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Preliminary Communication

ACOUSTIC RHINOMETRY STUDY IN PATIENTS WITH ALLERGIC RHINITIS

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SUMMARY — Acoustic rhinometry is a non-invasive technique that requires minimal cooperation from patients compared to other diagnostic methods. This technique can be used even in children under 3 years of age, which makes it widely applicable in the practice of rhinologists. The aim of this research was to study nasal patency and nasal volume in patients with persistent allergic rhinitis (PAR) and intermittent allergic rhinitis (IAR) using acoustic rhinometry and to compare the degree of swelling of the nasal mucosa in patients with different forms of the disease. The study was conducted on the territory of the University Hospital "Prof. Dr. St. Kirkovich" (Stara Zagora, Bulgaria), where 139 participants (111 with allergic rhinosinusitis [AR] and 28 controls), aged 19 to 84 years, were examined. To compare the results, an acoustic rhinometry study was performed on the participants and the control group. The main indicators considered were the volume of the nasal cavity, the minimum cross-section area of the left and right halves, as well as the distance from the nasal entrance where it is located. To check the reactivity of the nasal mucosa, the same test was repeated after using a nasal decongestant. Increased nasal mucosal swelling in patients with IAR than those with PAR has been found. More manifested nasal congestion is observed in patients with IAR, probably because pollen has a stronger immunological stimulus and causes more manifested expression of symptoms than allergens provoking year-round forms of AR. A severely reduced reactive response to nasal decongestants has been demonstrated in participants with persistent AR.

Keywords: *Allergic rhinitis*; *Acoustic rhinometry*; *Nasal obstruction*

Introduction

Rhinoscopy is one of the most commonly used methods for the assessment of nasal patency. Although it is included in almost all nasal pathology evaluations, several studies have shown that there is not always a clear relationship between anterior rhinoscopy, subjective evaluation, or other nasal breathing tests[1,2]. The introduction of rigid and flexible endoscopes significantly improves the examination and therapy of nasal pathology, but the results of using the endoscopic technique are not always comparable and correspond to rhinomanometry when it comes to assessing nasal patency[3,4].

The use of X-rays poses a threat to human health, and it is deemed to be a more expensive method in diagnosing nasal pathologies.

On the other hand, acoustic rhinometry (ARm) examination is a non-invasive technique and requires minimal cooperation from patients compared to other diagnostic methods. This technique can be used even in children under 3 years of age, which makes it widely applicable in the practice of rhinologists: in deviations

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of the nasal septum and after surgery for their correction, in pathological changes in the nasal cavities, adenoid vegetations, for detecting the presence of benign and malignant tumors, as well as in patients with sleep apnea[5].

With its development, ARm seeks to strengthen its applicability in allergic sinonasal pathology. The good correlation of the results reported by Austin and Foreman, comparing it with rhinomanometry, gives us a clear direction. In their study, the researchers found that the changes reflected by the two diagnostic techniques induced by intranasal exposure with histamine and bradykinin were completely comparable. Furthermore, some authors give preference to ARm, stating that it is much easier to use[6,7] when testing nasal patency in allergic pathology.

Aim

The aim was to study nasal patency and nasal volume in patients with persistent allergic rhinitis (PAR) and intermittent allergic rhinitis (IAR) using ARm and to compare the degree of swelling of the nasal mucosa in patients with different forms of the disease.

Materials And Methods

The study was conducted on the territory of the University Hospital "Prof. Dr. St. Kirkovich" (Stara Zagora, Bulgaria), where 139 participants (111 with allergic rhinosinusitis [AR] and 28 controls), aged 19 to 84 years, were examined. Those with bilateral nasal polyposis, involving the entire nasal passage, as well as patients with nasal septal deviation, were excluded. For participants who exhibited the intermittent form, the study was performed in a period of exacerbation and clinical manifestation of their symptoms. To compare the results, an ARm study was performed on the participants and the control group.

