DEVELOP REQUIREMENTS FOR AUTOMATED COMPLEX OF EXPRESS DIAGNOSTICS OF PIGMENTED SKIN LESIONS

РАЗРАБОТКА ТРЕБОВАНИЙ ДЛЯ АВТОМАТИЗИРОВАННОГО КОМПЛЕКСА ЭКСПРЕСС-ДИАГНОСТИКИ ПИГМЕНТНЫХ НОВООБРАЗОВАНИЙ КОЖИ

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Abstract: *The work contains the main results of the development of a non-invasive method for the early diagnosis of skin pigmented lesions. The risk factors for the development of melanoma, their influence on the formation, development and degeneration of benign pigmented lesions in malignant ones are considered. Noninvasive methods for early diagnosis of pigmented skin lesions, their advantages and disadvantages, and informative indicators of diagnostic methods for early detection of lesions have been analysed. Diagnostic signs for the development of an automated noninvasive method for the early diagnosis of pigmented skin lesions have been formulated. And also formulated technical requirements for an automated complex for express diagnosis of pigmented skin lesions.*
***KEYWORDS**: MELANOMA, MELANOMA RISK FACTORS, CLINICAL SIGNS, DIAGNOSTIC FEATURES, TECHNICAL REQUIREMENTS.*

1. Introduction

Melanoma among other lesions occupies a special position, since it has aggressive properties. To date, skin melanoma remains the leading cause of death in patients with oncodermatology, with a steady increase in the incidence of skin melanoma all over the world[1].

In this regard, the questions of melanoma clinic remain extremely relevant. In order to automate the system and develop a complex for express diagnostics of pigmented skin lesions, it is necessary to consider the features of the origin, development and degeneration of benign pigmented skin lesions into malignant ones.

For the emergence of any tumor disease, in particular melanoma, it is necessary to combine the effects of the main causal factor with the conditions both surrounding the environment and the internal environment of the human body. Recently, it has been possible to identify a significant number of factors whose effect statistically significantly increases the likelihood of melanoma. To do this, exogenous and endogenous risk factors for melanoma development were analysed[2].

2. Melanoma risk factors

Scientists managed to separate risk factors for melanoma development into exogenous and endogenous ones[3].

Melanoma risk factors:

1 Exogenous risk factors are physical, chemical, biological agents of the environment that have a direct effect on the skin.
- 1.1 Physical factors:
  - 1.1.1 Ultraviolet radiation
  - 1.1.2 Ionizing radiation
  - 1.1.3 Electromagnetic radiation
  - 1.1.4 Fluorescent lighting
  - 1.1.5 Traumatism of the skin
- 1.2 Chemical factors:
  - 1.2.2 Contact with benzene, polyvinyl chloride, plastics, pesticides and radioactive materials
- 1.3 Biological factors:
  - 1.3.1 Food habits
  - 1.3.2 Skin diseases
  - 1.3.3 Viral infections
  - 1.3.4 Medications

2 Endogenous factors are divided into two groups: biological factors and melanoma precursors.
- 2.1 Biological factors:
  - 2.1.1 Racial and ethnic predisposition
  - 2.1.2 The level of pigmentation
  - 2.1.3 Hereditary (family) factors
  - 2.1.4 Anthropometric indicators
  - 2.1.5 Immune disorders
  - 2.1.6 Endocrine factors
  - 2.1.7 Reproductive factors in women
- 2.2 Predictors of melanoma:
  - 2.2.1 Skin pigmentary xeroderma
  - 2.2.2 Melasma
  - 2.2.3 Nevi

Risk factors for developing melanoma cause "damage" to normal cells and tissues. As a result of such damage, necrosis of cells or tissues occurs with subsequent proliferation, regeneration and restoration of normal tissue structures. However, prolonged proliferation under the influence of these factors can lead to a violation of cell differentiation, a change in their membrane antigenic structure, and hyporeactivity to the effects of regulatory factors in the body. Thus, under the influence of risk factors, normal cells and tissues are transformed into tumor cells. Also, in the case of primary damage, changes in the DNA of the cell can immediately occur, followed by a violation of its protein structure and differentiation (Fig.1).

