3D, HAPTICS AND VIRTUAL REALITY TECHNOLOGIES IMPLEMENTATION RESULTS IN QUALITY ASSESSMENT AND ASSURANCE OF OBSTETRICIAN-GYNECOLOGISTS' HYSTEROSCOPY TRAINING

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Abstract

✦ Introduction:

Modern practical gynecology requires mandatory diagnostic and therapeutic hysteroscopic (HS) procedures. Their high-quality and safe performance is due to repeated trainings for mastering motor skills. This should ultimately lead to a tactile sensation and understanding of depth, fulcrum and force of impact. Simulation training is especially important, which gives effective theoretical and practical training of novice gynecologists for basic HS manipulations, the ability to conduct and evaluate their teamwork. The virtual simulator is widely used for objective assessment of clinical skills and abilities associated with the competence.

✦ Objective:

To evaluate the implementation results of quality assessment and assurance of obstetrician-gynecologists' training using a virtual HS simulator.

✦ Materials and methods:

During 4 years 156 obstetricians-gynecologists underwent "HS with resectoscopy" (72 hours) training in small groups up to 8 people in the simulation medicine department of Odessa National Medical University. After short lecture course the trainees practiced HS skills using conventional mechanical HS instruments used in clinics. Diagnostic HS was practiced (mastering the technology and specifics of conducting, examining cavities, photographing, etc.). Technique of hysteroresectoscopic operations: taking tissue samples, mechanical polypectomy, dissection of synechia and intrauterine septum, removal of small sub-mucous nodes was carried out using a virtual feedback haptic simulator VirtaMedHystSim (Simbionix, Israel).

The initial and final anonymous self-assessment questionnaire of qualification characteristics, which we developed, for their practical skills in carrying out HS was filled out, as well as theoretical knowledge level. We also used before and after training the well-known methodology for teaching and testing HS skills (HYSTT) - a practical test for measuring the level of competence of a trainee in the field of basic HS psychomotor skills in the uterine cavity, which mainly assesses video camera navigation and hand-eye coordination. We also developed a test card that takes into account the effectiveness of cadets' teamwork, which was also studied at the beginning and at the end of the cycle.

✦ Results:

More often doctors with work experience of up to 5 and over 20 years were trained. Almost half did not have a qualification category, and only 9.5% hold an academic degree. 75% have never performed HS in practice.

At the beginning of the cycle the average number of self-assessment points among trainees was 30.2, and after training - 59.9 ($p < 0.001$) (maximum was 80) proving they felt much more confident in performing practical skills.

The average score during outgoing testing was 3.7, and the final - 4.6, which testified to theoretical knowledge significant improvement ($p < 0.001$).

For the teamwork effectiveness assessment the average grade was 2.8, and after training it significantly increased to 4.8 ($p < 0.001$).

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✦ *Conclusions:*

After completion the training course of HS using both theory, real instruments, virtual 3D haptic techniques the level of practical skills, cadets' self-esteem, theoretical knowledge level, teamwork effectiveness have increased significantly. That complex educational curriculum quantifies the skills required to perform hysteroscopy and makes it necessary for the quality assessment and assurance of obstetrician-gynecologists' not only training but every day's work with real patients.

Keywords: obstetrician-gynaecologist, hysteroscopy, 3D, virtual realty, haptics, quality assessment, quality assurance, simulation training, postgraduate training.

1 INTRODUCTION

High-quality and safe performance of hysteroscopy (HS) is largely due to repeated training to acquire motor skills. This should ultimately lead to a tactile sensation and understanding of depth, fulcrum and force of impact. In this case, simulation trainings (ST) are important, which provide effective theoretical and practical training of novice doctors for basic HS manipulations, the ability to conduct and evaluate their teamwork. Its advantages are: safety for the patient and the trainee, the possibility of repeated and long-term trainings, modelling of clinical situations rarely encountered in the practice of a gynaecologist, effective assessment of theoretical and practical learning outcomes, and predicting the survival of the knowledge gained. In addition, the virtual simulator is widely used for objective assessment, because it allows you to test clinical competence, in the process of which the level of clinical skills is assessed, the independent implementation of medical manipulations, and, unlike traditional assessment methods, it allows you to evaluate and demonstrate what learners "can do", and not what they "know" ...

