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REVIEW ARTICLE

Optical rhinometry – new challenges and possibilities of rhinitis diagnostics and not only

Authors' Contribution:
A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

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ABSTRACT: Optical rhinometry is the only diagnostic tool in rhinitis for assessing real-time changes in nasal occlusion. It illustrates lumen changes of nasal mucosa vessels in response nonspecific/specific factors and not only. The first attempts to standardize the method conducted by German researchers show the potential of optical rhinometry not only as regards challenge tests, but also vice versa, in respect of the anemization of the mucosa it evaluates the extent of the oedema which occurred in the pathomechanism of non-allergic rhinitis. The relatively small number of publications in the domain of interest demonstrates there is a need to conduct further research on the suitability of the above-mentioned technique for the evaluation of nasal patency in the field of rhinological diagnostics.

KEYWORDS: optical rhinometry, nasal patency, nasal cavity

INTRODUCTION

Nasal patency disorders can be evaluated with the use of highly specialized techniques such as computed tomography, magnetic resonance, rhinostereometry, rhinohygrometry, thermorhinography, acoustic rhinometry, nasometry, pressure rhinometry, oscillatory rhinomanometry, active/ passive rhinomanometry, anterior/posterior rhinomanometry, and peak nasal inspiratory flow (PNIF). A common feature of the above-mentioned techniques is that they determine the extent to which the nasal cavity is obstructed. This, in turn, can be the result of complex pathomechanisms triggered by various factors located in the nasal vestibule and/or in the area of the head of the inferior nasal concha.

In order to meet modern standards, a group of German researchers developed a new technique called optical rhinometry (ORM, emission spectroscopy). ORM evaluates not only nasal obstruction but also enables the monitoring of mucosal response to external stimuli. Thus, it is able to determine the onset as well as the maximum intensity of the reaction in the nasal mucosa vessels.

ORM measures the absorption of light passing through a layer of tissue. The measurements are based on the Beer-Lambert law stating that the absorbance of the sampling light is directly proportional to both thickness and concentration of the absorbing environment [1,2]. Similarly to a pulse oximeter, ORM's signal can be constant or pulsatile. This helps calculate oxygen saturation and monitor changes in the volume of blood flow. ORM devices contain an emitter and a detector that are placed on the opposite sides of the nasal ridge (the device resembles eyeglasses). The emitter gives off pulses of infrared light with a mean wavelength of 600–800 μm (Fig. 1). The measurement sites are located in the region of the head of the inferior turbinate and the nasal isthmus (Kiesselbach area). This yields either separate readings for different wavelengths or a combined reading for the nasal cavity.

The result is an absorbance curve of infrared light in function of time. One of the measures of nasal patency is optical density (OD) defined as the magnitude of reduction in speed of the sampling light as it passes through an absorbing layer. Another parameter assessed with the use ORM is the reaction onset (T1). T1 is the time needed for the infrared light absorption curve to climb or drop to a certain threshold that, depending on the stimulus, can have a positive (allergen, histamine) or a negative (a decongestant, cold air) value. The maximum reac-

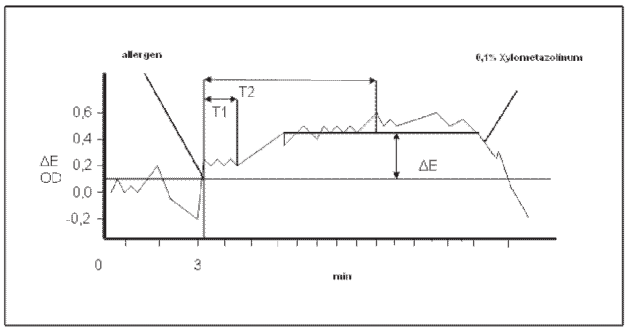
tion (T2) is the time after which the curve stabilizes and reaches a plateau. T1 and T2 indicate a chronological sequence of different phenomena in edema formation while ΔE indicates the extent of local reaction.

OPTICAL RHINOMETRY IN CLINICAL TRIALS

The literature on the subject describes the potential of ORM in rhinologic diagnostics, especially as regards rhinitis or the evaluation of the effectiveness of different treatments. Similarly to other objective methods of nasal patency assessment, ORM requires standardization in order to determine appropriate reference values for given populations. Tillmann et al. made the first attempt to standardize ORM in a group of 52 healthy volunteers, aged between 21 and 80 years. The study showed clear age-dependent differences in the extent of infrared light absorption – in the group of 21–40-year-olds OD increased by 0.14, in the group of 41–60-year-olds by 0.22, and in the group of 61–80-year-olds by 0.31, respectively [3]. These differences were attributed to greater vessel wall stiffness and co-morbidities in the elderly.

The nasal septum is a strategically important part of the nose due to its extensive vasculature, which makes it the most common source of pathological bleeding. Despite this, it is often omitted in assessments of the nasal mucosa response to environmental factors. This was demonstrated in a study by Scheibe et al. They used a cold (4°C) collar placed on the nape of the neck in a group of 15 healthy volunteers and showed significant changes observed over 10 minutes. Namely, a decrease in OD by 0.33, a decrease in T1 by 2 minutes (T1=111 s ± 73 s) and a decrease in T2 by 6 minutes (T2=337 s ± 119 s) [4].

