

Research Article

The Novel Platform for Self-Directed Peer-To-Peer Medical Simulation for Development of the Technical and Non-Technical Competences

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Abstract

Background: HybridLab is a fusion of distance learning and self-directed medical simulation that allows learners to train 24/7 at their work place without direct presence of the instructor and/or technician.

Methods: In 2014, original trauma course developed on the new HybridLab learning platform was evaluated. Twenty-seven surgical residents of Lithuanian University of Health Sciences were enrolled. Skills were grouped into 7 categories according to ABCDE principles and were independently evaluated by 3 reviewers. Reviewer 1 was present during the simulation and reviewers 2 and 3 assessed skills using the video recording system. Progress of the students and the interobserver agreement were evaluated.

Results: Participants significantly improved their skills using the blended learning platform without an instructor and/or a technician. There was a 2.5 fold increase in the overall performance score (from 35% to 89%) with the significant improvement in each group of practical skills. Re-evaluation after 6 months revealed only slight decrease in the performance of the students (mean score decreased from 89% to 82%). Interobserver agreement was overall good when comparing results of skills assessment by reviewer present during the simulation exercise and online reviewers. In almost all categories the kappa levels were moderate or substantial (range 0.45 to 0.77), implicating those practical skills of the course participants can be evaluated online.

Conclusion: The study showed that HybridLab based course significantly improves basic trauma management skills. Participants were highly satisfied with the course; instructional organisation and usability were judged to be very good. Better agreement of the reviewers could be achieved by more clearly defining the rules of the skills evaluation. Clear and structured algorithms, well defined rules for formative and summative assessment are the key factors ensuring the functioning and reliability of the self-directed learning platforms.

Keywords: Blended learning; Medical simulation; Self-directed learning; Technical competences; Non-technical competences

Abbreviation

CPR: Cardiopulmonary Resuscitation; CRC: Crisis Research Center; AHA: American Heart Association; ERC- European Resuscitation Council; LUHS: Lithuanian University of Health Sciences; VLE: Virtual Learning Environment; NTS: Non-Technical Skills; ILCOR: The International Liaison Committee on Resuscitation

Introduction

Higher public and patient expectations have both encouraged the development and use of innovative educational methods. Blended learning has grown substantially in health care education [1]. Traditional face-to-face learning in medical simulation gradually replaced by the technology-enhanced simulation training which is

associated with beneficial effects for outcomes of knowledge, skills, behaviours, and patient-related outcomes [2]. Simulation training enables practice and error without risking patient safety [3]. Modern medical simulation centres currently are required to have not only high-fidelity mannequin-type simulators, but also to employ the full-time faculty and instructors as professionals of Simulation-Based Medical Education (SBME) are essential to ensure quality.

However, high fidelity simulation is very expensive and requires a lot of human resources. With financial pressures facing health care, there is a demand to provide equivalent standards of education at lower costs [4]. This is also the reason why many advanced medical courses (such as Advanced Life Support (ALS), Advanced Trauma Life Support (ATLS), etc.) compulsory for health care practitioners in western countries are still not routinely available for the medical students and/or residents in many countries throughout the central and Eastern Europe. It is highly recommended that advanced trauma life support courses should be taught for all doctors who are involved in the management of multiple trauma patients [5]. Training surgical residents to manage critically injured patients in a timely fashion presents a significant challenge. In Lithuania residents are involved in the management of polytrauma patients, however, in majority of cases they have possibility to attend the standardized advanced trauma life support course only after accomplishing their studies. Various Cardiopulmonary Resuscitation (CPR) self-directed learning programmes have been compared with instructor-led courses and recommended for training lay people and healthcare providers [6].

