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Comparison of Plasma Adrenaline and Noradrenaline in Patients Using Subarachnoid Block Anaesthesia Technique with Immersive Virtual Reality

Widiartha Wahyudi[1], Prananda Surya Airlangga[2], Christrijogo Sumartono[3]

[1]Specialist Study Program-1 of Anesthesiology and Intensive Therapy, Faculty of Medicine, Universitas Airlangga, Dr. Soetomo Hospital, Surabaya, Indonesia
[2,3]Department of Anesthesiology and Intensive Therapy, Faculty of Medicine, Universitas Airlangga, Dr. Soetomo Hospital, Surabaya, Indonesia
Emails: [1]widiarthasam@gmail.com
ORCID ID: [1]https://orcid.org/0000-0002-3570-1486,
ORCID ID: [2]https://orcid.org/0000-0002-4674-6751,
ORCID ID: [3]https://orcid.org/0009-0001-1923-3117

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ABSTRACT

Background: Most patients undergoing surgery using spinal anesthesia experience perioperative anxiety. Anxiety can affect patient well-being and trigger a physiological stress response that can have a negative impact on surgery. One way to deal with perioperative anxiety is with non-pharmacological therapy, one of which is Immersive Virtual Reality technology. The use of IVR technology in healthcare contexts has shown potential in reducing anxiety and stress responses in patients. Adrenaline and noradrenaline as stress hormones are involved in the body's response to stressors. Measuring adrenaline and noradrenaline levels can be used as an indicator of anxiety and stress.
Aim: This study aims to ascertain the impact of employing IVR in diminishing the stress response, as indicated by the levels of plasma adrenaline and noradrenaline, among patients undergoing surgery with the subarachnoid block anesthesia technique.
Material and Methods: Analytical study, experimental single blind randomized control trial. A total of 30 subjects aged 18-45 years, who underwent caesarean section surgery using subarachnoid block anesthesia technique, were randomly divided into two groups, the intervention group would be given IVR experience and the control group would not be given IVR experience. Both groups were examined for baseline and evaluation adrenaline and noradrenaline levels, and tested statistically.
Results: Statistical tests showed a significant difference in evaluation adrenaline levels (intervention group 45.86 ± 11.40 pg/mL and control group 70.80 ± 37.17 pg/mL p=0.019) and a significant difference in evaluation noradrenaline levels (intervention group 134.2 ± 34.5 pg/mL). and control group 164.2 ± 36.6 pg/mL p=0.029).
Conclusion: Baseline adrenaline levels in the two groups were not statistically significantly different. Evaluation adrenaline levels in the two groups had statistically significant differences. Initial noradrenaline levels in the two groups were not statistically significantly different. Evaluation noradrenaline levels in the two groups had statistically significant differences.

Keywords: Subarachnoid Block Spinal Anesthesia, Adrenaline, Noradrenaline, Immersive Virtual Reality

1. Introduction

Regional anesthesia provides several advantages compared to general anesthesia, it poses a lower risk of respiratory complications, shorter duration of hospitalization, lower incidence of nausea and vomiting, and lower systemic effects. Spinal anesthesia is very commonly used in surgical procedures. According to data from the American Society of Anesthesiologists (ASA), more than 70% of all operations performed in the United States use spinal anesthesia techniques (Apfelbaum et al., 2019). However, the regional anesthesia approach has the unique characteristic of allowing patients to have varying levels of consciousness during the surgical procedure, leading to the concern and anxiety often expressed by patients.

Most patients who undergo surgery using spinal anesthesia experience significant anxiety before the procedure. According to a study conducted by Sankar (2022), around 60-80% of patients before surgery experience moderate to severe anxiety. Perioperative anxiety can affect patient well-being and trigger a physiological stress response that can have a negative impact on surgical outcomes. If this is not controlled, activation of the sympathetic nervous system will occur, and cause various physiological responses that are detrimental. Therefore, managing preoperative anxiety is important in the care of patients undergoing subarachnoid block (Tulgar et al., 2017).

A way to treat perioperative anxiety is with non-pharmacological therapy. Recently, the use of Immersive Virtual Reality (IVR) technology has attracted attention in reducing the level of perioperative anxiety (Wang & Jotwani, 2023). IVR offers new solutions in the health sector and has gradually been implemented in the medical world. IVR is believed to be able to divert the patient's mind from processing pain and has been proven superior in reducing pain scores in inpatients with pain greater than 3/10 (Tashjian et al., 2017). The use of IVR technology in a healthcare context has shown great potential in reducing anxiety levels and stress responses in preoperative patients. This is because IVR provides a strong distraction for patients (Alaterre et al., 2020). By fully engaging in the virtual experience, patients can distract themselves from surgery-related worries and anxieties. A calming and enjoyable virtual environment can create a more positive atmosphere and help reduce feelings of anxiety (Koo et al., 2020).

