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Comparing the Effect of Guided Visualization and Virtual Reality Techniques on Cannulation Pain in Hemodialysis Patients

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ABSTRACT

Introduction: The cannulation of arteriovenous fistula [AVF] is a painful procedure in hemodialysis patients. This study aimed to investigate the effect of guided visualization and virtual reality techniques on cannulation pain in hemodialysis patients.

Method: The present pre and post-blinded clinical trial was conducted on 58 hemodialysis patients selected by convenience sampling method. The guided visualization technique was used twice before hemodialysis to attenuate the cannulation pain, followed by the virtual reality technique twice after two weeks. The data collection tools were demographic information form and VAS.

Results: The mean score of pain after intervention was significantly decreased with both techniques and this decrease was more in intervention with virtual reality ($p<0.001$).

Conclusion: The results showed that both distraction techniques are effective in relieving the severity of cannulation pain in hemodialysis patients, and virtual reality, owing to greater effect, is a proposed intervention to reduce pain in these patients.

Key words: Guided visualization, Virtual reality, Pain, Cannulation, Hemodialysis

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INTRODUCTION

Hemodialysis is the most prevalent alternative to renal function [1] and the most commonly used treatment in renal failure patients [2], which promotes the quality of life of hemodialysis patients by prolonging survival and reducing complications. Statistics show that the number of hemodialysis patients will reach 3.5 million in the world by 2020 [1]. There are also over 13,000,000 dialysis patients in Iran, with about 150,000 dialysis sessions each month [3]. According to some studies, the growth rate of this disorder in Iran is about 12% annually [4,5] and 15%, according to others, higher than the global average [3].

Chronic dialysis requires access to safe vessels that can be used for months; therefore, an arteriovenous fistula [AVF] is an appropriate option [1]. About 90% of patients in Iran and about 84% in Europe use AVF for hemodialysis [6]. Despite positive points, AVF has some disadvantages in comparison with other vascular access methods, including the inevitable pain of needle insertion in the fistula [7]. Each dialysis patient undergoes dialysis of approximately 3 times a week and 3 to 4 hours each time, which inevitably tolerates the pain caused by AVF cannulation 3 times a week. This pain will accompany these patients until the end of life unless they perform kidney transplantation [8]. Half of dialysis patients express dissatisfaction with the experience of various types of pain, especially pain caused by AVF cannulation [2]. Reports have shown that 47% of dialysis patients, in addition to fear of cannulation pain, expressed this stage as the most stressful part of dialysis [5]. The main cause of this fear and apprehension is the diameter and length of the needle used for cannulation [7].

The patient pain management is one of the most important nursing cares but there is no certain and standardized method for relieving the cannulation pain

[9]. The use of EMLA cream, local anesthesia, local thermotherapy and cryotherapy are interventions that have been previously investigated to reduce the cannulation pain, but the analgesic effect of these interventions has not yet been fully proven [2]. The main problems with the use of local anesthetic drugs are low absorption rate and long exposure time [10], skin rash and allergic reactions in the long term [11]. The adverse effects of chemical drugs [12], the imposition of economic costs [13], and drug tolerance [14] have also led people to relieve pain with complementary medicine. Complementary medicine is an integral part of nursing care [15], which has become popular today, owing to its ease of use, less adverse effect and cost-effectiveness compared to other methods [16]. Based on the available evidence, distraction is one of the most effective nonpharmacologic analgesic methods to reduce the pain associated with aggressive procedures [13,17]. One of the distraction techniques is the guided visualization, which is also part of muscle relaxation [18]. It is a mind-body technique, which can be transmitted through self-learning books and educational videos, or directly through a coach, and used to relieve and manage pain [19]. This technique involves abdominal and diaphragmatic breathing, muscle relaxation and visualization of presence in places such as the seashore, the mountains and the forest, to imagine natural sounds and smells in the mind [19,20]. Related studies have shown that the use of this technique is effective in reducing pain in patients undergoing coronary angiography [19], laparoscopic cholecystectomy [21], and patients with chronic tension type headache [22] and orthopedic surgery [23]. However, some researchers reported the negligible and insignificant influence of guided visualization [20]. In addition, there is little evidence on the effect of guided visualization on reducing the cannulation pain in hemodialysis patients.

