Original article

# MODEL FOR PREDICTING RECURRENCE OF INGUINAL HERNIA IN MEN

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**A R T I C L E   I N F O**

**A B S T R A C T**

One of the most frequent complications of surgical treatment of inguinal hernias is recurrence. The goal of this research was to develop a mathematical model for predicting the probability of recurrence of inguinal hernias. 54 men were examined for recurrence of inguinal hernia using generally accepted methods. The construction of a prognostic model for the risk of recurrence of inguinal hernia in men was carried out using a multiple regression analysis, considering the following factors: age, period of occurrence of recurrence, type of previous plastic surgery, place of residence (village / city), presence of heart and lung failure. Thus, the quantitative assessment model of existing risk factors and regression analysis for predicting recurrence of inguinal hernias in men, which we have proposed, will allow to reduce the risk of recurrence of inguinal hernias among this cohort of patients with early diagnosis and optimal treatment and prevention tactics.

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## 1. Introduction

For many decades, surgical treatment of inguinal hernias has attracted the attention of surgeons. Hernias of the anterior abdominal wall are diagnosed annually in 7 % of men and 2.5 % of women. It is known that herniotomy ranks second among all surgical procedures on abdominal organs after appendectomy [1].

One of the most common complications of surgical treatment of inguinal hernias is recurrence, the frequency of which depends on many factors: technical nuances of the previous surgical operation [2], individual characteristics of the patient's body [3], the course of the postoperative period, when the patient ignores the doctor's recommendations regarding load physical limitations and diet [4].

The probability of recurrence of inguinal hernias increases if the patient has concomitant diseases, specifically cardiovascular and respiratory diseases. The relevance of the problem of comorbidity in surgical patients is due to the trend of an increasing number of young patients with various chronic diseases, and the increase in the negative impact of environmental factors [5].

Inguinal hernia recurrence is also affected by the choice of surgical procedure. According to the results of clinical studies by certain authors, modern methods of alloplasty prevail over methods of autoplasty of the inguinal canal, especially in relation to their recurrences. The recurrence rate after autoplasty of the inguinal canal varies between 4.4-17%, while with alloplasty – 0.3-2.2%.

Despite the success of surgery, the frequency of recurrence of inguinal hernias does not have a clear tendency to decrease [6]. Patients with large hernias had the worst results. Failures in the treatment of straight hernias occurred 2-3 times more often than oblique ones. The worst results were observed after surgery for recurrent hernias.

It is known that with age, muscle tone of the anterior abdominal wall decreases significantly, so relapses of inguinal hernias occur much more often in elderly people [7]. Also, physically demanding work is also one of the factors that directly affect the probability of recurrence of inguinal hernia, especially this applies to villagers who are mainly engaged in agricultural work.

Currently, most scientific research is devoted to various methods of surgical treatment of inguinal hernias, and very few to the possible causes of their recurrence [8]. Thus, we considered it significant to analyze the factors that directly affect the recurrence of inguinal hernias in men, allowing timely prevention.

The goal of this research was to develop a mathematical model for predicting the probability of recurrence of inguinal hernias.

## 2. Methods

A comprehensive examination of 54 men for recurrence of inguinal hernia was carried out using generally accepted methods.

All patients were divided by age according to the classification of UN experts for socio-economic and demographic calculations as follows: 15-24 years-old — early working age (n=0); 25-54 years-old — the main working age (n=26); 55-64 years-old — mature working age (n=23), 65 years and above — old age (n=5).

To predict the recurrence of inguinal hernia in men, the following factors were studied: the timing of the recurrence of inguinal hernia, the type of primary hernioplasty, the age of patients, the presence of heart and respiratory failure, as well as such a socio-economic factor, such as the place of residence (village or city).

*Ethical details*

The ethical principles included in the Declaration of Human Rights adopted in Helsinki in 1975 and revised in 2008, were fully respected in this study. The enrolled subjects participated in this study voluntarily and with completed and signed written informed consent. Study protocol was approved by the Ethics Committee (Protocol No. 73) of I. Horbachevsky Ternopil National Medical University of 03.04.2023.

