Article

Use of Virtual Reality to Reduce Anxiety and Pain of Adults Undergoing Outpatient Procedures

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Abstract: (1) *Background*: Research has demonstrated that virtual reality (VR) has reduced pain and anxiety for patients undergoing health procedures. The aim of this quality improvement project was to implement and evaluate immersive VR as a non-pharmacological intervention to reduce pain and anxiety in those adults undergoing outpatient procedures under monitored anesthesia care. (2) *Methods*: This quality improvement project incorporated the Plan-Do-Study-Act (PDSA) model and employed a pre/post-implementation evaluation. Seven patients used VR during outpatient surgeries. Pain and anxiety scores were evaluated. (3) *Results*: Patients using VR exhibited lower pain and anxiety scores post-procedure compared to pre-procedure. Both patients and providers indicated high satisfaction with the VR experience. (4) *Conclusions*: This quality improvement project demonstrated the successful translation of research into practice. VR is a novel intervention that can reduce both pain and anxiety to improve the patient's perioperative experience.

Keywords: virtual reality; pain; anxiety; virtual reality therapy; non-pharmacologic; anesthesia

1. Introduction

Over one-third of Americans who undergo procedures involving anesthesia have them outside of the operating room (OR) [1]. This growth reflects a trend in anesthesia of increasing diagnostic and minimally invasive outpatient procedures [2,3]. Under anesthesia care, these procedures range from elective diagnostic procedures to lifesaving emergency situations. Anesthesia care can range from analgesia or light sedation to general anesthesia. Anesthetic considerations and choice for one's anesthetic plan include main diagnosis, vital sign status, comorbidities, assessment of airway, a risk of aspiration, ability to lie still or flat, anxiety and pain threshold. Procedures are usually performed under light to moderate sedation with a local anesthetic with or without the use of short-acting opioids. Increasingly, complex interventional radiology procedures call for deeper sedation and general anesthesia [2,4]. However, aging patient populations with unstable cardiovascular disease and comorbidities often preclude the use of general anesthesia or moderate to deep sedation [3].

Some centers use monitored anesthesia care (MAC) as a preference for procedures that were once routinely performed under general anesthesia. During procedures, patients may be awake and aware with varying degrees of anxiety regarding the procedures. Moreover, patients may experience the pain of having to remain supine and immobile for the duration of the procedure. Despite the benefits of the less-invasive anesthetic technique, some centers have experienced conversion rates to general anesthesia as high as 17% which then negate those benefits [5].

Distraction has been shown to be an effective non-pharmacologic intervention to decrease pain and anxiety in both children and adults. Virtual reality (VR) is one form of distraction that is a non-pharmacologic type of anesthesia to potentially modulate pain. This modulation helps to draw attention away from mental processing and decrease the amount or perception of pain. Specifically, immersive VR has been found to produce greater pain reductions than other forms of distractions

like television, listening to music or playing games [6–10]. Previous research has shown VR to be a supportive, beneficial intervention in wound care, physical therapy, chemotherapy, venipuncture and urologic procedures [11]. Current research has shown VRs' effectiveness in decreasing pain and anxiety in adult patients undergoing dressing changes for burn wounds, chemotherapy infusions, cystoscopy and dental procedures [12–14]. VR can provide clinical value with its application in adults undergoing outpatient procedures by offering a novel non-pharmacologic means to address common patient needs. This innovation can lead to optimal patient care, reduced costs, fewer pharmacological side-effects and enhanced staff and patient experiences during outpatient procedures.

1.1. Uses of VR

Current research has demonstrated the application of VR in numerous medical settings. Outpatient settings where researchers have applied VR include periodontal scaling and root planing procedures ($N = 50$) in a dental hygiene clinic [12], bone marrow aspiration and biopsy procedure ($N = 97$) in an outpatient cancer center [15], serious hand injury requiring surgical wound care ($N = 98$) in an outpatient surgical center [16] and cystoscopy in ambulatory surgical center ($N = 45$) [17].

Researchers have also tested the use of VR inside the perioperative environment. This includes orthopedic surgery under regional anesthesia ($N = 20$) [18], skin cancer surgery ($N = 20$) [19] and endoscopic urology surgery under spinal anesthesia ($N = 37$) [20]. Collectively, these studies support a role for the standard use of VR in specific contexts and settings.