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session, also assess the performance of the leader and give an instant feedback after the simulation. The assistant could serve as a live model during some stages of the simulation sessions but usually he/she acts as member of the medical team, thus performing certain tasks delegated by the team leader and/or providing the required equipment and instruments to the leader during the simulated procedures and clinical tasks. Length of one session usually is one hour, but the learners can (should) book multiple sessions. During the session, each of the team members should take a role of the team leader, the assessor and the assistant. Each of scenarios is repeated multiple times to get the learners acquainted with the taught skills. We utilise a modified traditional 4-step training approach, with the main focus on independent practice and application of the skills or knowledge in practice. At the beginning, the learner runs the scenario while reading aloud an appropriate algorithm (1st level of competence - performs correctly a certain skill or procedures by reading aloud an algorithm). This step allows the learner to become successful from the first attempt. At the second step the learner practices without an algorithm, but verbalising every step to the rest of the team members before performing the action. The verbalisation/vocalisation of the clinical decisions and/or main steps of the clinical procedures serve as a mental training scheme and allows for the effective training of the other team members. Furthermore, this is also the powerful tool to develop and improve the non-technical skills, including the team work, communication, situation awareness and prevention of the adverse events (the learners are encouraged to intervene, if the team leader suggests inappropriate actions and/or demonstrates inadequate clinical skills). These goals are achieved by having different clinical scenarios, strict time interval for every session and scenario, the rotation and need of continuously communication of the team members. The third level of competence is achieved when the learner performs skills or procedures without clarifying every step. The fourth level of competence is ability to perform a certain task correctly and fluently, and the learner demonstrates confidence and readiness to transfer the acquired skills and knowledge in to their clinical practice.

Different learners need different time to achieve the fourth level, but this is not an obstacle for group work because the system allows each participant to take to role of the leader as many times as needed and practice at their personal pace.

Evaluation process

The faculty of the course responsible for development of the learning programme and assessment of the participants using the Virtual Instructor Environment (VIE) (working remotely and without direct presence in the simulation sessions) consisted of the experienced anaesthesiologists and surgeons, ALS and ATLS instructors. As all the session of the learners were recorded and stored, the faculty members were able to evaluate the learners at desired time. The faculty members had the same assessment forms the learners had during the sessions. All the evaluation was done on specially designed VIE. Each of the learners had to be evaluated by faculty members no later than 2 days after completing the interim or final session. Not only the score (in %), but also the comments/structured feedback and recommendations of the faculty members were immediately given.

Materials and Methods

We performed an observational study comparing pre- versus post-training performance in trauma life support of the surgery residents using HybridLab learning platform. A four-part, scenario-based trauma curriculum was developed specifically for this study.

The curriculum focused on strengthening basic trauma management skills (airway management, ventilation, bleeding control, spinal immobilisation), setting ABCDE priorities for the early management of critically injured trauma patients and strengthening non-technical skills (task allocation, teamwork, leadership, closed-loop communication) working in a small team. Scenarios described various clinical situations when a team of three learners had to manage trauma patients with different combinations of life-threatening injuries. Main focus of each scenario was the implementation of ABCDE principals and the application of needed practical skills.

An autonomous learning HybridLab station, as described previously, was made available in a room in the Department of Surgery secured with a badge reader, accessible 24/7. Three cameras of different angles were used for continuous video recording. All the videos were stored at specifically designed server. During a 5-weeks study period each student was directed to practice trauma skills for at least 12 hours. They were also encouraged to attend the skills lab additionally and practice more, should there be a need. Surgery residents from 1st to 4th year (total length of the residency- 5 years) were enrolled in to the study on a voluntary basis. During the first day of the course all participants were informed about the aims and the structure of the course.

Special standardized assessment form was developed for evaluation of the practical skills (Supplementary material). For each scenario, individual changes to the evaluation form may be done. Practical skills were grouped into 7 categories: (1) Baseline skills assessment (pre-course control scenario); (2) "A" skills (Airways); (3) "B" skills (Breathing/Ventilation); (4) "C" skills (Circulation); (5) "D" skills (Disability); (6) "E" skills (Exposure); (7) Final skills assessment (post-course control scenario and skills retention testing after 6 months). Baseline practical skills of all participants were evaluated before the course. After the first evaluation participants had one month to learn and improve their practical skills using the blended learning module. Progress of the participants during the course was evaluated by online instructors. Summative assessment of the student performance was done at the end of the course and re-evaluation was performed 6 months after the course.

In order to evaluate possible differences in assessing skills of the participants by instructors present during the simulation exercise (Reviewer 1) and online reviewers (Reviewer 2 and 3), all participants of one of the simulations were assessed by all three reviewers.

Residents' characteristics (age, sex, height and weight) were registered before the training. Participants' perceptions about the instructional organisation and about the utility of the self-directed learning course were surveyed to obtain a qualitative insight of the effectiveness of the autonomous learning model.

The Regional Ethics Committee approved the study, and all participants provided written informed consent. The study was conducted in the teaching hospital of the Lithuanian University of Health Sciences (Level I Trauma centre) between July and December 2014.