*Statistical analysis*

Construction of a prognostic model for the risk of recurrence of inguinal hernia in men was carried out using a multiple regression analysis. The statistical processing of the research results was carried out using the statistical package Statistica 10.0 and the spreadsheet editor Microsoft Excel 2007. The normality of the distribution of features was assessed using the coefficients of asymmetry and kurtosis, as well as the Kolmogorov-Smirnov and Shapiro-Wilk criteria. Statistical differences between comparison groups were considered probable at $p < 0.05$.

# 3. Results

To predict recurrence of inguinal hernia, 54 men were examined with an average age of $55.1 \pm 4.8$ years. The type of primary inguinal hernia plastic surgery in the examined patients was also studied. Plastic surgery according to Gerard-Spasokukotskyi was performed in 7 patients (12.96%), according to Postempsky – 29 patients (53.70%), according to Sholdice – 11 cases (20.37%), according to Bassini – in 7 men (12, 96%). Therefore, in 87.04% of cases, plastic surgery of the back wall of the inguinal canal was performed.

During further examination of the patients, the timing of recurrence of inguinal hernias was studied. We observed recurrence of inguinal hernia in patients under the age of 44 in 7 cases (12.96%). It should be noted that in this age group, recurrence of inguinal hernia was not observed within 1 year, in 1 case (1.85%) within 3 years; 3-10 years – in 4 cases (7.41%) and more than 10 years – in 2 cases (3.70%).

It is known that the term for the formation of a strong aponeurotic scar is 2-3 months; however, in 4 patients (7.41%) of various ages it occurred before 1 year, which may be associated with non-compliance with the surgeon's recommendations regarding a sparing regimen after surgery.

In the age range of 25-75 years, hernia recurrence within 1-3 years was observed only in 7 patients, 5 of whom lived in rural areas, which may be related to physical work. In 3 patients, who were city residents, relapse is possibly related to age changes.

In terms of 10 or more years, the largest number of inguinal hernia recurrences was observed at the age of 44-75 years (12.96% and 16.67%, respectively), which is determined by an increase in the index of

comorbidity in these patients, specifically by the presence of heart and respiratory failure.

Furthermore, the socio-economic living conditions of patients as a cause of recurrence of inguinal hernia are significant at the age of 44-75 years, which is explained by physical activity in this age range and an increase in the index of comorbidity.

The recurrence of inguinal hernia within 1 year can be explained by surgical technical errors. The rate of recurrence of inguinal hernia before the age of 44 is probably related to excessive physical activity of patients, and it occurs almost 2 times more often in the period of 3-10 years.

Social factors – age, comorbidity and socio-economic living conditions of the patient are significant in the rate of recurrence of inguinal hernias.

The regression analysis method was used as a mathematical model, which allows, based on the data of regression coefficients and values of risk factors that have a probable influence on the development of inguinal hernia recurrence, to identify the correlation between them and predict the probability of occurrence of inguinal hernia recurrence in men.

Probable factors for the development of inguinal hernia recurrence in men were selected to build a mathematical forecasting model. Using a linear regression analysis, the 6 most significant risk factors that had the greatest influence on the risk of relapse were identified: X1 — age; X2 — type of previous plastic surgery; X3 — term of recurrence of inguinal hernia; X4 — place of residence (village or city); X5 — presence of heart failure; X6 — the presence of respiratory failure (Table 1).

| Predictor | Factor | Indexing |
|---|---|---|
| X1 | **Age** | |
| | up to 40 years | 0 |
| | 41-50 years | 1 |
| | 51-60 years | 2 |
| | 61-70 years | 3 |
| | more than 71 years | 4 |
| X2 | **Plastic surgery type** | |
| | by Sholdice | 1 |
| | by Bassini | 2 |
| | by Girard | 3 |
| | by Postempsky | 4 |
| X3 | **The term of recurrence** | |
| | more than 10 years | 1 |
| | 3-10 years | 2 |
| | 1-3 years | 3 |
| | till 1 year | 4 |
| X4 | **Place of residence** | |
| | Resident of the city | 0 |
| | A resident of the village | 1 |
| X5 | **Heart failure (HF)** | |
| | HF 0 degree | 0 |
| | HF 1 degree | 1 |
| | HF IIA degree | 2 |
| X6 | **Pulmonary failure (PF)** | |
| | PF 0 degree | 0 |
| | PF 1 degree | 1 |

**Table 1. Risk factors for recurrence of inguinal hernia in men and their indexing**

A stepwise logistic regression analysis was performed to assess the probability of selected factors: multicollinearity risk factors for inguinal hernia recurrence were determined, a correlation matrix was constructed with correlation coefficients calculated.