For our study, we chose the A1 Acoustic Rhinometer by GM Instruments Ltd. (Kilwining, Scotland). The data analysis was performed after two measurements were taken: before and after nasal decongestion, with drops containing 0.1% xylometazoline hydrochloride.

The statistical analysis was performed with the statistical software IBM SPSS Statistics, v.21.0/2012. The hypotheses were assessed for equality between two or more average variables and the normal distribution was performed with ANOVA analysis with Dunnett post-hoc. To compare averages in two independent samples, we used Student's t-test. The nonparametric Mann-Whitney U test was applied to detect a trend in a series of values. The achieved results were discussed at a degree of statistical significance $p<0.05$.

Ethical aspects

After a detailed presentation of the aims, tasks and methodology of the study, and the opportunity for discussion, all participants signed an informed consent form. The form was prepared in accordance with the principles of the Helsinki Declaration for Good Clinical and Laboratory Practice and approved on 7 May 2014 at a meeting of the Medical Ethics Committee at the Medical University, Stara Zagora.

Results

To analyze the patency of the nasal passages and the degree of mucosal congestion in patients with AR, we performed an ARm examination on the participants of the clinical and control groups. The main indicators that were taken into account were the volume of the

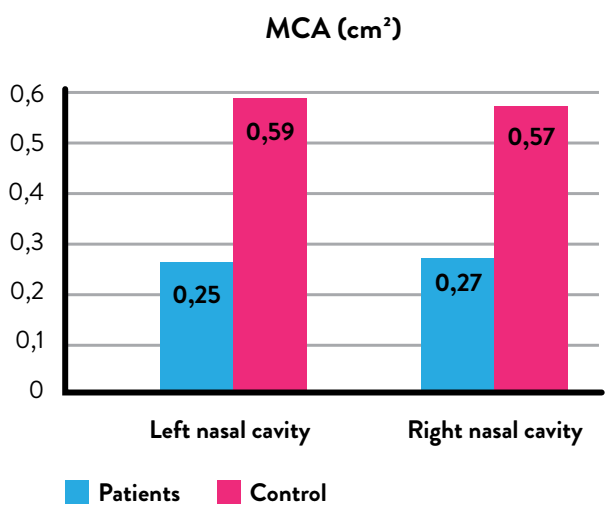

Figure 1. MCA in AR patients and controls

MCA = minimum cross-section area; AR = allergic rhinosinusitis

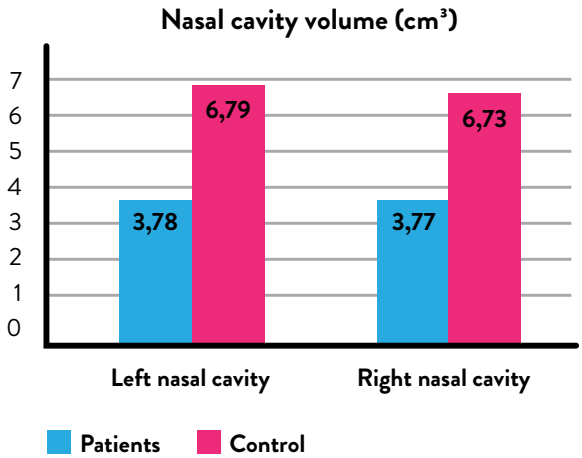

Figure 2. Nasal cavity volume in AR patients and controls

AR = allergic rhinosinusitis

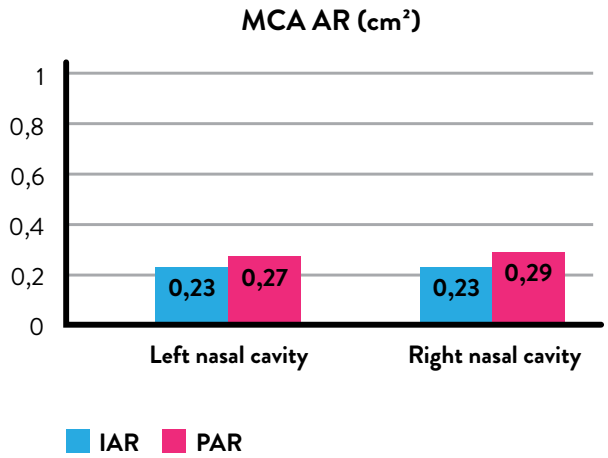

Figure 3. MCA in IAR and PAR patients

MCA = minimum cross-section area; AR = allergic rhinosinusitis; PAR = persistent allergic rhinitis; IAR = intermittent allergic rhinitis

nasal cavity, the minimum cross-section area (MCA) of the left and right halves, as well as the distance from the nasal entrance where it is located. To check the reactivity of the nasal mucosa, the same test was repeated after using a nasal decongestant. We compared the degree of congestion in the clinical group of patients with AR and the control group of healthy individuals (Figure 1).