But the methods and assessment of ST results are still poorly scientifically substantiated, as noted in the latest review, which analysed and critically discussed the literature available on modelling hysteroscopy, published over the past 30 years [1]. Research has shown that a wide range of HS procedures, including diagnosis, resection and sterilisation, have a significant impact on the knowledge and technical skills of beginners. Pre- and post-workout studies show significant improvements in their execution times. But, a significant disadvantage is that the ST performance score distinguishes beginners from experts. The reviewers reasonably write that caution should be exercised with these data because the available evidence largely comes from heterogeneous, weakly designed studies conducted in an experimental setting with non-clinical participants (students). Moreover, neither the clinical outcomes nor the clinical value of the modelling-based assessment were considered. We also believe that the simulation HS should, first of all, be considered as a practical training with all the resulting drawbacks, but it has one indisputable advantage - it is the possibility of multiple, extended training, combining theoretical and practical skills together, and most importantly, bringing no harm to the future patient and our trainees. We consider this to be the main one, which allows us to close our eyes to many existing problems.

Yes, of course, it is good to draw clinical parallels in the practical work of our trainees in clinics with the results of their training on a simulator. This is a worthy task and we started to solve it, because a truly practical ST output is to improve trainees' outcomes in practical clinical work. This is the gold standard of education. HS education and training is challenging for an obstetrician-gynaecologist due to the specific instruments, skills and complex surgical environment. Patient profiles vary greatly and procedures can lead to serious complications (uterine perforation, energy damage from electrical energy, fluid absorption). In addition, there is often slower and less expected progress from observing the procedure of a novice obstetrician-gynaecologist than with procedures in which junior and senior obstetricians-gynecologists can cooperate, such as laparoscopy. The survival of knowledge and skills in time is of particular importance in ST, since its determination allows you to identify the necessary time for repeated trainings and, in general, to evaluate the ST system.

The existing methods for assessing the survival of knowledge are also one-sided - most often they are questionnaires, questionnaires (self-assessment). In medical education, in assessing and determining effectiveness, indicators that are determined in the general pedagogical process can be used (for example, the coefficient of practical skills (CPS), the coefficient of long-term survival rate of knowledge [2]. To calculate the CPS, all the collected points are made up and divided by the maximum possible number of points [4; 5]. Thus, the highest CPS corresponds to 1. Possibly, in accordance with the recommendations and generally accepted world practice, the CPS is not less than 0.7 [4; 6]. Usually to determine the coefficient of long-term survival of knowledge, a comparative analysis of the survival of knowledge is carried out by testing at least six months after the first period of training [2]. According to the literature, it is considered a positive result of the survival of knowledge and skills when the coefficient of long-term survival of knowledge is ≥0.50 [3]. no method for predicting the long-term survival of knowledge has been found in the available literature that would use both subjective and objective indicators, questionnaires, computer testing [7]. It was decided to study for this purpose the summary indicators aimed at calculating the content of the questionnaires and directly the results of mastering practical skills on the modern virtual HS simulator.

TASKS. To study the first results of the application and evaluation of the system of simulation training of obstetricians-gynecologists in hysteroscopy using a virtual simulator and to develop indicators of long-term survival of basic hysteroscopic knowledge.

2 METHODOLOGY

In 2014, a simulation center was opened at ONMedU and immediately began to conduct two-week training courses for obstetricians-gynaecologists of practical health care (cycles of thematic improvement "Hysteroscopy with resectoscopy" (72 hours)). During the period 2014-2018, 156 obstetricians and gynecologists were trained. They were trained in the scope of all tasks of the cycle, at least 10 trainings. The number of repetitions of each skill over the cycle period varied from 1 to 4, depending on the expected result. The time of practical skill execution, safety parameters, hand-eye coordination, choice of devices, manipulation of instruments, work with pedals, diathermy, aspiration, irrigation, with video cameras with a viewing angle of 30 ° and 0 ° were recorded.

