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Research Article

# Effects of Virtual Reality Technology on Knowledge, Attitudes, and Skills of Anesthesia Residents

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## ABSTRACT

**Background:** This study aimed to assess the effect of virtual reality technology on knowledge, attitude, and skills of first-year anesthesia residents in spinal anesthesia procedure training.

**Methods:** 25 anesthesia residents were enrolled in this experimental study. They were randomly divided into two groups of virtual reality (n=11) and conventional training (n= 14). The virtual reality (VR) group received a combined virtual and clinical training environment while the conventional group received only a clinical training environment for one month. A Similar content (herein, spinal anesthesia procedure) was trained to the both groups. The participants were the anesthesia residents in the academic year 2020-2021. Similar exams assessed knowledge, attitudes, and skills in both groups and data were analyzed using t-test and ANCOVA.

**Results:** The mean knowledge score acquired by residents in the VR group was higher than the conventional learning group (16.45 ± 2.5 vs 13.57 ± 2.1). The method of training had also a significant effect on the post-test score; F (1) = 6.16, P= 0.02. In addition, the mean attitude score acquired by residents in the VR group was higher than the conventional learning group (110.63 ± 14.7 vs 107.64 ± 12.3), although the method of training had not a significant effect on residents' attitude score; T (23) = 0.55, P= 0.58). The mean skills score acquired by residents in the VR group was higher than the conventional learning group (100.4 ± 3.17 vs 88.14± 11.8); While the method of training had a significant effect on residents' skill score. T (23) = 3.34, P < 0.05), too.

**Conclusion:** The combined virtual and clinical training environment was superior to a conventional method for enhancement of knowledge and skill in spinal anesthesia procedure training in anesthesiologist residents. This study can help the educational designers of the University of Medical Sciences to improve the competence of residents by using a combined learning environment.

Spinal Anesthesia (SA), as a professional and complex activity in anesthesia residency, requires specific knowledge, attitudes, and skills (KAS). Although spinal anesthesia is better than general anesthesia for some surgeries such as elective cesarean section [1], it is an invasive procedure with potential complications; hence, mastery is quite essential in order to provide patient safety [2]. There are many barriers to teach SA to anesthesia residents such as scarcity of elective surgical patients due to COVID-19 pandemic [3], residents' anxiety [4], concerns about patient safety [5], fear of patients complications [6], and ethical considerations of real patient based education [7]. Accordingly, it seems that the conventional method of clinical training for anesthesia residents is insufficient to

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improve their clinical competency (KAS) and needs to be changed [8].

VR as a simulated task environment is a computer-based simulation of a three-dimensional environment that can be similar to the real world and users can interact with special electronic equipment, such as a headset and gloves adjusted by sensors which are sensitive to moving of the head, holding, pushing, and pulling of virtual objects. It can persuade the brain to perceive an artificial environment as a real one [9-11]. Specifically, VR-based training provides safe learning environments for anesthesia residents via eliminating potential risks in a patient. The residents can experience damaging, risky, dangerous, and harmful situations while never putting the patient's safety in jeopardy. Not only safe virtual situations that are hazardous in reality, such as operating medical devices in healthcare training, can be created by VR for learners, but also can be personalized according to each learner's need via simulating countless scenarios. Hitherto, VR has been studied in different medical educational researches [5,12-14]. More specifically, it has been investigated for the training of technical procedures in imaging [15], surgery [16], dentistry [17], and neuropsychiatric symptoms following stroke [18]. Keri et al, in a randomized clinical trial used a computerized training platform that displays an ultrasound image and real-time needle position in a three-dimensional (3D) anatomical model and showed that it may add benefit to the residents learning if is incorporated in training for ultrasound-guided lumbar puncture (LP), particularly when faced with anatomical spinal abnormalities [19].