In the first group, we established an MCA in the left nasal fossa of 0.25±0.06 cm^2 and 0.27±0.07 cm^2 in the right half. The cross-sectional area was significantly larger, doubling the dimensions of the narrowest part of the nasal cavity in the clinically healthy subjects, and was 0.59±0.14 cm^2, p=0.008 and 0.57±0.11 cm^2, p=0.006, respectively, for the left and right halves.

The mean volume of the nasal cavity in allergic patients before decongestion was 3.78±0.12 cm^3 on the left and 3.77±0.10 cm^3 on the right. Significantly larger volumes were recorded in the group without sinonasal pathology, with the value in the left half of the nasal cavity being 6.79±0.19 cm^3, p=0.011, and 6.73±0.14 cm^3, p=0.007 measured in the right half (Figure 2).

Comparing the two forms of the disease (Figure 3), we found a statistically significant difference between MCA in the group of patients with IAR – left nasal cavity – 0.23±0.09 cm^2 and right nasal cavity – 0.23±0.08 cm^2 compared to the group affected by PAR – left nasal half – 0.27±0.08 cm^2 (p=0.007, Mann-Whitney U test) and right nasal half – 0.29±0.10 cm^2 (p=0.007, Mann-Whitney U test). This increased nasal mucosal swelling in patients with an intermittent form of AR could be explained by the fact that most participants with IAR were examined during exacerbation and clinical manifestation of the disease, whereas we can assume that some patients with PAR were included in the study at a time when they did not exhibit any clinical signs of their pathology.

The mean MCA distance from the nasal entrance in IAR patients was determined at 2.24±0.04 cm in the left nasal fossa and 2.21±0.05 cm in the right one. In the group of patients with persistent form, the average distance was 2.16±0.04 cm and 2.14±0.07 cm in the left and right nasal cavities. These distances in both forms corresponded to the anterior part of the lower nasal concha.

The reactivity potential of the lower nasal concha mucosa showed significant differences in patients with IAR (Figure 4) and PAR (Figure 5). In the first group, the degree of nasal decongestion was 156.5% (0.23 to 0.59 cm^2) on the left and 147.8% (0.23 to 0.57 cm^2) on the right side (p=0.000, Mann-Whitney U test), while in the second group was significantly reduced – 81.5%

