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Development of a novel Virtual Reality simulation training curriculum for laparoscopic transabdominal preperitoneal inguinal hernia repair

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ABSTRACT

Background: Advances in modalities such as Virtual Reality (VR) laparoscopic simulators have led to their widespread implementation in surgical training. Various modules exist, spanning across basic tasks and even segmented procedures. For one of the most common surgical procedures performed, laparoscopic transabdominal preperitoneal (TAPP) inguinal hernia repair, a structured training curriculum can be developed for future surgeons, and shorten the learning curve of training. Practicing the associated techniques in a complication-free environment, prior to application in the operating theatre, is a crucial aspect of safe and effective training, which can be achieved through VR simulators.

Material and Methods: The development of the program will include an arm of ten expert general surgeons and an arm of thirty novice general surgery trainees performing a group of three tasks at a single Simulation Center. Analysis of their performance will be used to test face and construct validity of the program. Data acquired will also be assessed based on Messick's framework.

Results: Data from the development will be analysed to formulate the preliminary curriculum proposal. The success baseline will be defined according to experts' performance data and will be adjusted to novices' level (±1 SD). A Delphi consensus will ultimately be conducted to formulate the final curriculum parameters.

Conclusions: In light of technological advances that reshape medical education, VR simulators are transformative in surgical skill acquisition while engaging trainees effectively. In order to utilise their full potential in effective training, evidence-based curricula are necessary. They can contribute to skill acquisition to a predetermined level of proficiency before progression to more challenging cases and can objectively evaluate each trainee. Such validated training curricula will result in more efficient skill acquisition and retention, ultimately contributing to better patient outcomes.

Key Words: *Laparoscopic training curriculum; virtual reality (VR); simulation; laparoscopic inguinal hernia; surgical training*

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The emerging need to train future surgeons and evaluate their acquired skills in a safe and controlled environment led to the development of simulation. Simulation is now an integral part of surgical training with the use of "box trainers", as well as more advanced modalities such as Virtual Reality (VR) simulators. Its ultimate goal is that

skills acquired in VR modalities are transferable to actual operating room performance, especially for laparoscopic procedures. Through VR simulators it is feasible to train on basic skills, as well as on full operations, according to preset objective criteria [1-3].

Worldwide, over 20 million inguinal hernia repairs are performed annually, making it one of the most common surgical procedures [4]. In the context of the rapid development of modern medicine, various surgical modalities for the treatment of inguinal hernia through laparoscopic techniques have arisen. Therefore, it is necessary for trainees to familiarise themselves with the associated techniques in a complication-free environment, to avoid pitfalls that could lead to patient harm. Simulation tools such as box trainers have played a major role in achieving this goal. However, such modalities are ideal for the initial development of fundamental skills. VR simulators using haptic feedback, visual guidance and objective performance criteria, can help provide a more holistic training as well as a more objective assessment, before trainees apply their skills in the operating room.

Through the implementation of established scientific research methods and by recording the performance of experienced surgeons and novice trainees, a structured Virtual Reality simulation training curriculum in laparoscopic transabdominal preperitoneal (TAPP)inguinal hernia repair can be designed. Such curriculum will ultimately contribute to more efficient training in this common surgical procedure.

PROGRAM DEVELOPMENT

Developing the index Virtual Reality simulation training curriculum for laparoscopic TAPP inguinal hernia repair will take place at the AKISA Simulation Lab, Attikon Campus, School of Medicine, National and Kapodistrian University of Athens, Athens, Greece. The equipment used will be the VR simulator LAP Mentor III (Simbionix Corporation, Cleveland, Ohio, USA). The software on which the educational program will be developed is the Inguinal Hernia Module v. 1.0.1.169.

The sample size will involve forty participants with specific selection criteria. One of the two arms will include ten experts, defined as specialised surgeons who perform over 25 laparoscopic inguinal hernia operations yearly and have no previous experience in VR simulation. The second arm will comprise thirty non-experts, defined as novice-general surgery residents, who have already completed the Basic Skills program in the VR simulator but have not practiced at the inguinal hernia module.

The above-mentioned group of forty participants will perform three tasks, each focusing on a crucial phase of the inguinal hernia repair operation. For both groups the frequency of practice will be one attempt per day, lasting 40 minutes. For experts, three attempts will be required for three consecutive days, and for novices, three attempts per week until achievement of performance plateau in the scale metrics.

Task description

Task 1 – Anatomy Identification

The anatomy identification task provides an opportunity to become familiar with the anatomy of the inguinal region and identify the anatomical landmarks essential for the TAPP technique for inguinal hernia repair. Pathology involves a right inguinal hernia. The objective of the task is to inspect the operative field and identify the important anatomical structures.

Task 2 – Incision and Dissection

The incision and dissection task allows for practicing an accurate peritoneal incision, performing a safe dissection and gentle reduction of the hernia sac, and preparing a peritoneal flap for further mesh placement. A variety of complications and emergency situations such as injuries to the vessels, vas deferens, nerves, or bladder, are included.

Task 3 - Mesh Placement and Fixation

The mesh placement and fixation task allows for practicing the accurate positioning of the mesh over the primary hernia defect, performing a safe fixation of the mesh to the anterior abdominal wall and closure of the peritoneum. A variety of complications and emergency situations such as injuries to the vessels, vas deferens, nerves, or bladder, are included.

