Ukrainian Scientific Medical Youth Journal
Issue 2 (139), 2023
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ISSN 2786-6661
eISSN 2786-667X

PEDIATRICS / ПЕДІАТРІЯ

UDC:616-073.46:616.211-002-007.61-089.168-053.2
https://doi.org/10.32345/USMYJ.2(139).2023.99-104

Received: January 30, 2022
Accepted: April 20, 2023

The use of acoustic rhinometry as a postoperative evaluation method in children with chronic hypertrophic rhinitis

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Abstract: *acoustic rhinometry has opened new perspectives in the objective estimation of nasal physiology. With the help of this method, it is easy to determine the geometry of the nasal fossae, using minimal resources. The method offers an objective control of the surgery of the cartilages and bones of the nasal pyramid. That method represents an objective method of measuring nasal permeability, which in recent years is increasingly used in pediatric patients. In this study, we aim to evaluate nasal patency in children with chronic hypertrophic rhinitis. Study of nasal permeability using acoustic rhinometry in children with chronic hypertrophic rhinitis in order to evaluate the effectiveness of diode laser surgical treatment for hypertrophy of the inferior nasal turbinate. The study was conducted on 50 children with chronic hypertrophic rhinitis. The comparison group was represented by the control group, which includes 50 children without nose and paranasal sinus pathology. These children were selected from the number of patients hospitalized in the clinic with other forms of pathology. In patients from the study groups, nasal patency was evaluated at certain postoperative time intervals, in order to determine the efficiency of the applied surgical technique. There is a dynamic increase in nasal cavity volumes and ASTmin postoperatively in patients from the study group. Compared to the control group, the differences are insignificant, which indicates that the surgical treatment had an effect. Acoustic rhinometry is an objective method of evaluating the geometry of the nasal cavities, with a special role in the postoperative monitoring of patients with chronic hypertrophic rhinitis.*

Keywords: acoustic rhinometry, child, nasal cavity, nasal mucosa, nasal obstruction, rhinitis, turbinates

Introduction

The term chronic hypertrophic rhinitis defines a state of congestion of the mucous membranes of the nasal membrane and the submucosal tissues of the inferior nasal turbinates, which manifests symptoms such as unilateral, bilateral nasal obstruction, snoring, oral breathing, hyposmia-anosmia, anterior or posterior rhinorhea (Komshian, Cohen, Brook & Levi, 2019). Chronic hypertrophic rhinitis is one of the most common pathologies in rhinology. Although it is a benign chronic condition, the disease has a major impact on the patients' quality of life.

The prevalence of chronic hypertrophic rhinitis in children is 20-55%, and in recent years this index has been increasing. Epidemiological data on chronic hypertrophic rhinitis (CHR) estimate that more than 200 million people worldwide suffer from this condition. In the pediatric population, the disease showed a prevalence of 16.1% by the age

ISSN 2786-6661
eISSN 2786-667X

of 5 years and a prevalence of 42.3% by the age of 14 years (Hellings et al., 2017).

One of the perspective directions in improving medical care for children with chronic hypertrophic rhinitis is the establishment of risk factors that contribute to the development of the pathology.

In this sense, the group of children predisposed to chronic hypertrophic rhinitis can be identified, which would contribute to early diagnosis, dispensary and timely performance of treatment and prophylaxis actions, reducing the possibilities of chronicity and the occurrence of complications. One of the major symptoms presented by the patient with chronic hypertrophic rhinitis is nasal obstruction, which is a subjective parameter. The etiology of the obstruction and the treatment are often based on clinical, rhinoscopic data and very rarely – on objective methods (Rüttgers, Waldmann, Schröder & Lintermann, 2021).

Although the importance of the pathology is obvious, many aspects of it are still not elucidated. Therefore, the estimation of the permeability of the nasal passages, the architecture of their internal surface and the respiratory system as such is not sufficiently revealed. At the same time, it is very important, for the objectification of the results of the surgical treatment and for the monitoring of the postoperative period, to know the mentioned characteristics.

