Simulation Training of Practical Skills in Measuring Intraocular Pressure of Human Eye

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Abstract: In this publication, we present the results of the development, creation and application of a simulation hardware and software complex (computer appliance) for mastering the skills of measuring intraocular pressure in the learning process. The appliance is designed to simulate clinical conditions, which are used to acquire practical skills in identifying intraocular pressure. It uses standard equipment for measuring intraocular pressure. In the computer appliance for mastering the skills of measuring intraocular pressure, it is possible to record videos of the learning process and obtaining practical skills, with subsequent archiving and analysis carried out by both professor and a student. The simulator is intended for use in specialist physician training and certification courses.

Keywords: virtual systems, ophthalmology, training, continuing education, certification, tonometers, intraocular pressure, tonometry.

Introduction

Currently, simulation methods in professional medical education are actively developed, and realistic simulators are created for obtaining various practical skills [1]. Practical skills training in ophthalmology is difficult because of the small size of an eye. There are various computer appliances, i.e., hardware and software complexes for mastering the ophthalmoscopy technique and examination of the internal eye structures [2, 4]. In accordance with the requirements, patient simulators should provide maximum reliability and closeness to the actual doctor's routine [3, 5]. Organizational regulation in this field is conducted by the Russian Society for Simulation Education in Medicine.

The procedure of measuring intraocular pressure is called tonometry and is widely used. It is one of the required practical skills of both ophthalmologist and general practitioner. By the decree of the Russian Federation Ministry of Healthcare, it is necessary to carry out mandatory mass prophylactic examinations of people of ≥40 years old for early detection of glaucoma with a mandatory tonometry of the eyes, and the latter should be performed at least once a year [6]. With glaucoma, the eye pressure rises sharply, which eventually leads to blindness [7]. At present, the measurement of intraocular pressure through the eyelids is conducted by the plunger method using the IGD-02 Diathera Digital intraocular pressure indicator [8], depicted in Figure 1. However, for a practitioner, it is necessary to be proficient in the measurement technique *via* various methods and devices, as well as to have an ability to properly interpret the obtained data. In this regard, there is a need to develop a hardware and software complex, i.e., the computer appliance for testing acquired skills and accuracy of the intraocular pressure measuring procedure [9, 10].

OBJECTIVE. Creation and use of a simulation hardware and software complex (computer appliance) in the learning process for mastering the skills of measuring intraocular pressure.

Materials and Methods

Currently, different intraocular pressure measurement devices are used. ELAMED TVGD-02 intraocular pressure tonometer. IGD-02 PRA intraocular pressure indicator is a device for measuring intraocular pressure without contact with the cornea of an eye. In IGD-02 PRA indicator, a dynamic version of the dosed exposure is used to measure the parameters of intraocular pressure (Figure 1). The accuracy of tonometric indicators largely depends on the correct execution of the intraocular pressure measurement process.

The intraocular pressure measurement devices ELAMED TVGD-01 and ELAMED TVGD-02 differ significantly by the following: TVGD-01 is a transpalpebral digital pocket tonometer indicator, while TVGD-02 is a measuring instrument (tonometer). TVGD-02 has two modes for measuring intraocular pressure: the mode for measuring tonometric intraocular pressure, conventionally used in Russian ophthalmology; and the mode of measuring true intraocular pressure – an international scale for assessing intraocular pressure.

These devices are widely used, specifically, for dispensary observations of patients and for diagnostic examinations of people with ophthalmic hypertension, as well as patients with established or suspected glaucoma.

Intraocular fluid is secreted by the vitreous body. It flows into the anterior chamber and then enters the drainage system of the eye. The eye is a spherical body (volume) with an elastic shell filled with an incompressible fluid at a certain pressure. In a steady state, intraocular pressure is determined by the balance of the rates of inflow and outflow of intraocular fluid.

Figure 1. IGD-02 PRA indicator

A simulation hardware-ad-software complex (computer appliance) for mastering the skills of measuring intraocular pressure has conditions for measuring intraocular pressure that correspond to those in clinical settings. The dimensions of the head part and the simulated eye are identical to actual body parts. The hardware part provides a possibility of measuring intraocular pressure in the range of 16–40 mmHg with a possibility of regulating given parameters.

Since the examination is performed through the eyelids, the position of those should be the same as in conditions of actual examination. The main unit is an eyeball simulator, which is a sphere with a diameter of 22–23 mm. This diameter matches the diameter of a healthy eye.