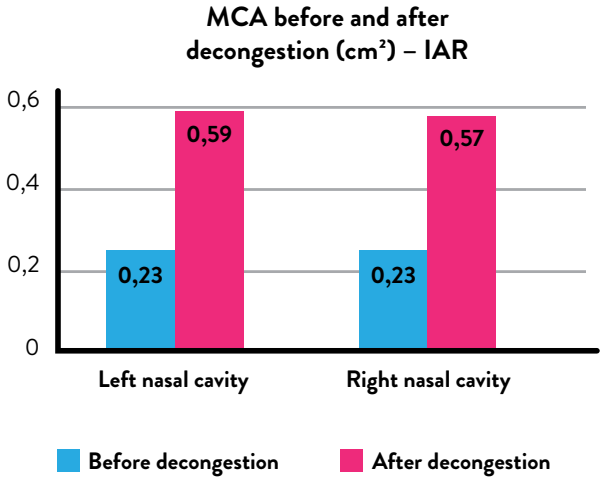

Figure 4. MCA in IAR patients before and after decongestion

MCA = minimum cross-section area; IAR = intermittent allergic rhinitis

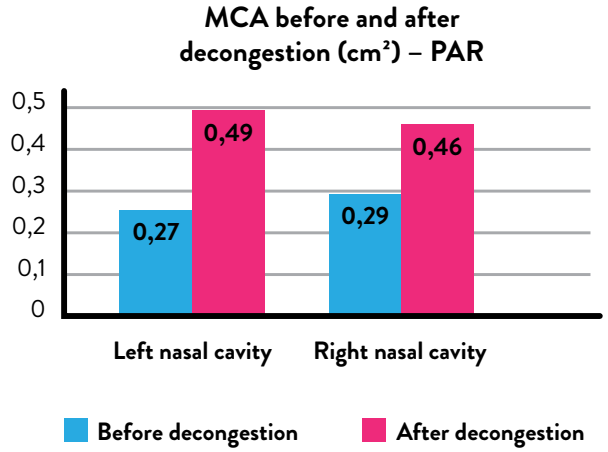

Figure 5. MCA in PAR patients before and after decongestion

MCA = minimum cross-section area; PAR = persistent allergic rhinitis

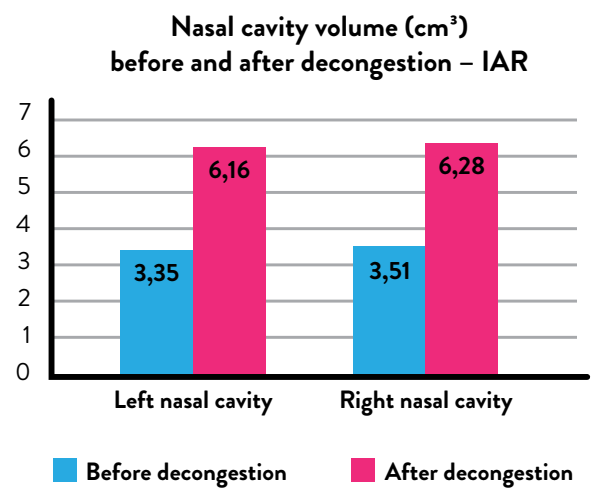

Figure 6. Nasal cavity volume in IAR patients before and after decongestion

IAR = intermittent allergic rhinitis

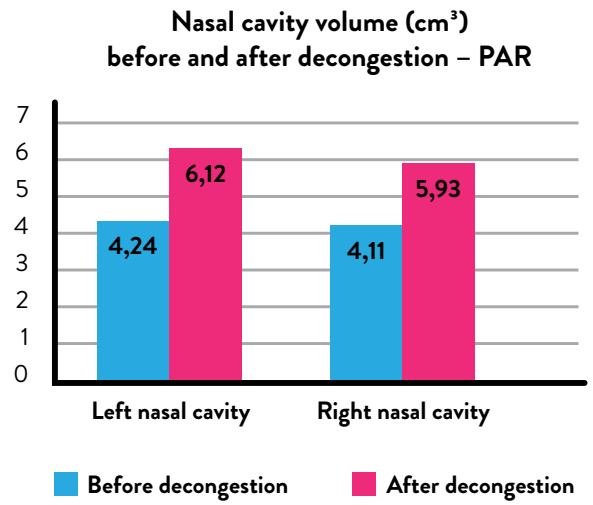

Figure 7. Nasal cavity volume in PAR patients before and after decongestion

PAR = persistent allergic rhinitis

(0.27 to 0.49 cm^2) for the left and 58.6% (0.29 to 0.46 cm^2) for the right nasal cavity (p=0.000, Mann-Whitney U test).