Another study showing the usefulness of ORM evaluated the response of nasal mucosa to combined anesthesia with either sevoflurane and remifentanil hydrochloride (n=12) or propofol and remifentanil hydrochloride (n=11) in a group of 23 patients with chronic sinusitis who were undergoing endoscopy. Additionally, the extent of blood loss was evaluated with the Boezaart scale and a visual analog scale. Optical density decreased 30 minutes following administration of anesthestics. The changes observed with the use of both sevoflurane and remifentanil hydrochloride were considerably greater (procedure duration 3.6 ± 1.8 hours, anesthesia duration 4.7 ± 2.0 hours, Boezaart score 14, blood loss 355.9 ± 394.4 mL) than those observed with a combination of propofol and remifentanil hydrochloride (procedure duration 2.4 ± 1.2 hours, anesthesia duration 3.3 ± 1.3 hours, Boezaart score 9.5, blood loss 152.9 ± 161.3 mL) [5].



OD – optical density, T1/T2 – onset/maximum nasal mucosal edema

Fig. 1. Changes in nasal patency evaluated using optical rhinometry.

Lambert et. al demonstrated the usefulness of ORM in a non-specific test with capsaicin, administered in increasing concentrations of 0.005 mM, 0.05 mM and 0.5 mM, in a group of 6 patients with non-allergic rhinitis and 6 healthy patients. A significant increase in the absorption of infrared llight was noted especially at the concentrations of 0.05 mM and 0.5 mM in the group of patients with non-allergic rhinitis as compared to healthy controls. Moreover, a substantial correlation between nasal symptoms (graded on a point scale) and optical density measured by ORM was seen already at the concentration of 0.05 mM [2].

Through the use of various wavelengths, ORM helps assess various parts of the nose (nasal cavity, nasal isthmus, combined nasal readings) in terms of the mucosal response to external stimuli. In the study by Wüstenberg et al. who wanted to differentiate histamine-induced reaction intensity in different areas of the nasal cavity, performed in a group of 11 healthy volunteers, the most pronounced changes were seen in the head of the inferior turbinate (880-µm wavelength yielded an increase in OD by 0.37 ± 0.027), while less pronounced changes, though not clinically insignificant, were observed in the anterior part of the nasal septum, i.e. in the Kiesselbach's plexus (950-µm wavelengths; an increase in OD by 0.29 ± 0.007) [6].

A vast majority of ORM-related studies have focused on objectifying nasal provocation tests. In order to assess the usefulness of ORM in nasal provocation tests with allergens triggering specific and non-specific reactions, Mittenzwey et al. divided their study group into five subgroups. Specific provocation with histamine demonstrated that OD increased by 0.32 ± 0.19, T1 by 18 ± 34 s, and T2 by 224 ± 122 s. A positive provocation with an allergen demonstrated an increase in OD by 0.37 ± 0.16, in T1 by 3.9 ± 1.6 s, and in T2 by 330 ± 170 s, whereas a negative provocation demonstrated an increase in OD by 0.03 ± 0.05, and in T1 by 0.23 ± 0.44 s. Non-specific provocation testing (with normal saline as a negative control)

demonstrated similar results to those in allergen provocation tests. Namely, OD increased by 0.03 ± 0.07, T1 by 0.03 ± 0.07m, whereas following the application of a decongestant OD decreased by 0.18 ± 0.16 OD, T1 by 3 ± 2.5, and T2 by 183 ± 160 s. The observed differences were largely due to the type of a trigger, local nasal mucosa reaction, blood pressure, changes in heart rate, and age. This was substantiated in subsequent studies. A comparison between a group of children and adults showed distinct differences in the time of onset (T1) and maximum edema (T2) of the nasal mucosa - in children T1 and T2 were 120 s and 330 s, respectively, and in adults 156 s and 466 s, respectively [7].

So far, there has been only one study performed in order to assess the specificity and sensitivity of ORM as compared to ARM. The study by Agarwal et al., conducted in a group of 22 subjects (11 patients diagnosed with allergic rhinitis and 11 healthy volunteers, mean age 29 ± 9 years), assessed the specificity and sensitivity of nasal provocation tests (with the use of two allergens: *Alternaria* (n=8) and *Aspergillus* (n=7)). NAPT with *Alternaria* demonstrated higher specificity (AUC=0.76, P<0.05 for VAS; AUC=0.48, P=0.9 for ORM; and AUC=0.74, P=0.8 for ARM) than NAPT with *Aspergillus* (AUC=0.70, P=0.14 for VAS, AUC=0.53, P=0.81 for ORM; and AUC=0.42, P=0.05 for ARM). The specificity and sensitivity of ORM were comparable to those of ARM [8].

CONCLUSION

The standardization of ORM in nasal allergy requires further studies as the existing reports are scare (15 articles). ORM combines structural and functional parameters, which makes this method unique among other objective techniques assessing nasal patency.

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