However, despite the benefits of VR technique in training, its effectiveness for anesthesia residents training has not been evaluated in Iran, to the best of our knowledge. Hence, the effect of virtual reality technology on knowledge, attitude, and skills of first-year anesthesia residents in spinal anesthesia procedure training is assessed in this study.

## Methods

This experimental study has been conducted in 2021 at three associated hospitals affiliated to Tehran university of medical sciences. The study protocol was approved by Iran National Committee for Ethics in Biomedical Research (IR.UM.REC 1399.102).

All residents who were registered in the anesthesia residency course for the academic year 2020-2021 were invited to participate voluntarily in the study (N= 33). All the anesthesia residents were in their first academic year of a four-year discipline-based program. Residents were randomly assigned to two groups: a conventional learning environment (n= 17) and a VR learning environment (n= 16).

The virtual reality training environment was defined as using a combination of virtual reality technology in the laboratory on the virtual patient and clinical training in an operating room on the real patient. For one month, training of the spinal anesthesia procedure was conducted on the virtual patient (first week) and real patients (three weeks) in the operating room environment with the authors supervision.

The conventional training environment in this study was defined as the ''see one, do one'' method in an operating room, i.e., an observer or a participant in presence of a staff anesthesiologist. This method is routinely practiced on a real patient in all universities in Iran. For one month, training of the spinal anesthesia procedure was conducted on real patients in the operating room environment with the authors supervision.

Three instruments were used to measure the effects of VR on three dependent variables of knowledge, attitudes, and skills. A researcher-made exam, comprised of two sections, served as the tool for measuring acquired knowledge on the topic of spinal anesthesia. The first section dealt with respondents' demographic characteristics including age, marital status, and the hospital name. The second section consisted 10 essay questions on the knowledge including the subjects related to spinal anatomy, pharmacology of anesthesia, indication and contraindication of spinal anesthesia, different methods, possible complications and its management, normal patients and patients with special conditions, and spinal anesthesia approaches with priority of topic content budgeting. The score of each question is two points and the sum of the questions' scores is 20. For the reliability of the scores, the examiners' reliability was used. Furthermore, in order to ensure the content validity of the questionnaire, the questions were based on the most recent scientific literature and then submitted to 7 expert faculty members. The initial review indicated that 10 of 17 questions were approved with CVI 90% and the other 7 were excluded from the analysis.

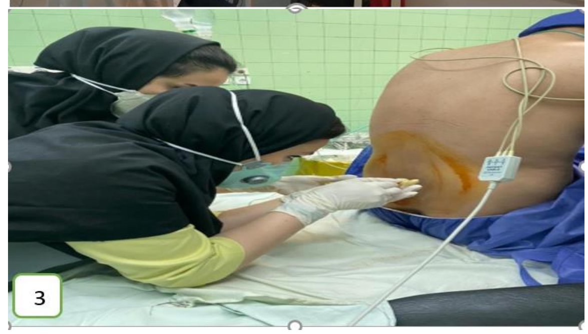
Skills were measured with the Direct Observation of Procedural Skills (DOPS) test tool. DOPS is a structured rating scale for assessing and providing feedback on practical procedures. This test was comprised of two sections: first section dealt with respondents' demographic characteristics including evaluator, student, and patient name, marital status, the hospital name, practice frequency, and evaluation frequency. The second section included 11 questions about the procedure technique, sterilization, pre-and post-anesthesia preparation, communication skills, and appropriate sedation. Each question was scored with a score between zero and ten (as unacceptable, below expectations, borderline, adequate performance, above expectations) according to the student performance. One of the staff anesthesiologists observed the anesthesia resident while performing the skill and then evaluated the performance based on the checklist, in the presence of a peer observer (another staff anesthesiologists). The validity and reliability of this tool were also confirmed [20].

Finally, attitudes were measured with an attitude questionnaire tool. This questionnaire comprised of two sections: One section dealt with respondents' demographic characteristics including name, marital status, and hospital name. The second section included 34 questions in the domain of opportunity, success, emotion, teacher, spontaneity, social cooperation, and overall satisfaction. Each question was scored with a five-point Likert scale between one and five (strongly disagree, agree, no opinion, agree, strongly agree). This questionnaire's validity and reliability were confirmed [21].

