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ABSTRACT

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A NEW APPROACH TO PREDICTING THE RISK OF CHRONIC MESOTYMPANITIS RECURRENCE IN PATIENTS OF DIFFERENT SEXES USING REGRESSION ANALYSIS

Chronic mesotympanitis is a variant of chronic suppurative otitis media, accompanied by perforation of the tympanic membrane in the stretched part and characterized by decreased hearing acuity, otorrhea, intoxication syndrome, a feeling of "stuffiness" in the ear, and noise of various nature.

The aim of the work is to propose a new approach to predicting the risk of chronic mesotympanitis recurrence depending on the sex of patients using multivariate regression analysis.

Materials and methods. We examined and operated on 222 patients (130 women and 92 men) aged 18 to 80 years with a diagnosis of chronic mesotympanitis and underwent tympanoplasty.

Results. Using multivariate regression analysis, 13 factors with a significance level of less than 0.05 for the group of men and 9 factorial characteristics for the group of women were analysed. Histograms of residual deviations of the prediction of chronic mesotympanitis recurrence, as well as normal probability plots, the results of which confirm the statistical hypothesis that the residual deviations correspond to the normal distribution law, were obtained.

The coefficient of determination, which shows the proportion of factors taken into account in the prediction, was 0.944 in the group of men and 0.919 in the group of women, which gives grounds to assert that 94.4% of factors in the group of men and 91.9% in the group of women, respectively, were taken into account in the model for predicting recurrence of chronic mesotympanitis and that it is highly reliable and acceptable in general.

Conclusions. The use of a mathematical model of multifactorial regression analysis, which considers the most likely risk factors for the recurrence of chronic mesotympanitis, allows for timely prevention of

the disease, prevention of potential complications and recurrences, as well as the development of algorithms for preoperative preparation and postoperative rehabilitation.

Keywords: regression analysis, chronic mesotympanitis, prediction, sex, recurrence, tympanoplasty.

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РЕЗЮМЕ

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НОВИЙ ПІДХІД ДО ПРОГНОЗУВАННЯ РИЗИКУ РЕЦИДИВУ ХРОНІЧНОГО МЕЗОТИМПАНИТУ У ПАЦІЄНТІВ РІЗНОЇ СТАТІ ЗА ДОПОМОГОЮ РЕГРЕСІЙНОГО АНАЛІЗУ

Хронічний мезотимпаніт – це варіант хронічного гнійного середнього отиту, що супроводжується перфорацією барабанної перетинки у натягнутій частині та характеризується зниженням гостроти слуху, отореєю, інтоксикаційним синдромом, відчуттям «закладеності» вуха, шумом різного характеру.

Мета роботи – за допомогою використання багатофакторного регресійного аналізу запропонувати новий підхід до прогнозування ризику рецидиву хронічного мезотимпаніту залежно від статі пацієнтів.

Матеріали та методи. Нами обстежено та прооперовано 222 пацієнти (130 жінок та 92 чоловіки) віком від 18 до 80 років з діагнозом хронічного мезотимпаніту та перенесли тимпанопластику.

Результати. За допомогою багатофакторного регресійного аналізу проаналізовано 13 факторів із рівнем значущості меншим 0,05 для групи чоловіків та 9 факторних ознак для групи жінок. Отримані гістограми залишкових відхилень прогнозування рецидиву хронічного мезотимпаніту, а також нормально-ймовірнісні графіки, результати яких підтверджують статистичну гіпотезу про відповідність залишкових відхилень нормальному закону розподілу.

Коефіцієнт детермінації, який показує, яка частка факторів врахована при прогнозуванні, становив 0,944 у групі чоловіків та 0,919 у групі жінок, що дає підстави стверджувати про врахування 94,4 % факторів у групі чоловіків та 91,9% у групі жінок відповідно, в моделі прогнозування рецидиву хронічного мезотимпаніту та про високу її достовірність і прийнятність в цілому.

