DIAGNOSIS AND TREATMENT OF PATIENTS WITH ACUTE AND CHRONIC SINUSITIS USING DATA FROM STUDIES OF PHYSICOCHEMICAL PARAMETERS OF NASAL SECRETIONS

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ABSTRACT

Research and analysis of the physicochemical parameters of nasal secretions obtained in the production of the nasal tract are important in the treatment of various diseases. The influence of these parameters on the effective use of drugs is also essential. The acidity of the medium (pH), the density (ρ), and the viscosity (η) of the medium were determined and the specific electrical conductivity (χ) was changed. The selected physicochemical parameters must provide certain values (varying within narrow limits) for the human body. Significant changes in the nature of these indicators are observed in various misconceptions. Based on the above aspects, it can be concluded that it is of great importance to study these parameters.

Samples of nasal secretions were taken from people at different stages of their illness (at diagnosis, in the treatment process and after its completion). Samples from individuals with chronic and acute sinusitis were tested.

Based on the obtained data, for the acidity of the medium, density, viscosity, and specific electrical conductivity, it could be concluded that all patients benefitted from nasal saline irrigation. After the therapy, the general parameters under study, reach values close to the physicochemical parameters.

The results can be used as proper drug treatment or for improving the current drug studies.

Keywords: *physicochemical parameters, nasal secretions, chronic sinusitis*

INTRODUCTION

Sinusitis is an inflammation that causes pain, pressure, and swelling of the sinuses. Chronic sinusitis is an inflammation that lasts for a long period of time, usually in the time range of three to twelve weeks. Many people in the world suffer from this disease (more than fifty million people). In a healthy patient, the sinuses are full of air. In a patient suffering from sinusitis (regardless of whether it is acute, recurrent, or chronic), the sinuses fill with fluid. This condition causes inflammation and swelling of the nasal cavity. The discomfort experienced by patients is related to difficulty breathing (as a result of nasal congestion), tearing and swelling of the eyes and the area around them. Chronic sinusitis, also called chronic rhinosinusitis, can be caused by bacteria (less often), by upper respiratory tract infections, or by polyps in

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the area of the nasal cavity. This condition is more common in adults than in children. Chronic sinusitis is sometimes referred to as an occupational disease in various professions. Inflammation and blockage of the nasal cavity, impaired sense of smell, discharge of different thickness and color, puffiness of the face in the area of the nose and eyes, pain in the forehead and ears, allergies, disorder in the taste receptors, red throat, chronic fatigue, and others are among the most the common symptoms of this disease (1–4).

As mentioned above, bacteria are rarely the cause of chronic sinusitis. In these cases, patients are prescribed an antibacterial drug, such as amoxicycline. It is more common, however, for the cause to not be bacterial, and in these cases other treatment approaches are used. These can be antifungal preparations (if there is a fungal infection), vitamins and immunostimulating preparations (in case of weakened immunity), osteosteroids, sterols, steroids, antihistamines. In some patients, chronic sinusitis is a concomitant disease, and then treatment of the underlying disease is required first. Although rare, some patients with deviated nasal septum can be treated surgically.

AIM

The aim of the study is to research of the physicochemical parameters of nasal secretions obtained in the production of the nasal tract and their application in the treatment of various diseases.

MATERIALS AND METHODS

1. Materials

Samples of nasal secretions were taken from people (nine patients) at different stages of their illness.

2. Solutions

Saline solutions were purchased from a pharmacy.

3. Experimental conditions

Stock solutions of nasal secretions were homogenized and stored at 7°C ± 1°C in a refrigerator. All experiments were performed at temperature 36.5°C ± 0.5°C. All glassware was cleaned with hot concentrated chromic sulfuric acid and rinsed before use with double distilled water.

4. Methods

4.1. Potentiometry—physicochemical methods based on the measurement of the electromotive force of circuits. These circuits consist of two main elements: an indicator electrode and a reference electrode. At the heart of the potentiometric method of analysis lies the Nernst equation. The essence of potentiometry is to measure the difference in the electromotive force of the two electrodes. One of them is measuring and the other is auxiliary. In addition, both electrodes should be placed in the test solution. It is very important to note that the electromotive force strongly depends on the temperature. For this reason, all instruments used for analysis, in particular, pH meters and ionometers, are additionally equipped with temperature compensators that can be controlled manually and automatically. The acidity of an aqueous solution can be measured by direct potentiometry. The essence of this method is that it is necessary to measure the exact value of the electrode potential and then to find the activity of the potential-determining ion in the solution according to the Nernst equation (5, 6).

