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Nasal flow, volumes, and minimal cross sectional areas in asthmatics

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Summary
Background: The Unified Airways hypothesis suggests an involvement of the upper airways in asthma. Critical parameters of the nasal airway can be quantified objectively with acoustic rhinometry (AR) and peak nasal inspiratory flow (PNIF).
Objective: We aimed to investigate nasal airway patency in asthmatics compared to non-asthmatic controls. Nasal volume, cross sectional area and flow were measured using acoustic rhinometry (AR) and peak nasal inspiratory flow (PNIF) in 87 asthmatics and 93 non-asthmatic controls before and after decongestion with xylometazoline. Nasal congestion index (NCI) was calculated, and allergy status was assessed by skin prick test or specific IgE.
Results: We found significantly smaller minimum cross sectional area and nasal cavity volume in asthmatics than controls, and the cross sectional area is at its minimum at 2–3 cm from the nasal orifice in both groups. AR and PNIF measurements are not different in allergic and non allergic subjects in either group. The effect of xylometazoline is not significantly different between the 2 groups with regard to AR, but there is a significant improvement in PNIF for the asthmatics when assessed by the NCI.

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Conclusion: The present study demonstrates a significantly smaller nasal airway when assessed by minimum cross sectional area and nasal cavity volume in asthmatics than controls, and these findings apply to asthmatics and controls irrespective of allergy status.
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Introduction

The Unified Airways hypothesis suggests an involvement of the upper airways in asthma [1–3]. Rhinitis typically precedes the development of asthma and can contribute to unsatisfactory asthma control. Nasal symptoms, airflow, and markers of inflammation directly correlate with lower airway involvement [4]. In both rhinitis and asthma, an inflammatory cell infiltrate with subepithelial oedema is present in the mucosa [5]. Unlike the lower airway, the nasal mucosa contains venous sinusoids that undergo periodic congestion and decongestion (the nasal cycle) that are important for regulation of airflow, humidification and warming of the inspired air. Nasal obstruction may be indicative of structural deformities, infections and inflammatory conditions in the nose, and is frequently reported by asthmatics [6]. Their lack of nasal patency may also be due to factors such as mucosal congestion and changed perception of flow.

Critical parameters of the nasal airway can be quantified objectively with acoustic rhinometry (AR) and peak nasal inspiratory flow (PNIF) [7,8]. While the former measures internal nasal volume and minimum cross-sectional areas, the latter measures the maximum nasal inspiratory flow during forced inspiration. The Nasal Congestion Index (NCI) has been suggested as a useful instrument for the evaluation of nasal obstruction by quantifying the effect of topical decongestants applied on the nasal mucosa [9]. There are few studies that have used these tools to investigate the relative contribution of subepithelial oedema and congestion of the venous sinusoids in asthmatics. Hellgren et al. [10] demonstrated increased nasal mucosal swelling in asthmatics compared to healthy controls.

In this study, we measured nasal volume, cross sectional area and flow using AR and PNIF, and assessed the effect of xylometazoline using the NCI in order to further elucidate the role of oedema and congestion in the nasal mucosa of asthmatics.

Methods

Subjects

The study consisted of 87 patients with asthma, and they were recruited from the out-patients' clinic at the Department of Lung Medicine, St Olavs Hospital, University Hospital of Trondheim. The asthma diagnosis was based on the presence of typical asthma symptoms, with either $\geq$12% and $\geq$200 ml improvement of forced expiratory volume in the first second (FEV_1) from baseline after inhalation of salbutamol or positive methacholine bronchial provocation test (PD20 $FEV_1 \leq 1600$ μg) and in accordance with the British Thoracic Society criteria [11].

Ninety-three non-asthmatic controls were mostly recruited from the out-patients' clinic of Department of Otolaryngology, Head and Neck Surgery, St Olavs Hospital, University Hospital of Trondheim, among patients with disorders not affecting the upper airways (e.g. external otitis, and skin diseases in the ENT area). Some controls were also randomly invited from nearby businesses with all types of employments, from manual labour to skilled work. The sample, allergy status, questionnaires and additional recordings were based on a database that has previously been described [6]. Exclusion criteria were the presence of acute and chronic rhinosinusitis and nasal polyposis on oto-rhino-laryngological examination and in accordance to the EPOS 2012 criteria [12], pregnancy, previous nasal surgery, systemic disease with potential affection of the nose, such as Wegener's granulomatosis, cystic fibrosis, primary ciliary dyskinesia, Kartagener's syndrome and sarcoidosis, and a history of cancer. For the NCI we analyzed 85 patients with asthma and 93 non-asthmatic controls. The missing values were discarded because of one patient with missing decongested values and one patient was resistant to accept topical xylometazoline. The study was approved by the Regional Committee for Medical Research Ethics, and conducted according to the Helsinki Declaration. Written informed consent was obtained.

AR

AR is a sonic echo technique which was used to measure the nasal volumes and minimal cross sectional areas. Nasal passage volumes are calculated from contiguous cross-sectional values.

The measurements were made with an impulse acoustic rhinometer (RhinoMetrics SRE2100, Rhinoscan version 2.5, built 3.2.5.0; Interacoustics, Minneapolis, MN) by two trained operators throughout the study. The probe was hand held with the subject sitting upright and opposite to the investigator. An appropriate anatomic nose adaptor and contact gel between the nose adaptor and the nostril were used, and measurements were made during a breath hold.

Recordings were performed according to published protocols [13]. Briefly, three satisfactory recordings were made from each nasal cavity. The values for each nasal cavity were averaged. Due to the variations represented by the nasal cycle, the sum of the two averages was divided by 2 to obtain the minimal cross sectional area (MCA, cm^2) and nasal cavity volume (NCV, cm^3). The rhinometer was programmed to calculate the MCA_{0-3} and $MCA_{3-5.2}$, and NCV_{0-3} and $NCV_{3-5.2}$, defined as MCA and NCV at 0–3 cm and 3–5.2 cm, respectively from the nasal orifice. $MCA_{0-5.2}$ is the minimum cross sectional area at 0–5.2 cm from the nasal orifice. $NCV_{0-5.2}$ is the sum of NCV_{0-3} and $NCV_{3-5.2}$.

After visual inspection of the rhinometric curves, the rhinometer was reprogrammed to calculate MCA_{0-2} and

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