Intelligent System for Retrobulbar Injection Surgical Skills Training

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For citation:
Danilova T.V., Bakutkin V.V., Bakutkin I.V, Zelenov V.A., Klyuev Ya.A. Intelligent System for Retrobulbar Injection Surgical Skills Training. *Scientific Research and Innovation. 2020;(1)3:167–170*
DOI:10.34986/MAKAO.2020.83.94.005

Competing interests:
The authors declare no competing interests.

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Acknowledgements:
The article is written under Agreement with the Federal Foundation for Basic Research No. 18-29-02008 "Intelligent Laser Eye Surgery System".

Abstract: The recent years have witnessed a large number of virtualization and simulation technologies being introduced in education and training of medical professionals. The reason behind it is the efficiency and safety requirements to medical training methods. The surgical skills feature special importance as those implying the highest risks for the patient. Introducing the simulation methods for practicing medical procedures opens up new possibilities, such as multiple repetition of procedures for gaining clinical experience or variation of clinical conditions and their combinations. A very important advantage is offered by the option of photographic or video recording of the training process enabling impartial assessment of acquired practical skills and mastered procedures. In ophthalmology simulators are successfully used in training ophthalmoscopy for both adult and juvenile patients. Surgical skills can be mastered using simulators of surgery, vitreoretinal surgery or cataract. Both the Russian and international markets offer a number of simulators for practicing injection skills. Such equipment is shaped as various body parts and is intended for practicing intravenous, intramuscular and intraarticular injections. Most of such devices feature the mechanical operating principle. It is worth mentioning that despite of the vast diversity of injection simulators none of them addresses retrobulbar injections. There is enough high-quality dummy and model eyeballs available for ophthalmology training purposes, but none of them is intended for injections.

Retrobulbar injections are common practice in ophthalmology, endocrinology and ophthalmosurgery [1]. They are peculiar in that they can be performed only by the professionals having practical surgical experience [2, 3]. This is due to the high risk of complications which may result from improper performance of the procedures [4]. Retrobulbar injections involve risks of damaging blood vessels and nerves including the visual one [5, 6]. There also exists the possibility of globe rupture which constitutes a serious complication capable of resulting in blindness [7]. That is the reason for retrobulbar injections being classified as surgical procedures [8]. This underscores the need for efficient training practices related to this procedure.

This research aims at development and practical application of the simulating hardware and software package to establish true-to-life retrobulbar injection training with the procedure's proper performance monitoring option.

Keywords: robotic simulators, retrobulbar injections, ophthalmosurgery.

Introduction

The simulating hardware and software package is intended for practical training in retrobulbar injections. The simulator provides all the conditions required for both a student to acquire the practical skills and the teacher to supervise the training. This goal has predetermined the tasks:

- developing a mathematical and software model of a patient's eye including eye parts and sections, blood vessels and nerve endings;

- making of a highly realistic robotic simulator mocking up in detail the eye's anatomical formations and supporting retrobulbar injection practice;

- development of a hardware solution to enable recording of the needle movement throughout the eye formations during the injection.

- development of the software to evaluate the injection technique and the needle path.

The simulating hardware and software package is intended for practicing retrobulbar injection skills and is used for training student ophthalmologists, as well as paramedical personnel and middle grade medical staff. The simulator can also be used for evaluating students' proficiency and medical staff competence assessment.

The developed software combines the virtual model with the video record evaluating the needle introducing accuracy. Prior to the simulator-aided practice the student must receive theoretical training to become familiar with the anatomical and physiological peculiarities of the patient's eye socket area.

Whenever the student fails to perform the procedure correctly the software indicates the error with a sound notification. The hardware and software simulator enables practicing the needle insertion point and angle choice, pressure force during puncturing, needle introduction speed and its position inside the simulated eye socket. The capability of properly choosing the puncture point and inserting the needle without damaging the eye tissues is imperative for acquisition of retrobulbar injection skills, wherein good knowledge of eye structure is a crucial issue, which cannot be mastered without eye elements.

Figure 2 demonstrates the general appearance of the simulating hardware and software package for retrobulbar injection training.

