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Original Article

Perioperative use of immersive head-mounted virtual reality display enhances patient satisfaction in great saphenous vein surgery: a single-center clinical observation study

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Abstract: Objective: To explore the application effect of head-mounted virtual reality display immersive experience in improving the perioperative satisfaction of patients undergoing great saphenous vein surgery. Methods: A total of 158 patients undergoing saphenous vein surgery at the First Affiliated Hospital, Jiangxi Medical College, Nanchang University from January 2020 to January 2023 were randomly divided into an observation group and a control group in a 1:1 ratio, with 79 cases in each group. The observation group received head-mounted display virtual reality immersive experience, whereas the control group received midazolam. The study compared the perioperative satisfaction, changes in preoperative and postoperative anxiety and depression scores, intraoperative blood pressure and heart rate, postoperative visual analog scale (VAS) score, and the incidence of postoperative nausea and vomiting between the two groups. Additionally, the satisfaction of patients, anesthesiologists, and chief surgeons was compared. Results: All surgeries were completed successfully. Patients in the observation group exhibited higher perioperative satisfaction compared to those in the control group ($P<0.001$). There were no significant differences in anxiety or depression scores between the two groups before surgery ($P>0.05$). However, both groups showed a reduction in anxiety and depression scores postoperatively, with the observation group demonstrating lower scores than the control group (both $P<0.05$). The observation group also had lower intraoperative blood pressure, heart rate, postoperative VAS scores, and incidence of nausea and vomiting compared to the control group (all $P<0.05$). Furthermore, the satisfaction levels of the anesthesiologists and chief surgeons were higher in the observation group than in the control group ($P=0.043$, 0.012). Conclusion: Head-mounted display virtual reality immersive experience can enhance perioperative satisfaction among patients undergoing great saphenous vein surgery, reduce anxiety and depression scores, and contribute to the stabilization of hemodynamics during surgery, thereby decreasing postoperative nausea and vomiting.

Keywords: Head-mounted display virtual reality immersive experience, midazolam, perioperative satisfaction, great saphenous vein

Introduction

It is widely acknowledged that surgical procedures often evoke varying degrees of anxiety among patients during the perioperative period [1, 2]. Preoperative anxiety is primarily influenced by factors such as age, gender, and the type of surgery [3, 4]. While most patients can self-manage their emotions to cope with negative feelings, failure to do so can worsen treatment outcome and postoperative recovery [5]. Consequently, effectively addressing these negative emotions is crucial for patients.

With the rapid advancement of digital technology, numerous artificial intelligence applica-

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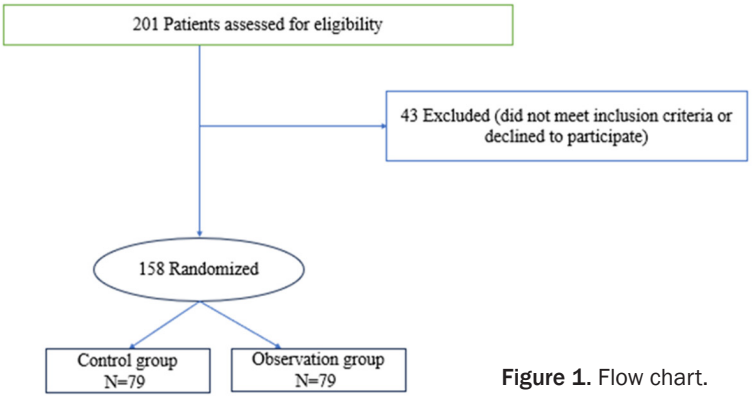

Figure 1. Flow chart.

tions have been incorporated into perioperative therapeutic practices [6, 7]. Among these, virtual reality (VR) technology, which leverages computer science to create immersive virtual environments enabling real-time user interaction, has successfully reduced pain and anxiety in various patient populations [8]. As a non-invasive alternative to sedative drugs, VR has been explored as an adjuvant or substitute in regional anesthesia. Its effectiveness and acceptability have been demonstrated in arthroscopic knee surgeries under spinal anesthesia, where VR showed higher satisfaction rates compared to midazolam [9, 10]. However, its application in great saphenous vein surgery remains understudied. Therefore, this study aims to compare the satisfaction rates of VR and conventional midazolam sedation in patients undergoing great saphenous vein surgery, aiming to provide insight for improving patient satisfaction during the perioperative period.