The next stage was to determine the relative importance of multicollinearity factors in predicting the recurrence of inguinal hernia with the determination of regression coefficients (Beta), which reflect, for each factor included in the analysis, the relationship regarding the chances of influencing the development of recurrence of inguinal hernia in the examined men (Table 2).

| Predictor | Multiple logistic regression | | |
|---|---|---|---|
| | beta | SE | P-value |
| X1 | 0.685 | 0.096 | <0.05 |
| X2 | 7.603 | 0.899 | <0.001 |
| X3 | 2.943 | 1.279 | <0.05 |
| X4 | 2.667 | 0.953 | <0.05 |
| X5 | 4.426 | 1.633 | <0.05 |
| X6 | 1.429 | 1.945 | <0.05 |
| Constant | 3.881 | 0.097 | <0.05 |

**Table 2. IMRT Prognostic value of the influence of individual parameters on the probability of recurrence of inguinal hernias in men.**

Based on the results of the multiple regression analysis of predicting the probability of inguinal hernia recurrence in men, we created a multiple regression equation to determine the risk factor for inguinal hernia recurrence (RFHI):

$RFHI = 3{,}881 + 0{,}685x_1 + 7{,}603x_2 + 2{,}943x_3 + 2{,}667x_4 + 4{,}426x_5 + 1{,}429x_6$, (1)

($R = 0{,}993$; $R^2 = 0{,}986$; $F = 567{,}74$; $p < 0{,}05$),

where RFHI – the risk factor for inguinal hernia recurrence; 3,881 – constant; risk factors and coefficients to factors, the calculation of which is the task of building the model: $x_1 - x_7$ – risk factors with regression coefficients.

The value of the coefficient of probability of recurrence of inguinal hernia was in the range from 0 to 1 and reflected the probability of the development of recurrence of inguinal hernia, the closer the value of the predicted probability to 1, the higher the risk of occurrence of recurrence of inguinal hernia in men.

Thus, we obtained a mathematical model for predicting the probability of inguinal hernia recurrence in men. The model we developed was tested on 54 patients with inguinal hernias.

After calculating the sensitivity and specificity of this mathematical model according to the corresponding formulas, we found that its sensitivity is 95%, and its specificity is 97%.

Therefore, based on the obtained statistically significant prognostic relationships, we obtained a mathematical model for predicting the probability of recurrence of inguinal hernias in men, which will allow to prevent the development of repeated recurrences of inguinal hernias as effectively as possible at all levels of medical care, and especially in the surgical procedures.

## 4. Discussion

Despite all the successes achieved in the surgical treatment of inguinal hernias, the recurrence rate of inguinal hernias among the total number of patients with inguinal hernias is between 12-15% [9]. Depending on the cause, relapse can occur very quickly after the primary operation or develop much later [10].

In the literature, there is a discrepancy between the rates of recurrence of inguinal hernias found in different cohorts of the population. This is probably due to the fact that in many studies the maximum follow-up period is only 5 years, during which only about 40% relapse, while it is known that in the following years (10 years and more) the remaining 60% develop a relapse [ 11]. Therefore, patients with inguinal hernia repair require long-term follow-up. There are also reports in the literature about numerous surgical factors of inguinal hernia recurrence, specifically that

inguinal hernia recurrence directly depends on the method of surgical procedure, which is confirmed by our research.

As for certain social risk factors for inguinal hernia recurrence, they have already been published in other studies [12]. It is known that the age of patients and physically demanding work, which occurs mainly in people engaged in agricultural activities, also affect the probability of relapse, which is confirmed by our research results [13]. In men, inguinal hernia recurrence is many times more common than in women. There are also data indicating that factors related to the operation and the surgeon's experience also affect the recurrence of inguinal hernia [14]. It can also be assumed that surgical risk factors for inguinal hernia recurrence after primary surgery, play a greater role than patient-specific factors, such as the presence of comorbidities [15].