Moreover, 36 cadets underwent similar training the next year, which allowed us to further study the survival rates of their knowledge. All cadets had a short course of daily lectures (theory). HS training was carried out using a complex system based on the virtual simulator VirtaMedHystSim (Simbionix, Israel). It has a feedback, tactile sensitivity - a haptic. It used genuine HS instruments (hystero-resectoscope, loop electrode, clamp, scissors, morcellator, forceps, etc.). Those. cadets practiced HS skills using common mechanical instruments that are used in clinics. Diagnostic HS was worked out (mastering the technology and specifics of conducting, examining cavities, photographing, etc.). Then the cadets were taught the technique of HS operations: taking tissue samples, mechanical polypectomy, dissection of synechia and intrauterine septum, removal of small sub-mucous nodes. After performing the manipulations, the student received an assessment for the performed manipulations.

All his actions were recorded for further discussion (debriefing) and joint viewing. The system allowed the trainee to turn to the help of the "Instructor control" function during work. There was an opportunity to practice skills in the treatment of possible intrauterine complications (bleeding, uterine perforation). At the beginning and at the end of the cycle, cadets filled out an anonymous self-assessment questionnaire that we developed, in which they assessed their skills in conducting HS. Each skill was scored from 0 to 5 points.

We also developed a test card that takes into account the effectiveness of cadets' teamwork, which was also studied at the beginning and at the end of the cycle. Also, the initial and final testing of the level of theoretical and practical knowledge about the pathology of the uterus, about HS was carried out. The tests were developed in our center and included 30 questions. For additional research, ST results were taken from 36 of our total 156 cadet physicians. These 36 cadets were trained in the first year, forming a comparison group (CG) (to obtain initial indicators for mathematical forecasting), repeated the same TR cycle for the next year - forming a main group (MG) (this group for calculating the survival of knowledge).

To achieve this goal, the task of self-assessment and external assessment of the initial (at the end of the 1st training) and final (at the end of the 10th training) level of practical skills of cadets of the CG and MG groups during these 2 years of study was solved. According to these two estimates, 4 groups were obtained throughout the years of study. All questionnaires (questionnaires), score sheets and self-assessment rate (SRC) were specially developed by us for the ST conducted on a specific virtual simulator.

The initial questionnaire was filled in independently by cadets before the first training, the final one - after the 10th training. The initial assessment checklist was filled in by the instructor at the end of the 1st training, the final one - after the 10th training. The questions that were used in the questionnaires and in the assessment checklists are given below (Figure 1, 2) (in abbreviated form, where the numbers from 0 to 5 are points).

A 6-point scale (0-5) was used for the total assessments of Lykert competence levels. Statistical processing was carried out using Microsoft Excel 2007 for Windows.

How much do you rate your skills when performing HS manipulations (There are none = 0; Very weak = 1; Weak = 2; Average = 3; Good = 4; Excellent = 5).
How long have you been involved in HS operations as an observer? (Didn't take = 0; <1 hour = 1; 1-2 hours = 2; 2-3 hours = 3; 3-4 hours = 4;> 4 hours = 5)
Have you had any experience with the HS simulator? (No = 0 <1 h = 1; 1-2 h = 2; 2-3 h = 3; 3-4 h = 4;> 4 h = 5)
Have you had any experience of independent work with devices for HS? (No = 0; <1 hour = 1; 1-2 hours = 2; 2-3 hours = 3; 3-4 hours = 4;> 4 hours = 5)
How easy was it to work with the HS tools? (Didn't work = 0; Very difficult = 1; Difficult = 2; Moderate = 3; Easy = 4; Very easy = 5).
How easy was it to operate the pedals? (Didn't work = 0; Very difficult = 1; Difficult = 2; Moderate = 3; Easy = 4; Very easy = 5).
How easy was the imaging optical system to work with? (Didn't work = 0; Very difficult = 1; Difficult = 2; Moderate = 3; Easy = 4; Very easy = 5).
How easy was it to work with the camcorder? (Didn't work = 0; Very difficult = 1; Difficult = 2; Moderate = 3; Easy = 4; Very easy = 5).
How easy was diagnostic HS imaging (Failed = 0; Very difficult = 1; Difficult = 2; Moderate = 3; Easy = 4; Very easy = 5).
How easy was it for you to coordinate work with two hands? (Not given = 0; Very difficult = 1; Difficult = 2; Moderate = 3; Easy = 4; Very easy = 5).