1.2. Pain Distraction

VR has been most commonly used for pain distraction. Distraction, as a pain control method, has exhibited scientific validity in the modern medical community [16,21,22]. A majority of the studies specifically investigating pain found that the use of VR decreased the experience of pain compared to the control group [12,16,23]. Similarly, this view is supported from the results of two systematic reviews [11,13].

Guo et al. (2015) studied the effectiveness of VR distraction on pain among patients with hand injury undergoing dressing change [16]. Ninety-eight patients were divided into a control group and intervention group. The intervention group demonstrated better scores after the dressing change ($t = -30.792$, $p < 0.01$) compared to the control group. They found a statistically significant correlation between the level of involvement or engagement in the VR with decreased pain level ($R^2 = 0.5538$, $p < 0.05$). The authors recommended frequently assessing the patient's level of involvement in the VR to obtain better results.

Schwartz et al., (2020) conducted a quality improvement project intended to use VR to reduce pain and perioperative anxiety in pediatric burn patients [24]. Forty-six children were given either VR or distraction before dressing changes. Post treatment scores were statistically significantly different in the intervention group with VR performing better than distraction in all measures of pain and anxiety. The authors concluded that VR may be used as a non-pharmacologic treatment to decrease pain and anxiety.

Promising research about AppliedVR™ (Los Angeles, CA, USA) innovative platform has shown clinical success with VR use for pain management in acute inpatient settings. For instance, Tashjian et al., (2017) aimed to measure the impact of a one-time 3D VR intervention versus a two-dimensional (2D) distraction video for pain in hospitalized patients ($N = 100$) [23]. The results of this comparative cohort study found a significant mean pain reduction ($p = 0.008$) in hospitalized patients vs. those who exposed to a controlled distraction video.

1.3. Anxiety

The majority of the research highlighted in the past five years on VR found it to be efficacious [12,16,19,20,23,25]. Dehghan et al., (2019) studied the effect of virtual reality technology on preoperative anxiety in children [26]. Forty children were randomized into two groups—a control group

and an intervention group using VR. Results demonstrated significant changes in the intervention group from baseline to post-test ($p < 0.05$). The authors concluded that VR reduced anxiety in children in the perioperative setting [26]. Sweta et al. (2019) studied the use of VR in pain perception of patients following the administration of local anesthesia [27]. Fifty patients were placed into a control group or intervention group using VR. The researchers obtained statistically significant results for preoperative and postoperative oxygen saturation, intraoperative pulse rate and postoperative visual analog scale pain scale [27]. Findings from Moon et al. (2018) suggested that VR performed significantly better than the use of the medication midazolam on patients' ($p = 0.042$) and anesthesiologists' ($p = 0.001$) satisfaction scores [20]. Further, three systematic reviews concluded that VR demonstrated effectiveness in reducing acute and procedural pain through a distraction mechanism which may contribute to an anxiolytic effect [11,13,28].

Therefore, the summarized results indicate that immersive VR is a viable non-pharmacologic method for both pain and anxiety control. The findings promote its use and its potential for positive clinical outcomes within a variety of clinical settings. Based on the synthesis of the research, the decision was made to move forward with a pilot quality improvement project to translate research into practice to improve patient care in the perioperative setting.

1.4. Project Goal and Objectives

The overarching goal of this quality improvement project was to implement immersive VR as a non-pharmacologic intervention to reduce pain and anxiety of adult patients undergoing outpatient procedures under monitored anesthesia care. The primary objectives of this project were to (a) decrease patient-reported pain post-procedure, (b) decrease patient-reported anxiety post-procedure, (c) increase patient satisfaction and (d) increase provider satisfaction.

2. Materials and Methods

This practice improvement project employed a pre/post-implementation design. The Plan-Do-Study-Act (PDSA) model was used as the methodological framework to guide the project [29]. The PDSA model is a four-step model used for carrying out change and accelerating improvement in a healthcare system [29]. This model entails formation of the team, setting aims, establishing measures, selecting changes, testing changes, implementing changes and spreading changes [29]. This practice improvement project was reviewed by the Human Subjects Research Office at the University of (blinded for review) and was determined to have met the criteria of "not human subjects research". Therefore, the project was not subject to review under 45 CFR 46. Additionally, the project was approved by the chief anesthesiologist.

2.1. Site

The quality improvement project occurred at a large, urban, tertiary care medical center that served military veterans in the Southeastern United States. The project was conducted over six weeks between September 2019 and October 2019. The veteran population is a unique subset in which post-traumatic stress disorder (PTSD) and anxiety are more prevalent which may correlate with increased pain scores and more sedation to treat anxiety [30]. Thus, the use of immersive VR in the clinical setting had the potential for a substantial impact with this patient population.