Materials and methods

General information

From January 2020 to January 2023, a total of 158 patients undergoing greater saphenous vein surgery at the First Affiliated Hospital of Jiangxi Medical College, Nanchang University, were randomly assigned to an observation group and a control group, with 79 patients in each group (**Figure 1**).

Inclusion criteria: 1. Patients undergoing great saphenous vein surgery; 2. Patients aged 18 years or older; 3. Patients with an ASA classification of I to III.

Exclusion criteria: 1. Patients with prolonged use of sedatives or anesthetic drugs; 2. Patients with motion sickness, glaucoma, mental illness, or neurologic disorders; 3. Alcohol or drug abusers; 4. Patients with obstructive sleep apnea, baseline oxygen saturation less than 90%, or baseline hemodynamic or respiratory instability (i.e., initial systolic blood pressure <80 mmHg, respiratory rate >25 or <10 breaths/minute); 5. Patients with regular use of benzodiazepine drugs or allergies to them; 6. Patients unable to assess visual scoring changes. This study gained the approval from the ethics committee of The First Affiliated Hospital, Jiangxi Medical College, Nanchang University and also obtained informed consent from all participants. Clinical Trial Registration Number: ChiCTR2300076473.

Sample size calculation

This study aimed to estimate the sample size for a parallel 1:1 design with two equal groups: control and observation. Similar literature with parallel control design was reviewed, showing an average VAS score of μ1=5.9 points for the control group and μ2=5.0 points for the observation group, with a standard deviation of s=1 point. Considering a 10% dropout rate, a Type I error probability of α=0.05, and a power (1-β) of 80%, the required sample size for this study was estimated. Based on the design of this clinical trial study and considering the primary efficacy outcome indicator, the following formula was used for sample size estimation:

$$n1 = n2 = \frac{2\,(Z\alpha/2 + Z\beta)\,2 \times \sigma 2}{(\mu 1 - \mu 2)^2}$$

Using μ1=5.9, μ2=5.0, σ=1, α=0.05, β=0.2, substituted into the equation, we finally obtained n1=n2=20 cases. Therefore, the minimum sample size for this study was 20. To increase the reliability of the research results, all patients meeting the inclusion criteria during the study period were selected, totaling 158 cases.

Intervention methods

The observation group was introduced to a VR program, which showcased preoperative education, surgical room layout, modern instruments, spinal anesthesia procedures and precautions, and a simplified surgical process. Using the Aqua30 Korean version 4.0 (OnsoskSa, Wavre, Belgium) connected to an Android phone (Galaxy 7.0, Samsung, Seoul, South Korea), patients could watch VR videos via a head-mounted display and earphones. This program aimed to alleviate anxiety and pain by presenting calming landscapes and narratives promoting relaxation and meditation. Lens focal length and audio volume were adjusted to suit each patient's comfort level, and researchers were available for any technical assistance. Patients could request intravenous midazolam sedation at any time, while retaining the option to use or remove the headphones.

Meanwhile, the control group underwent standard preoperative education and conversation, with midazolam sedation administered initially at 1-2 mg and maintained with 1-2 mg doses every 30 minutes. Both groups received oxygen supplementation by face mask at a rate of 5 L/min.

Outcome measures

The primary outcome measures encompassed a customized patient satisfaction scale and a self-designed follow-up table specifically tailored for anesthesiologists and chief surgeons [11]. This satisfaction scale comprised four levels: unsatisfied, moderately satisfied, quite satisfied, and very satisfied. The authors identified the 'moderately satisfied' and 'very satisfied' categories as indicators of overall satisfaction for surgical and anesthetic physicians.