Висновки. Застосування математичної моделі багатофакторного регресійного аналізу, яка враховує найбільш вірогідні фактори ризику виникнення рецидиву хронічного мезотимпаніту дає можливість вчасної профілактики захворювання, запобігання потенційних ускладнень та рецидивів, а також розробки алгоритмів передопераційної підготовки та післяопераційної реабілітації.

Ключові слова: регресійний аналіз, хронічний мезотимпаніт, прогнозування, стать, рецидив, тимпанопластика.

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ABBREVIATIONS

CM – chronic mesotympanitis;

CSOM – chronic suppurative otitis media;

QoL – quality of life;

WHO – World Health Organization;

MERI – Middle Ear Risk Index;

RCCMR – risk coefficient of CM recurrence

INTRODUCTION

Chronic mesotympanitis (CM) is a variant of chronic suppurative otitis media (CSOM), accompanied by perforation of the tympanic membrane in the stretched part and characterized by decreased hearing acuity, otorrhea, intoxication syndrome, a feeling of "stiffness" in the ear, noise of various nature. The clinical picture is occasionally supplemented by vestibular disorders and pain.

In mesotympanitis, the mucous membrane of the middle ear is thickened, in particular with the presence of granulation. Large granulation is called an ear polyp, which can prolapse into the external auditory canal through the perforation and even obstruct it. This leads to retention of pus in the cavities of the middle ear and can cause the development of complications.

CSOM is characterized by a significant reduction in auditory function, which can lead to communication problems, impairing social interaction and professional life. Conductive hearing loss is considered a serious disability, contributing to a significant burden of disease worldwide [1]. In addition, persistent ear discharge, pain or frequent visits to the doctor can lead to a serious deterioration in the quality of life (QoL) of patients [1].

Early detection and appropriate treatment of these cases are vital, especially to alleviate the complications associated with this disease. According to the World Health Organization (WHO), the prevalence of CSOM in the world is 65-330 million people, with 60% of them having hearing loss. The incidence rate is 9 cases per 100,000 population [2].

Tympanoplasty is a relatively common procedure performed by otosurgeons for various indications, such as creating a safe ear, repairing perforated eardrums, and improving hearing [2, 3]. The primary goal of tympanoplasty is to restore the integrity of the tympanic membrane [2, 4].

The severity of CSOM affects the prediction and course of the disease. Kartush introduced the Middle Ear Risk Index (MERI) scoring system, which indicates the severity of Eustachian tube dysfunction and infection in CSOM [2, 5]. MERI is one of the methods used to predict the outcome of surgery. It considers both preoperative and postoperative middle ear conditions [2, 5].

Also, the most relevant characteristics of CSOM, including clinical symptoms, functional and

psychological impairments, are well represented in the COMOT-15 questionnaire [2, 6].

Despite such many questionnaires, the prediction of the risk of chronic mesotympanitis recurrence remains open to date. It is particularly noteworthy that none of them provides for the determination of sex-dependent prediction of relapse risk.

The creation of appropriate predictive mathematical models, which include several predictors that may be the cause of a repeated inflammatory process, will allow for timely and reliable diagnosis of the possibility of CM recurrence, as well as be one of the options for solving the current problem of effective treatment of ENT diseases.

One of the fairly accurate and widely used methods for predicting the recurrence of various diseases today is the construction of a multifactorial regression model [7].

Approaches to building multifactorial regression prediction models in medicine are considered in the works of Herasymiuk M. et al. (2024); Herasymiuk M. et al. (2023), Musiienko V. et al. (2021); Musiienko V. et al. (2022) [7, 8, 9].

The purpose of the work is to propose a new approach to predicting the risk of chronic mesotympanitis recurrence depending on the sex of patients using multifactorial regression analysis.

MATERIALS AND METHODS

We examined and operated on 222 patients (130 women and 92 men) aged 18 to 80 years with a diagnosis of chronic mesotympanitis, who were inpatients in the otolaryngology department of the Ternopil Regional Clinical Hospital and underwent tympanoplasty.