Data analysis

SPSS statistical package version 23.0 was used for analysis of the data. Data was assessed for normality and found to have a non-parametric/parametric distribution. Descriptive results are demonstrated as the mean (range). The level of significance was defined as $p=0.05$.

Interobserver agreement was calculated between the both online reviewers and each of the online reviewers and reviewer present during the simulation exercise. Cohen's kappa test was used for each of the practical skills scored on the evaluation sheet. Agreement levels were defined as: κ level 0.00 to 0.20 slight; 0.21 to 0.40 fair; 0.41 to 0.60 moderate; 0.61 to 0.80 substantial and 0.81 to 1.00 almost perfect.

Results

Acquisition and retention of clinical skills

Twenty-seven residents (1st to 4th year) were enrolled into the course and 20 (74%) of them have finished the course. Only 10 (37%) residents were available for the knowledge and skills retention assessment after 6 months (Table 1). The main reasons failure to finish the course was rotation to other hospitals.

Analysis of practical skills evaluation showed a 2.5 fold increase in the overall performance score during the course (from 35% to 89%). The minimal pass score was set at 80% for this course. Re-evaluation after 6 months showed only slight decrease in the overall performance score (from 89% to 82%) (Figure 3). The minimum score before the course was only 15% (maximum score- 64%). After the course the minimum score increased to 72% (maximum score 98%). Six months after the course the minimum score decreased to 53%, but maximum score remained as high as 92%.

When analysing every group of practical skills according to the ABCDE (airways, breathing/ventilation, circulation, disability, exposure) separately, significant increase in all groups (A to E) was observed. The highest increase was in "D" skills group (assessment of the neurological status of trauma patient) from 19.9% before the course to 96.7% after the course. In all groups, slight decrease in the overall performance score was observed 6 months after the course (Figure 4).

Interobserver agreement between the on-site and remote instructors

For evaluation, special standardized assessment form (checklist of performed skills) was used (Supplementary material). The average kappa values of the interobserver agreement in each of the practical skills categories are shown in Table 2. There was moderate - substantial agreement between reviewers in five categories. Almost perfect agreement was reached only in category 5 (Disability skills evaluation). In category 7 (Final skills assessment) moderate agreements was reached between Reviewer 1 to Reviewer 2 and Reviewer 2 to Reviewer 3. Only fair agreement (0.39) was reached between Reviewer 2 to Reviewer 3 in the same category. The results show that the interobserver agreement is overall good when comparing results of skills assessment by reviewer present during the simulation exercise and online reviewers. In almost all categories the kappa levels are moderate or substantial (range 0.45 to 0.77), implicating those practical skills of the course participants can be reliably evaluated online. This idea is also supported by results showing moderate to substantial agreement between both online reviewers (Reviewer 2 and 3). Structured and clearly defined practical skills evaluation questionnaire is one of the main reasons why overall good interobserver agreement between reviewers was found. To achieve even better agreement, the rules of the practical skills evaluation must be clearly defined and all the instructors should be trained to perform assessment in a standardized fashion.

Post-course survey of the course utility and effectiveness

During the post-course survey 92% of the participants stated that

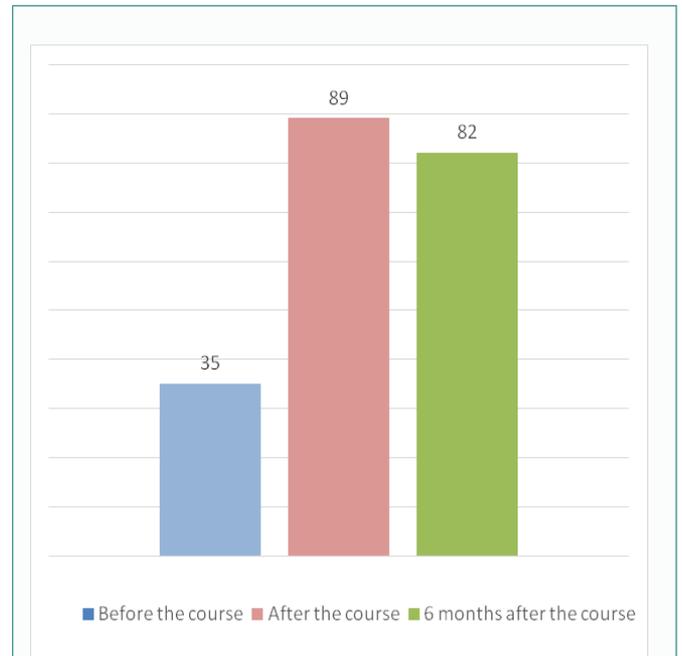


Figure 3: Overall performance evaluation score (%). Analysis of practical skills evaluation shows increase in the overall performance score during course from 35% to 89%. Re-evaluation 6 months after the course showed only slight decrease in the overall performance score from 89% to 82%.