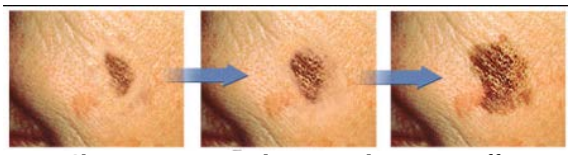

Fig. 1 Changes in pigment lesions under various effects

In connection with the frequency of melanoma from benign pigment neoplasms, as a rule, 70% of melanomas develop from the previous pigmented growth, and 30% arise on clean skin, it is necessary to know the clinical manifestations of their malignancy:

• growth of the nevus, its compaction or ulceration;
• change in color (strengthening or weakening);
• occurrence of hyperemia or stagnant halo around its base:
•development of radiant growths of a pigment or non-pigmentary nature around the primary formation;
•the appearance of an exophytic component on the surface of the nevus;
•formation near the nevus pigmented or unpigmented daughter nodules - satellites.

Therefore, pigmented skin tumors can be characterized by the following complex of clinical signs:

1 Color
2 Pigmentation uniformity

3 Pigmentation intensity
4 Size: diameter, area
5 The border of lesions
6 Border sharpness
7 Form
8 Structure: pigmented network, globules, dots and streaks, heterogeneity
9 Temperature of lesions
10 Echogenicity
11 The accumulation index of a photosensitizing drug

Identification of several of the listed signs allows clinically with a greater degree of probability to establish the correct diagnosis. However, in the presence of one of the listed signs, the diagnosis may remain insufficiently reliable, since the first signs of malignancy are often difficult to distinguish from usual inflammatory changes.

The initial pattern of the disease in typical cases proceeds as follows: the birthmark at different periods of the life of the carrier begins to increase after the previous trauma or without visible causes, change the color, shape, structure, temperature, etc., and turns into an exophytic tumor, which sometimes arises Eccentric on one of the sites of pigmented formation.

Analyzing the issues of clinical diagnosis of primary skin melanomas, it is necessary to dwell on the aspects of differential diagnosis. There are various methods for early non-invasive diagnosis of skin melanoma.

3. Methods of early non-invasive diagnostics of melanoma

Methods of early non-invasive diagnostics are divided into two types: primary diagnosis and secondary diagnostics, which is of a more precise nature in case of suspected melanoma (Fig. 2)[4].

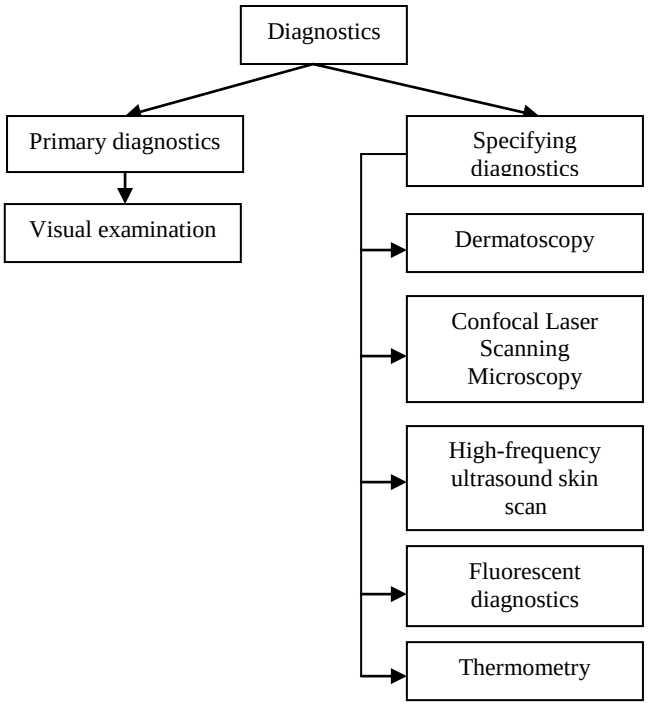

Fig. 2 Methods of early non-invasive diagnostics of melanoma

The analysis of the examined non-invasive methods of early diagnosis of skin melanoma made it possible to determine the main indicators of the informative value of the diagnostic methods: accuracy, sensitivity and specificity presented in Table 1.