All patients signed an informed consent to participate in the study. After receiving the conclusion of the ethics committee of the I. Horbachevsky Ternopil National Medical University (minutes 81 dated April 03, 2025), the study was carried out in compliance with all moral and ethical principles, taking into account the World Medical Association Declaration of Helsinki.

On the eve of hospitalization and surgery, each patient underwent a comprehensive clinical and laboratory examination (complete blood count with leuko-formula, biochemical blood test), a traditional otolaryngological examination, collection of life and disease history, to register previous ear surgeries and the

duration of the disease, and, if necessary, consultations with related specialists.

According to a specially developed questionnaire for assessing the risk of CM recurrence, which included MERI criteria, all patients were surveyed on 19 potential risk factors for CM development: age, sex, environmental living and working conditions, the presence of leucocytosis (according to the leuko-formula), ESR and glycemia levels, the presence of diagnosed diabetes mellitus and kidney disease, nasal septum deviation, chronic sinusitis, nasal polyposis, vasomotor rhinitis, adenoid vegetations (in history), incidence of acute respiratory viral infections during the last 12 months, chronic tonsillitis, as well as local otological symptoms such as the size of the perforation of the eardrum, the presence of a middle ear polyp, the duration of the disease and previously undergone surgical interventions on the middle ear. Based on the data obtained, their gradation was established from numerical values.

The construction of a predictive model of the risk of CM recurrence was carried out by multivariate regression analysis. Statistical processing of the obtained data was performed using the statistical package Statistica 10.0 and the spreadsheet editor Microsoft Excel 2019.

RESULTS

To build a multivariate regression model for predicting CM recurrence, probable factors of chronic mesotympanitis were selected. The use of this method, which considers the most informative factors and variants of their severity, allows predicting the possibility of recurrence, which helps in the development of effective methods of treatment, prevention of the development and progression of pathology.

Since the aim of this study was to establish the dependence of disease progression on sex, the factor

"Sex" was removed from the analysis even before the beginning of the study, and patients were divided into two groups accordingly.

Using multivariate regression analysis, 15 probable factors of CM occurrence were analysed for each sex separately: age, environmental living and working conditions, presence of leucocytosis (according to leuko-formula), ESR and glycemia levels, presence of diagnosed diabetes mellitus, nasal septum deviation, chronic sinusitis, nasal polyposis, vasomotor rhinitis, incidence of flu infection during the last 12 months, as well as local otological symptoms such as the size of the perforation of the eardrum, the presence of a middle ear polyp, the duration of the disease and previously undergone surgical interventions on the middle ear.

To determine the significance of factorial features influence, in the Statistica 10.0 program, a stepwise multivariate regression analysis was performed to calculate the regression coefficients "b" (Beta), which reflect for each selected factor the relationship regarding the influence on the development of CM recurrence in the examined patients.

During the regression analysis, 6 factorial characteristics were removed from the group of women ("ESR level", "Diabetes mellitus", "Glucose level", "Nasal polyposis", "Incidence of flu infection", "Duration of the disease"), and in the group of men – 2 characteristics ("ESR level" and "Polyposis of the nasal cavity"), which are determined by the model as invalid, since they have a significance level of $p \geq 0.05$.

The result of obtaining significant factors for predicting recurrence of CM for each group when conducting multivariate regression analysis in the Statistica 10.0 program is shown in Fig. 1 and Fig. 2.