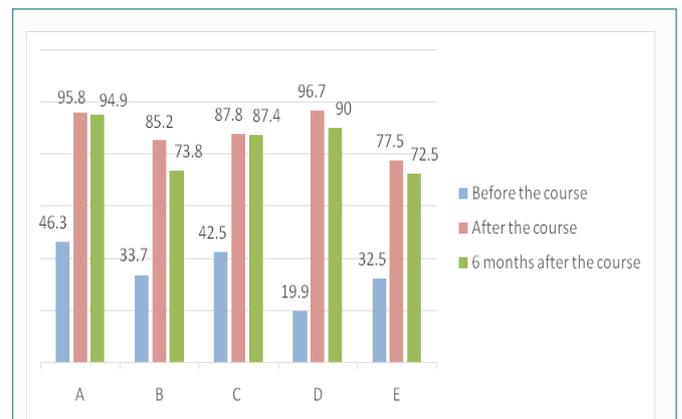


Figure 4: Comparison of evaluation scores (%) between practical skills groups (x-axis). Separate analysis of every group of practical skills (ABCDE) shows significant increase in the performance rate at the end of the course and only slight decrease 6 months after the course.

Table 1: Characteristics of the residents enrolled into the study.

| | Started the course | Finished the course | Re-evaluated after 6 months |
|--------------------------|--------------------|---------------------|-----------------------------|
| Gender, n (%) | | | |
| Male | 23 (85%) | 18 (90%) | 9 (90%) |
| Female | 4 (15%) | 2 (10%) | 1 (10%) |
| Year of residency | | | |
| First (1) | 7 (26%) | 4 (20%) | 1 (10%) |
| Second (2) | 9 (33%) | 8 (40%) | 5 (50%) |
| Third (3) | 7 (26%) | 5 (25%) | 3 (30%) |
| Fourth (4) | 4 (15%) | 3 (15%) | 2 (20%) |

they found the acquired knowledge and skills clinically relevant and applicable (60% said it was very useful, 32% useful, while only 8% expressed their doubts about clinical applicability of knowledge and/or skills).

Table 2: Interobserver agreement between course instructors (reviewers).

| | Reviewer 1 to Reviewer 2 | Reviewer 1 to Reviewer 3 | Reviewer 2 to Reviewer 3 |
|------------|-----------------------------|-----------------------------|-----------------------------|
| Category 1 | 0.76 (substantial) | 0.63 (substantial) | 0.59 (moderate) |
| Category 2 | 0.62 (substantial) | 0.56 (moderate) | 0.65 (substantial) |
| Category 3 | 0.58 (moderate) | 0.57 (moderate) | 0.77 (substantial) |
| Category 4 | 0.59 (moderate) | 0.66 (substantial) | 0.64 (substantial) |
| Category 5 | 0.95 (almost perfect) | 0.92 (almost perfect) | 0.87 (almost perfect) |
| Category 6 | 0.54 (moderate) | 0.5 (moderate) | 0.73 (substantial) |
| Category 7 | 0.54 (moderate) | 0.39 (fair) | 0.45 (moderate) |

Based on the participants feed-back the most useful structural elements of the course beside the simulation were instructional videos (70% of candidates watched all the video material, another 14% watched more than half of all the instructional videos), self-control tests (30% said it was very useful, 66% useful, while only 4% stated it was not relevant), and instructional algorithms (99% stated they were useful or very useful, while only 1% indicated that algorithms were not useful).

During the post-course survey, we asked the participants to estimate their self-perceived ability to carry out the crucial clinical tasks and skills, including the primary and secondary survey of the patient, management of the airways, immobilization and control of external bleeding. After the course 88% of the respondents was confident that they were capable of safely applying the acquired skills in the clinical setting (43% stated that they felt proficient, 45% skilled and only 12% felt they had moderate or poor skills). Overall, 94% of the course participants acknowledged that the course has increased their competence to provide advanced care for the severely injured patient and 56% of the respondents stated the change was really significant and encouraged them to review their daily clinical practice.

