ХИРУРГИЯ / SURGERY

THE RISK PREDICTION OF THE FIRST TOE INGROWN NAIL DEVELOPMENT IN POPULATION AT THE OUTPATIENT STAGE

Research article

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Abstract

Primary outpatient care for the population must meet criteria such as affordability, preventive focus, and the usage of savings medical technologies. These parameters are fully consistent with the using of methods for predicting the risk of disease development and timely measures to prevent them in clinical practice. One of the most common outpatient complaints is an ingrown toenail, which most often develops on the first toe. The authors carried out a retrospective analysis of the medical records of patients with an ingrown toenail and identified the main risk factors for the development of the disease. The identified factors were analyzed using the method of direct expert assessment and determining the significance of each of them. The results of the work formed the basis of the author's methodology for predicting the development of an ingrown nail of the first toe in patients at the outpatient stage and made it possible to create an eponymous software product for a computer. A certificate of state registration of the computer program was received for this software product. The expert assessment showed the high quality of the prognosis (92.4%), of the proposed method and the program product created on its basis, which makes it possible to recommend them for use in routine clinical practice in outpatient facilities.

Keywords: ingrown toenail, outpatient stage, risk factors, prediction, expert assessment.

ПРОГНОЗИРОВАНИЕ РИСКА РАЗВИТИЯ ВРОСШЕГО НОГТЯ ПЕРВОГО ПАЛЬЦА СТОПЫ У НАСЕЛЕНИЯ НА АМБУЛАТОРНОМ ЭТАПЕ

Научная статья

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Аннотация

Первичная амбулаторная помощь населению должна отвечать таким критериям, как доступность, профилактическая направленность и использование экономичных медицинских технологий. Этим параметрам в полной мере соответствует использование в клинической практике методов прогнозирования риска развития заболеваний и своевременных мер по их профилактике. Одним из наиболее распространенных амбулаторных заболеваний является вросший ноготь, который чаще всего развивается на первом пальце стопы. Авторы провели ретроспективный анализ медицинских карт пациентов с вросшим ногтем первого пальца стопы и выявили основные факторы риска развития данного заболевания. Выявленные факторы были проанализированы с помощью метода прямой экспертной оценки и определения значимости каждого из них. Результаты работы легли в основу авторской методики прогнозирования развития вросшего ногтя первого пальца стопы у пациентов на амбулаторном этапе и позволили создать одноименный программный продукт для ЭВМ. На данный программный продукт получено авторское свидетельство о государственной регистрации программы для ЭВМ. Экспертная оценка показала высокое качество прогноза (92,4%), предложенного метода и созданного на его основе программного продукта, что позволяет рекомендовать их для использования в рутинной клинической практике в амбулаторных учреждениях.

Ключевые слова: вросший ноготь, амбулаторный этап, факторы риска, прогнозирование, экспертная оценка.

Introduction

One of the most common reasons of patients' referrals to surgeons at outpatient stage is the development of ingrown toenail (hereinafter – IT), predominantly affecting the first toe [9], [10]. Ingrowth of the lateral edge of the nail plate into the soft tissues of the toe leads to the development of chronic inflammation in the area of the nail fold and accompanied by complaints of discomfort, as well as pain in the affected toe, aggravated by wearing shoes and walking [6], [7]. Given the prevalence of pathology (at least 3% in the structure of the overall morbidity), the gender-age composition of patients (young people of working age) and the average period of disability (from 2 to 4 weeks), IT should be attributed to the urgent problems of outpatient surgery and healthcare in general [1], [4], [5], [8].

The etiological component of IT is represented by pathogenic fungi and opportunistic microflora of the skin of the feet and toes, and in the pathogenesis of the disease, it is possible to distinguish groups of risk factors (hereinafter – RF) that produce and also contribute to the development of IT, such as feet hyperhidrosis and periungual roller injuries [3], [6], [11]. Accounting and control of these RF will make it possible to assess the risk of developing pathology and take the necessary measures in a timely manner to prevent it.