4.2. Ostwald's method (viscosimetry)—when a liquid moves under the action of some applied force, layers of liquid slip. During this slip, an internal friction force arises between them, which according to Newton's law is proportional to the area of the friction surfaces and the velocity gradient. The viscosity **η** is the force of internal friction between two layers with contact area S = 1 m2, if one moves relative to the other at a speed of 1 m/s and covers a distance of 1 m. Viscosity depends on the nature of the liquid, temperature, and pressure (for gases). In the SI system it is measured in Pa·s and is called the absolute viscosity. The viscosity η can be determined by Poisoy's law by measuring the time for which a certain volume of liquid flows through a standard capillary at a known pressure difference. Most often, relative measurements are performed, which determines the relationship between the viscosities of two liquids—the studied one and the one with known viscosity. The Ostwald viscometer is used for this type of measurement and the viscosity determined by this method is called relative viscosity. It follows from Poisoy's law applied to the flow of liquid through the capillary of the viscometer that, on the one hand, will be proportional to time and,

on the other, to the relative weight of the liquid, because in this case the pressure difference is created by hydrostatic fluid pressure. Since the coefficient of internal friction (viscosity) strongly depends on the density and temperature, the density needs to be taken into account and the temperature controlled (6, 7).

4.3. Weight method for measuring density—density is measured for various substances, solutions, biological and physiological fluids of solids. Combining density data with data for other physicochemical methods may be an indicator of possible causes of changes in the properties of the test substance. Density determination is one of the most commonly used weighing methods in laboratories using a flask called a pycnometer. The pycnometer is a glass or metal container with a fixed volume that is used to measure both density and dispersion by simply weighing the fixed volume. It is primarily used to determine the density of substances in the form of powder or granules, which are brought into a solution. Depending on their field of application, pycnometers have different shapes and meet different standards. During the measurement, it is important that all weighing operations are performed at a constant temperature and that no air is allowed to remain in the liquid or between the sample particles. In the general case, the viscosity of a solution can be determined using an additional liquid of known density and three weighings are performed. The density of the tested liquid is determined by a mathematical formula, based on the results obtained for: mass of the dry and clean pycnometer; for the mass of the pycnometer filled with the reference liquid; for the mass of the pycnometer filled with the test fluid; density of the reference fluid at the corresponding temperature (8, 9).

4.4. Conductometry—a method for measuring the specific electrical conductivity. Electrochemical methods of analysis are a set of methods for qualitative and quantitative analysis based on electrochemical phenomena. The application of these methods in quantitative analysis is based on the dependence of the values of the measured parameters in the course of the electrochemical process on the substance released in the analyzed solution, participating in this electrochemical process. These parameters include the difference in electrical potentials and the amount of electricity. Any electrolyte solution has the ability to conduct an electric current. In such a solution, a chemical process takes place on the one hand, and an electrochemical process on the other. The chemical process is usually associated with the phenomenon of hydrolysis, and the electrical—with the electrical properties of a system. In analytical practice, an electrochemical system usually consists of an electrochemical cell, which includes a vessel with an electrically conductive test solution in which the electrodes are immersed. Conductometric analysis is based on measuring the specific electrical conductivity of an electrolyte solution. Equivalent electrical conductivity can also be calculated using a mathematical formula, which demonstrates the relationship between the specific electrical conductivity and the concentration of the solution. The values obtained for both quantities can be shown graphically as a function of the concentration of the respective solution. The electrical conductivity of electrolyte solutions—conductors of the second type—is assessed on the basis of measuring their electrical resistance in an electrochemical cell, which is a glass vessel (glass) with two electrodes soldered in it, between which the test electrolyte solution is located. An alternating electric current is passed through the cell. The electrodes are most often made of platinum, which is coated with a layer of spongy platinum to increase the surface of the electrodes by electrochemical deposition of solutions of platinum compounds (9).