Therefore, the method of multifactorial mathematical analysis, taking into account the most informative factors and variants of their severity, makes it possible to create a system for predicting the recurrence of inguinal hernia in men, which develops as a result of the joint influence of a number of factors. The use of this method makes it possible to predict not only the fact of the occurrence of pathology, but also the degree of probability of its occurrence, which is important for the further creation of effective preventive measures.

## 5. Conclusions

In conclusion, the quantitative assessment model of existing risk factors and regression analysis of predicting recurrence of inguinal hernias in men, which we have proposed, will allow to reduce the risk of recurrence of inguinal hernias among this cohort of patients with early diagnosis and optimal treatment and prevention tactics.

## References

1. Berndsen MR, Gudbjartsson T, Berndsen FH. Inguinal hernia - review. Laeknabladid 2019;105(9):385-391.

2. Hernia Surge Group. International guidelines for groin hernia management. Hernia 2018;22(1):1-165.

3. Köckerling F, Simons MP. Current Concepts of Inguinal Hernia Repair. Visc Med 2018;34(2):145-150.

4. Ali, A. Y., & Abdulla, B. H.. Recurrent Inguinal Hernia (A Descriptive Study on Etiology & Management). Diyala Journal of Medicine 2023; 24(1): 92-101.

5. Köckerling F, Sheen AJ, Berrevoet F, Campanelli G, Cuccurullo D, at al. The reality of general surgery training and increased complexity of abdominal wall hernia surgery. Hernia 2019;23(6):1081-1091.

6. Kohno S, Hasegawa T, Aoki H, Ogawa M, Yoshida K, at al. Analysis of risk factors for surgical site infection and postoperative recurrence following inguinal and femoral hernia surgery in adults. Asian J Surg 2022;45(4):1001-1006.

7. Lu Y, Chen DC, MacQueen IT. General Surgery: Management of Postoperative Complications Following Ventral Hernia Repair and Inguinal Hernia Repair. Surg Clin North Am 2021;101(5):755-766.

8. Clapp, B., Kara, A. M., Nguyen-Lee, P. J., Annabi, H. M., Alvarado, L., Marr, J. D. & Davis, B.. Does bioabsorbable mesh reduce hiatal hernia recurrence rates? A meta-analysis. Surgical Endoscopy 2023; 37(3): 2295-2303.

9. Burcharth J, Pommergaard HC, Bisgaard T, Rosenberg J. Patient-related risk factors for recurrence after inguinal hernia repair: a systematic review and meta-analysis of observational studies. Surg Innov 2015;22(3):303-17.

10. Niebuhr H, Köckerling F. Surgical risk factors for recurrence in inguinal hernia repair – a review of the literature. Innov Surg Sci 2017;2(2):53–59.

11. Köckerling, F., Koch, A., Lorenz, R., Schug-Pass, C., Stechemesser, B., & Reinpold, W.. How long do we need to follow-up our hernia patients to find the real recurrence rate?. Frontiers in surgery 2015; 2: 24.

12. Lee CS, Kim JH, Choi BJ, Lee JI, Lee SC, at al. Retrospective study on prevalence of recurrent inguinal hernia: a large-scale multi-institutional study. Ann Surg Treat Res 2020;98(1):51–55.

13. Louie M, Strassle PD, Moulder JK, Overby W. Risk factors for repeat hernia repair in women of childbearing age. Hernia 2020;24(3):577-585.

14. Yaguchi Y, Inaba T, Kumata Y, Horikawa M, Kiyokawa T, Fukushima R. Two cases of early recurrence after transabdominal preperitoneal inguinal hernia repair. Asian J Endosc Surg 2018;11(1):71-74.

15. Plymale, M. A., Ragulojan, R., Davenport, D. L., & Roth, J. S.. Ventral and incisional hernia: the cost of comorbidities and complications. Surgical endoscopy 2017; 31: 341-351.