Acoustic rhinometry has been successfully applied by several authors to study nasal geometry and permeability in the pre- and postoperative periods, in patients with chronic hypertrophic rhinitis (Krzych-Fałta et. al., 2022; Volstad et. al., 2019). At the same time, in pediatric practice this method was used much less frequently (Ottaviano et. al., 2022).

The review of existing literature contains controversial data regarding the importance of acoustic rhinometry in the diagnosis of nasal obstruction. There are studies that state that acoustic rhinometry cannot be applied in the evaluation and monitoring of rhinological patients. On the other hand, in other works, the role of examinations using the rhinometric method in the pathology of the nose and paranasal sinuses is highly appreciated (Vogt et. al., 2018; Ottaviano et. al., 2019). Most of the works of this kind are devoted to septoplasty or surgery of the nasal turbinates. They denote the fact that the rhinometric data correlate with the results of rhinoscopy, rhinomanometry and/or tomodensitometry. Considering the above, we proposed to conduct a study devoted to the application of acoustic rhinometry in children with chronic hypertrophic rhinitis, subject to surgical treatment, in the aspect of objectification and evaluation of the results of surgical treatment.

Aim

Study of nasal permeability using acoustic rhinometry in children with chronic hypertrophic rhinitis in order to evaluate the effectiveness of diode laser surgical treatment for hypertrophy of the inferior nasal turbinate.

Material and methods

The researches were carried out on the basis of the Emilian Coțaga Republican Clinical Hospital. 50 children with chronic hypertrophic rhinitis, undergoing surgery, were included in the study. Children's age – from 7 to 17 years, 30 boys and 20 girls, subjected to diode laser surgery on the inferior nasal turbinates.

The clinical-instrumental examination of the patients was carried out on the basis of an examination sheet, developed by the author at the beginning of the study, which included: the data of the anamnesis, of the general clinical and otorhinolaryngological investigations, blood and urine summary, nasal endoscopy, rhinomanometry, computerized tomography, bacteriological examination, nasal mucosa thermometry.

We studied nasal permeability by acoustic rhinometry, with the RHIN2000 acoustic rhinometer. Postoperative monitoring of nasal patency was performed on the 7th day after surgery, 1 month, 6 months, and 18 months postoperatively. The equipment consists of: the generator of acoustic pulses, with the frequency from 150 to 10000 Hz; the acoustic tube with a diameter of 15 mm and a length of 580 mm; the adapter, the connection piece between the acoustic tube and the nostril, the microphone and the computer (fig. 1).

The entire curve contains the information about the geometry of the nasal cavity (fig. 2).

Nasal permeability changes more due to the anterior parts of the nose, the posterior ones influence less. In the anterior region of the nose, 2 minimum ASTs are described – curvature-I (area of the isthmus) and curvature C (anterior part of the inferior nasal turbinate). The volume between the distance 0-5 cm is also calculated. The surfaces between 5