Secondary outcome metrics encompassed intraoperative hemodynamic parameters at admission (T0), 30 minutes into surgery (T1), and surgery completion (T2), including mean arterial pressure (MAP) and heart rate (HR). Additional measures were the visual analog scale (VAS) score, preoperative and postoperative anxiety and depression levels, and the incidence of postoperative adverse reactions such as nausea and vomiting in both groups.

Statistical analysis

Data analysis was conducted using SPSS version 24.0. Normally distributed measured data were presented as mean ± standard deviation, and comparisons between groups were made using independent sample t-tests. For multiple timepoint comparisons, repeated measures ANOVA was applied, with Bonferroni correction for post-hoc analyses. Counted data were presented as absolute numbers (percentages), and chi-square tests were used for intergroup comparisons. A *P*-value of <0.05 was considered statistically significant.

Results

Comparison of baseline data

There were no statistically significant differences in gender, age, comorbidities (hypertension, diabetes), lower limbs, course of illness, treatment history, anesthesia method, or surgical duration, between the two groups, indicating good comparability (all P>0.05). See **Table 1**.

Comparison of MAP and HR at different time points during surgery

Statistically significant differences were observed in MAP and HR at different times for the two groups (both P<0.001). Regardless of monitoring time, there were significant differences in the main effects between the two groups (P<0.001). Taking no account of monitoring time, a significant difference could be found in the indicators in each group (P<0.001). Furthermore, there were interactions between the groups and time points (P<0.001). Specifically, the MAP and HR of the observation group were higher than those of the control group at T1-T2 (both P <0.05), with no significant difference at T0 (P>0.05). See **Figures 2**, **3**.

Comparison of VAS scores

The results of this study indicated that the postoperative VAS scores in the observation group were lower than those in the control group (P<0.001). See **Figure 4**.

Comparison of anxiety and depression scores

There were no significant differences in the state anxiety, trait anxiety, or depression scores of the two groups preoperatively. However,

Table 1. Comparison of baseline data

Group	Observation group (n=79)	Control group (n=79)	χ^2/t	P
Gender (n)			0.106	0.744
Male	49	47		
Female	30	32		
Age (year)	58.5±4.2	58.7±4.3	0.296	0.768
Body mass index (kg/m^2)	25.1±2.5	25.3±2.7	0.483	0.630
Hypertension (n)	15	14	0.042	0.837
Diabetes (n)	7	9	0.278	0.598
Limb (n)			0.101	0.750
Left	41	39		
Right	38	40		
Course of illness (year)	4.5±2.4	4.4±2.6	0.338	0.662
Treatment history (yes/no)	58/21	62/17	0.554	0.380
Anesthesia method (local/combined)	65/14	70/9	0.602	0.431
Surgical duration	1.2±0.8	1.1±0.6	0.772	0.062

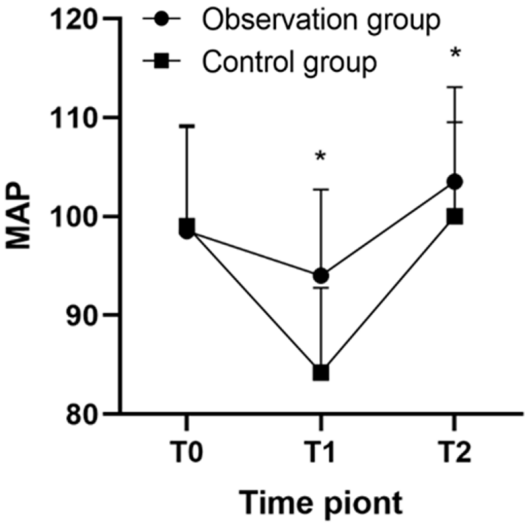

Figure 2. Comparison of mean arterial pressure (MAP) at different time points during surgery. Note: T0: at admission; T1: 30 minutes into the surgery; T2: at the end of the surgery. Compared with control group, *P<0.05.

