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Research Article

The History of Remote Diagnosis of Glaucoma with the Help of "Artificial Intelligence" in the Form of Artificial Neural Networks

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Abstract

Aim: Aim of the study is to report on the development and application of a remote method for the early diagnosis of POUG with the help of artificial neural networks.

Methods: Traditional ophthalmic methods of examination of patients with suspected primary open-angle glaucoma were used.

Results: Encouraging results have been obtained for the early detection of glaucoma using artificial neural networks remotely, without direct involvement.

Conclusion: Thus, the technology of remote diagnosis of glaucoma with the help of self-learning artificial neural networks allows you to diagnose remotely, quickly and early, thus reducing the diagnostic stage, leaves the possibility of comprehension for the doctor.

Keywords: *Open-Angle Glaucoma; Self-Learning Artificial Neural Networks; Diagnostics*

Introduction

One of the main causes of incurable blindness - glaucoma - still disturbs the minds of ophthalmologists. Common trends can be traced in Russia - the number of visually impaired people due to glaucoma is steadily increasing. At the same time, the methods of early diagnosis of primary open-angle glaucoma have always been very diverse. Already in 1966, E.I. Ustinova noted that there are more than a hundred different methods for the early diagnosis of glaucoma, but none of them can claim absolute reliability. In addition, undoubtedly, during glaucoma there is an initial period when it can only be suspected, and no, the most sophisticated research methods do not allow you to make an accurate diagnosis. Therefore, despite the abundance of diagnostic tests, early diagnosis of glaucoma is difficult even for an experienced doctor and without a long, sometimes for several years of observation, it is not always possible to make a diagnosis. Early detection of primary open-angle glaucoma remains the "cornerstone" in the XXI century, as it is known that only at an early stage the disease can be suspended/stabilized [1].

In June 2021, the WHO warned about the risks of using artificial intelligence in medicine. What does the WHO see as a danger? In a report published in Geneva, the organization warned of the need to "protect human autonomy" in medical decision-making and to preserve the confidentiality of patients' personal data. WHO Director-General Tedros Adanom Ghebreyesus said: "Like all new technologies, artificial intelligence has huge potential to improve the health of millions of people in the world, but like all technologies, it can be misused and harmful." In addition, he stressed that the new WHO report is intended to be a valuable guide for states "how to maximize the benefits of artificial intelligence and at the same time minimize risks and avoid traps" (according to the TASS News Agency of 28.06.2021).

It should be noted that the so-called "artificial intelligence" was used by us in our work long before the present time. In 1998, at the Department of Eye Diseases of the Krasnoyarsk State Medical University (Russia), a study was launched on the possibilities of creating new medical technologies for the early diagnosis of primary open-angle glaucoma. In 2002, the work was completed, becoming the foundation for one doctoral and several master's theses [1].

Artificial intelligence is nothing more than artificial self-learning neural networks, which have universal capabilities and advantages, which include the ability to solve classification problems, the ability to self-study and subsequent retraining as the accumulation of factual data, as well as functioning with some lack of material, which is quite common in practical medicine. At the same time, the number of training signs (in this case, medical parameters) and clinical examples (cases) can be unlimited. In addition, the more medical parameters and clinical cases will be used, the better will be the recognizing (in our case - diagnostic) ability of artificial neural networks.

In this case, self-learning artificial neural networks, diagnostics can function on an ordinary personal computer. Another advantage is the quick receipt of an answer. In addition, self-learning artificial neural networks, diagnostics can determine the diagnostic significance of clinical signs for decision-making, thus determining from their set the most informative and reliable for diagnosis. As artificial neural networks, diagnostics are trained on new clinical examples, their recognizability and flexibility in decision-making increases. All of the above allowed us to develop a new medical neuroinformation technology for early and remote diagnosis of primary open-angle glaucoma using artificial intelligence, or rather self-learning artificial neural networks [2,3].

Purpose of the Study

The purpose of the study is to report on the development and application of a remote method for the early diagnosis of POUG with the help of artificial neural networks.

Materials and Methods

The study was conducted in one of the satellite cities of Krasnoyarsk, with a population of about one hundred thousand people. Examination of patients with suspected glaucoma was carried out according to a minimized complex adapted to the diagnostic methods available in the city polyclinic, since, methods such as HRT or OCT were available only in large medical and diagnostic centers in the early 2000s. For each patient, an individual card developed by us was filled. Research methods: visometry without correction and with correction, ophthalmobiomicroscopy, contact tonometry according to Maklakov with 10.0g, dynamic perimetry with the determination of peripheral boundaries of visual fields, as well as with the identification of cattle inside the fields of view, the study of hydrodynamics of the eye, measurement of blood pressure. Particular attention was paid to the detection of glaucoma characteristic of the early stage of glaucoma in the anterior segment of the eyes and on the fundus in comparison with both eyes. The asymmetry of all eye parameters was taken into account.