ISSN 2786-6661
eISSN 2786-667X

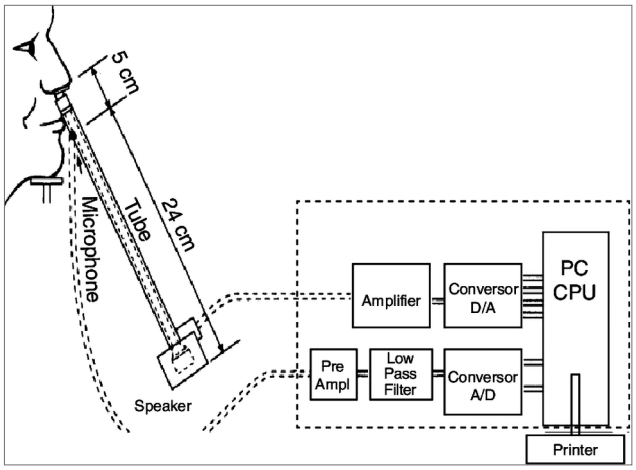

Figure 1. Diagram of the acoustic rhinometry device

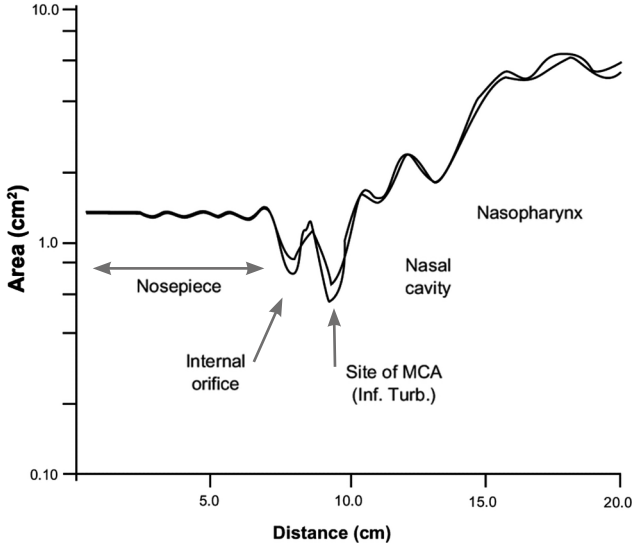

Figure 2. Surface/ distance graph, obtained by acoustic rhinometry

and 10 cm contain information about the paranasal sinuses and, in particular, about their ostia. The small size of the paranasal sinuses in children reduces artifacts due to loss of sound in the sinuses.

At the same time, in the aspect of determining the norms of the rhinometric examination of the nose, 50 children were investigated – the control group (35 boys and 15 girls), without the pathology of the nose and paranasal sinuses. These children were selected from the number of patients hospitalized in the clinic with other forms of pathology.

Results

We investigated the nasal permeability by acoustic rhinometry in the patients in the study group, compared to the children in the control group at the first visit. From the obtained results, it can be concluded that in the patients from the reference group, values were determined that indicate a state of substantial modification of the endonasal geometry, translated by decreasing the volume of the nasal fossae and by reducing the minimum cross-sectional area. Edema of the pituitary mucosa, its hyperplastic changes, hypertrophy of the nasal turbinates, nasal polyps constitute the anatomical substrate of the mentioned rhinometric disturbances. Therefore, acoustic rhinometry data, in patients with chronic hypertrophic rhinitis, are declared as an objective expression of the pathological processes within the nasal cavities. Due to the effects of the applied laser surgical treatment, the rhinometric indices in the research group had a generally positive evolution (figs. 3 and 4).

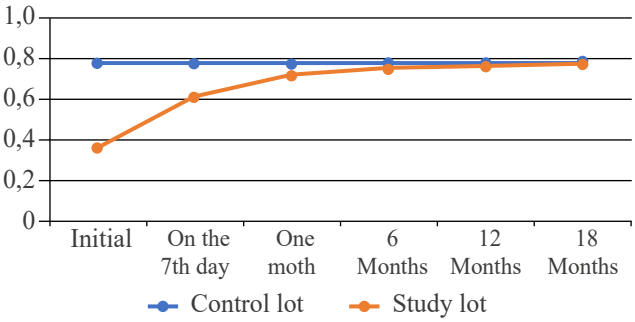

Figure 3. Dynamics of acoustic rhinometry (cross-sectional areas)

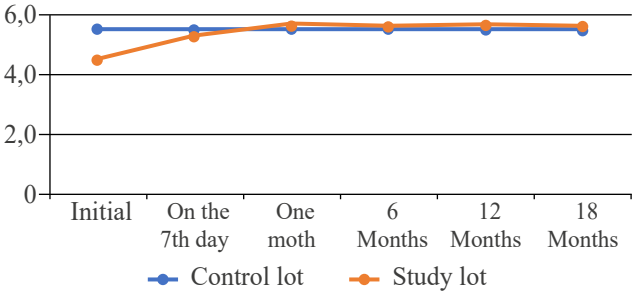

Figure 4. Acoustic rhinometry dynamics (nasal cavity volume)