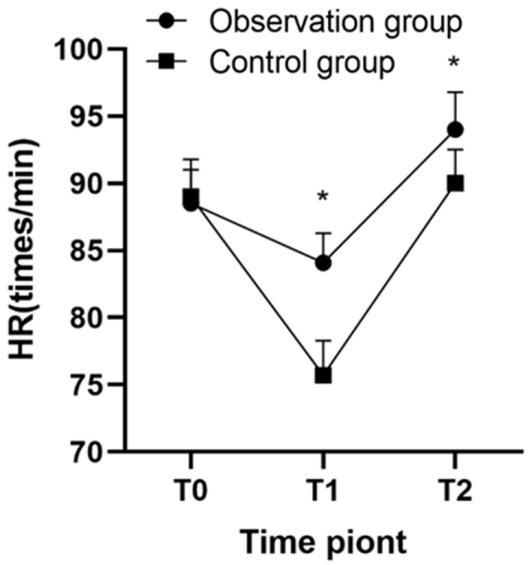

Figure 3. Comparison of heart rate (HR) at different time points during surgery. Note: T0: at admission; T1: 30 minutes into the surgery; T2: at the end of the surgery. Compared to control group, *P<0.05.

there were differences in these scores postoperatively, with lower scores in the observation group compared to the control group. See **Table 2**.

Comparison of satisfaction

There were differences in the satisfaction of patients, chief surgeons, and anesthesiologists between the two groups. Patients in the observation group demonstrated higher satisfaction compared to the control group. See **Table 3**.

Comparison of postoperative adverse reactions

There was no significant difference in the incidence of postoperative adverse reactions between both groups (P>0.05). See **Table 4**.

Discussion

The current trend in anesthesia practice has shifted its emphasis from solely focusing on disease incidence, mortality, and surgical out-

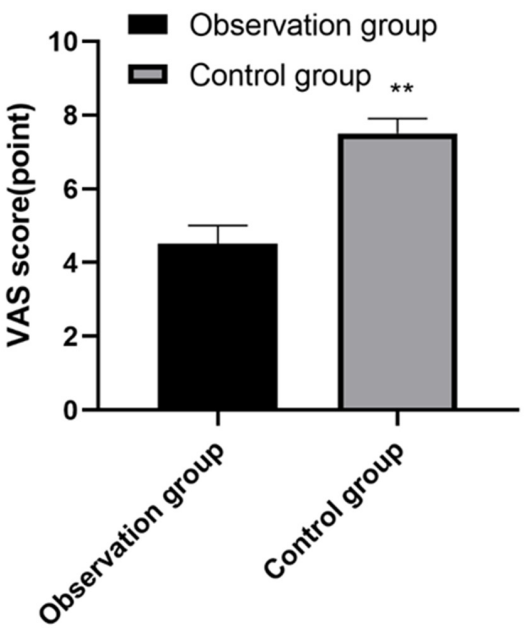

Figure 4. Comparison of visual analog scale (VAS) scores. Note: Compared to control group, **P<0.001.

come to a greater emphasis on the quality of care, patient comfort, and satisfaction [12-14]. Patient satisfaction serves as an ideal, subjective, and multidimensional metric of care outcome, reflecting patients' perception of the quality of healthcare they receive [15]. Elevating patient satisfaction during the perioperative period has garnered significant attention in clinical practice, as higher perioperative satisfaction levels are associated with improved patient compliance.

Since great saphenous vein surgery often involves regional anesthesia, where patients remain fully conscious during the procedure, improved compliance can mitigate possible conflicts between anesthesiologists and patients, as well as between patients and surgeons, fostering a more harmonious doctor-patient relationship [16, 17].

The effective reduction of preoperative negative emotions, such as tension and anxiety, is crucial in enhancing patient perioperative comfort [1]. Currently, sedative drugs are proven effective in mitigating the discomfort caused by the surgical environment, sounds from surgical monitoring equipment, and respiratory machines, as well as fear of surgery. Studies have demonstrated that sedative agents like midazolam can effectively alleviate negative emotions in patients [18]. The present study findings indicate that following sedative administration, anxiety and depression scores were notably lower in the control group, thereby reaffirming midazolam's capacity to alleviate negative emotions, aligning with previous research [19]. However, sedative drugs can introduce complications like respiratory depression or hemodynamic instability, posing potential risks, such as arrhythmia due to low perfusion. Moreover, patients passively receiving drug interventions may not achieve optimal outcomes.

