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Research Article

Automated screening of melanocytic skin tumors using a robotic complex

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Abstract:

Annotation: An analysis of the results of diagnosing melanocytic skin tumors using a robotic complex developed at the university with the participation of students was carried out. The analysis included 232 photographs after a questionnaire survey of 902 patients, most of whom are women of reproductive age. Photo and chromomicroscopic diagnostics on the a robotic complex (RK) made it possible to evaluate 90 microphotographs as melanoma-dangerous nevi and in 5 patients to identify them as superficial melanomas requiring treatment, including one woman during pregnancy. The calculation of the melanoma hazard index was carried out in an automated mode using a special formula. The RK program generates recommendations and a library of photographs of dangerous melanocytic skin tumors for subsequent clinical examination over time. After modeling melanocytic dysplasias and superficial melanomas, the logistics of "supervised neural network training" began.

Keywords: robotic complex; screening; melanoma-dangerous nevi; superficial melanomas

Introduction

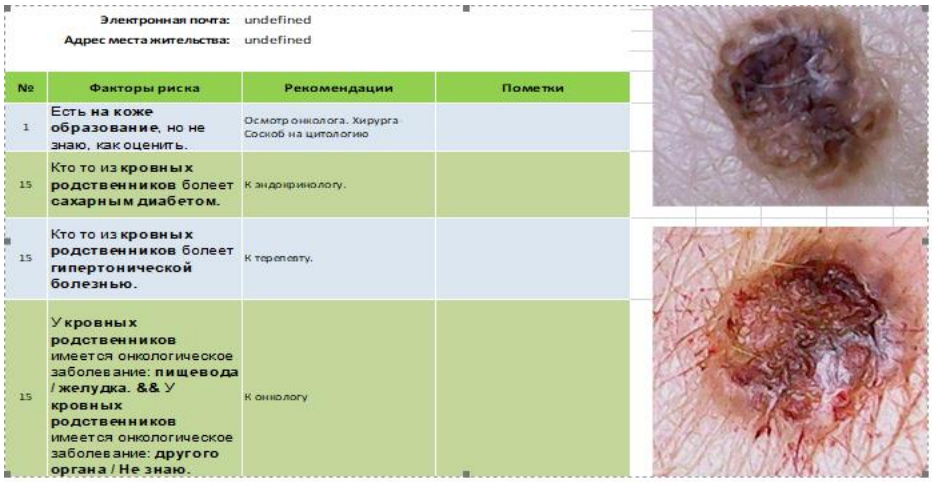
It is known that skin melanoma, before turning into a nodular form in most cases (with an unfavorable prognosis), exists for a long time in the form of melanocytic dysplasias and superficial melanomas with a favorable prognosis. Unfortunately, skin melanomas are diagnosed mainly in stages II-IV of the disease or the vertical growth phase – 61.1% [1]. Artificial intelligence (AI) is increasingly being developed to process a variety of information data, in particular automated radiographic interpretation of lung cancer and other imaging methods [2]. Despite a number of works related to the attempt to identify individual pigmented nevi using AI, the diagnostic accuracy is slightly higher than 80% [3,4,5]. The complexity of the problems of identifying skin nevi is associated with their extreme diversity and individuality of mosaics (patterns), time limits and the difficulties of their diagnosis by general practitioners. Oncologists cannot stand behind every doctor, but they can create robotic complexes (RC) with neural networks.

It seems to us that at the stage of developing the RK model for population screening, first of all, non-genic neoplasms, it is important to identify nevus carriers of 3 fundamental modulations: 1) with low transformation; 2) with melanocytic nevi (for preventive measures) and 3) melanocytic dysplasia (in need of treatment).

Purpose of the study. Creation of a model for identifying cancer risk factors and, in particular, melanocytic dysplasias and radial melanomas using a robotic complex at the primary care stage.

Materials and methods

On the basis of the robotic complex (RC) we created, we carried out a system survey in the format "Yes", "No" of similar formations, signs or risk factors with color illustrations on the touch screen [8,10,11,13]. When the patient indicated the presence of pigmented moles of more than 6 mm that are prone to change (symptoms of ABCDE), photographs were taken using a USB microscope (magnification more than x 300) and transferred to the RK screen. For melanoma-dangerous nevi, they were additionally painted with a special dye [patent for invention No. 2716811 dated March 16, 2020], which colors collagen fibers in a bright red color (normally in the form of diamonds), other structures in yellow and other colors that are disturbed in melanoma [9].