The first rhinometric investigation was performed on the 7th day after the operation, at the end of the early postoperative period. Acoustic rhinometry is performed after the removal of crusts, clotted blood, remnants of ointment, granulations or synechiae. The 2nd rhinometric examination was performed towards the end of the late postoperative period – at 1 month, when the postopera-

ISSN 2786-6661
eISSN 2786-667X

tive cavities were well visualized. I performed the next investigation 6 months after the operation. Table 1 presents the data regarding the results of the nasal permeability examination by the rhinometric method. As the data presented in the table reveal, on the 7th day after the operation, in the patients of the study group, a statistically significant increase was found in the rhinometric values in the immediate postoperative period, both in the volume of the nasal cavities and in the minimum cross-sectional area ($p < 0.001$). More than a month after the surgical intervention, in the patients in the study group, the investigative indices approached in their value the results attested in the control group. The results of the acoustic rhinometry, more than 18 months after the surgical intervention, show a continuous increase in the results in the group of children with chronic hypertrophic rhinitis.

The surface of the nasal turbinates is made up of a pseudostratified columnar ciliated epithelium of the respiratory type that has an associated thick layer of glandular tissue with rich vascularity and erectile properties. The nasal turbinates are inserted into the lateral walls of the nasal cavities, curving medially and inferiorly into the nasal airways.

The inferior turbinates are responsible for most of the control of airflow direction, humidification, heating and filtering of air inhaled through the nose.

Camacho et al. classified the inferior turbinate's size as four grades based on its position in the total nasal airway space as visualized on nasoendoscopic assessment:

- Grade 1 is 0–25% of the airways;
- Grade 2 represents 26–50% of the airways;
- Grade 3 is 51–75% of the airways;
- Grade 4 is 76–100% of the airways.

The turbinates are responsible for filtering, warming and humidifying the air inhaled through the nose. Of the three functions listed above, filtration is mainly accomplished by other, more efficient means such as mucus and mucosal cilia. As the air passes through the turbinates, it is heated to 32–34 °C (89–93 °F), humidified (up to 98% water saturation), and filtered.

The respiratory epithelium covering the erectile tissue (or lamina propria) of the turbinate plays a major role in the body's first line of immunological defense. The respiratory epithelium is partly composed of mucus-producing goblet cells. This mucus, after being secreted, lines the nasal cavities and serves as a filter, capturing airborne particles larger than 2 to 3 micrometers. The respiratory epithelium also serves as a way for the lymphatic system that protects the body from viruses or bacteria to reach the nose.

Laser surgery is one of the methods frequently used in the volumetric reduction of the inferior nasal turbinates. The main advantages of using the laser in surgical practice are: the subsequent lack of bleeding (the hemostatic properties of the laser treatment being so strong that postoperative bleeding is very rare), the advantage of a controlled resection with minimal tissue effect, the possibility of performing it under local anesthesia, in most cases, and good hemostasis in the operative field and, therefore, no need for nasal tamponade.

Postoperative fibrin formation and crusting occur as a result of thermal damage to the mucosa and suggest the need for proper postoperative care. The wounds produced heal, on average, in 3–6 weeks, depending on the degree and extent of mucosal damage.

The advantage of the diode laser is the possibility of guiding the laser beam on the fiber and it is done through its direct contact with the turbinate hypertrophied tissue.

Regardless of the type of laser used, an important objective of laser turbinate surgery is to

Table 1. Acoustic rhinometry results

Parameter	Control lot	Study lot					
		Initial	On the 7th day	One month	6 months	12 months	18 months
AST (cm^2)	0,79	0,385	0,607	0,745	0,785	0,788	0,781
Volume (cm^3)	5,6	4,65	5,48	5,62	5,58	5,62	5,6

Note: AST – cross-sectional area.

ISSN 2786-6661
eISSN 2786-667X

perform this intervention under direct endoscopic control, with the 0º endoscopic rod, which allows the complete preservation of the nasal mucosa tissue to preserve its functions.

The analysis of the obtained results shows that the operations undertaken had a beneficial effect in the aspect of recovering the space parameters of the nasal fossae.

Discussion

Using acoustic rhinometry as a method to assess nasal patency in children with hypertrophy of the inferior nasal turbinate, our study confirms previous research in the field.