AppliedVR™. This project was completed with the use of a 3-dimensional (3D) VR by AppliedVR™ (Los Angeles, CA, USA). AppliedVR is a VR technology that projects video, graphics and sound using a headset (Figure 1). With implementation of AppliedVR, the user's visual perception of stimuli from the outside world are blocked. Patients experienced 6 to 30-min VR module(s) that were specifically designed by AppliedVR for relaxation and distraction from anxiety and pain (i.e., beach, guided relaxation, international travel, underwater dolphin experience) (Figure 2). Patients chose the module(s) that they felt would offer them a beneficial experience.

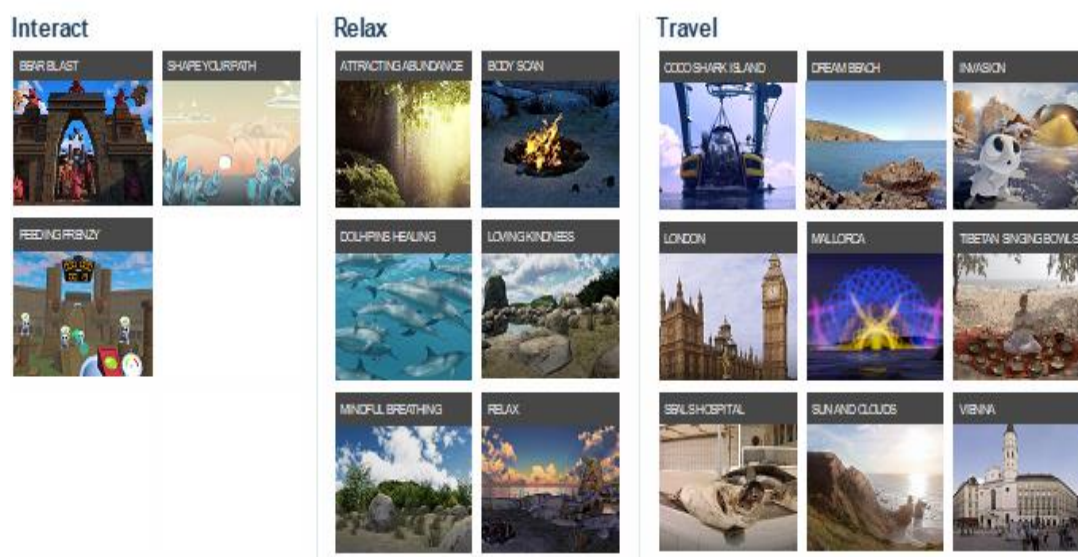**Figure 1.** Example of a virtual reality (VR) headset provided by AppliedVR.

Figure 2. Example patient view using the AppliedVR software.

2.2. Participants

Participation was voluntary. Adults (>18 years old) admitted to the perioperative area for outpatient procedures under monitored anesthesia care were screened and offered participation in the program. Those patients with documented motion sickness and/or visual or hearing impairment were excluded. Those who declined to participate were excluded.

2.3. Methods

For those who agreed to participate, the headset was placed over the participants' eyes while they were waiting for the procedure to begin. The nurse assisted the patient with fitting and use of the device. Participants wore the VR headset during their procedures and removed them post-procedure. Patient and provider data were collected using Qualtrics survey software ™ (Qualtrics, Provo, UT, USA). Additional evaluation metrics recorded include total sedation and opioid consumption before and during the procedure. Patients were offered the surveys for completion pre/post procedure via tablet. Similarly, health care providers were asked to complete a survey post procedure.

2.4. Measures

In order to measure the outcomes of this quality improvement project, the following instruments were used: (a) The Patient Reported Outcomes Measurement Information System (PROMIS) pain intensity short form 3a, (b) Spielberger State-Trait Anxiety Inventory (STAI: Y-6 item) and (c) Patient and Provider satisfaction survey. Additional data were collected, such as demographic and clinical characteristics like age, sex, race, procedure type and any medications given during the procedure.