Changes in the mucosa lining of the entire nasal cavity maintained the hyporeactivity trend shown by MCA analysis, resulting in the increasing of nasal cavity volume of only 44.3% (4.24 to 6.12 cm^3) for the left and 45.7% (4.11 to 5.93 cm^3) for the right nasal half in the PAR group (Figure 7), unlike the mucosa of patients with IAR where decongestion increased

the volume by 83.9% (3.35 to 6.16 cm^3) in the left and 78.9% (3.51 to 6.28 cm^3) in the right nasal cavity (Figure 6).

Discussion

In normal breathing, about half of the total resistance of the respiratory tract is in the nasal airways, which means that relatively small changes in nasal patency significantly affect airway resistance and thus compromise overall respiratory function[8]. This finding primarily outlines one of the symptoms of AR – nasal obstruction – as potentially the most significant for the development of bronchopulmonary system complications and the key factor for such severe manifestations. ARm is widely used to evaluate specific dynamic changes in the nasal cavity. It is sensitive enough and provides information about the geometry and patency of the cavum nasi. It is also considered applicable in the detection of minimal abnormalities due to intranasal vasodilation or vasoconstriction[9].

To analyze nasal congestion in patients, caused by the presence of allergic rhinitis, and the compatibility of ARm in this pathology, we conducted a study of clinical participants and compared their results with a control group of healthy volunteers. We were able to identify significant differences between the two groups in terms of the MCA and the total nasal cavity volume. In allergic patients, the MCA values for the left and right half showed significant narrowing, respectively, 0.25 ± 0.06 cm^2 and 0.27 ± 0.07 cm^2. When comparing results with healthy participants, we can conclude that there is more than a 50% reduction of free air space in the narrowest place of the nasal cavity. For those without rhinitis, we obtained values of 0.59±0.14 cm^2, p=0.008 in the left, and 0.57±0.11 cm^2, p=0.006 in the right nasal cavity. Between the two main forms of the disease, we found a statistically significant difference in the measured area of MCA. In patients with intermittent AR in the left nasal half, we measured 0.23±0.09 cm^2 and 0.23±0.08 cm^2 in the right. In the subgroup affected by PAR, the value for the left nasal half was 0.27±0.08 cm^2, p=0.005, and for the right one 0.29±0.10 cm^2 (p = 0.007, Mann-Whitney U test). This data indicates that there is more manifested nasal congestion in IAR patients, possibly caused by the fact that pollen exerts a stronger immunological stimulus and induces a stronger expression of allergen-provoked symptoms, which induce year-round forms of AR. The distance of the minimum cross-section in the two analyzed groups was projected at approximately the same distance from the nasal entrance. In patients with IAR, the localization was at 2.24±0.04 cm in the left half and 2.21±0.05 cm in the right half. In the other subgroup, it was at 2.16±0.04 cm and 2.14±0.07 cm in the left and right nasal cavities, respectively. This location corresponds to the anterior pole of the lower nasal concha[10], where, according to the data presented in the literature, the place with the most significant narrowing is in patients with AR. The localization of the most marked swelling of the mucosa determined by our study – the lower nasal concha – corresponds entirely to the localization published in the report of Lenders *et al*.[11].