The technology plays a key role in today's everyday life. Although the advantages and disadvantages of this technology are still controversial and its use is associated with concerns, it is generally one of the best options for distraction [13]. Previous studies have shown the effectiveness of virtual reality in reducing pain during needle-related procedures [24], pediatric dentistry [25], burn injuries [26,27], venipuncture in children and adults with cancer [28,29], acute and chronic pediatric pain [30] and general pain in adults [31]. Considering that some studies have not shown any difference in the effectiveness of virtual reality to reduce pain, it is still uncertain about the effect of this method to reduce pain [32,33]. Therefore, we examined the hypothesis that virtual reality, compared with guided visualization, could provide a more effective and newer solution for distraction with the aim of reducing the cannulation pain in patients undergoing hemodialysis.

MATERIALS AND METHODS

The present pre and post blinded clinical trial was conducted in 2018 after obtaining approval by the Ethics Committee of the Gonabad University of Medical Sciences (GMU.REC.1396.163) and registration code of IRCT20171219037966N3 by the Iranian Registry of Clinical Trials, on eligible hemodialysis patients referred to Imam Reza Hospital of Mashhad and Allameh Behlol Hospital of Gonabad. Sample size was estimated to be about 25 samples per group according to similar study data [34], using the formula of comparing the means for pain variable, and taking 95% confidence interval and 90% test power. Finally, 30 individuals in each group and a total of 60 people were selected, considering the probability of 10% drop-out in samples, (2 of them were excluded due to failure in the first attempt for Cannulation) (Equation 1).

$$n = \frac{\left(Z_{1-\frac{a}{3}} - Z_{1-\beta}\right)^2 \left(s_1^2 + s_2^2\right)}{\left(\overline{x_1} - \overline{x_2}\right)^2}$$

$$= \frac{(1.96 + 1.29)^2 \left(1.2^2 + 0.7^2\right)}{(3.1 - 2.2)^2} = 25.16$$

The data were collected after obtaining permission from relevant authorities and receiving informed written consent of the samples selected by the convenience sampling method among all patients undergoing hemodialysis referring to the Imam Reza Hospital of Mashhad and Allameh Behlol Hospital of Gonabad. Before the study, the study objectives were fully explained for patients and they were ensured to leave freely the study at any time. Inclusion criteria were the age range of 18 to 60 years, consciousness of time, place and persons at the time of data collection, minimum reading and writing skills, no history of mental illness, non-diabetic neuropathy, no use of alcohol and drugs, and lack of damaged skin in the intended position. Exclusion criteria were the unwillingness to participate in the study, the failure of venipuncture in the first attempt, and the use of analgesics 24 hours before hemodialysis.

The patients who met the inclusion criterion at first completed a demographic questionnaire including age, sex, educational level, marital status, income level, occupation, and disease-related factors (neuropathy etiology, fistula age, type, site, and duration of dialysis, frequency and duration of dialysis sessions). This part of the questionnaire was prepared after studying the literature on the subject of research, and reviewed and completed using expert opinions. Visual Analogue Scale (VAS) was used to measure the pain intensity. In this method, the patient determined the pain intensity during venipuncture by marking a 10 cm ruler, graded from 0 to 10. The distance between these two points is divided into 1 cm intervals without numbering. The researcher assistant measured and recorded the distance between the zero point and the marked location with a precision of 0.5 cm. In this method, scoring for the pain score is as follows, 0 (no pain), 1-3 (mild pain), 4-6 (moderate pain) and 7-10 (severe pain). This scale is a standard tool whose validity has been confirmed by Ferreira-Valente et

al. [35]. Phan et al. verified its reliability by a test-retest method [36].

Study intervention

At the first hemodialysis session, after obtaining informed consent from the patient, the researcher assistant first completed the demographic questionnaire. Then the patient lay on the bed and marked the score of cannulation pain on the VAS. At the second dialysis session, which was the first intervention session, 25 minutes before hemodialysis, the patients were placed in the supine position, with a few deep abdominal and diaphragmatic breaths, closed eyes and comfortable in the best state of relaxation. By providing a completely quiet and relaxed environment, and minimizing environmental stimuli (such as low light room and limited travel), the audio file was displayed to perform mental imagery for 20 minutes, taking into account a sound level between 10 to 21 dB through a device calibrated by an audiologist. In the early minutes of the file, the speaker directs the patients how to prepare for the technique, and then describes the natural environments that they should imagine. When the 15 minutes of the file was played (5 minutes to complete the audio), the fistula was inserted while listening to the audio file, and the pain data was collected by the assistant researcher. After two sessions of intervention by guided visualization, a two-week interval was applied to eliminate the effect of the previous intervention. In the virtual reality group, special glasses were placed on the patient's head 10 minutes before hemodialysis, followed by exhibiting the images designed to reduce pain. After 15 minutes of playing the file and during the watch, the fistula was inserted and then the researcher recorded the pain score. The researcher and data analyst were unaware of the type of intervention performed in the sessions. Given that the patients were hospitalized in two separate hospitals, the same nurse made the cannulation for all patients to minimize the error caused by the difference in the technique of cannulation. In the virtual reality group, the video was displayed through a smartphone (Asus Zenfone 4, 1080 × 1920 pixels, ratio, ~ 401 ppi density) inserted inside the virtual reality headset (VR Box 2, Virtual Reality Headset, Lens diameter: 42 mm, China). To hear the sounds, the headphones were connected to the same smartphone. In the guided visualization group, the same headphones were connected to the smartphone to play audio files.

