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MODERN METHODS FOR DIAGNOSTICS OF GLAUCOMA

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Abstract
Glaucoma is a chronic optical neuropathy characterized by loss of ganglion cells with the development of specific changes in the optic nerve head (ONH) and retinal nerve fiber layer (RNFL).
Early detection of the disease plays an important role in preventing the development structural abnormalities and irreversible vision loss. Diagnosis of glaucoma is based on assessing the safety of optic nerve structures and visual functions results clinical examination of the optic disc and RNFL are subjective and vary greatly.
In connection with this, research in recent years has been aimed at developing additional objective methods for diagnosing glaucoma. The possibility of using confocal scanning laser ophthalmoscopy, scanning laser perimetry and optical coherence tomography to assess the condition of the optic disc. In order to ensure early detection of visual field defects options are currently being considered replacing standard automated perimetry (SAP) with selective, which includes short-wavelength automated perimetry (SWAP) and perimetry with the illusion of spatial doubling frequencies (frequency-doubling technology perimetry, FDT). The article is an overview modern method for diagnosing glaucoma in the context of their use in clinical practice.

Keywords glaucoma, diagnostics, perimetry, standard automatic perimetry, short-wave automatic perimetry, doubling illusion perimetry spatial frequency, stereo photography, confocal laser scanning ophthalmoscopy, optical coherence tomography, scanning laser polarimetry.

INTRODUCTION

Irreversible loss of retinal ganglion cells (RGCs) in glaucoma accompanied by the formation of pathological excavation of the optic nerve head (OND), and limited or diffuse thinning of the retinal nerve fiber layer (RNFL).

Current evidence suggests that significant visual damage nerve in many cases precedes the appearance of visual field defects. An example is the Ocular Hypertension Treatment Study (OHTS), in which more than half of the patients who eventually developed glaucoma group, changes occurred in exactly this sequence. As a result, in recent over the past decade, methods have become widely used in the diagnosis and monitoring of glaucoma visualization of the ONH and RNFL.

However, there is still no evidence in favor of any of the devices used not received yet. Regarding the available studies, most of them have criteria diagnoses of glaucoma are based on perimetric data, but recently the emphasis in the assessment glaucomatous damage shifts towards progressive changes in the optic disc [2, 3]. The problem of timely and accurate differentiation between norm and pathology in diagnosis of primary open-angle glaucoma (POAG) along with obvious the need to determine traces of even minimal disease progression are a priority in modern glaucomatology [1–4].

This statement is an axiom in clinical practice, which is confirmed by the scale of the problem and the obvious lack of solution over the past decades, despite

tremendous development of the diagnostic technology market [5, 6]. Starting from the first half 1990s and until the mid-2000s. (i.e. almost a decade and a half) accent

diagnostic search in patients with glaucoma has been shifted to the area of improvement technologies and devices. Traditional ophthalmoscopy has been replaced by fundus photography, and with the development of computer technology, confocal

laser ophthalmoscopy (Heidelberg retinotomography, HRT) and in parallel developing laser polarimetry [7]. Later the dominant position was occupied by optical coherence tomography (OCT), which has become one of the most successful and widely used imaging methods in ophthalmology. Over the past decades, resolution devices have improved tens of times, and the scanning speed has increased hundreds of times [8].

At the same time, the development and launch into mass production of diagnostic methods, conducting non-invasive examination of the structures of the fundus in patients with POAG - this is only one of the promising directions. It is obvious that even the most accurate machines, firstly, only compare the specific results obtained with the regulatory framework, previously built into their hardware, and secondly, they can analyze limited number of parameters due to the peculiarities of computing resources. Finally one type research (for example, structural diagnostics) is just the only one, albeit obvious but limited method of diagnosis, while in general the diagnosis of POAG is initial manifestations requires comparison of relationships of a sufficient number parameters, such as characteristics of the level of intraocular pressure (IOP), condition retinal photosensitivity and morphometry of the optic nerve head (ONH) and layer retinal nerve fibers (RNFL), as well as a number of others (for example, subjective or socio-gender) components, etc. It is obvious that the definition of such relationships requires a significant amount of human and computing resources.

Ophthalmoscopy with assessment of the condition of the optic nerve head (OND) is often is a key examination in making a diagnosis: it must be carried out with taking into account several parameters of the optic disc, as well as analyzing the thickness of the nerve fiber layer retina (RNFL), with mandatory determination of the difference in these parameters between paired eyes. It is the presence of asymmetry in the state of the ONH and RNFL that is one of the signspresence of glaucoma. However, the features of the description of the state of the ONH and RNFL and the correct assessment of detected changes, especially during the initial manifestations of the disease, is more degrees depend on the professional competence of the ophthalmologist and even on features of the interpretation of results obtained using specialized technology [8, 9].