The purpose of the study: elaboration of a methodology for predicting the development of an ingrown nail of the first tie in patients at the outpatient stage, followed by the creation of an eponymous software product.

Material and research methods

By design, this study is a retrospective analysis with statistical processing and expert evaluation of medical data. We analyzed 4185 outpatient medical records of patients who received medical aid at the outpatient Center of the Samara State Medical University Clinics from September 2020 to January 2023 with various nosological forms of diseases belonging to the group of surgical infections. Outpatient records of 132 patients were selected and analyzed from the array of medical documents. The selection criterion for the study with further analysis and expert evaluation of the data was the presence of IT of the first toe in the patient.

At the next stage, based on the results of a retrospective analysis of outpatient medical records, RF were identified, contributing to the development of IT of the first toe in the patient (Table 1).

Table 1 - RF for the IT of the first toe's development in patients at the outpatient stage

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Factors	Decoding
Predisposing factors	
"Internal pressure" factors	
Onychomycosis, onychogryphosis, mycosis of the feet, psoriatic lesion of the nail plate of first toe	no
	yes
Pathological (flattened, hourly, etc.) shape of the nail and first toe	no
	yes
Post-traumatic nail deformity	no
	yes
"External Pressure" factors	
Hyperkeratosis of the periungual ridges of 1 toe	no
	yes
Wearing uncomfortable (tight, high-heeled) shoes	no
	yes
Deformity of 1 toe a of the foot (hallux valgus, hallux varus, hallux rigidus)	no
	yes
Deformity of the foot (flat feet, clubfoot)	no
	yes
Adiposis	no
	1-2 degrees
	3-4 degrees
Contributing factors	
Poor feet hygiene	no
	yes
Hyperhidrosis of the feet	no
	yes
Diabetes mellitus	no
	yes
	presence with local trophic disorders
The presence of obliterating vascular diseases of the lower extremities	no
	yes
	presence with local trophic disorders
Producing factors	
Injury of the periungual roller of the first toe with the nail plate	no
	yes, due to mechanical injury
	yes, due to improper nail clipping

At the next stage, the identified RF were analyzed using the expert assessment technique. At the same time, a gradation and determination of the significance of each of the RF related to both productive and predisposing ones for the development of an IT of the first toe were carried out, as well as assignment of a point value to each of them.

The expert assessment was carried out by 18 field-oriented specialists – doctors of the surgical chairs of the Samara State Medical University, who have clinical experience in providing medical care to patients with an IT. The method of direct independent personal assessment was chosen, which, on the part of medical experts, was carried out by means of anonymous questionnaires. The experts were asked, considering their own clinical experience, to assign each RF a point value from 0 to 10, depending on its significance and influence on the occurrence of an IT of the first toe. Then the data of the expert assessment were compared with the data of a retrospective analysis of outpatient medical records of patients and subjected to mathematical analysis.

Research results and discussion

According to the clinical data, presented in the array of medical records, as well as considering the scores of various expert assessments, the total scores were calculated for each patient on 18 scales. Thus, for each patient in the data set, 18 new variables were created, corresponding to the scores collected on the assessment scales of medical experts.

When several medical experts participate in an anonymous survey, discrepancies in their assessments of the significance of certain RF are inevitable, but the magnitude of this discrepancy is important. A group assessment can be considered sufficiently reliable only if there is good agreement between the answers of individual specialists. To assess the significance of this parameter, Kendall's multiple rank correlation coefficient (W) was calculated. As a result of the calculations, the Kendall coefficient turned out to be 0.83 ($p < 0.001$). Cronbach's alpha coefficient was used to determine the internal consistency of characteristics describing an object. The calculations showed that the value of Cronbach's alpha was 0.98. These values of the Kendall and Cronbach coefficients characterize the consistency of the assessments of expert doctors as rather high.