Statistical analysis

After sampling, the data were analyzed by SPSS version 16 software. First, the Kolmogorov-Smirnov test was used to examine the normality of data distribution. Descriptive statistics were applied to determine the measures of central tendency and dispersion indices for quantitative variables and determine the frequency for qualitative variables. The paired-t test was used to compare the quantitative data of pain variable in the two groups before and after the intervention. The significance level of results from the statistical tests was considered to be less than 5%.

RESULTS

The mean age of the patients was 45.7 ± 0.32 years. The mean duration of dialysis and the mean fistula age was 4.43 ± 0.93 days and 2.84 ± 0.69 years, respectively. Demographic data and disease-related factors are shown in Table 1.

Table 1: Demographic and disease-related information among the patients

Variables	Variable levels	Frequency	Percentage (%)
Age (years)	Male	30	51.7
	Female	28	48.3
Educational level	<High school	22	37.9
	High school	17	29.3
	Academic	19	32.8
Occupation	Self-employed	17	29.3
	Worker	17	29.3
	Housekeeper	24	41.4
Smoking	Yes	6	10.3
	No	56	89.7
Fistula site	Right hand	24	41.4
	Left hand	34	58.6
Fistula type	Brachiocephalic	27	46.6
	Radiocephalic	31	53.4

Etiology of nephropathy	Idiopathic	5	8.6
	Diabetic	18	31
	Hypertension	23	39.7
	Glomerulonephritis	5	8.6
	Lupus	1	1.7
	Polycystic kidney	2	3.4
	Obstructive or urological problems	4	6.9

The process of Implementation based on CONSORT flowchart can be seen in Figure 1. Figure 2 shows the cannulation pain score at different time points, and classified results. In the intervention with virtual reality, no patient experienced severe pain. The number of patients with perceived moderate pain was equal in both types of intervention, whereas the number of patients with mild pain in the virtual reality group was greater than the guided visualization in both intervention sessions (Figure 2). The changes in the mean score of pain during intervention sessions can be seen in Figure 3. Both techniques effectively reduced the pain score, and this decrease was more in the virtual reality group. Based on the results of paired t-test, the mean pain scores in the first and second sessions of both techniques were different, and were significantly lower in the second session in the virtual reality group (Table 2 and Figure 3).