The system supports video recording of the training process with saving of the resulting file in an archive or its submission over the Internet to the teacher for evaluation, which appears to be a most valuable option now that the pandemic-related hazards have boosted the demand for remote training and

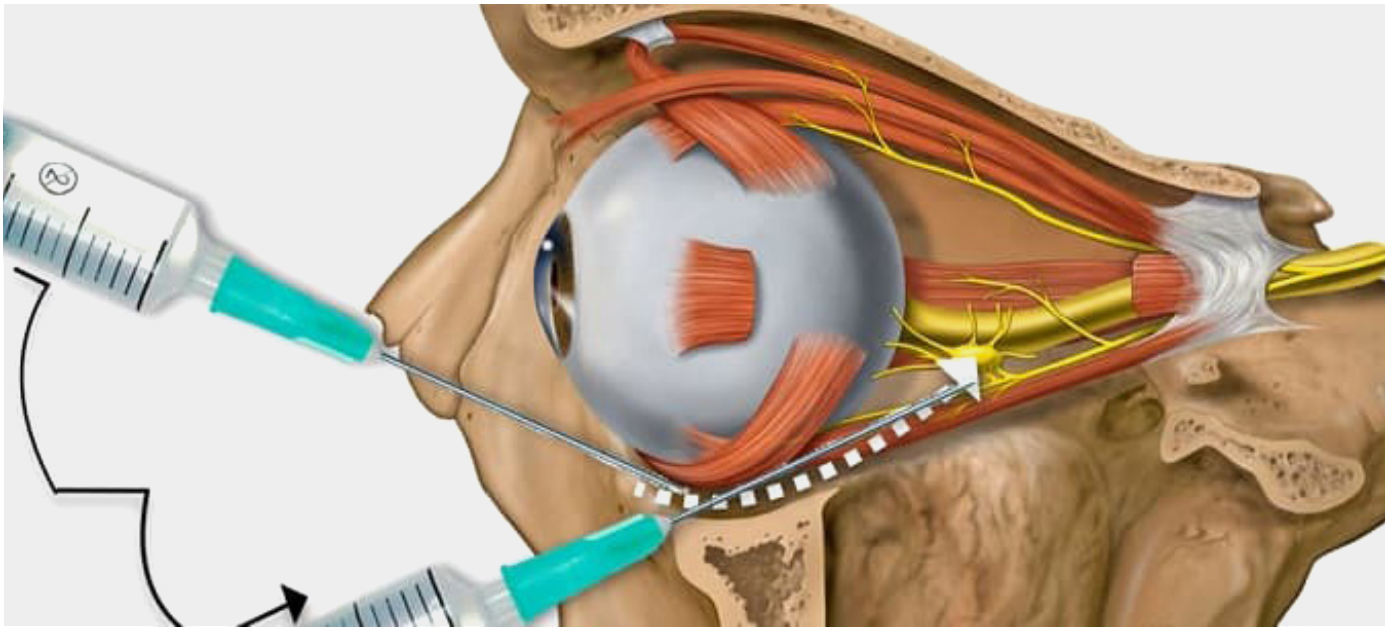

Figure 1. Eye socket structure and needle path during retrobulbar injection

Figure 2. General appearance of the simulating hardware and software package for retrobulbar injection training

competence assessment technologies. The described simulating hardware and software package ensures compliance with all the above-mentioned requirements. It must be mentioned that no similar systems providing injection training in ophthalmology have been offered in the market so far. Figure 3 shows a needle being introduced into the retrobulbar space.

The system also supports evaluation of the student's performance by videorecording the procedure results and enabling their following visual examination onscreen or their submission to the teacher via telecommunication.

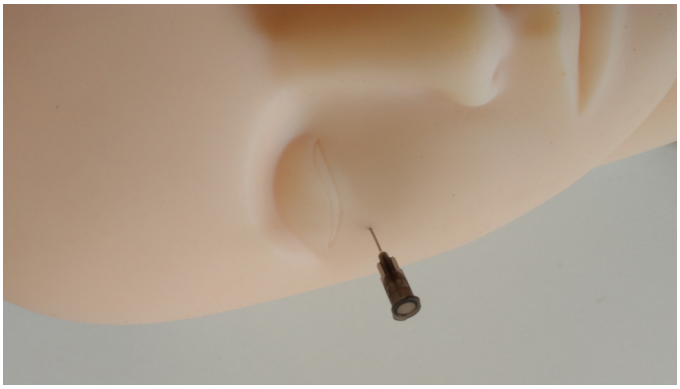

Figure 3. Introducing a needle into the retrobulbar space

Results

The simulating hardware and software package for retrobulbar injection practice is intended for practical exercises within the framework of medical specialists' postgraduate training (18-hour ophthalmology courses). The training curriculum includes both theoretical and practical sections. The system is the first to offer an option of videorecording the simulated retrobulbar injection providing the opportunity to watch the injection needle being introduced into the eye tissues. This enables electronically-aided inspection of the mock retrobulbar injection procedure for errors. An algorithm and a related hardware and software solution have been developed to combine the eye digital model with the video recording of the procedure for evaluation of the retrobulbar injection performance quality. The developed algorithms and software solutions support footage-based evaluation of the needle movement path during the injection. The simulating hardware and software package provides a true-to-life environment for retrobulbar injection training. It can be used for both instruction of the medical trainees and upgrading skills of ophthalmology and endocrinology professionals.

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