The third stage of the study consisted in assessing the quality of recognition of the possible development of an IT of the first toe in patients at the outpatient stage using the identified RF. To this end, we used ROC-assay, built characteristic ROC-curves with an estimate of the area under the graph and a proposal for possible threshold values of points on a scale, above which the risk of IT developing was considered increased with the corresponding sensitivity and specificity. The use of ROC-assay made it possible to assess the professional skills and qualifications of medical experts.
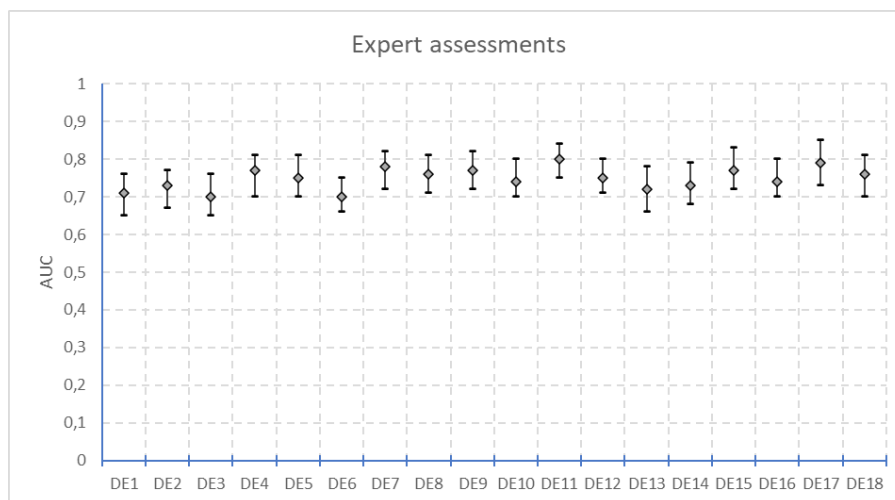

Figure 1 - Areas under the graphs of ROC-curves (AUC) according to expert assessments of RF
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Note: DE – doctor-expert, "mustache" – the limits of the 95% confidence interval

As a result, the areas under the ROC-curves (Figure 1) for all doctor-experts statistically significant exceeded the value of 0.5. This value corresponds to the area under the diagonal on the graph, and a random guess. It can also be seen from the graph that the assessments of all doctor-experts have approximately equal discriminatory characteristics, since their "mustache" – 95% confidence intervals, overlap.

The quality of recognition (sensitivity, specificity) of the risk of IT of the first toe developing in patients at the outpatient stage according to the scale of each of the doctor-experts is presented in Table 2.

Table 2 - The quality of predicting of the IT of the first toe development according to the assessment scales of doctor-experts

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Scale	AUC	SE AUC	R	Split point	Se	Sp
DE 1	0.71	0.047	<0.001	74.0	0.72	0.64

DE 2	0.73	0.046	<0.001	30.5	0.74	0.65
DE 3	0.70	0.051	<0.001	50.0	0.71	0.69
DE 4	0.77	0.050	<0.001	53.0	0.77	0.58
DE 5	0.75	0.047	<0.001	33.5	0.74	0.70
DE 6	0.70	0.049	<0.001	40.5	0.68	0.72
DE 7	0.78	0.046	<0.001	26.5	0.80	0.61
DE 8	0.76	0.054	<0.001	15.5	0.68	0.71
DE 9	0.77	0.048	<0.001	34.5	0.72	0.70
DE 10	0.74	0.051	<0.001	51.5	0.70	0.61
DE 11	0.80	0.052	<0.001	41.5	0.60	0.68
DE 12	0.75	0.048	<0.001	20.5	0.86	0.72
DE 13	0.72	0.054	<0.001	52.5	0.76	0.62
DE 14	0.73	0.048	<0.001	39.5	0.74	0.62
DE 15	0.77	0.047	<0.001	33.5	0.76	0.60
DE 16	0.74	0.049	<0.001	31.5	0.74	0.63
DE 17	0.79	0.050	<0.001	34.0	0.72	0.68
DE 18	0.76	0.056	<0.001	32.5	0.75	0.54