RCCMR	Regression Summary for Dependent Variable: RCCMR (1 in 11)					
	R= .97162428 R²= .94405374 Adjusted R²= .93472936 F(13,78)=101.25 p<0.0000 Std. Error of estimate: .19288					
N=92	b*	Std. Err. of b*	b	Std. Err. of b	t(78)	p-value
Intercept			-1.64859	0.139893	-11.7846	0.000000
X1 – Age	0.288585	0.040340	0.24734	0.034575	7.1538	0.000000
X2 – Working	0.231348	0.043153	0.15218	0.028387	5.3611	0.000001
X3 – WBC level	0.351619	0.030989	0.14353	0.012650	11.3464	0.000000
X4 – Diabetes	-0.160187	0.051054	-0.42687	0.136049	-3.1376	0.002404
X5 – Glycemia level	0.229204	0.051717	0.49097	0.110782	4.4319	0.000030
X6 – Middle ear polyp	0.166093	0.037306	0.25329	0.056891	4.4521	0.000028
X7 – Nasal septum deviation	0.276215	0.040833	0.21841	0.032288	6.7646	0.000000
X8 – Chronic sinusitis	0.105482	0.043779	0.16409	0.068102	2.4094	0.018335
X9 – Vasomotor rhinitis	0.110841	0.036803	0.18088	0.060058	3.0117	0.003501
X10 – Incidence of flu	0.204359	0.033999	0.19691	0.032759	6.0108	0.000000
X11 – Size of the eardrum	0.245621	0.031043	0.36921	0.046663	7.9122	0.000000
X12 – Duration of the disease	0.252646	0.042640	0.14307	0.024147	5.9252	0.000000
X13 – Previous surgeries on the middle ear	0.238516	0.044329	0.36373	0.067601	5.3805	0.000001

Figure 1 – The result of obtaining significant factors for predicting recurrence of CM in the group of men when conducting multivariate regression analysis in the Statistica 10.0 program

Regression Summary for Dependent Variable: RCCMR (1 in 1)						
R= ,95890538 R ² = ,91949953 Adjusted R ² = ,91346200						
F(9,120)=152,30 p<0,0000 Std. Error of estimate: ,21183						
N=130	b*	Std. Err. of b*	b	Std. Err. of b	t(120)	p-value
Intercept			-0,501665	0,105054	-4,77531	0,000005
X1 - Age	0,271236	0,034833	0,235903	0,030295	7,78675	0,000000
X2 - Working conditions	0,066564	0,031849	0,049762	0,023809	2,08999	0,038731
X3 - WBC level	0,453021	0,032242	0,178353	0,012694	14,05072	0,000000
X4 - Middle ear polyp	0,218122	0,029876	0,349658	0,047892	7,30090	0,000000
X5 - Nasal septum deviation	0,213245	0,034465	0,206248	0,033334	6,18724	0,000000
X6 - Chronic sinusitis	0,137309	0,038077	0,201052	0,055753	3,60611	0,000454
X7 - Vasomotor rhinitis	0,119844	0,027355	0,178135	0,040660	4,38103	0,000025
X8 - Size of the eardrum	0,179529	0,027431	0,235819	0,036031	6,54483	0,000000
X9 - Previous surgeries on the middle ear	0,332940	0,028234	0,376063	0,031891	11,79206	0,000000

Figure 2 – The result of obtaining significant factors for predicting recurrence of CM in the group of women when conducting multivariate regression analysis in the Statistica 10.0 program

According to the results of multivariate regression analysis of predicting the rate of CM recurrence, which are shown in Fig. 1 and Fig. 2, we build a mathematical

model to determine the risk coefficient of CM recurrence (RCCMR) for men and women:

$$\text{RCCMRM} = X1 * 0,24734 + X2 * 0,15218 + X3 * 0,14353 + X4 * (-0,42687) + X5 * 0,49097 + X6 * 0,25329 + X7 * 0,21841 + X8 * 0,16409 + X9 * 0,18088 + X10 * 0,19691 + X11 * 0,36921 + X12 * 0,14307 + X13 * 0,36373 - 1,64859;$$

$$\text{RCCMRW} = X1 * 0,235903 + X2 * 0,049762 + X3 * 0,178353 + X4 * 0,349658 + X5 * 0,206248 + X6 * 0,201052 + X7 * 0,178135 + X8 * 0,235819 + X9 * 0,376063 - 0,501665;$$

where RCCMRM – risk coefficient of CM recurrence for men;

RCCMRW – risk coefficient of CM recurrence for women;

X1-X13 – selected risk factors for CM recurrence with regression coefficients in each group;

-1.64859 – constant in the group of men;

-0.501665 – constant in the group of women.