In our study, when looking for differences between IAR and PAR patients, we compared the mucosal reactivity of the lower nasal concha in the two main subgroups. The ability to respond with withdrawal caused by decongesting drops was 156.5% (0.23-0.59 cm^2) in the left and 147.8% (0.23-0.57 cm^2) in the right nasal half (p=0.000, Mann-Whitney U test) for patients with intermittent AR. A highly reduced reactive response in participants with persistent AR was demonstrated, with only 81.5% (0.27-0.49 cm^2) on the left side, and 58.6% (0.29-0.46 cm^2) on the right (p=0.000, Mann-Whitney U test) increased the size of the MCA. Concerning the total volume of the nasal cavity and the consequent ability of alpha-adrenergic receptors of the entire nasal mucosa, the results displayed a huge overlap in the findings we obtained in analyzing the MCA. Thus, the suppressed reactivity of the mucosa of the lower nasal concha in patients with PAR was confirmed for the rest of the mucosa covering the nasal cavity. Achieving an increase in the volume of only 44.3% (4.24-6.12 cm^3) for the left and 45.7% (4.11-5.93 cm^3) for the right nasal half in patients with PAR, showed almost a 50% reduction in achieving decongestion compared to participants with IAR, where the passability increased by 83.9% (3.35-6.16 cm^3) in the left half and by 78.9% (3.51-6.28 cm^3) in the right.

Conclusions

More manifested nasal congestion is observed in patients with IAR, probably because pollen has a stronger immunological stimulus and causes a more manifested expression of symptoms than allergens provoking year-round forms of AR. A severely reduced reactive response to nasal decongestants has been demonstrated in participants with persistent AR.

The presence in the literature of conflicting opinions about the use of ARm in patients with allergic nasal diseases leaves questions about the accuracy of its use in diagnosis and follow-up. However, ARm provides accurate measurements of the degree of swelling of the nasal mucosa and the size of the passable part of the nasal cavity making its application a reliable method for use in patients with this type of pathology. Also, the technique is suitable for assessing the condition in people with total or near-total nasal obstruction, as well as in those without nasal airflow, e.g. those who underwent laryngectomy. In the future, all the listed advantages will make ARm an integral part of the rhinologist's practice, as a chief or a supplementary diagnostic process.

Funding Statement

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Sažetak

STUDIJA AKUSTIČKE RINOMETRIJE U PACIJENATA S ALERGIJSKIM RINITISOM

A. Vlaykov

Akustička rinometrija neinvazivna je metoda koja zahtijeva minimalnu suradnju pacijenata u usporedbi s drugim dijagnostičkim metodama. Ova se metoda može primijeniti čak i kod djece mlađe od tri godine, što je čini široko primjenjivom u praksi rinologa. Cilj je ovog istraživanja bio proučiti nazalnu prohodnost i nazalni volumen u pacijenata s perzistentnim alergijskim rinitisom (PAR) i intermitentnim alergijskim rinitisom (IAR) koristeći akustičku rinometriju, te usporediti stupanj otečenosti sluznice nosa u pacijenata s različitim oblicima bolesti. Istraživanje je provedeno na području Sveučilišne bolnice „Prof. dr. St. Kirkovich" (Stara Zagora, Bugarska), gdje je pregledano 139 sudionika (111 s alergijskim rinosinusitisom [AR] i 28 kontrolnih ispitanika), u dobi od 19 do 84 godine. Za usporedbu rezultata, provedena je studija akustičkom rinometrijom na sudionicima i kontrolnoj skupini. Glavni pokazatelji uzeti u obzir bili su volumen nosne šupljine, minimalna površina poprečnog presjeka lijeve i desne polovice, kao i udaljenost od nosnog ulaza gdje se nalazi. Za provjeru reaktivnosti sluznice nosa, isti je test ponovljen nakon primjene nazalnog dekongestiva. Utvrđena je povećana otečenost sluznice nosa u pacijenata s PAR-om u usporedbi s onima s IAR-om. U pacijenata s IAR-om uočena je izraženija nazalna kongestija, vjerojatno zbog toga što pelud ima snažniji imunološki stimulus i uzrokuje izraženiju ekspresiju simptoma od alergena koji izazivaju cjelogodišnje oblike AR-a. U sudionika s perzistentnim AR-om demonstriran je značajno smanjen reaktivni odgovor na nazalne dekongestive.

Ključne riječi: *Alergijski rinitis*; *Akustička rinometrija*; *Nazalna opstrukcija*