific Society of Respirology
Respirology Case Reports
OPEN ACCESS
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The value of spirometry and exercise challenge test to diagnose and monitor children with asthma

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Keywords
Asthma/classification, child, spirometry.

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Received: 27 June 2014; Revised: 26 November 2014; Accepted: 09 December 2014

Respirology Case Reports **2015; 3(1): 25–28**

doi: 10.1002/rcr2.92

Abstract

Asthma is defined as a chronic inflammatory disease of the airways with characteristic symptoms including recurrent episodes of wheezing, breathlessness, chest tightness, and coughing. It may result in abnormalities of ventilator function, which can be assessed by different pulmonary function tests. In this case report, we present a 15-year-old boy with asthma and illustrate the value and limitations of spirometry and exercise challenge test in daily practice.

Introduction

International guidelines have been published to improve the feasibility of lung function assessment in children for diagnosing and monitoring asthma [1]. Spirometry is the most frequently used technique for measuring lung function based on forced expiratory maneuvers. Airway hyperresponsiveness (AHR) is a characteristic feature of asthma but assessment of AHR by bronchial provocation tests is not a part of routine asthma management for every patient. In this case report, we illustrate the value and limitations of spirometry and exercise bronchial provocation test to diagnose and monitor children with asthma.

This case report is an illustration of an invited review available in *Respirology*: http://dx.doi.org/10.1111/resp.12480. van den Wijngaart LS, Roukema J, Merkus PJFM. Respiratory disease and respiratory physiology: putting lung function into perspective: pediatric asthma, Respirology, 2015, doi:10.1111/resp.12480.

Case Report

The boy described in this study had a history of asthma, severe eczema, allergic rhinitis, and an allergy for pistachio, peanuts, and cashew nuts, with one documented episode of anaphylaxis. Asthma was diagnosed by the general practitioner on clinical grounds: recurrent daily episodes of persistent dry cough, dyspnea, and wheezing, mostly triggered by infections, exercise, cigarette smoke, and change of weather. He was prescribed inhaled corticosteroids (fluticasone 125 µg twice daily) and beta-2 mimetics (salbutamol as needed). Furthermore, he used a corticosteroid cream for his skin and antihistamines for allergic symptoms. An adrenaline autoinjector was to be used in case of anaphylactic reaction. Development and growth were normal and his immunizations were up to date. Family history was positive for asthma and allergy, and environmental history revealed no exposure to cigarette smoke or pets.

At the age of 15, he was referred to the pediatric pulmonology outpatient clinic for evaluation and

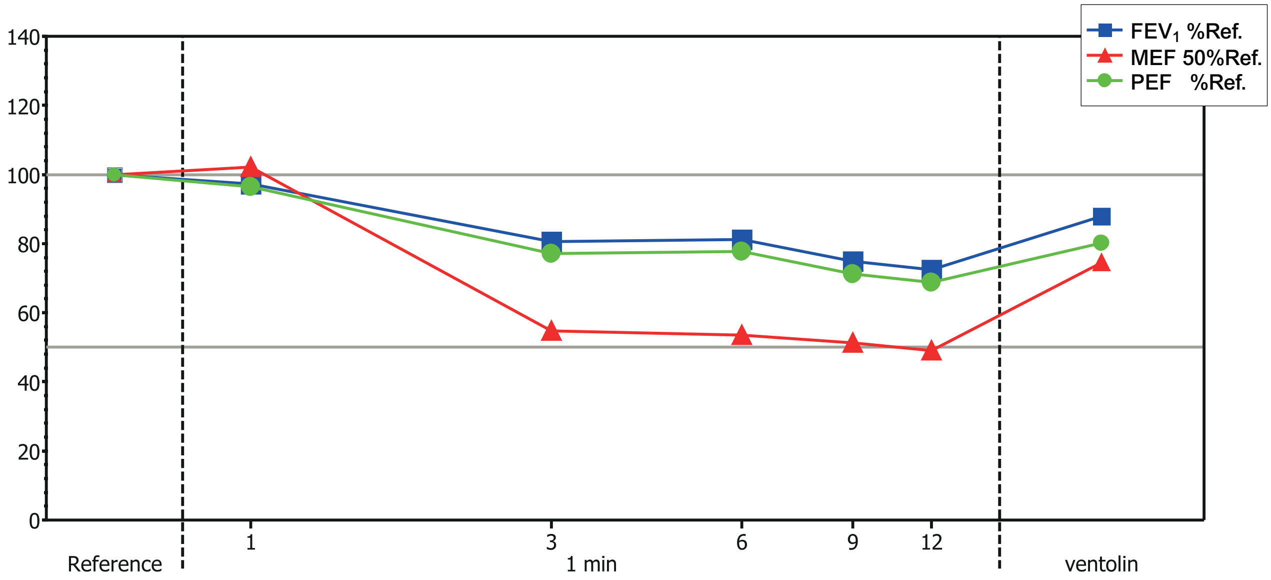

Figure 1. Exercise challenge test.