Recent studies have highlighted the safe and effective use of VR as an adjunctive measure to standard sedation and analgesia protocols during surgery [20]. VR has been shown to reduce pain and anxiety in patients undergoing upper gastrointestinal endoscopy, dental surgery, burn dressing, and first-stage labor. Our results demonstrate this efficacy, with the observation group exhibiting lower postoperative emotional scores and higher satisfaction compared to the control group, thereby validating VR's role in alleviating intraoperative anxiety, depression, and enhancing satisfaction [21, 22]. The increasingly immersive VR experience provides a profound perspective, mitigating unfamiliarity, fear, and discomfort within the surgical setting, while diverting patients' attention during the surgical process. Additionally, patients can enjoy pleasant visual stimuli while listening to narratives intended to induce relaxation and meditation [23].

This study evaluated the effectiveness of two methods by analyzing intraoperative hemodynamic indicators and postoperative VAS scores. Notably, the observation group exhibited significantly lower postoperative VAS scores, alongside more stable blood pressure and heart rate compared to the control group. These preliminary findings indicate that VR positively stabilizes intraoperative hemodynamics and reduces postoperative pain, likely stemming from its influence on patients' psychological state.

By educating patients on VR equipment usage and presenting preoperative information, such as the operating room environment, surgical instruments, anesthesia procedures, and sur-

Table 2. Comparison of anxiety and depression scores

Time	State anxiety scores	Trait anxiety scores	Depression scores
Before surgery			
Observation group (n=79)	50.9±2.4	51.3±2.7	58.7±5.0
Control group (n=79)	50.8±2.5	50.8±2.8	59.0±4.7
After surgery			
Observation group (n=79)	44.6±1.9*	43.3±2.0*	46.5±4.1*
Control group (n=79)	48.7±2.0*,#	47.6±1.5*,#	52.9±3.5*,#

Note: Compared with before surgery, *P<0.05; Compared with control group, #P<0.05.

Table 3. Comparison of satisfaction level

Group	Patient satisfaction (n)	Anesthesiologist satisfaction (n)	Surgeon satisfaction (n)
Observation group (n=79)	75	69	68
Control group (n=79)	59	58	56
χ^2	2.577	4.114	6.202
P	0.000	0.043	0.012

Table 4. Comparison of postoperative adverse reactions

Group	Observation group (n=79)	Control group (n=79)	χ^2	P
Postoperative adverse reactions (n)			0.098	0.755
Nausea	1	2	0.353	0.552
Vomiting	2	1	0.339	0.560
Arrhythmia	1	2	0.353	0.552
Hypertension	1	1	0	1.000

gical steps, VR effectively mitigates patients' negative emotions. This reduction in negative emotions, in turn, leads to decreased blood pressure fluctuations and subjective sensitivity to stimuli, ultimately translating to lower postoperative pain scores, corroborating previous research [24].

Furthermore, VR effectively alleviates adverse emotions, enhances patient satisfaction, minimizes potential anesthesia and surgical disputes, and improves compliance and satisfaction among anesthesiologists and surgeons, aligning with prior studies [25]. Finally, a comparison of adverse reaction incidences between the groups revealed no statistically significant difference, suggesting that VR did not increase common surgical complications, thereby demonstrating its high safety profile.

However, considering the single-center nature and relatively small sample size of this study, future large-scale investigations are needed to validate its clinical implications. Moreover, studies incorporating additional objective indicators and long-term follow-up would greatly enhance the robustness of the findings on the effects of VR intervention in local anesthesia.

In summary, the application of head-mounted display virtual reality immersive experience during great saphenous vein surgery has demonstrated the potential to alleviate negative emotions like anxiety and depression, stabilize hemodynamic parameters, and improve patient satisfaction, without increasing the risk of adverse reactions. These findings warrant its clinical application.

Disclosure of conflict of interest

None.

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