Although the use of IVR in the medical field shows promising potential in reducing anxiety and perioperative stress response, further research is needed to understand the deeper mechanism of the effect of IVR on patient physiology. Adrenaline and noradrenaline as one of the stress hormones produced by the suprarenal gland are involved in the body's response to stressors. Measurement of plasma adrenaline and noradrenaline levels can be used as an indicator of the patient's physiological response to anxiety and stress as it is one of the main stress hormones that can reflect the patient's overall physiological stress response.

This study aims to explore the effect of using IVR in reducing the level of stress response as reflected in plasma adrenaline and noradrenaline levels in patients undergoing surgery with subarachnoid block anesthesia technique can be known. Comparison of plasma adrenaline and noradrenaline levels may provide insight into the effects of IVR on patients' hormonal responses, which can be used as a reference to evaluate the effectiveness of IVR in managing anxiety and stress in patients during surgery.

2. Methodology

This study was conducted at Airlangga University Hospital from January to March 2024. After approval by the Research Ethics Committee (No. 002/KEP/2024), a total of 30 patients scheduled for elective caesarean section under spinal anesthesia were recruited for the study.

Study Procedure

This is an experimental single blind randomized control trial study, conducting a total

of 30 patients aged 18-45 years who were at their first or second pregnancy with physical status ASA I-II to undergo elective cesarean delivery using the spinal anesthesia technique. Patients with visual and/or hearing impairments that could affect the immersive virtual reality experience, history of psychiatric illness, seizures, and pacemaker use, as well as those with contraindications to the subarachnoid block anesthesia technique, and with medical conditions that could affect plasma adrenaline and noradrenaline levels were excluded.

Patients who met the inclusion criteria were randomized into two groups using a sealed envelope. The intervention group (n = 15) underwent surgery with the immersive virtual reality experience and the control group (n = 15) underwent surgery without the immersive virtual reality experience.

Prior to surgery, the patient received a preoperative visit to be examined and informed of the research procedures and asked to provide written consent for the anesthesia and research procedures. The patient also informed about the use, including side effects, of the Immersive Virtual Reality technology using the Oculus Quest device and will have blood drawn twice for adrenaline and noradrenaline hormone testing.

No patients were given premedication prior to surgery. In the premedication room, patients are re-checked for identity, diagnosis, and informed consent. The patient then entered the operating room and was given an Immersive Virtual Reality experience by watching a video selected by the patient using the Oculus device under the doctor supervision. During the experience, close monitoring of vital signs, special events, and possible side effects will be conducted and recorded on the data collection sheet.

Prior to anesthesia, the patient is given 10 ml/kg crystalloid fluid loading. The patient was positioned left lateral decubitus and the insertion area was disinfected with povidone iodine 10% and covered with sterile drape. Lidocaine 5% was used for local anesthesia using spinocaine size 26G at the L3-L4 level. The insertion area was then covered aseptically and the patient was returned to supine position. We planned to achieve the level of sensation block between T6 and T8. After motor and sensation block developed, surgery was initiated. 30 minutes after anesthesia, the patient will have a second blood draw for evaluation of adrenaline and noradrenaline hormone levels. If the patient experienced any side effects or unusual events while using the Oculus device, it will be removed, and appropriate therapy will be administered.

Data Analysis

Statistical analyses were conducted using SPSS 26 for Windows. All demographic characteristics data (age, gender, etc.) are summarized using descriptive statistics. Changes in plasma adrenaline and noradrenaline levels were analyzed using the paired T-test. A p-value of less than 0.05 was considered statistically significant in all analyses.

3. Results and Discussion

Results

Of the 30 female patients who participated in this study, there were no significant differences in age, weight, height, BMI, and vital signs before surgery, as listed in table 1.

Table 1. Demographic Characteristics

Variables	Intervention Group (n = 15)	Control Group (n = 15)	p-value
Age (years)	24.6 ± 3.66	25.07 ± 4.33	0.75[a]
Body Weight (kg)	70.00 (56-111)	75.00 (58-90)	0.74[b]
Height (cm)	155 (142-165)	150 (146-162)	0.74[b]
BMI (kg/m^2)	28.80 (24.1-43.7)	31 (22.9-40.0)	0.93[b]

Data shown as mean ± SD or median (min-max)

Variables	Intervention Group (n = 15)	Control Group (n = 15)	p-value

[a] T test
[b] *Mann Whitney - U*

Adrenaline and noradrenaline measurements were taken twice, 1 day before surgery (preoperative) and 30 minutes after spinal anesthesia. Preoperative mean adrenaline levels were not much different between two groups, the intervention group was 132.4 pg/mL and the control group was 132.9 pg/mL, statistically there was no significant difference. 30 minutes after spinal anesthesia, adrenaline levels in the intervention group were lower when compared to the control group. The mean intervention group was 45.86 ± 11.40 pg/mL and the control group was 70.80 ± 37.17 pg/mL and this difference was statistically significant.