management of the atopic syndrome. He inhaled corticosteroids and beta-2 mimetics via a spacer without mouthpiece. He had no documented asthma exacerbations for the last few years. He reported dyspnea and breathlessness during and after exercise, but there were no complaints at rest. Medications were not used frequently. At physical examination, a healthy-looking boy with normal weight and height was seen (height 171.6 cm weight 50 kg). He was breathing comfortably and quietly without respiratory distress. There were no chest retractions and auscultation was normal. Further physical examination was unremarkable. Baseline spirometry showed forced vital capacity (FVC) of 4.27 l (96% of predicted), a forced expiratory volume in 1 sec (FEV_1) of 3.43 L (92% of predicted), and an FEV_1/FVC ratio of 80%; there was no obstructive pattern or reversibility to bronchodilator agents.

The child and his mother received asthma education, instructions on inhaler technique, and he was prescribed twice daily inhaled corticosteroids. Beta-2 mimetics were continued as needed. An indirect bronchial provocation test was planned to identify exercise-induced bronchial hyperresponsiveness (EIB). Instructions to withhold short-acting bronchodilators for 8 h prior to the test were given.

At the start of the exercise challenge test, physical examination was normal and there was no dyspnea. FEV_1 was measured before and after exercise according to protocol. The patient performed the treadmill test without any complaints. However, 12 min after finishing the test, a rapid airway obstruction was observed, with a significant fall of FEV_1 >20% (Figure 1). The bronchoconstriction was rapidly reversed after inhaling a bronchodilator. In hindsight, baseline FEV_1 was 2.37 L (63% of predicted), and therefore, the test should have been aborted.

At a regular visit a week later, he still had no complaints of dyspnea in rest. However, auscultation revealed diminished breath sounds with a prolonged expirium. Spirometry results confirmed a rather severe airways obstruction (Figure 2). He was treated with systemic corticosteroids (prednisolone 40 mg twice daily for 5 days) and frequent use of beta-2 mimetics (salbutamol). Spirometry was repeated after 1 week (Figure 3), showing an improved flow-volume loop.

Discussion

Spirometry is considered to be the "gold standard" of measuring airway caliber in cooperative children. It can be used to diagnose, manage, and monitor asthma [1].

Normal spirometry does not exclude asthma. Indeed, asthma is considered to be a clinical diagnosis [2]. A family history of asthma, and a family/personal history of atopic constitution, may contribute to this diagnosis. An obstructive lung function (characterized by decreased FEV_1, decreased FEV_1/FVC ratio, and a normal FVC), with reversibility to a bronchodilator agent, can also be supportive. In monitoring asthma, spirometry can provide information about the severity of the airways obstruction: it may help to identify an acute asthma exacerbation or may provide parents and children insight in their perception of asthma severity (frequently underestimated) and their subjective feeling of asthma control (frequently overestimated). Hence, the so-called "poor perceivers" of airways

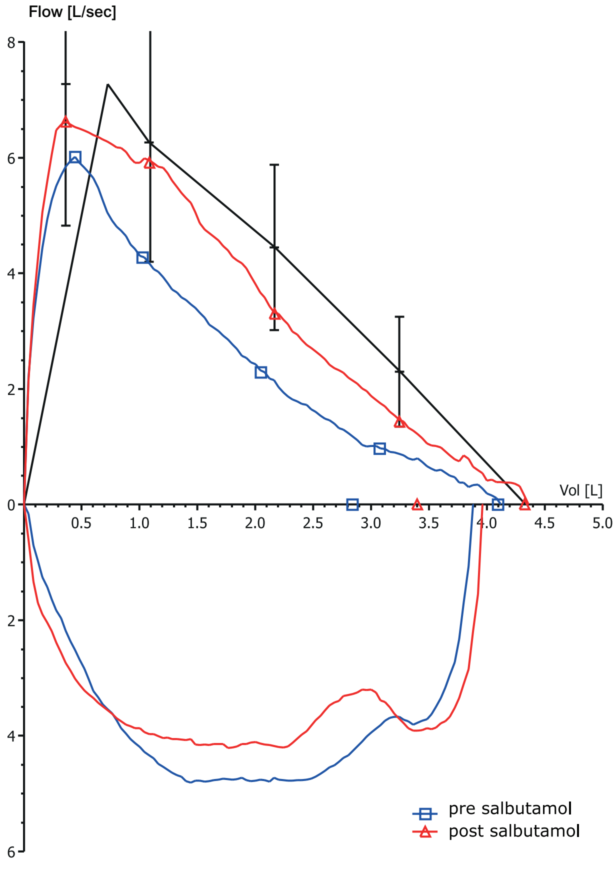

Figure 2. Obstructive curve during asthma exacerbation. Blue curve (pre-bronchodilation): Forced vital capacity (FVC) 4.12 l (95% of predicted), forced expiratory volume in 1 sec (FEV_1) 2.63 L (73% of predicted), FEV_1/FVC 64% (77% of predicted), maximum midexpiratory flow ($FEV_{0.25–0.75}$) 1.66 L (41% of predicted). Red curve (post-bronchodilation): FVC 4.33 L (100% of predicted), FEV_1 3.40 L (95% of predicted), FEV_1/FVC 78% (94% of predicted), maximum midexpiratory flow ($FEV_{0.25–0.75}$) 2.76 L (73% of predicted).