Note: DE – doctor-expert; AUC – area under the ROC-curve graph; SE AUC is the standard error of the AUC estimate; p – the statistical significance of the difference between the AUC and the area under the diagonal (random guessing); Se and Sp – the sensitivity and specificity at the given split point

At the final stage, we built a summary table of the predictive significance of RF by superimposing them on the results of the analysis of outpatient medical records of patients (Table 3).

Table 3 - Characterization of the significance of RF among patients with and without IT of the first toe

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Factors	Decoding	IT not developed		IT developed		p
		abs.	%	abs.	%	
Onychomycosis, onychogryphosis, mycosis of the feet, etc.	no	30	60.0	20	40.0	<0.001
	yes	18	22.0	64	78.0	
Pathological (flattened, hourly, etc.) nail shape	no	28	57.1	21	42.9	0.003
	yes	24	28.9	59	71.1	
Post-traumatic nail deformity	no	36	75.0	12	25.0	<0.001
	yes	22	26.2	62	73.8	
Hyperkeratosis of the periungual ridges	no	21	58.3	15	41.7	0.012
	yes	31	32.3	65	67.7	
Wearing uncomfortable (tight, high-heeled) shoes	no	40	63.5	23	36.5	0.004
	yes	25	36.2	44	63.8	
Toe deformity (hallux valgus, hallux varus, hallux rigidus)	no	41	78.8	11	21.2	0.002
	yes	40	50.0	40	50.0	
Deformity of the foot (flat feet, clubfoot)	no	51	70.8	21	29.2	<0.001
	yes	20	33.3	40	66.7	
Adiposis	no	51	83.6	10	26.4	<0.001
	1-2 degrees	12	46.2	14	53.8	
	3-4 degrees	4	8.9	41	91.1	
Poor foot hygiene	no	24	61.5	15	38.5	0.080
	yes	40	43.0	53	57.0	
Hyperhidrosis of the feet	no	57	78.1	16	21.9	<0.001
	yes	20	33.9	39	66.1	
Diabetes mellitus	no	27	56.3	21	43.7	<0.001
	yes	19	24.4	59	63.6	
	presence with local trophic disorders	1	16.7	5	83.3	
The presence of	no	31	54.5	26	43.5	0.315

obliterating vascular diseases of the lower extremities	yes	30	78.3	38	21.7	
	presence with local trophic disorders	3	58.1	4	41.9	
Injury of the periungual roller with the nail plate	no	22	66.7	11	33.3	<0.001
	yes, due to mechanical injury	12	34.3	23	65.7	
	yes, due to improper nail clipping	7	10.8	58	89.2	

Note: p – the significance level of the chi-square (Pearson) test with Yates correction

The Pearson's criteria for assessing the strength of the relationship between the RF and the outcome showed that strong and relatively strong factors include producing (trauma to the nail plate), from predisposing – fungal nail lesions, coupled with their deformation, as well as congenital deformities of feet, and from additional RF - the presence of diabetes mellitus and adiposis, as well as hyperhidrosis of the feet.

The generated table of outcomes (Table 4), in which the observed indicators according to the analysis of 132 medical records are opposed to those predicted on the basis of the calculated model, demonstrates a high quality of prognosis, namely 92.4%, in terms of the risk of IT of the first toe developing in patients at the outpatient stage.

Table 4 - Classification table of observation's outcomes

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Observed indicator	Predicted		
	no	yes	percentage of correct results, %
no	57	7	89.1
yes	3	65	94.2
cumulative percentage, %	45.5	54.5	92.4

Based on the developed forecasting methodology, the authors team created a computer software product – "Determination of the Risk of Primary Development of an Ingrown Nail of the First Toe". For this application, a certificate of state registration of the computer program No. 201617934 of 07.15.2020 was received [2]. The application is a program that allows the user from the proposed data set to select those RF that correspond to the data obtained during the examination of the patient. Further, the user automatically receives information in the form of a forecast about the possibility of developing an IT of the first toe in a particular patient and the need to apply appropriate preventive measures.