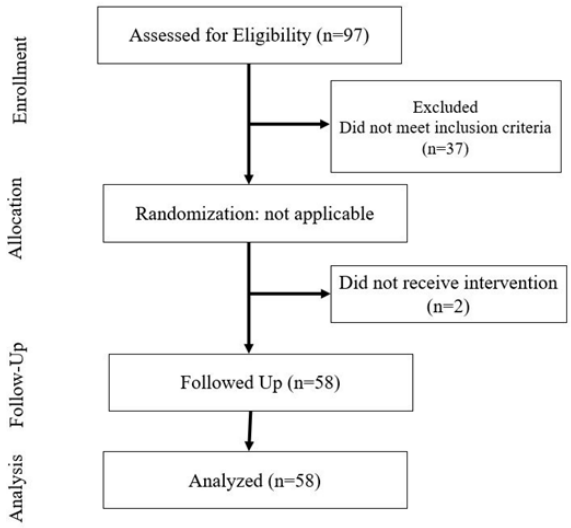

Figure 1: Implementation process based on CONSORT flowchart

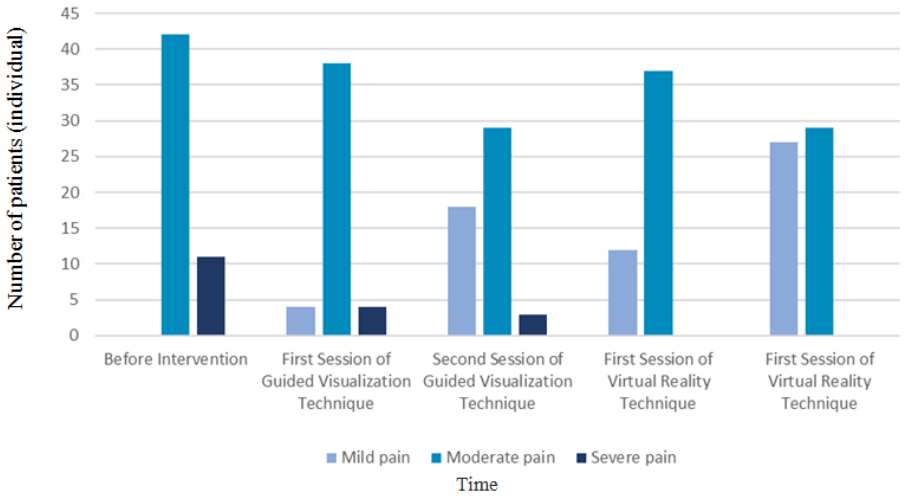

Figure 2: Number of patients in each hemodialysis session based on the class of pain score

Table 2: Comparison of reductions in mean pain score in the first and second sessions of intervention with guided visualization and virtual reality

Type of intervention	Pain score (mean ± standard deviation)		Paired t-test
	First session	Second session	
Guided visualization	4.69 ± 1.17	4.10 ± 1.11	T=9.78

			Df=57
			p<0.001
Virtual reality	4.31 ± 0.98	3.86 ± 0.97	T=7.38
			Df=57
			p<0.001
Paired t-test	T=6.13	T=5.02	
	Df=57	Df=57	