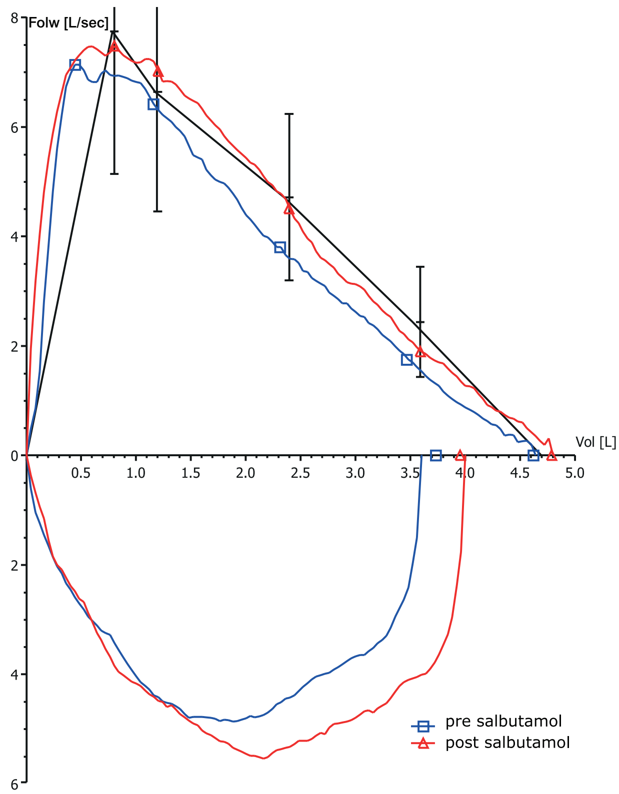

Figure 3. Reversible obstruction after 5 days of treatment with systemic corticosteroids. Blue curve (pre-bronchodilation): Forced vital capacity (FVC) 4.62 L (99% of predicted), forced expiratory volume in 1 sec (FEV_1) 3.73 L (96% of predicted), FEV_1/FVC 81% (97% of predicted), maximum midexpiratory flow ($FEV_{0.25–0.75}$) 3.40 L (79% of predicted). Red curve (post-bronchodilation): FVC 4.79 L (103% of predicted), FEV_1 3.95 L (102% of predicted), FEV_1/FVC 83% (99% of predicted), maximum midexpiratory flow ($FEV_{0.25–0.75}$) 3.68 L (90% of predicted).

obstruction, as seen in this case, can be identified. However, even when optimal anti-inflammatory treatment is administered, abnormalities in ventilator function may persist [3]. Therefore, it may be helpful to assess spirometry when asthma is well controlled and to document a child's personal best values following maximal bronchodilation as a reference.

Dyspnea or breathlessness during or after exertion can be an indication to conduct an exercise challenge test to diagnose EIB. This reflects more directly the ongoing airway inflammation and is more specific to identify active asthma compared with direct provocation tests [4]. The advantage of this test is the lack of false-positive tests; healthy subjects respond with mean falls in FEV_1 of 2–6%. An exercise test is also indicated for testing the effect of treatment of asthma [4].

However, performing an exercise challenge test in children with a baseline FEV_1 <70%, as in this case, could be dangerous because a maximum stimulus is reached during exercise, without measuring FEV_1 during the test. A progressive FEV_1 decline may not be detected and the reduction in FEV_1 post-exercise could therefore be rapid on onset and severe, with the risk of a severe airway obstruction in children with uncontrolled asthma. In this particular case, baseline FEV_1 before the challenge test was 30% lower than during the previous visit, making it needless to perform an exercise challenge test to support the asthma diagnosis.

In summary, this case report illustrates both the added value and limitations of spirometry and exercise challenge test in children with asthma. Baseline spirometry may be normal in asthma at one time and obstructive another time, and, hence, spirometry will not always support the diagnosis of asthma. In children with poor perception of dyspnea, spirometry may not reflect sensations of dyspnea at all, and often it is very useful to document a personal best spirometry result. An exercise challenge test may reveal poor asthma control while spirometry results are still in the normal range. Bronchoconstriction following a bronchial (exercise) challenge can be severe, and should preferably be conducted with a physician standby, and not be conducted during times of symptoms and significant airways obstruction at baseline.

Disclosure Statements

No conflict of interest declared.

Appropriate written informed consent was obtained for publication of this case report and accompanying images.

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