Acoustic rhinometry has opened new perspectives in the objective estimation of nasal physiology.

With the help of this method, it is easy to determine the geometry of the nasal fossae, using minimal resources. The method provides an objective control of the surgery of the cartilages and bones of the nasal pyramid.

An indispensable feature, which puts in the foreground the study, as well as the imminent treatment of this nosological entity in children, are the particularities of their upper respiratory tracts compared to those of adults. Namely, these differences make the child's pulmonary system more responsive to disturbances in the permeability of the upper respiratory tract. Among them, they have clinical relevance: narrow airways, poor collateral ventilation, reduced compliance of the lungs and ribcage, horizontal location of the ribs, rapid fatigue of the respiratory muscles, etc.

All these factors, in association with the deviation of the nasal septum, lead to profound damage, up to the decompensation of the activity of the respiratory system as a whole.

The sinus rhinometry is a very effective and easy to perform method, with the aim of establishing the degree of obstruction of the nasal passages. It is very useful for assessing the effectiveness of surgical treatment. The method was introduced a decade ago by investigating the airways of adults and provides for the description of the geometry of the nasal passages. This simple, fast and non-invasive method has very attractive features to be applied to children.

Conclusions

Acoustic rhinometry offers new perspectives and possibilities in the investigation of the nasal passages and their pathological changes. The minimally invasive nature, simplicity and speed of the method have a special value in applying this method to children.

Acoustic rhinometry can be successfully applied to study nasal geometry and permeability in the pre- and postoperative periods, in patients with chronic hypertrophic rhinitis.

Financing

This article received no financial support from a government, public or commercial organization.

Conflict of interest

Authors declare the absence of any conflicts of interests and own financial interest that might be construed to influence the results or interpretation of the manuscript

Consent to publication

Author read and approved the final version of the manuscript. All authors agreed to publish this manuscript.

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A – Conception and design of the work, B – Data collection and analysis, C – Responsibility for the statistical analysis, D – Writing the article, E – Critical review, F – Final approval of the article

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ISSN 2786-6661
eISSN 2786-667X

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Застосування акустичної ринометрії як методу післяопераційного обстеження дітей із хронічним гіпертрофічним ринітом

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Анотація: *акустична ринометрія відкрила нові перспективи в об'єктивній оцінці фізіології носа. За допомогою цього методу можна легко визначити геометрію носових ямок, використовуючи мінімальні ресурси. Метод дозволяє об'єктивно контролювати результати оперативнихвтручаннь хрящів і кісток носової піраміди. Цей метод являє собою об'єктивний метод вимірювання прохідності носа, який в останні роки все частіше використовується у дітей. У цьому дослідженні ми прагнемооцінити прохідність носа у дітей з хронічним гіпертрофічним ринітом. Дослідження назальної прохідності за допомогою акустичноїринометрії у дітей з хронічним гіпертрофічним ринітом з метою оцінкиефективності хірургічного лікування гіпертрофії нижньої носової раковинидіодним лазером. Обстежено 50 дітей з хронічним гіпертрофічнимринітом. Групу порівняння представляла контрольна група, до якої увійшло50 дітей без патології носа та навколоносових пазух. Ці діти були відібрані з числа хворих, госпіталізованих в клініку з іншими формами патології. У пацієнтів досліджуваних груп через певні післяопераційні терміни оцінювалипрохідність носа з метою визначення ефективності застосованої хірургічноїметодики. У пацієнтів основної групи в післяопераційному періоді спостерігається динамічне збільшення об'ємів носової порожнини та ASTmin. Порівняно з контрольною групою відмінності незначні, що свідчить про ефект від хірургічного лікування. Акустична ринометрія – це об'єктивний метод оцінки геометрії порожнини носа, який відіграє особливу роль у післяопераційному спостереженні за хворими на хронічний гіпертрофічний риніт.*

Ключові слова: акустична ринометрія, дитина, порожнина носа, слизоваоболонка носа, закладеність носа, риніт, носові раковини