Analysis of residual deviations provides grounds for assessing the quality of the regression model (Fig. 3). As can be seen from the obtained histograms, the residual deviations, both in the group of men and in the group of women, are distributed symmetrically, approaching the curve of the normal distribution of residuals, therefore, the statistical hypothesis that their distribution conforms to the normal distribution law is not rejected.

To further confirm the normal distribution of residual deviations, a normal probability plot was constructed (Fig. 4). It is worth noting that the plot does not show any systematic deviations from the normal probability line. From this, we conclude that the residual deviations are also distributed according to the normal distribution law.

The final stage of assessing the overall goodness of fit of the model was an ANOVA analysis (Fig. 5, Fig. 6). Since the significance level in both groups was $p < 0.001$, we can conclude that the overall goodness of fit of the model for predicting the risk of CM recurrence is high. The results obtained indicate that the model

itself will perform better than a simple prediction using average values.

The last criterion of the quality of the mathematical model was the analysis of the Nigelskirk's coefficient of

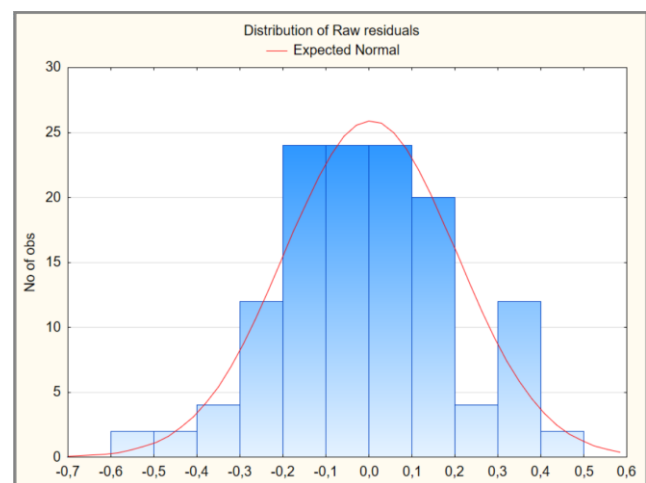


Figure 3 – Histogram of residual deviations of the multivariate regression model for predicting CM recurrence in the group of women

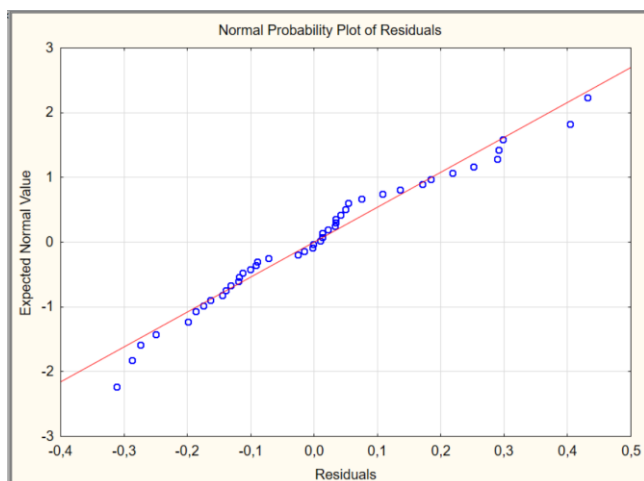


Figure 4 – Normal probability plot of residual deviations of the multivariate regression model for predicting CM recurrence in the group of men

determination (R^2), which shows what proportion of factors is considered in the prediction. The closer its value approaches "1", the higher the quality of the multifactorial regression model. In the proposed mathematical model of the RCCMR in the group of men, the coefficient of determination was $R^2=0.944$ (in the Statistica 10.0 program $R^2=,94405374$ (Fig. 1)), in

the group of women - $R^2=0.919$ (in the Statistica 10.0 program $R^2=,91949953$ (Fig. 2)). Thus, in our case, 94.4% of factors were considered in the model for predicting the risk of CM recurrence in the group of men and 91.9% of factors in the group of women, respectively.