Discussion

The purpose of this study was to assess the feasibility of the self-directed peer to peer teaching employing the complex medical simulation scenarios without the on-site presence of the instructor and/or technician. The study also gives some insights into the utility and effectiveness of autonomous HybridLab blended learning system in acquisition of life-saving basic skills and procedures in management of trauma patient. To our knowledge this is one of the first studies to describe the autonomous peer-to-peer learning system employing elements of the e-learning and medical simulation that allows training of the students, residents and medical staff in their working place 24/7 with the aid of the remotely working instructors that facilitate the learning process, provide feedback, formative and summative assessment. However, there is already some data showing that students in modern study curricula learn better through modern self-instructed methods than through conventional methods. These methods should be used more, as they show good levels of participant acceptance and higher scores in personal self-assessment of knowledge. Our findings fully support this notion and demonstrate that the concept is applicable not only for acquiring theoretical knowledge but also could be transferred teaching practical skills/competences in the context of medical simulation [7].

Evaluations of students' opinion and acceptance can be seen as first step when establishing a new learning program. Our study revealed a high approval of the participants for the offered blended (hybrid) learning environment and contents. Broad acceptance is crucial for successful programme implementation, but it is also important to evaluate its influence on participants' gain of practical skills [8].

Another advantage of the HybridLab course is that it renders learning more learner-centred as opposed to instructor-centred. This empowers candidates, providing them with greater autonomy to decide when, what, with whom and how much they would like to learn and/or practice. The need of the participants to gather a team, to find a suitable time for team practice, to book the session in the electronic calendar and to find the pace of learning suitable for the members of the team provides excellent opportunity to practice Non-Technical Skills (NTS). The International Liaison Committee on Resuscitation (ILCOR) recommends that 'specific teamwork training, including leadership skills, should be included in the courses [6]. The need to work in a group of three and the requirement to rotate roles of the team leader, observer and helper allows participants to practice all main NTS, such as situational awareness, decision making, task allocation and management, leadership and team working [9]. The continuous simulation of different roles possible in the real-life situations is one of the main strengths of described learning platform. Results of the study showed that learners of the course significantly improved their practical skills just in one month time and there was no need of instructor and/or technician to be present during the learning sessions. Data from this study supports findings of other groups that demonstrated that Team-Based Learning (TBL) increases participant engagement, positively affects examination scores and other learning objectives, as well as produces students who have a better ability to function well in groups [10]. Furthermore, the peer-to-peer teaching and peer-to-peer structured instant feedback on the performance of the colleagues are important structural elements of HybridLab course that by other researchers have already been proven to be valuable and effective assets in medical education [11].

The fact that all the content is online improves standardisation. The e-learning section of the online system routinely collects user data regarding access to online content. This allows us to constantly monitor, evaluate and improve the online material and enhance the platform interface. The learners also regularly access online knowledge tests for self-assessment, review and summative evaluation during the course. Recent data also supports these findings and shows that despite significant heterogeneity amongst platforms, e-learning is at least as effective as other methods of training [12].

Hybrid training can be a useful model for teaching healthcare providers who are dispersed over a wide area with limited faculty availability, and successfully use medical simulation for training and assessment which is currently already is an established practice [13]. Accessing standardized course content through e-learning, using peers to guide learners through checklists designed to build skill mastery, and using video links for remote faculty to affirm successful skill application in final simulation scenarios can be a valuable asset for areas with difficulty bringing high level faculty expertise to remote areas but also under circumstances when there is a need to educate all the staff in a certain unit or institution within a relatively short time to promote effective changes and quality improvement.

Conclusion

The study showed a positive effect of the HybridLab learning approach on basic trauma skills enhancement and satisfaction of participating residents. The knowledge and skills retention as assessed 6 months after course was good and equally distributed throughout all the main domains of trauma care. Instructional organisation and usability were judged to be very good. In order to achieve better agreement between the instructors involved in assessment, we must

more clearly define the rules for the skills evaluation. Clear and structured algorithms, team-based learning, well defined rules for formative and summative assessment are the key factors ensuring the functioning and reliability of the self-directed learning platforms.

Study Limitations

The main limitation of the current study was the small study sample with a high dropout rate. The other limitation that the data comes from the observational study where student performance after the course was only self-directed compared to the results of similar traditional 2 days to 3 days instructor-led trauma courses comprised of lectures and medical simulation sessions. A larger well planned randomized or cross-over study would be needed in the future to confirm the findings and more explicitly demonstrate the value and effectiveness of self-directed learning platform for practical skills training using the medical simulation.

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