Figure 1. Fragment "Self-assessment questionnaire, initial and final."

Time for assembling and disassembling the histreroscope and hysteroresectoscope (> 5 minutes = 0; 4.5-5 minutes = 1; 4-4.5 minutes = 2; 3.5-4 minutes = 3, 3-3, 5 minutes = 4; <3 minutes = 5)
Time for "resection of myomatous nodes" (detected from the moment of capture) (> 5 minutes = 0; 4.5-5 minutes = 1; 4-4.5 minutes = 2; 3.5-4 minutes = 3 , 3-3.5 minutes = 4; <3 minutes = 5)
Time for "dissection of the intrauterine septum" (> 5 minutes = 0; 4.5-5 minutes = 1; 4-4.5 minutes = 2; 3.5-4 minutes = 3, 3-3.5 min = 4; <3 min = 5)
Time for "resection of polyps" (> 5 minutes = 0; 4.5-5 minutes = 1; 4-4.5 minutes = 2; 3.5-4 minutes = 3, 3-3.5 minutes. = 4; <3 min. = 5)
Execution errors when "applying a loop electrode", the distance from the indicated lines (> 20 mm = 0; 15-20 mm = 1; 10-15 mm = 2; 5-10 mm = 3; K 5 mm = 4; Exactly along the line = 5)
Errors when working with a hystero-resectoscope (Not done = 0; Errors more than 75% = 1; Errors from 50 to 75% = 2; Errors from 25 to 49% = 3; Errors up to 25% = 4; No errors = 5)
Errors when working with the optical system for visualization (Not done = 0; Errors more than 75% = 1; Errors from 50 to 75% = 2; Errors from 25 to 49% = 3; Errors up to 25% = 4; No errors = 5)
Time for "lysis of intrauterine adhesions" (> 5 minutes = 0; 4.5-5 minutes = 1; 4-4.5 minutes = 2; 3.5-4 minutes = 3, 3-3.5 min = 4; <3 min = 5)
Time for “frozen curettage” (> 5 minutes = 0; 4.5-5 minutes = 1; 4-4.5 minutes = 2; 3.5-4 minutes = 3, 3-3.5 minutes. = 4; <3 min. = 5)
Time to perform a practical skill (fixation, capture, removal of tissue) with instruments through the channel of the hysteroresectoscope "(recorded from the moment the image of the instrument appears in the field of view) (> 3 minutes = 0; 2.5-3 minutes = 1; 2-2 , 5 minutes = 2; 1.5-2 minutes = 3; 1-1.5 minutes = 4; <1 minute = 5)
Time to “change instruments in the channel of hysteroresectoscope instruments” (> 5 min. = 0; 4.5-5 min. = 1; 4-4.5 min. = 2; 3.5-4 min. = 3; 3- 3.5 minutes = 4; <3 minutes = 5)
Time for "targeted endometrial biopsy" (> 5 minutes = 0; 4.5-5 minutes = 1; 4-4.5 minutes = 2; 3.5-4 minutes = 3, 3-3.5 min = 4; <3 min = 5)
Time for "endometrial ablation" (> 5 minutes = 0; 4.5-5 minutes = 1; 4-4.5 minutes = 2; 3.5-4 minutes = 3, 3-3.5 minutes. = 4; <3 min. = 5)
Time for "endometrial resection" (> 5 minutes = 0; 4.5-5 minutes = 1; 4-4.5 minutes = 2; 3.5-4 minutes = 3, 3-3.5 minutes. = 4; <3 min. = 5)

Figure 2. Fragment of the “Evaluation checklist, preliminary and final.”

3 RESULTS

When analysing the length of service of cadets in the clinic, it was revealed that doctors with work experience of up to 5 and over 20 years were trained more often. Almost half of obstetricians and gynecologists did not have a qualification category, and only 1.8% had an academic degree. Three-quarters of the cadets had never done HS in practice before. Self-assessment of the fulfilment of their skills was extremely important for each cadet. The analysis revealed that at the beginning of the cycle the average number of self-assessment points among cadets was 30.2, and after the end - 59.9 ($p < 0.001$) (the maximum number of points is 80). The results obtained indicate that the trainees, after completing the thematic improvement cycle, felt much more confident in performing a number of practical skills.