Table 1 - Indicators of informative value of diagnostic methods for early diagnosis of skin melanoma[5,6,7

Type of diagnostics	Accuracy,%	Sensitivity,%	Specificity,%
Visual examination	66	50-90	50-90
Dermatoscopy	92,4	93,7	87,8
Confocal laser scanning microscopy	80	93	76
High-frequency ultrasound skin scan	85-95	84	90
Fluorescent diagnostics	72	87,2	94,8
Thermometry	83,5	90,5	80,2

The analysis of the data made it possible to identify the advantages and disadvantages of each of the methods for diagnosing skin pigmented lesions.

Table 2 - Comparative characteristics of methods for diagnosing melanoma[8]

Parameter	Visual examination	Dermatoscopy	Confocal laser scanning microscopy	High-frequency ultrasound skin scan	Fluorescent diagnostics	Thermometry	Automated diagnostic method
Accuracy > 80%	-	+	+	+	–	+	+
Sensitivity > 90%	±	+	–	+	+	–	+
Specificity > 90%	±	+	+	+	–	+	+
Exposure dose	–	–	+	–	+	–	–
Performance procedures	+	+	+	+	–	+	+
Non-invasive	+	+	+	+	+	+	+
Requirements for staff training	+	+	+	+	+	+	+
Requirements for the subsequent diagnostics	+	–	–	+	–	+	–

According to the data in Table 2, the following conclusions can be drawn: the sensitivity and specificity of dermatoscopy for the diagnosis of pigmented skin lesions are very high, therefore it is a good diagnostic tool for diagnosis, which avoids extensive traumatic surgeries in the treatment of pigmented skin lesions with a low risk of malignancy. However, despite the high sensitivity of the method of digital dermatoscopy in the early diagnosis of skin melanoma and benign melanocytic neoplasms, this method has so far limited application in Russia. In Russia, until now, doctors use a conventional manual dermatoscope, assessing visually every birthmark [6].

Fluorescent diagnostics helps to actively search for hidden, small tumor lesions on the skin surface [9].

The coincidence of thermometric and histological diagnoses occurs in 94.8% of cases with skin melanoma and in 67.9% in benign skin tumors. The accuracy of the thermometric method is limited by the fact that not all skin melanomas have hyperthermia properties [10].

From all of the above, it follows that the development of an automated, non-invasive method of early diagnosis based on the

advantages of all known methods of diagnosing skin pigmented lesions is undoubtedly relevant.

After analysing all the data obtained, the following diagnostic features were formulated for the development of an automated non-invasive method for early diagnostics[11]:

1 Color
2 Pigmentation uniformity
3 Pigmentation intensity
4 Size: diameter, area
5 The border of lesions
6 Border sharpness
7 Form

As well as formulated the main requirements for the technical system:

1 The system should with a high degree of accuracy, at least 90% detect pigmented skin lesions on the image;
2 The system should automatically perform segmentation of pigmented skin lesions;
3 The system should with a high degree of accuracy, at least 90% recognize the boundaries of skin pigmented lesions;
4 The system should automatically calculate parameters of skin pigmented lesions with an accuracy of at least 80% (maximum, minimum diameters, area, pigmentation uniformity, pigmentation intensity, color, border sharpness, shape);
5 The system should display the detected boundaries and calculated parameters of skin pigmented neoplasms;
6 The system should monitor the dynamics of changes in parameters of skin pigmented lesions, storing the data in the database;
7 The system should save the current result of calculating parameters of skin pigmented lesions in the form of a file.pdf;
8 The system should have a high degree of accuracy, sensitivity and specificity, at least 90%, of an automated method for early diagnosis of skin pigmented lesions;
9 The system should have a working wavelength range of 420-640 nm;
10 The system must have a resolution of at least 320 dpi;
11 The system should scan the areas of the surface of a person's body with an area of at least 50x50 mm;
12 The system should have a photodetector array with a resolution of at least 5 megapixels.

4. Conclusions

1 As a result of the analysis of risk factors for the development of skin melanoma, clinical signs of skin pigmented lesions were formulated.
2 The results of a comparative analysis of non-invasive methods of early diagnosis of skin pigmented lesions allowed to formulate the advantages and disadvantages of each method, as well as to determine the informative indicators of diagnostic methods for early detection of lesions.
3 Based on a comparative analysis of early diagnostic methods, diagnostic features were developed to develop an automated non-invasive method for early detection of skin pigmented lesions.
4 As a result of the analysis of all data, technical requirements were formulated for an automated complex for express diagnostics of skin pigmented lesions.

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