DISCUSSION

The use of the prognostic mathematical model proposed by us, which considers possible risk criteria for the development of CM recurrence and rejects non-significant factors, provides the possibility of early prediction of potential complications and the likelihood of disease progression. This, in turn, contributes to early diagnosis and selection of more effective and less harmful methods of prevention in the early postoperative period, in patients who have undergone surgery on the middle ear due to chronic mesotympanitis.

The rejection by the model of factorial characteristics associated with the pathology of the paranasal sinuses in the group of women ("Polypsis of the nasal cavity", "Incidence of flu infections") may be due to the fact that complicated chronic sinusitis is more often observed in men over the age of 45 [10].

Analysis of Variance; DV: KPPXMC (1 in 11)					
Effect	Sums of Squares	df	Mean Squares	F	p-value
Regress.	48,96766	13	3,766743	101,2458	0,00
Residual	2,90191	78	0,037204		
Total	51,86957				

Figure 5 – Analysis of the determination coefficient of the multivariate regression model for predicting CM recurrence in the group of men

Analysis of Variance; DV: KPPXMC (1 in 1)					
Effect	Sums of Squares	df	Mean Squares	F	p-value
Regress.	61,50745	9	6,834161	152,2972	0,00
Residual	5,38486	120	0,044874		
Total	66,89231				

Figure 6 – Analysis of the determination coefficient of the multivariate regression model for predicting CM recurrence in the group of women

Regarding diabetes mellitus and the factor characteristics associated with it ("Diabetes mellitus", "Glucose level"), a pattern is also observed here, since type 2 diabetes mellitus usually affects people over 45 years of age, who are overweight and have a burdened family history. The average age of the patients in this study was within 42 years.

Today, in otolaryngology, there are a few indices for predicting the long-term results of surgical interventions. One of these is MERI (Middle Ear Risk Index). MERI is one of the many methods used to predict the results of surgery. It considers both preoperative and postoperative conditions of the middle ear [2, 5].

It was created to predict a positive result of tympanoplasty based on internal factors of the middle ear [11, 12]. The MERI consists of the Bellucci criteria, which assess the severity of otorrhea, and the Austin-Kartush criteria, which assess the condition of the ossicles, cholesteatoma, middle ear granulation and effusion, and the results of previous middle ear surgeries. In 2001, Becvarovski and Kartush added smoking to the scoring system as a factor that may exacerbate chronic otitis media [13]. The MERI scores are summed, and the results are classified according to the healthy middle ear as mild, moderate and severe of CSOM [14].

The MERI score is a valuable and evidence-based tool for predicting the success of tympanoplasty procedures. Traditionally, the success of tympanoplasty has been assessed solely by the postoperative integrity of the graft. However, there are still many unstudied factors that may contribute to better surgical outcomes [14].

Such factors include the patient's sex and age. Since the rehabilitation and recovery period after surgery may differ in patients of different sexes and age groups.

In this work, we presented the prediction of the risk of chronic mesotympanitis recurrence using the MERI criteria, including depending on sex, and found a difference in the involved factor characteristics.

It would be advisable in further studies to also investigate the age dependence of the risk of chronic mesotympanitis recurrence.

CONCLUSIONS

1. The use of a mathematical model of multivariate regression analysis, which considers the most probable risk factors for the recurrence of chronic mesotympanitis, allows for timely prevention of the disease and prevention of potential complications and recurrences.

2. The use of this model allows for the development of algorithms for preoperative preparation and postoperative rehabilitation of patients with chronic mesotympanitis.

3. The results obtained in the future can be used to design an information and diagnostic system for assessing and predicting the recurrence of CM.

PROSPECTS FOR FUTURE RESEARCH

The results obtained in the future can be used to design an information and diagnostic system for assessing and predicting the recurrence of CM.

AUTHOR CONTRIBUTIONS

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

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Nil.

CONFLICT OF INTEREST

The author have no conflict of interest to declare.

ARTIFICIAL INTELLIGENCE DISCLOSURE

No AI was used.

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