For each of the topics studied, it was proposed to answer 30 theoretical questions. The average score during outgoing testing was 3.7, and the final (at the end of the cycle) - 4.6, which testified to a significant improvement in the level of theoretical knowledge of cadets ($p < 0.001$).

During the assessment, great attention was paid to the effectiveness of teamwork. According to the results of this testing, it was revealed that at the beginning of training the average grade was 2.8, and after the end of the cycle it significantly increased to 4.8 ($p < 0.001$).

In additional groups created in the study of ST results in the first and second years of study, the self-rating coefficient (SRC) of the cadet developed by us was determined by questionnaires and the practical skill coefficient (PSC) by assessment checklists. The obtained coefficients were summed up and the overall assessment indicators were obtained for each group. SRC was calculated by dividing the total number of points received during the survey by the maximum possible number of points (in these questionnaires, this is 50 points). If a cadet assessed his skills in self-assessment at only 25 points, then the SRC is, accordingly, 0.5 (TOTAL / 50 = 0.5).

The PSC was calculated by dividing the total number of points received at this stage when the instructor evaluated this cadet by the maximum possible number of points (in the assessment sheets we developed, this is 50 points). If the cadet received only 25 points during the assessment by the teacher, then, accordingly, the PSC is 0.5 for this case (TOTAL / 50 = 0.5).

The obtained SRC and PSC for each cadet in each group (initial and final in the first and second years of study) were summed up with each other and divided by two. As a result, the resulting coefficient of practical skills (RCPS)) were obtained for a particular student at each stage (RCPS I initial, RCPS I final, RCPS II initial, RCPS II final).

RCPS was then calculated for each group and used in basic calculations and discussions, group comparisons. The overall RCPS for all groups was 0.67 ± 0.06.

The dynamics of the coefficients (SRC, PSC, RCPS) of cadets' assessment over two years is given below (see Table 1.).

Table 1. Survival rates dynamics of knowledge during the first and second years of study (M ± SD, n = 36).

	I initial	***I final***	***II initial***	***II final***
SRC	0,14 ± 0,15	0,55 ± 0,04	0,50±0,11	0,74 ± 0,12
PSC	0,17 ± 0,13	0,54 ± 0,03	0,60 ± 0,11	0,85 ± 0,08
RCPS	0,16 ± 0,14	0,54 ± 0,03	0,55 ± 0,11	0,80 ± 0,12

Note: differences between the indicators of groups of different years of study (I and II) and different stages of assessment (preliminary and final) are significant ($p < 0.001$).

After processing the obtained data for each group (according to the calculated RCPS), it was found that the highest indices of the coefficients of practical skills had the groups of the second year at the end of the 10th training ($p < 0.001$ compared to all other groups), (see Figure 3).