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№	Факторы риска	Рекомендации	Пометки
1	Есть на коже образование, но не знаю, как оценить.	Осмотр онколога. Хирурга Соскоб на цитологию	
15	Кто то из кровных родственников болеет сахарным диабетом.	К эндокринологу.	
15	Кто то из кровных родственников болеет гипертонической болезнью.	К терапевту.	
15	У кровных родственников имеется онкологическое заболевание: пищевода / желудка. && У кровных родственников имеется онкологическое заболевание: другого органа / Не знаю.	К онкологу	

Figure 1: Fragment of a questionnaire and microphoto of a skin tumor on a robotic complex

Modeling of images in 3 categories was carried out on the basis of a matrix of the main melanoma-dangerous dermoscopic patterns described in guidelines and recommendations [1,6,7] and additions to a patient questionnaire (skin phototype 1-2, nevus evolution) with assignment of scores for their significance (Table 1) and correction after testing. The calculation of the melanoma hazard index was carried out in an automated mode using a simplified formula:

ММИ=2 Pn/(N (10)) where

MMI – morpho-microscopic melanoma hazard index,

P n – number of installed patterns,

N -10 – total constant number of main melanoma-dangerous patterns

2 – "double" coefficient of oncological alertness

With MMI up to 1.0 - low degree of transformation (benign formation);

With MMI more than 1.1 – 2.0 - nevus with a high risk of transformation

When MMI is more than 2.1 - melanocytic dysplasia, melanoma.

The RK program interprets, formulates the risks of dangerous melanocytic skin tumors, recommendations and a library of photographs (Figure 2) for subsequent clinical examination over time, "double control" and training in recognizing them.

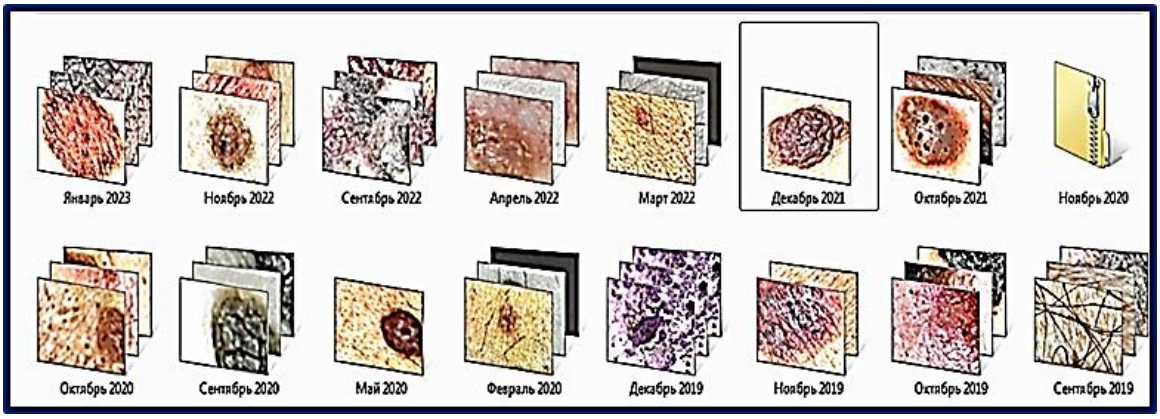

Figure 2: Database of melanocytic formations

Results

The material for automated processing and further training of the Republic of Kazakhstan was 232 photographs and analysis of 902 questionnaires completed at the clinics of Veliky Novgorod and the Starorusskaya Central District Hospital (24 questionnaires of patients after examination with pyogenic granuloma, hemangiomas and papillomas were excluded from the sample, indicating the presence of "troubled moles"). The average age of patients is 44±1.4% (from 27 to 68 years) with a male to female ratio of 1:2.4, including one woman during pregnancy.

Photo- and chromomicroscopic diagnostics were performed on the RK platform, which made it possible to sequester 137 patients with low-transformation nevi, evaluate 90 microphotos as melanoma-dangerous nevi, and in 5 patients identify them as superficial melanomas requiring non-invasive additional examination and treatment. To increase the statistical reliability of the test processing, 9 superficial melanomas were included, admitted for surgical treatment at the State Budgetary Institution OKOD and subjected to preliminary USB chromomicroscopy.

54 patients with melanoma and melanocytic dysplasia were operated on and morphologically verified (56.8 ± 2.18%). The rest were followed for more than 2 years. In only 1 case, the transformation of melanocytic dysplasia into melanoma with a score of 2.2 was not confirmed by histological examination

.