Conclusion

The quality of the prognosis of the proposed author's methodology for assessing the risk of developing an IT of the first toe in patients at the outpatient stage and of the program developed on its basis, allows us to recommend their use in everyday clinical practice.

Список литературы / References

1. Фролов С.С. Анализ результатов оперативного лечения вросшего ногтя / С.С. Фролов, Г.П. Миронова, Н.О. Новикова [и др.] // Доказательная медицина – основа современного здравоохранения. — Хабаровск: Институт повышения квалификации специалистов здравоохранения, 2015. — С. 246-248.

2. Пат. 2020617934 Российская Федерация. Определение риска первичного развития вросшего ногтя первого пальца стопы / Е.С. Желтякова, В.Н. Гусев, Д.Г. Алексеев [и др.]. — №2020614175; заявл. 10.04.2020; опубл. 15.07.2020, Бюл. №7. — 1 с.

3. Cho S.Y. Epidemiology and Bone-related Comorbidities of Ingrown Nail: A nationwide population-based study / S.Y. Cho, Y.C. Kim, J.W. Choi // The Journal of Dermatology. — 2018. — Vol. 45. — № 12. — P. 1418-1424. — DOI: 10.1111/1346-8138.14659.

4. Ibrahim E.A. Clinical and Sociodemographic Characteristics of Patients with Ingrown Nails / E.A. Ibrahim, S. Bostanci, P. Kocyigit [et al.] // The Journal of the American Podiatric Medical Association. — 2019. — Vol. 109. — № 3. — P. 201-206. — DOI: 10.7547/17-023.

5. Claire R.S. Effect of Onychomycosis and Treatment on Patient-reported Quality-of-life Outcomes: A systematic review / R.S. Claire, L. Algu, R. Kamran [et al.] // Journal of The American Academy of Dermatology. — 2021. — Vol. 85. — № 5. — DOI: 10.1016/j.jaad.2020.05.143.

6. Geizhals S. Review of Onychocryptosis: Epidemiology, Pathogenesis, Risk Factors, Diagnosis and Treatment / S. Geizhals, S.R. Lipner // Dermatology Online Journal. — 2019. — Vol. 25. — № 9. — DOI: 13030/qt9985w2n0.

7. Голямов П.С. К вопросу классификации форм вросшего ногтя / П.С. Голямов, В.С. Захарова, А.В. Осиновик // Здравоохранение Дальнего Востока. — 2014. — № 4(62). — С. 55-57.

8. Mayeaux Jr. E.J. Ingrown Toenail Management / E.J. Mayeaux Jr., C. Carter, T.E. Murphy // American Family Physician. — 2019. — Vol. 100. — № 3. — P. 158-164.

9. Pavotbawan K. Der Unguis incarnatus / K. Pavotbawan, T.S. Müller // Therapeutische Umschau. — 2020. — Bd. 77. — № 5. — S. 227-333. — DOI: 10.1024/0040-5930/a001180.

10. Сабельников О.Н. Лечение вросшего ногтя в амбулаторно-поликлинических условиях / О.Н. Сабельников // Астраханский медицинский журнал. — 2012. — Т. 7. — № 3. — С. 173-176.

11. Зайцева О.Ю. Нормальная морфология ногтей и её изменения при онихомикозе / О.Ю. Зайцева // Молодёжь XXI века: шаг в будущее. — Благовещенск: Благовещенский государственный педагогический университет, 2017. — С. 930-931.