Table 2. Adrenaline level

Time	Intervention Group (n = 15)	Control Group (n = 15)	p-value
Preoperative	132.40 ± 22.34	132.93 ± 26.55	0.95
30 minutes post spinal anesthesia	45.86 ± 11.40	70.80 ± 37.17	0.02

Preoperative noradrenaline levels between the intervention group and the control group also had similar results, the intervention group was 269.6 ± 56.5 pg/mL and the control group was 272.9 ± 58.6 pg/mL, statistically there was no significant difference. 30 minutes after spinal anesthesia, noradrenaline levels in the intervention group were lower when compared to the control group. The intervention group was 134.2 ± 34.5 pg/mL and the control group was 164.2 ± 36.6 pg/mL. Statistically, there was a significant difference between the intervention group and the control group.

Table 3. Noradrenaline level

Time	Intervention Group (n = 15)	Control Group (n = 15)	p-value
Preoperative	269.60 ± 56.54	272.93 ± 58.68	0.87
30 minutes post spinal anesthesia	134.2 ± 34.5	164.2 ± 36.6	0.03

The results of this study illustrate the advantages of providing Immersive Virtual Reality experiences on plasma adrenaline and noradrenaline levels in patients undergoing surgery with subarachnoid block anesthesia techniques.

Discussion

The present study investigated the cathecolamine hormones, adrenaline and noradrenaline. These hormones were measured two times, preoperatively and 30 minutes after spinal anesthesia and these values were compared. At 30 minutes after spinal anesthesia, both adrenaline and noradrenaline level in intervention group has lower level compared to control group, and the difference is statistically significant.

Spinal anesthesia works by blocking the conduction of nerve signals in the lower body, which includes some of the fibers of the sympathetic nervous system. The blockage of these fibers typically results in decreased sympathetic tone, which in turn reduces the release of catecholamines such as adrenaline and noradrenaline.

Immersive Virtual Reality, on the other hand, has emerged as a significant tool in reducing preoperative and postoperative anxiety, which is known to indirectly stimulate the sympathetic nervous system and increase catecholamine secretion. VR environments can significantly lower anxiety levels in patients undergoing procedures ranging from minor surgeries to invasive diagnostic tests (Arifin et al., 2023; Dehghan et al., 2019; Eijlers et al., 2019; Theingi et al., 2022). By diverting a patient's attention from the surgical environment and generating a calming experience, IVR likely contributes to the reduction of adrenaline and noradrenaline levels.

The further decrease in adrenaline and noradrenaline levels post induction with spinal anesthesia in patients exposed to Immersive Virtual Reality (IVR) underscores the potential of integrating anesthetic techniques with non-pharmacological interventions to modulate the body's stress responses. This intersection of technology and medicine offers a new perspective on controlling perioperative stress and sympathetic nervous system activity, both of which play critical roles in patient outcomes.

The synergy between spinal anesthesia and IVR might offer a dual mechanism of action in reducing sympathetic nervous system activity—physiological through the anesthesia and psychological through the virtual reality experience. This dual approach can be particularly beneficial in managing patients who are at high risk for surgery-related stress and its complications. Combining pharmacological and psychological interventions can lead to more comprehensive management of the patient's physiological status, enhancing safety and comfort.

The clinical implications of these findings are significant, especially considering the role of elevated catecholamines in perioperative complications such as myocardial ischemia and hypertension. Lowering these levels through combined interventions could potentially reduce these risks. Further research into this could confirm the broader applicability of these findings across different patient populations and surgical settings.

However, while the current results are promising, the precise physiological pathways through which IVR influences catecholamine levels remain underexplored. Future studies should aim to map these interactions more clearly, providing a deeper understanding of how sensory inputs and cognitive distractions from IVR can affect neuroendocrine responses.

In conclusion, the integration of spinal anesthesia with immersive virtual reality appears to be a promising approach to managing the stress response in surgical patients. This could represent a shift towards more holistic, patient-centered anesthesia practices that address both the physical and emotional needs of patients.

4. Conclusion

In conclusion, our study found that there is an influence of using Immersive Virtual Reality on plasma adrenaline and noradrenaline levels in patients undergoing cesarean section operations with spinal anesthesia techniques.

Conflict of Interest

There have been no competing interests regarding this manuscript.

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Author Contribution

Design, intelligent content description, literature quest, data collection, data processing, manuscript writing, manuscript editing, and manuscript review are contributed by all authors.

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