Anesthesia residents were enrolled in this study for one-month periods, from January 2021. The knowledge of all residents was evaluated by a pre-test with 10 essay questions and in 20 minutes. The residents had to read the introduced reference book [22]. The VR group was taught in the virtual reality laboratory in the first week. During this step, at first a 15-minute performance training video was shown to all the members of the group using VR technology. Then, the residents individually faced virtual patients and performed the procedure with the help of the anesthesiologist. They also received feedback from the staff anesthesiologist and the virtual reality machine if the procedural steps were performed incorrectly, e. g., by displaying the phrase "out of zone" for incorrect needle injection. They were allowed to practice and repeat frequently. For the next three weeks, the residents observed all the spinal anesthesia procedures done by the staff anesthesiologists on real patients. Thereafter, the residents were allowed to perform the procedure with the expert anesthesiologist's supervision on the real patients and received the corrective feedbacks. In the conventional group, all the learning processes were performed on the real patients in the operating room for one month. At the end of one month, three tests were done. Firstly, the post-test with 10 essay questions was taken in a 20- minute time. Then, the skills of the residents were evaluated by DOPS checklist with 11 items by the staff anesthesiologists in the presence of a peer observer on the real patient, and also, the attitude of the residents was assessed by a 34-item questionnaire. For the conventional group, the three tests were completely similar to the VR group. Figures 1-3 illustrates the figures of training procedures for the VR and conventional groups.

**Figures 1-3. Show the procedure of training**






Data were collected and analyzed using SPSS Software (SPSS, 20). The mean and standard deviation were reported for descriptive data while the normal distribution of inferential data was assessed using the Kolmogorov-Smirnov test. The independent t-test and ANCOVA were applied to compare the knowledge, attitude, and skills scores acquired by anesthesiology residents in the two groups of VR and traditional training. To eliminate the confounding effect, ANCOVA was used to analyze the normally distributed data.

## Results

Out of 33 participants, eight residents were excluded from the study due to dropout and COVID 19 pandemic. The difference between the two groups was not significant in terms of marital status or gender ($P > 0.05$) (Table 1).

The mean knowledge, attitudes, and skill scores acquired by residents in the two method groups are shown in (Table 2).

The mean skills score acquired by the residents in the VR group (100.4 ± 3.17) was higher than the traditional learning group (88.14± 11.8), while the difference was statistically significant between the two methods and residents' skills. Therefore, the VR learning environment method is significantly more effective for the residents' skills than the conventional method, $T (23) = 3.34$, $P < 0.05$. Table 3 displays the results of two groups.

The mean attitude score acquired by the residents in the VR group (110.63 ± 14.7) was higher than the conventional learning group (107.64 ± 12.3), however, there was not statistically significant difference between the two methods and residents' attitudes, $T (23) = 0.55$, $P= 0.58$) (Table 3).

The mean knowledge score acquired by the residents in the VR group (16.45 ± 2.5) was higher than the conventional learning group (13.57 ± 2.1). In an analysis of covariance, the pre-test scores were used as a random covariate variable and the post-test scores were used as a dependent variable. The Kolmogorov-Smirnov test showed the normal distribution of data (P > 0.05). The interaction of variables was not significant and the homogeneity of regression slope assumption was observed. method * pretest: F (1) = 0.12, P= 0.7. The error variance was equal in both groups as p> 0.05. Additionally, the independent variable in the post-test was significant, F (1) = 6.16, P= 0.02. Then, the VR method has increased the test post score (Table 3).