Список литературы на английском языке / References in English

1. Frolov S.S. Analiz rezul'tatov operativnogo lechenija vrosshego nogtja [Analysis of the Results of Surgical Treatment of an Ingrown Nail] / S.S. Frolov, G.P. Mironova, N.O. Novikova [et al.] // Dokazatel'naja medicina – osnova sovremennogo zdravoohranenija [Evidence-based Medicine – the Basis of Modern Healthcare]. — Khabarovsk Institute for Advanced Studies of Healthcare Professionals, 2015. — P. 246-248. [in Russian]

2. Pat. 2020617934 Russian Federation. Opredelenie riska pervichnogo razvitija vrosshego nogtja pervogo pal'ca stopy [Determining the Risk of Primary Development of an Ingrown Nail of the First Toe] / E.S. Zheltjakova, V.N. Gusev, D.G. Alekseev [et al.]. — №2020614175; appl. 10.04.2020; publ. 15.07.2020, Bul. №7. — 1 p. [in Russian]

3. Cho S.Y. Epidemiology and Bone-related Comorbidities of Ingrown Nail: A nationwide population-based study / S.Y. Cho, Y.C. Kim, J.W. Choi // The Journal of Dermatology. — 2018. — Vol. 45. — № 12. — P. 1418-1424. — DOI: 10.1111/1346-8138.14659.

4. Ibrahim E.A. Clinical and Sociodemographic Characteristics of Patients with Ingrown Nails / E.A. Ibrahim, S. Bostanci, P. Kocyigit [et al.] // The Journal of the American Podiatric Medical Association. — 2019. — Vol. 109. — № 3. — P. 201-206. — DOI: 10.7547/17-023.

5. Claire R.S. Effect of Onychomycosis and Treatment on Patient-reported Quality-of-life Outcomes: A systematic review / R.S. Claire, L. Algu, R. Kamran [et al.] // Journal of The American Academy of Dermatology. — 2021. — Vol. 85. — № 5. — DOI: 10.1016/j.jaad.2020.05.143.

6. Geizhals S. Review of Onychocryptosis: Epidemiology, Pathogenesis, Risk Factors, Diagnosis and Treatment / S. Geizhals, S.R. Lipner // Dermatology Online Journal. — 2019. — Vol. 25. — № 9. — DOI: 13030/qt9985w2n0.

7. Golyamov P.S. K voprosu klassifikacii form vrosshego nogtja [On the Issue of Classification of Ingrown Nail Forms] / P.S. Golyamov, V.S. Zakharova, A.V. Osinovik // Zdravoohranenie Dal'nego Vostoka [Healthcare of the Far East]. — 2014. — № 4(62). — P. 55-57.

8. Mayeaux Jr. E.J. Ingrown Toenail Management / E.J. Mayeaux Jr., C. Carter, T.E. Murphy // American Family Physician. — 2019. — Vol. 100. — № 3. — P. 158-164.

9. Pavotbawan K. Der Unguis incarnatus [Ingrown toenails] / K. Pavotbawan. T.S. Müller // Therapeutische Umschau [Therapeutic review]. — 2020. — Vol. 77. — № 5. — P. 227-233. — DOI: 10.1024/0040-5930/a001180. [in German]

10. Sabelnikov O.N. Lechenie vrosshego nogtja v ambulatorno-poliklinicheskih uslovijah [Treatment of an Ingrown Nail in an Outpatient Clinic] / O.N. Sabelnikov // Astrahanskij medicinskij zhurnal [Astrakhan Medical Journal]. — 2012. — Vol. 7. — № 3. — P. 173-176. [in Russian]

11. Zaitseva O.Yu. Normal'naja morfologija nogtej i ejo izmenenija pri onihomikoze [Normal Morphology of the Nail and Its Changes in Onychomycosis] / O.Yu. Zaitseva // Molodjozh' XXI veka: shag v budushhee [Youth of the XXI Century: a Step into the Future]. — Blagoveshchensk: Blagoveshchensk State Pedagogical University, 2017. — P. 930-931. [in Russian]