After examining a patient with suspected POUG, the completed card was sent to the Department of Eye Diseases of the Krasnoyarsk State Medical University for further processing with the help of artificial neural networks. For this purpose, the program "MultiNeuron 2.0" [2] and the neuroimitator program "NeuroPro 0.25" developed at the Institute of Computational Modeling of the Siberian Branch of the Russian Academy of Sciences were used [3]. As a result of neural network processing, each new example belonged to one of the classes ("patient with POUG" or "conditionally healthy") with varying degrees of reliability of the result obtained. Previous self-learning of artificial neural networks recognition was carried out on clinical data belonging to 350 (562 eyes) patients with verified diagnoses of POUG and 125 (185 eyes) conditionally healthy persons without signs of glaucoma of representative age. All patients in the study received voluntary informed consent to conduct the study. In addition, all of them were made aware of their rights.

Results

It was revealed that about 1/4 of the population of the satellite city were persons over 40 years old, of which 2.4% suffered from glaucoma. Glaucoma was the cause of primary visual disability in 19% of cases. In 2002, 592 people were registered for glaucoma, in 2003 only 10 additional patients were identified. After the introduction of a new neuroinformation technology for remote diagnosis of glaucoma using ANN, 112 patients with glaucoma were identified in 2004, 55 patients in 2005 and another 60 in 2006. In total, between 2005 and 2006, 344 patients with suspected glaucoma were examined remotely using artificial neural networks in the satellite city. In 2005, early neural network "diagnosis" of POUG was carried out in 189 patients, glaucoma was detected in 80 (42.3%) of them, rejected in 60 (31.7%), suspicion of glaucoma was left with subsequent additional examination and diagnosis using artificial neural networks in 49 (25.9%) people. In 2006, 155 people were examined, POUG was detected in 110 (70.9%) of them, glaucoma was rejected in 39 (25.2%), suspicion of glaucoma was left in 6 (3.9%) patients. Thus, for 2 years, 344 patients with suspected early stage of POUG were examined, the diagnosis was confirmed in 190 (55.2%), was rejected in 99 (28.8%), suspicion of glaucoma was left in 55 patients (16.0%). By 2007, the number of identified POUG patients had reached 829.

Discussion

The motives for creating a remote method for the early diagnosis of primary open-angle glaucoma were dictated by life itself - the huge length of the Krasnoyarsk Territory from north to south, the remoteness of large ophthalmological institutions from the places of residence of the population, long and cold winters, insufficient material support for patients in rural areas and limited diagnostic capabilities of rural medical and preventive institutions - all this did not contribute to early detection POUG. The proposed new neuroinformation technology of early remote diagnosis of POUG made it possible to obtain confirmation or refutation of the diagnosis of glaucoma without leaving the place of main residence with the help of only traditional ophthalmological methods, without the need for the patient's arrival in a highly equipped medical and prophylactic ophthalmological institution, the material costs of the patient, to obtain confirmation or refutation of the diagnosis of glaucoma without leaving the place of main residence, which is very significant in Siberia. The ophthalmologist receives additional confirmation or denial of his assumptions regarding the presence of an early stage of POUG in the patient. With the help of artificial neural networks, the diagnosis of POUG was confirmed in more than half of the patients, rejected in 28.8% of cases. Suspicion of glaucoma was left in only 1/6 of all with suspected glaucoma, which significantly reduced their total number. In monetary terms, remote diagnostics with the help of artificial neural networks allowed to save in 2005 - 2006 178 thousand rubles of patients for travel, accommodation, meals, etc. expenses.

With regard to the so-called "imperceptible effect", the number of persons with suspected glaucoma decreased by 84% over the time period presented, which undoubtedly contributes to improving the quality of life of these people by eliminating chronic stress in the form of the threat of glaucoma, because "nothing frightens more than uncertainty...". Patients with a confirmed diagnosis of glaucoma receive the necessary treatment, with the remaining suspicion of glaucoma after 6 months of observation at the place of residence undergo repeated remote testing.

Conclusion

Thus, the technology of remote diagnosis of glaucoma with the help of artificial neural networks allows you to diagnose remotely, quickly and early, thus reducing the diagnostic stage, leaves the possibility of comprehension for the doctor, since the answer is non-categoristic, allows you to store and accumulate medical information in a database with the ability to analyze in dynamics, to re-diagnose in difficult cases, to save state and personal funds of patients. In addition, one of the main advantages of the artificial neural networks is what the WHO is so afraid of - there is no "substitution" of the diagnostician with a computer, since the answer received is not categorical.

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