Recording and storage of data

Each participant's performance data will be extracted directly from the simulator and the manufacturer's existing software and stored in a spreadsheet file (Microsoft Excel, Microsoft, Redmond, Washington, USA). Data will be anonymised using a key/ascending number. Only the Principal Investigator and the Academic Supervisor of the protocol will have access to the matching file. Each participant will complete a written consent form for the purpose of using their performance data in this research project.

Statistical processing

The statistical processing of the data will be performed using the statistical processing package SPSS

v25 (IBM, Chicago, Illinois, USA). Descriptive statistics will consist of the median and interquartile range for numeric variables, and the absolute number and percentage of the total for non-numeric variables. The normality of the data distribution will be examined by visual analysis of frequency histograms, and by applying the Kolmogorov-Smirnov test. For continuous numerical data with a normal distribution, parametric tests (t-test, ANOVA, Spearman correlation) will be applied. For continuous numerical data with a non-normal distribution, non-parametric tests (Mann-Whitney-U test, Independent Samples Median Test) will be applied. For non-numerical data, χ^2 and Fisher's exact test will be used. The learning curves will be analysed using the serial comparison method, or the CUSUM analysis method, or the ROC/AUC method (depending on the characteristics of the data). Where possible, two-tailed tests will be applied. P-values <0.05 will be considered statistically significant, and p-values from 0.05 to 0.1 will be considered statistically suggestive. The level of agreement between two or more measurements of parameters will be investigated using concordance analysis.

Program planning

After the completion of the statistical analysis of the data, the program planning will take place. The estimated duration of the program will be determined by the average time (weeks) during which trainees' learning curve approach the baseline of success, defined by experts' opinion, relevant literature, and experts' performance. The success/pass baseline will be set based on the experts' performance data and adjusted to the trainees' level (±1 SD). The "Construct validity" [5] and "Face validity" [6] parameters of the training program will be tested with two different methods. The validity of the program will be assessed based on "Messick's framework" which is now the most widely accepted method [7].

Additionally, each participant will respond to a questionnaire before the start of the index program, regarding expectations, and after completion of the program regarding evaluation, comments, suggestions and observations about the whole experience. Approval has been granted from the Bioethics committee of the School of Medicine, National and Kapodistrian University of Athens (#1128).

Delphi consensus

A group of expert surgeons will take part in the Delphi consensus which is an iterative process aiming to reach a unified opinion on the proposed completion benchmarks of the module [8]. The involved panelists will be supplied with recorded videos of the performed tasks, raw data captured and learning curve analysis. The process will consist of multiple rounds of anonymous questionnaires, allowing experts to share and revise their views without the bias of direct interaction. Questions will refer to technique steps, selection of appropriate metrics and determination of the successful pass threshold. This process will ultimately lead to a structured consensus on curriculum development, aiming to accurately hone the skills needed for inguinal hernia repair on a real patient. The analysis of the data collected by the Delphi consensus will be performed with descriptive, qualitative methods and final curriculum parameters will be proposed.

Communication of results

The results of the index study and training curriculum will be presented in seminars and domestic or international conferences as well as in international scientific journals. The main areas of discussion will involve potential integration of the VR inguinal hernia repair curriculum in comprehensive training programs, in combination with classic box trainers and live tissue labs. Moreover,future research directions can include external validation and implementation of the curriculum. The concordance of the results among participants from different institutions can be investigated to formulate the final curriculum implementation among independent populations. Finally, its impact on actual clinical practice can be investigated, through translational research, by comparing trainees' actual performance in the operating theatre before and after attending the curriculum.

Conflicts of interest: *None*

REFERENCES

1. Aggarwal R, Crochet P, Dias A, Misra A, Ziprin P, Darzi A. Development of a virtual reality training curriculum for laparoscopic cholecystectomy. Br J Surg. 2009 Sep;96(9):1086-93. Doi:10.1002/bjs.6679
2. Sinitsky DM, Fernando B, Potts H, Lykoudis P, Hamilton G, Berlingieri P. Development of a structured virtual reality curriculum for laparoscopic appendicectomy. Am J Surg. 2020 Apr;219(4):613-21. Doi:10.1016/j.amjsurg.2019.04.020
3. Wynn G, Lykoudis P, Berlingieri P. Development and implementation of a virtual reality laparoscopic colorectal training curriculum. Am J Surg. 2018 Sep;216(3):610-7. Doi:10.1016/j.amjsurg.2017.11.034
4. Köckerling F, Simons MP. Current Concepts of Inguinal Hernia Repair. ViscMed. 2018 Apr;34(2):145-50. Doi: 10.1159/000487278
5. Strauss ME, Smith GT. Construct validity: advances in theory and methodology. Annu Rev Clin Psychol. 2009;5:1-25.

Doi: 10.1146/annurev.clinpsy.032408.153639
6. Rueda Esteban RJ, López-McCormick JS, Rodríguez-Bermeo AS, Andrade M, Hernández Restrepo JD, Targarona Soler EM. Face, content, and construct validity evaluation of simulation models in general surgery laparoscopic training and education: A Systematic Review. SurgInnov. 2023 Apr;30(2):251-60. Doi: 10.1177/15533506221123704
7. Hamstra SJ, Yamazaki K. A validity framework for effective analysis and interpretation of milestones data. J Grad Med Educ. 2021 Apr;13(2 Suppl):75-80. Doi: 10.4300/JGME-D-20-01039.1
8. Humphrey-Murto S, Varpio L, Wood TJ, Gonsalves C, Ufholz LA, Mascioli K, et al. The use of the delphi and other consensus group methods in medical education research: A Review. AcadMed. 2017 Oct;92(10):1491-8. Doi: 10.1097/ACM.0000000000001812