**Table 1- Gender and Marital status in studied groups**

| **Method** | **Gender (Frequency. Percent)** | | **Marital (Frequency. Percent)** | |
|---|---|---|---|---|
| | Female | Male | Single | Married |
| VR group | 6 (54%) | 5 (46%) | 6 (54 %) | 5 (46 %) |
| Conventional group | 7 (50 %) | 7 (50 %) | 9 (64%) | 5 (36%) |

**Table 2- Mean scores acquired by residents in the two groups**

| | | **Group** | **Mean** | **S.D** |
|---|---|---|---|---|
| Attitude | | VR group | 110.63 | 14.7 |
| | | Conventional group | 107.64 | 12.3 |
| Skill | | VR group | 100.4 | 3.17 |
| | | Conventional group | 88.14 | 11.8 |
| Knowledge | Pre-test | VR group | 12.36 | 3.1 |
| | | Conventional group | 10.75 | 1.9 |
| | Post-test | VR group | 16.45 | 2.5 |
| | | Conventional group | 13.57 | 2.1 |

**Table 3- Comparison of variables between two groups**

| **Variable** | **Levine's Test for Equality of Variances** | | **t-test for Equality of Means & ANCOVA** | | |
|---|---|---|---|---|---|
| | **F** | **Sig** | **T&F** | **df** | **P** |
| Skills | 2.25 | 0.14 | 3.34 | 23 | 0.003 |
| Attitudes | 0.99 | 0.32 | 0.55 | 23 | 0.58 |
| Knowledge | 0.46 | 0.5 | 6.16 | 1 | 0.02 |

## Discussion

In this study, the effectiveness of the VR versus conventional training spinal anesthesia to anesthesia residents, as a complex procedure, was evaluated in terms of knowledge, attitudes, and skills. The results showed that the mean scores of post-test in the virtual reality training group were higher than that in the conventional training group. In other words, the use of VR has increased the residents' knowledge of anesthesia residents about spinal anesthesia. As comparisons, in a study on dental students, the virtual learning increased the knowledge acquisition in the radiographic interpretation of bony lesions of the jaw compared to conventional learning method [23]. Another study by Beheiry et al also showed that VR can reduce knowledge gaps between experts and residents [9].

Moreover, our results showed that the mean scores of attitudes in the virtual reality training group were higher than those in the conventional training group, but, the method of training had not any significant effect on the residents' attitude scores. It means that the application of VR environment did not increase the residents' attitude about spinal anesthesia procedure learning. This result was confirmed by Nasrollahi et al [21], who concluded that the subtitles of attitude in the domain of success, teacher, spontaneity, social cooperation, and overall satisfaction were not significantly correlated with the method. This result not confirmed in the "Virtual Reality-Based Technologies in Dental Medicine" study [24], in which it was shown that dental students, educators, and practitioners had overall positive attitudes towards VR but very few had used VR in education and practice.

Furthermore, our results showed that the mean scores of skills in the VR training group were higher than those in the conventional training group. In other words, the use of VR has increased the residents' skills in spinal anesthesia. Comparably, Vaughan et al emphasized on skills practice before doing any procedure in the operating room and on a real patient, and indicated that surgeons have a great chance to develop and enhance their decision-making skills in a safe realistic operating room through the utilization of orthopedic VR training simulations. Thus, the utilization of VR technology can be seen as a useful practice opportunity for surgeons who have a lack of surgical experience to practice key skills in orthopedic and other types of surgeries [25]. Also, Gunn's study demonstrated that a VR simulation can enhance students' learning of technical skills in the medical imaging techniques[15].

## Conclusion

This study showed that the virtual reality method was more effective than the conventional method for the instructional design of the spinal anesthesia technique for anesthesia residents. Knowledge and skills scores were increased in residents that used a combination of virtual reality technology in the laboratory on the virtual patient and then be trained by the conventional training method in the operating room on the real patient. This study can help the educational designers of the University of Medical Sciences to improve the competence of residents by using a combined learning environment.

Limitations

Because of COVID 19 pandemic, the researchers faced difficulty teaching spinal anesthesia technique to anesthesia residents on real patients.

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