Minimizing the risk of decreased visual function is determined by a comprehensive

approach, including, in particular, accurate determination of the stage of the disease, assessment life expectancy and rate of disease progression per based on the state of the optic disc, RNFL, visual fields [1, 3]. For this reason, in the absence visual field defects, missing episodes of elevated IOP levels, researchers can miss both the onset of the disease and the opportunity to evaluate the dynamics of the process in the future,

which will directly affect the duration of the disease, namely the time during which will lead to blindness.

Characteristic changes in the visual field in patients with glaucoma have long served as an important guide to diagnosis. However, if glaucoma is suspected and even at the initial stage of primary open-angle glaucoma (POAG), specific glaucomatous changes during perimetry can be minimized or not at all not to be observed. Conducting and assessing specific tests may be difficult the need to train the subject, his insufficient concentration of attention when

research and changes in the transparency of refractive media, as well as in connection with concomitant eye pathology. All these factors can, to a greater or lesser extent

influence the results obtained, which will no longer have high reliability[9]. Based on the above, the question remains open about the relevance of identifying all three Graefe signs for diagnosis. In our opinion, these signs cannot be exclude glaucoma from diagnostic markers, but it is worth expanding and clarify the most important of them, especially the role of ophthalmoscopy. It is also necessary emphasize the importance of use (in sufficient quantities and in compliance with individual time intervals) additional specialized methods research: static automatic perimetry (SAP), perimetry with technology doubling spatial frequency - Frequency Doubling Technology (FDT) perimetry,

optical coherence tomography (OCT) and, in part, Heidelberg retinal tomography (Heidelberg Retinal Tomography, HRT) [5, 7]. Today the application

It is this set of methods that makes it possible to identify the disease and determine markers its progression. It is worth noting that the “decoding” of the obtained scans of the rear the eye segment also requires competent analysis taking into account population individuality.

For this reason, the search for a universal morphometric or a combined research method in order to increase the likelihood of obtaining an unambiguous answer about the presence of a disease or its absence, excluding subjective factors. In this case, possible risk factors in the subjects should be taken into account [1, 6].

With the advent of artificial intelligence (AI) technology, capable of learning and

carry out in-depth analysis, its application became possible [4, 5]. The use of AI has become easy as the basis for one of the areas of OCT and/or SAP data analysis with the possibility of introducing additional data to improve the accuracy of detection of glaucomatous changes [4, 8].

Currently, preference is given to convolutional neural networks (CNNs), which can learn quickly [5]. One of the promising directions can be considered the use of this technology in the evaluation of fundus images. Fundus photographs may be a suitable “candidate” for population screening for glaucoma, since it is the most a simple and widespread method for assessing ONH [4, 9], relatively inexpensive andperspective. AI models have now been developed that can identify and determine changes in diabetic retinopathy and age-related macular degeneration.

The AI was trained using data from OCT scans and fundus photographs of patients to determine the presence and stages of the pathological process according to the results of fundus photography.

Software developed by Google's DeepMind division allows you to perform parallel analysis for several retinal diseases at once [5]. In relation to the diagnosis of glaucoma, similar software algorithms have been developed, however, to make a final diagnosis they required several diagnostic examinations, based on the results of the analysis of which the neural network reported the likelihood of a glaucomatous process in a particular patient.

The use of deep learning models has shown excellent results in diagnostics

glaucoma, but researchers have encountered a number of problems associated with the use reference eyes at the neural network training stage, i.e. the machine will work no worse researcher, but repeat his mistakes. For example, in a study by Z. Li et al. [5] algorithm deep learning tended to exclude the diagnosis of glaucoma in myopic patients high degree, increasing the number of false negative results, but overestimated the presence of glaucoma with physiologically increased sizes of the optic disc, increasing the number false positive results.

CONCLUSION

An Alternative Approach to Setting Up Deep Learning Models for Evaluation Fundus photographs in patients with glaucoma were proposed by F.A. Medeiros et al[2] and called machine-to-machine (M2M). In such a model, the algorithm is formed using color fundus photographs labeled with a quantitative reference standard, corresponding to the measurement of total RNFL thickness measured using spectral OCT.

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