5. Calculation procedures

Calculation of the density and viscosity of work solutions. Based on the data of the weight of the pycnometer the density of work solution was calculated by Eq. 1, (9)

$$\rho=(m_1-m)/(m_0-m)\ \rho_0 \quad (1)$$

ρ—density of work solution

ρ0—density of saline solution

m—weight of pycnometer

m1—weight of pycnometer with work solution

m0—weight of pycnometer with saline solution

Based on the data of the density, the viscosity of work solution was calculated by Eq. 2

$$\eta=\eta_0\ (\rho\times t)/(\rho_0\times t_0) \quad (2)$$

η—viscosity of work solution
η0—viscosity of saline solution
ρ—density of work solution
ρ0—density of saline solution
t0—time to drain the saline solution
t—time to drain the work solution

6. Sequence of experiment

Samples of nasal secretion washes were stored in a refrigerator until the time of the experiment. All washes were done with saline. The first step of the experiment was to determine the studied physicochemical parameters of the saline solution, which has constant values for acidity, viscosity, density, and electrical conductivity. All experiments, both on the reference fluid (saline) and on specific patient samples, were performed at physiological temperature (36°C). This was followed by the determination of each of the parameters for the specific patient sample. When washing is performed on a patient in whom no momentary or chronic changes in physiological condition are observed, the test parameters tested should be identical to the saline values. Nasal secretion samples were taken from patients at different stages of their illness (at diagnosis and in the course of the treatment). The samples that were tested were from patients diagnosed with chronic sinusitis.

RESULTS AND DISCUSSION

Salt water, often used in pharmacy, contains a certain concentration of dissolved salts. It mainly contains the salt NaCl, the concentration of which can be expressed in parts per million (ppm) or as a percentage. The maximum solubility of various salts in water depends on the type of salts and on the temperature. For the sodium chloride salt, it was found that at standard temperature the maximum solubility is 357 g/dm3, and at a temperature corresponding to the boiling point of water, it is 391 g/dm3. Processed sea water is often used in the pharmaceutical industry (1,10,11). Rinsing of the nasal cavity with physiological solution is a new and very good alternative for accompanying treatment of chronic sinusitis. The physicochemical parameters of the saline used (physiological 0.9% NaCl solution) were studied. The values obtained are seen in Table 1.

Table 1. Data for saline solution.

Parameters	Values
Acidity	7.4
Density	994.06 kg/m3
Viscosity	0.001005 Pa·s
Conductivity	14.5 mS/cm

The tested samples were few in number and no definitive conclusion can be drawn. At present, there is not enough data available to perform statistical processing of the results. Based on the obtained data on the acidity of the medium, density, viscosity, and specific electrical conductivity, a trend was found that all patients benefited from nasal lavage. In the initial biological samples (relative to physiological values), the change in the studied physicochemical parameters was significant. After therapy, by washing the nasal mucosa, an improvement in the general condition and normalization of physicochemical parameters was found.

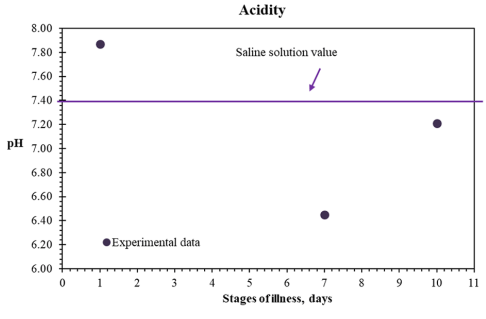


Fig. 1. Change in acidity during treatment.

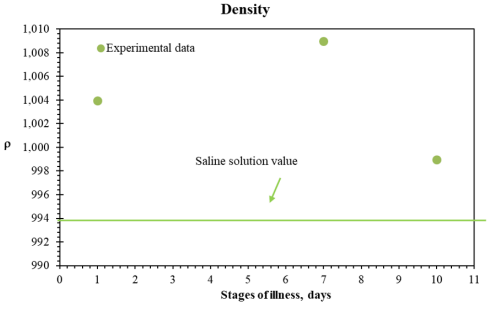


Fig. 2. Change in density during treatment.

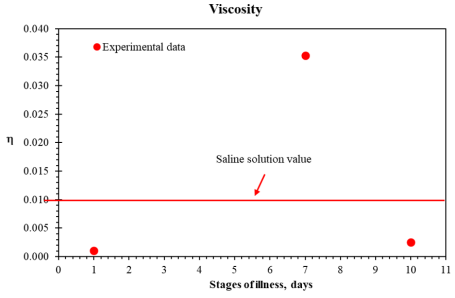


Fig. 3. Change in viscosity during treatment.

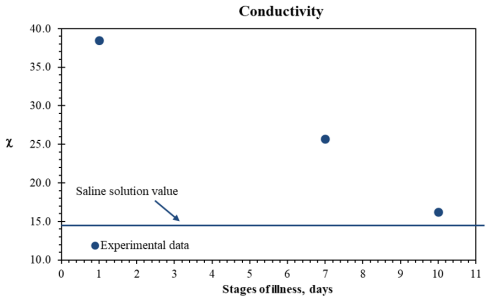


Fig. 4. Change in conductivity during treatment.