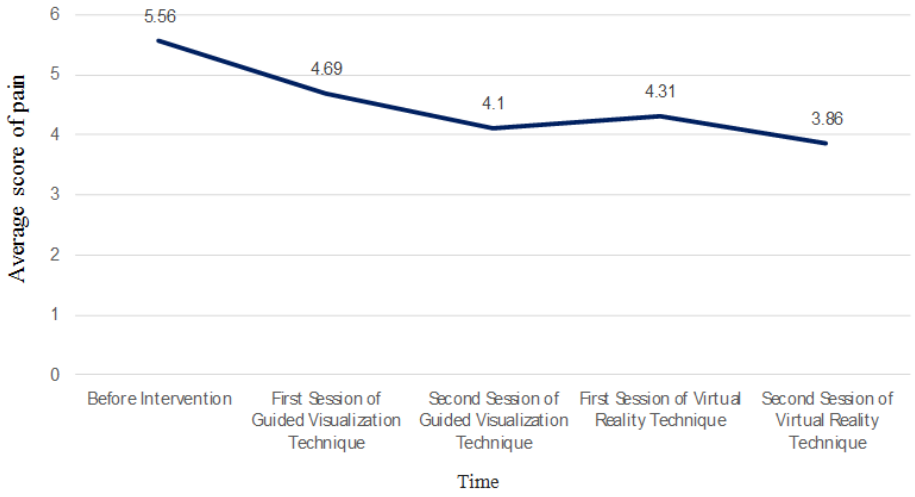

Figure 3: Change in average score during intervention sessions

DISCUSSION

Distraction methods attempt to increase pain tolerance and reduce pain sensation by distracting patient thought [13]. The secretion of endorphins in the brain, following stimulation induced by muscle relaxation techniques, causes a sense of euphoria in patients and relaxation in the muscles, and is effective in relieving pain [37]. The paired t-test result showed that the perceived pain intensity was significantly lower in patients during intervention with virtual reality than in intervention with guided visualization ($p<0.001$). It is thought that the reason for this issue can be attributed to the existence of a visual effect in interfering with virtual reality. The guided visualization only involves the sound effect, and the patient should use imagination to visualize the environments; that is, if the patient's imagination is not strong, the result will not be desirable. Displaying images with the virtual reality headset makes it easier for patients to work, and thus increase effectiveness. It should be kept in mind that intermittent cannulation leads to the adaptation of some patients with resulting pain, and this may reflect the effect of these techniques less than the actual value [38]. Hua et al. showed that the application of virtual reality when dressing burn patients effectively reduced anxiety and pain, and shortened the time required for treatment [39]. In a study by Brown et al., a distraction method with drug interventions could reduce the pain and anxiety of patients while caring for burn wounds, and could even increase the amount of epithelial tissue reconstruction and repair [40]. A study of people with a sense of discomfort due to chronic pain showed that the use of virtual reality relieved their pain [41]. Tashjian et al. using virtual reality managed to relieve pain significantly in hospitalized patients with a mean score of more than or equal to 3 (out of 10) in the intervention group compared to the control group. According to their claims, the VR can be used as a complementary and safe care option in managing the pain of hospitalized patients [31]. In addition to these studies, several investigations have also focused on the effect of VR on post-stroke rehabilitation [42] and musculoskeletal pain [43]. In our study, the pain intensity during intervention with virtual reality in the first and second sessions of intervention was 22.48% and 30.57% respectively, while the pain relief was 59% in a study by Piskorz et al., aimed at investigating the effect of virtual reality as an intervention to reduce stress and pain induced by venipuncture [38]. Schmitt et al. reported that the intervention with virtual reality reduced the pain up to 27% in the sensory dimension, and up to 32% in the emotional dimension in children with burn injuries [44]. Based on the results of Gershon et al., who evaluated the effectiveness of virtual reality to reduce pain, the venipuncture pain in cancer children was reduced up to 12.7% [45]. This difference may be due to the different nature of the pain types, the various therapeutic procedures, and the type of intervention with the virtual reality (screening or playing games). Moreover, the age difference of the samples could be due to the differences with the present study, because the above studies were

conducted on children who are most welcome virtual reality as a new technology. In addition, children have a greater sensitivity to pain and less pain tolerance. In a comprehensive review of the effectiveness of distraction with virtual reality, researchers found that findings from studies on relieving pain induced by venipuncture were inconsistent and did not express the results in line [46].

Comparison of the mean pain score based on the type of intervention showed that the guided visualization had a less pain-lowering effect than the virtual reality. The guided visualization has been effective to reduce pain in patients undergoing surgery [47], elective total knee replacement [48], and generally orthopedic surgery [49]. All of the results of these studies are consistent with the findings of the present study and suggest that the guided visualization can be used as an adjunct to pain management, but further studies with a larger sample size are required to support this conclusion [49,50].

In another study on patients undergoing surgery, the guided visualization could reduce the pain experienced at the second hour after surgery, but had no significant effect on reducing pain in the first hour and the amount of drug used by the patient [51]. The differences in the duration of the intervention, the type of content used and the different therapeutic procedures probably explain this contradiction. In cancer patients undergoing guided visualization, the pain was reported as a dilemma that did not decrease after 30 and 60 days [52].

Nilsson et al. do not recommend using guided visualization as a routine nursing intervention to relieve pain because it has not been beneficial during the vaccination of 11-12-year-old girls. However, further research is required on effective techniques to reduce pain and discomfort associated with invasive and needle procedures [53]. In the study of Chamanzari et al., the guided visualization reduced the total pain score, the duration of pain and the improvement of pain quality in the third day after the operation of patients with fractures, thereby confirming the effectiveness of this method for relieving pain, but did not affect pain intensity [23]. The reason for this difference could be the use of different instruments and various pain experiences in traumatic patients. The guided visualization with relaxing music has not been effective in reducing pain in patients with localized anesthesia under the cutaneous surgical procedures [54].

CONCLUSION

The virtual reality and the guided visualization, both as distraction techniques, are effective in attenuating the cannulation-induced pain in the hemodialysis patients. However, the virtual reality is a preferred method given the greater relief of pain in this group. Because using virtual reality have a visual effect in comparison with the guided visualization that makes the visualization of the environment easier for the patient and increases the effectiveness of the intervention.

STUDY LIMITATIONS

The pain is a subjective clinical factor that has no apparent presentation and specific clinical sign, except in severe cases. Therefore, we had to make patient scoring for information gathering. There was no possibility of blinding patients according to the nature of the study. As these patients alternatively have intravenous cannulation, their compatibility with this pain increases, which causes the effect of both techniques in this study to be less than actual value.

With regard to the sampling of two hospitals in Iran, the findings of the study will not be able to be generalized to other patients with different characteristics around the world. The lack of evaluation and comparison of the patients' ability to visualize before the study and their different talents in having this ability are among the factors that might lead to errors in the findings of this study.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

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