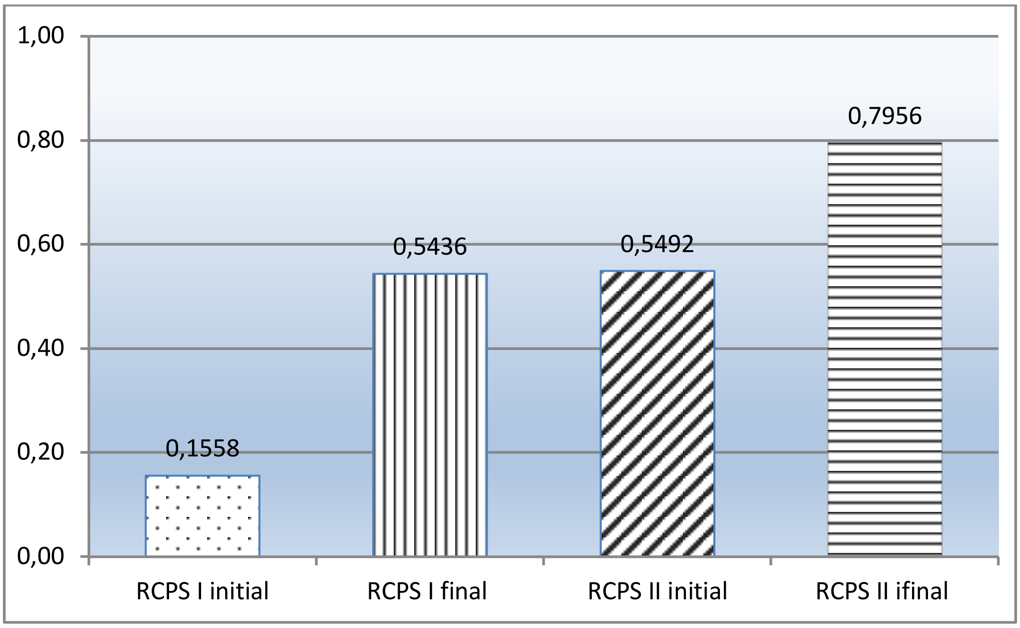

Figure 3. Dynamics of indicators of the resulting coefficient of practical skills (RCPS) in the studied groups (M ± SEx, n = 36).

We then examined the long-term survival of practical knowledge. The basis for this was the RCPS indicators in the groups of the second year of study and the relationship between these coefficients in different periods and stages of training. There was a high correlation ($r = 0.96$, $p < 0.001$) between the indicators in the first year groups at the end of trainings and in the second year at the beginning of trainings. There was also a high correlation ($r = 0.93$, $p < 0.001$) between the indicators in the groups of the first year at the end of trainings and the second years at the end of trainings.

This made it possible to assume that the long-term survival of knowledge depends on the number of trainings conducted (the required value is at least 0.65 at the end of trainings, that is, at the end of trainings of the first year of study), which made it possible not to lose significantly practical knowledge during the first year (RCPS did not decrease, but even increased from 0.54 ± 0.01 to 0.55 ± 0.02, although it remained below the permissible 0.65) and achieve a rapid increase in knowledge during 10 subsequent trainings (RCPS increased to 0.80 ± 0.02, that is, there remains a high survival of knowledge for the next year and this will make it possible in the future to continue training HS not only on simulation equipment, but also in a real operating room).

4 CONCLUSIONS

1. The cycle of thematic improvement in hysteroscopy in the simulation center has a positive effect on the level of theoretical knowledge, on the self-esteem of obstetricians and gynecologists, on the quality of practical skills, and is important in the training of medical personnel. After the trainings, the level of practical skills increased significantly: when analysing cadets' self-esteem, it was noted to increase almost 2 times ($p < 0.001$), the level of theoretical knowledge when tested at the end of the cycle increased 1.3 times ($p < 0.001$), assessment of the effectiveness of teamwork after the end of the cycle significantly increased by more than 1.7 times ($p < 0.001$).
2. The developed self-assessment coefficient has shown its effectiveness for general assessment and reliable calculations of the probability of survival of practical knowledge.
3. The dynamics of the coefficient of practical skills showed significant differences between the indicators of groups of different years of study and different stages of assessment.
4. The resulting coefficient of practical skills proposed by us showed its effectiveness for the general assessment and reliable calculations of the probability of survival of practical knowledge (it increased from 0.16 ± 0.02 to 0.80 ± 0.02 ($p < 0.001$) at the end of the last training, in total for all groups it was 0.67 ± 0.01).
5. The highest indices of the coefficient of practical skills were among the cadets at the end of the last training of the second year of study ($p < 0.001$ in comparison with all other groups).

6 There was a high correlation (r = 0.96, p <0.001) between the resulting coefficients of practical skills of cadets at the end of trainings in the first year and at the beginning of trainings in the second year.

7 There was a high correlation (r = 0.93, p <0.001) between the resulting coefficients of practical skills of cadets at the end of trainings in the first and second years.

8 The resulting coefficient of practical skills not less than 0.5 at the end of the trainings gave the cadets the opportunity not to lose practical knowledge during the first year (it did not decrease, but even increased from 0.54 ± 0.01 to 0.55 ± 0.02) and to achieve a rapid growth of skills during the next trainings (increased to 0.80 ± 0.02, that is, there remains a high survival of knowledge for the coming years).

9 The long-term survival of knowledge depends on the resulting ratio of practical skills. It should be at least 0.65 at the end of the trainings, if less - an urgent repetition of the course of simulation training in hysteroscopy is required.

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