Table 2. Summarized data.

	Acidity pH	Density ρ, (kg/m3)	Viscosity η, (Pa·s)	Conductivity χ, (mS/cm)
Saline solution	7.40	994.06	0.001005	14.5
Sample 1	7.87	1003.97	0.001020	16.6
Sample 1'	7.45	998.02	0.001028	15.1
Sample 2	8.30	1008.99	0.001180	22.3
Sample 2'	4.63	999.25	0.001009	15.5
Sample 3	7.96	1184.48	0.001240	15.8
Sample 4	7.87	1003.9725	0.001018	38.5
Sample 4'	6.45	1008.9836	0.035280	25.7
Sample 4''	7.21	998.9856	0.009005	16.2
Sample 5	5.96	1102.35	0.002528	15.8
Sample 6	8.45	1069.85	0.037410	25.7
Sample 7	8.63	1102.05	0.027410	19.6
Sample 7'	7.52	996.47	0.007981	14.9

CONCLUSION

Based on the obtained data on the acidity of the medium, density, viscosity and specific electrical conductivity, a trend was found that for all patients a positive benefit of nasal lavage was found. In the initial biological samples (relative to physiological values), the change in the studied physicochemical parameters was significant. After therapy, by washing the nasal mucosa, an improvement in the general condition and normalization of physicochemical parameters was found. The changes were most significant during the treatment itself (about 7 days). At the end of treatment, the values were closest to the physiological ones (about 10 days). The results can be used in deciding on the appointment of medical treatment. The results can be used in the production of new medicinal products.

From the presented graphs and tables, it has been established that:

- Changes are most significant during the treatment (about 7 days).
- At the end of the treatment the values are closest to the physiological ones (about 10 days).
- In order to present a reliable analysis of the data, it is necessary to examine samples before starting treatment, on the third, fifth, seventh,

and tenth day, and seven days after the end of treatment.

- Additional tests are needed to determine the effect of leaching.

REFERENCES

1. Meltzer EO, Hamilos DL. Rhinosinusitis diagnosis and management for the clinician: a synopsis of recent consensus guidelines. Mayo Clin Proc. 2011;86(5):427-43. doi: 10.4065/mcp.2010.0392.
2. Leung RS, Katial R. The diagnosis and management of acute and chronic sinusitis. Prim Care. 2008;35(1):11-24, v-vi. doi: 10.1016/j.pop.2007.09.002.
3. Aring AM, Chan MM. Current concepts in adult acute rhinosinusitis. Am Fam Physician. 2016;94(2):97-105.
4. Calhoun KH, Schofield ML. Rhinosinusitis: update on diagnosis and management. Consultant 360. 2013;53(7). Available at: https://www.consultant360.com/article/rhinosinusitis-update-diagnosis-and-management.
5. El-Ragehy A, Hegazy M, Sedik G, Ali S. Validated potentiometric method for the determination of sulfacetamide sodium; application to its pharmaceutical formulations and spiked rabbit aqueous humor. Bull Fac Pharm Cairo Univ. 2018;56(2):207-12. doi: 10.1016/j.bfopcu.2018.08.002.
6. Gerasimova A. Kinetic behavior of the foam films from aqueous solutions of bovine serum albumin and n-dodecyl-β-D-maltoside. Dissertation summary; 2016.
7. Verma M, Wasnik N, Sai Sneha T, Rajalingam S. Measurement of viscosity for various liquids by using Ostwald viscometer and interfacing with Labview. Int J Appl Eng Res. 2013;8(19):2369-72.
8. Joshi T, Mata J, Patel T. Conductometry and thermodynamics study of metal dodecyl sulfates in aqueous solution. J Dispers Sci Technol. 2007;28(8):1158-63. doi: 10.1080/01932690701525510.
9. Blake GR. Bulk density. In: Black CA, editor. Methods of soil analysis: part 1 physical and mineralogical properties, including statistics of measurement and sampling. American Society of Agronomy, Inc; 1965. pp. 374-90. doi: 10.2134/agronmonogr9.1.c30.
10. Lide DR, editor. CRC handbook of chemistry and physics. 86th ed. Boca Raton (FL): CRC Press; 2005. pp. 8–71, 8–116.
11. Weast R, editor. CRC Handbook of Chemistry and Physics. 63rd Edition. CRC Press;1982-1983.