The spheres are connected to the hydraulic system in the rear pole area. Tension sensors are located in the cavity of the eye simulator, in the hydraulic system and on the piston part of the hydraulic system. The control is carried out using a specialized program. The regulation of the pressure in cavity of the eye simulators is carried out by means of stepper motors moving the piston group of the mechanical part. After the pressure data are confirmed by three pressure gauges, the testing of tonometers is possible. The generated pressure range in the system is from 10 to 6 mmHg. The control is supposed to be carried out by means of a computer program that is currently under development. During testing, the tonometer is installed on the upper eyelid area, similar to the conventional examination procedure.

The methodology for measuring intraocular pressure is to touch an eyelid with the indicator. The main measuring component is the instrument stem, which should be in the working position. The primary fixation of the stem is performed by displacing the indicator in the vertical position, with its stem up. In the measurement mode, press the 'work' button; the indicator should be in a vertical position and set on the upper eyelid. It is possible to conduct research in both vertical and horizontal positions. We chose a horizontal examination position as more convenient for placement on the table.

Determination of the pressure measurement accuracy is a two-level procedure. It is measured by pressure gauges at the pressure of the hydraulic piston, and when determining the intraocular pressure in the cavity of the hydraulic system. The parameters are controlled by the Raspberry Pi 4 microcomputer. The control is carried out using a computer program, into which the parameters of the meter, its type and measurement results are entered. The integration of the results is performed in relation to the ratio of ocular pressure to atmospheric pressure, which is defined as the true intraocular pressure.

Figure 2. **The process of teaching basic skills in measuring intraocular pressure**

Results

The computer appliance for mastering the skills of measuring intraocular pressure has been tested in the educational process at advanced training courses for ophthalmologists, as well as in the course of training residents of ophthalmology specialization. As a result of increasingly widespread use of the technique for measuring intraocular pressure through the eyelid, using domestic tonometers, there is a high need for acquiring practical skills in measuring intraocular pressure. The stages of mastering practical skills include familiarization with the design of intraocular pressure tonometers, with their major elements and the sequence of switching them on and testing their performance. After studying the instructions, we move on to mastering practical skills. The positioning of the tonometer has a significant effect on the measurement results. There are several possible variants of the incorrect position of the indicator: the indicator tip does not correspond coaxially to the optical axis of the eye; it is not located vertically; it did not shift from the intermarginal edge by 1.5 mm. All of the above violations lead to underestimation of results. The computer appliance is controlled by a specialized computer program that regulates the pressure level in the hydraulic system. The pressure change interval is set by the professor. The control of the measurement accuracy is controlled in accordance with the data of the pressure gauges of the hydraulic system the hardware-and-software complex. Figure 2 shows the process of teaching basic intraocular pressure examination skills.

Also, the computer program provides the ability to record videos of the learning process. At the same time, the abilities to save a video file directly on the hard disk and to send the file to the e-mail for archiving is implemented. In this mode, the option of distance learning *via* Internet channels is possible. A professor can observe the learning process remotely, giving recommendations in a chat mode with a student.

Discussion

A simulation computer appliance for mastering the skills of measuring intraocular pressure is a training system within the framework of implementing the Federal Educational Standards of the third generation. They opened a novel stage for application of the teaching methods in medical education. The main advantage is the ability to master complex research methods without risk and harm to actual patients.

In accordance with the current conditions and the growing need for distance learning, we consider it mandatory to ensure extensive long-distance accessibility of both the learning process and knowledge control *via* the Internet.

The results of the development, creation and application of a simulation hardware and software complex for mastering the skills of measuring intraocular pressure in the learning process are presented. Despite the actively developing market of ophthalmological simulators, there are currently no computer appliances for teaching intraocular tonometry.

The training process employs standard equipment that is conventionally used in clinical settings. Various clinical conditions are simulated, on the example of which, the acquisition of practical skills in measuring intraocular pressure is carried out. In the hardware-and-software complex for mastering the skills of measuring intraocular pressure, it is possible to record videos of the learning process and obtain practical skills, with subsequent archiving and analysis by both professor and a student.

The developed complex is intended for use in training and certification courses for specialist physicians, which meets contemporary requirements for simulation training. It can be used in the ophthalmology-related educational process at various healthcare and preventive medical institutions for mastering practical skills and assessing the accuracy of their implementation.

Conclusion

We have presented the results of the development, creation and application of a simulation hardware-software complex for mastering the skills of measuring intraocular pressure in the learning process. The computer appliance is designed to simulate clinical conditions, which are conventionally used to gain practical skills in measuring intraocular pressure. It uses standard equipment to measure intraocular pressure through the eyelid. In the hardware and software complex for mastering the skills of measuring intraocular pressure, it is possible to record videos of the learning process and gaining practical skills, with subsequent archiving and analysis by both teacher and a student.

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