Nevus category	Number cases	Final clinical and morphological diagnosis	Morpho-microscopy ical index (MMI)	Sensitivity (Se)/ specificity (Sp) Accuracy (Ac)
From low transformation	137	Intradermal Mixed Blue	0,3-1,0 Average 0,6±0,13%	
Melanoma nevi	90	Border Lentigo Acrolentigo Dubreuil's melanosis	 1,1-2,0 Average 1,8 ±0,18%	
Melanocytic dysplasia Superficial melanoma	5 9 14	Melanocytic dysplasia Melanoma in situ Superficial melanoma	 2,1 - 4,7 Average 2,9 ±0,19%	Se = 0,93 Sp = 0,98 Ac=93,75%
Total	232			

Table 1: Results of clinical and photomicroscopic diagnostics using a robotic complex

As an example, we give the calculation of MMI (Figure. 3):

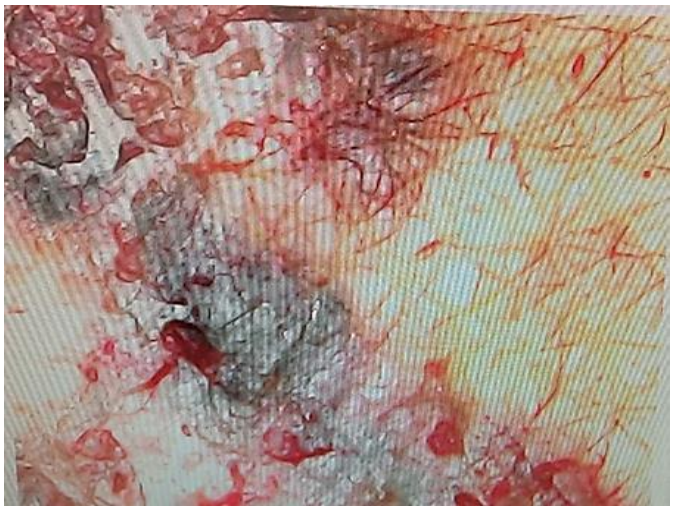

Figure 3: Superficial melanoma, magnification x 300 (Index calculation: asymmetry on both axes -5, colors beige, brown, red, black - 3, gray-blue veil -3, regression of the nevus area - 3, violation of rhomboid shape - 4, arachnid angioneogenesis - shown by arrow-5; General MMI = 4.6).

The statistical significance of the test for main melanoma-dangerous patterns was assessed using the formulas:

Sensitivity index $Se = \frac{ИП}{ИП + ЛО}$ = 0,93

Specificity index $Sp = \frac{ИО}{ИО + ЛП}$ = 0,98

Diagnostic accuracy $Ac = \frac{TP+TN}{TP+TN+FP+FN}$ x100% = 93,75%

After modeling melanocytic dysplasias and superficial melanomas, we began the logistics of "supervised learning," processing microimages with a program written in Python using the Tensor-Flow 2.0 machine learning framework, which requires further accumulation of material and step-by-step implementation into practice.

Discussion

Diagnosis of skin melanomas at the level of the radial growth phase remains a difficult task for primary care in "lean clinics". Despite the recommended algorithms for diagnosing melanomas using a dermatoscope, their reliability depends on the doctor's training, which requires "quite a lot of time" [14]. A retrospective analysis of digitization of microphotographs on the RK using a USB microscope, after a questionnaire survey of patients who indicated the presence of "troubled moles", showed the ability to identify nevi with a high risk of transformation, dysplasia and superficial melanomas with an accuracy of 93.75% (Se = 0.93; Sp = 0.98). The organizational and functional model (Fig. 4) of identifying cancer risk factors and, in particular, melanocytic dysplasias and melanomas using a series of booths with RK (with the participation of a nurse consultant) can become a breakthrough in "lean" clinics.

Figure 4: Scheme of the organizational and functional model of cancer screening in "lean" clinics

Computer training of neurosensory architectures in the RK application will in the near future make it possible to optimize and perform low-cost USB microscopy, increasing the efficiency of screening examinations of population flows and great diversity patterns of melanocytic dysplasias and skin melanomas.

Conclusions

1. A computer-hardware complex that combines a survey on systems with illustrations, USB microscopy (with and without staining) of melanogenic formations, makes it possible to diagnose and effectively treat melanocytic dysplasias and melanomas at the horizontal growth phase at a lower cost.

2. The proposed model for examining the population will allow us to gradually, from the standpoint of clinical practice, identify three groups of melanogenic skin formations: with low transformation; with melanoma-dangerous nevi (for preventive measures) and melanocytic dysplasias and melanomas (requiring treatment), accumulate material with subsequent training of neurosensory architectures for their automated identification.

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