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Exercise induced dyspnea in the young. Larynx as the bottleneck of the airways

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Summary
Background: Exercise induced asthma may symptomatically be difficult to differentiate from exercise related obstruction in the upper airways, sometimes leading to diagnostic confusion and inappropriate treatment. Larynx accounts for a significant fraction of total airway resistance, but its role as a limiting factor for airflow during exercise has been hampered by lack of diagnostic tools. We aimed to study laryngeal function in exercising humans by transnasal laryngoscopy.
Methods: Continuous video recording of the larynx was performed in parallel with continuous film recording of the upper part of the body and recording of breath sounds in subjects running to respiratory distress or exhaustion on a treadmill.
Results: A successful examination was obtained in 20 asymptomatic volunteers and 151 (91%) of 166 young patients with a history of inspiratory distress or stridor during exercise. At rest, six patients had abnormal laryngeal findings. During exercise, a moderate or severe adduction of laryngeal structures was observed in parallel with increasing inspiratory distress in 113 (75%) patients. In 109 of these, adduction started within supraglottic structures, followed by adduction of the vocal cords in 88. In four patients, laryngeal adduction started in the vocal cords, involving supraglottic structures secondarily in three.
Conclusion: Larynx can safely be studied throughout a maximum intensity exercise treadmill test. A characteristic laryngeal response pattern to exercise was visualised in a large proportion of patients with suspected upper airway obstruction. Laryngoscopy during ongoing symptoms is recommended for proper assessment of these patients.

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Introduction

Exercise induced dyspnea is a common complaint among adolescents and young adults. Symptoms may be caused by exercise induced asthma (EIA) and by obstruction in the upper airways.[1] Upper airway obstruction typically presents as inspiratory dyspnoea during exercise, often labelled exercise induced inspiratory stridor (EIIS).[2–4] EIIS typically peak towards the end of an exercise session and during the first 2–3 min of recovery, contrary to symptoms of EIA, typically peaking 3–15 min after the exercise has stopped.[5] The larynx (Fig. 1) accounts for a significant fraction of total airway resistance at rest, and becomes even more important during exercise.[6,7] Patients without symptoms or findings at rest may therefore exhibit inspiratory airflow obstruction at the laryngeal level during high intensity exercise.[2,4,8–19]

Current understanding of airflow obstruction in the upper airways during exercise has been hampered by lack of diagnostic tools. The literature on pathophysiology, prevalence rates, therapeutic strategies and terminology is equivocal. Similar clinical scenarios have been labelled by different terms, such as exercise induced vocal cord dysfunction (VCD)[2,4,13,15,16,18,19] or exercise induced laryngomalacia (EIL).[8–12,14,17] Discrepancies may partly be explained by differences in diagnostic approaches. It has therefore been recommended that EIIS should be examined by direct visual inspection of laryngeal structures during ongoing symptoms.[1]

We have previously presented a technique for continuous laryngoscopy during an incremental maximum exercise treadmill test (the CLE test).[3] The aim of the present study was to use this technique in an observational study design, to explore laryngeal response pattern(s) to exercise in a large group of adolescents and young adults with symptoms of EIIS.

Methods

Subject

Twenty volunteers with no history of symptoms resembling EIIS were recruited to demonstrate a normal laryngeal

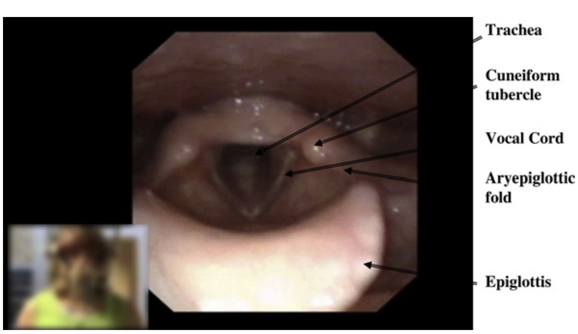

Figure 1 Normal larynx, as observed transnasally in a flexible laryngoscope, with the patient in the lower left corner (anonymised). Epiglottis (at front), the cuneiform tubercles and the aryepiglottic folds represent supraglottic structures. The vocal cords (glottis) and the upper part of the trachea are seen below.

response pattern to exercise. Patients ($n = 166$) were consecutively recruited over a period of five years (2002–2007) from the outpatient pulmonology clinic at the Paediatric Department, Haukeland University Hospital, Bergen, Norway. The CLE test was performed in patients with a history of exercise induced dyspnoea, symptoms of EIIS and no evidence of EIA on a standard exercise provocation test.[20] EIIS was defined by a prolonged inspirium, inspiratory distress, stridor, chest pain, hyperventilation attacks or frank panic reactions occurring during exercise.[2–4] A paediatrician or an otorhinolaryngologist obtained the medical history and performed a general physical examination. Basic characteristics of the study population are given in Table 1.

The Regional Ethics Committee approved the study and informed written consent was obtained from all participating subjects.

Continuous exercise laryngoscopy (CLE test)

The test has been described in detail elsewhere.[3] Briefly, the patients ran to symptom-limiting distress or to exhaustion on a treadmill (*Woodway ELG 70, Weil am Rhein, Germany*), wearing a face mask (*Hans Rudolph, Inc., Kansas City, MO, USA*) and hooked up to a Vmax 29 cardiopulmonary exercise (CPX) unit (*SensorMedics inc., Yorba Linda, CA, USA*) and a 12 lead ECG (*Marquette Medical Systems inc., Milwaukee, WI, USA*). An integrated set-up combined the CPX unit with a transnasal fiberoptic flexible laryngoscope (*Olympus ENF-P3, Tokyo, Japan*), and a video – and sound – recorder (*Telecam, Karl Storz, Tuttlingen, Germany*). The face mask and a specially devised head-set served to secure the laryngoscope in correct position throughout the test. The treadmill was run according to a locally developed protocol, with incrementing speed and/or grade every 1 min, aiming to obtain Peak VO_2 after 6–12 min of exercise. In addition to real-time videoscopy of the larynx, breath sounds were continuously recorded. To document symptoms and/or external signs of respiratory distress, a film recording of the upper part of the body was running real-time and saved onto the same screen as the video recordings of the larynx.

The test was considered successful if the patient reproduced his or her respiratory complaints, or indicated exhaustion, preferably supported by a plateau in oxygen consumption and/or the heart rate response. The video recordings were reviewed and scored throughout the exercise session according to a preset protocol (Table 2; see also Maat et al.[21]). The position and movements of the glottic (vocal cords) and supraglottic (the cuneiform tubercles and aryepiglottic folds) structures were graded as normal if the expected neutral position or abduction occurred as the exercise session proceeded. If adduction occurred, it was scored as mild, moderate or severe according to the criteria given in Table 2. Patients were classified according to the highest score assigned. If laryngeal adduction occurred, the sequence of events was determined, i.e. if adduction started in supraglottic or in glottic structures. The timing of the onset of symptoms (EIIS) and of the onset of laryngeal adduction was