2.4.1. PROMIS Pain Intensity Scale

Pain was assessed using the Patient Reported Outcomes Measurement Information System (PROMIS) pain intensity scale (v1.0) [31]. The Patient Reported Outcomes Measurement Information System (PROMIS) measures have been validated by the National Institutes of Health (NIH) for use in the general population with adults. The PROMIS pain intensity short form 3a assesses pain intensity over the past seven days with the last item asking patients to rate their pain intensity "right now" on a range of 1 (had no pain) to 5 (very severe). The 3-item scale allows for a broader range of pain assessment compared to the numerical rating (NRS) scale [31,32]. The scores are weighted to provide cross-comparability of scores across many samples. The PROMIS pain intensity short form has been shown to be valid and reliable with a reported Cronbach's alpha between 0.81 and 0.95 [33].

2.4.2. Spielberger State-Trait Anxiety Inventory

The Spielberger State-Trait Anxiety Inventory (STAI: Y-6 item) is a widely used tool to measure anxiety in the clinical setting [34]. Form Y-6 assesses immediate symptoms of anxiety like "I am worried" and "I feel calm." Items are rated on a 4-point scale from "Not at all" to "Very much". Scores range from 2–80. The STAI: Y-6 item has been tested and deemed reliable and valid in different patient populations such as adult patients undergoing cutaneous surgical procedures [35], parents of pediatric patients in a surgical waiting area [36] and blood donors [37]. The 6-item STAI has high reliability and concurrent validity with the original full scale. Reported Cronbach's alpha scores range from 0.78–0.844 and have a correlation of 0.92 to the original scale [35–38]. Permission was received from Mind Garden, Inc. to use the tool.

2.4.3. Patient and Provider Satisfaction Survey

A post-procedure questionnaire was used to collect data on patient and staff satisfaction related to VR experience. This two-item survey was developed by the project director based off of the literature. The patient and providers were asked the following question: Were you satisfied with your overall VR experience? The survey offered a 5-point Likert-type scale ranging from (1-Very Dissatisfied) to (5-Very Satisfied). An open-ended item for comments was also included.

2.5. Data Analysis

Data were aggregated via Qualtrics and imported into Microsoft Excel (Microsoft, Redmond, WA, USA). Data were analyzed using paired *t*-tests on Microsoft Excel, version 16.28. The *p*-value considered significant was set at a level of $p \leq 0.05$.

3. Results

3.1. Patient Demographics

Twelve patients screened were eligible for participation, but only data from seven patients were included. Three patients become ineligible after the anesthetic plan was changed to general anesthesia and two patients chose not to participate because they were not interested in using the technology. All participants were men with ages 45–74 years old. Four participants identified as Black and three participants identified as White. The most frequent procedure conducted was hand surgery (Table 1).

Table 1. Procedure types.

Procedure Type	Number
Carpal Tunnel Release	4
AVF Revision	1
Biopsy and debridement of finger	1
Angiogram	1

3.2. Post-op Pain

Pre/post-test scores from the PROMIS pain intensity short form 3a were examined. The patients' mean pre-test score was 56.05. The patients' mean post-test score was 20.47. This reduction in pain was statistically significant ($p = 0.036$).

3.3. Post-op Anxiety

The patients' mean pre-test score on the STAI was 33.81. The patients' mean post-test score was 20.48. Anxiety scores demonstrated a statistically significant reduction ($p = 0.033$).

3.4. Patient Satisfaction

All patients indicated satisfaction with their VR experience. Eighty-six percent of patients rated their VR experience as a whole as "Very Satisfied" ($M = 4.86$, $SD = 0.35$). Patients reported in the comments section that it worked well for taking their mind off being in the OR and that they enjoyed the experience.

3.5. Provider Satisfaction

Providers were satisfied with their VR experience. Eighty-six percent of providers rated their VR experience as a whole as "Very Satisfied" ($M = 4.71$, $SD = 0.70$). The remaining fourteen percent reported their experience as neutral. Providers reported that VR made surgery a positive experience instead of a frightening one and decreased the amount of intraoperative anxiolytics required.

4. Discussion

This practice improvement project suggested that the use of VR was effective in reducing pain and anxiety for patients undergoing surgical and non-surgical procedures. The results of this practice improvement project suggest that the patient and provider experience during surgical procedures under monitored anesthesia care can be enhanced with the use of immersive VR. These findings resonate with existing research suggesting that VR can assist in the reduction of pain and anxiety [12,16,19,23].

The results of this quality improvement project evaluation are a contribution to the literature. First, the pilot program demonstrated the successful translation of research into practice. As the body of evidence in virtual reality repeatedly has supported the utility of VR as an effective non-pharmacologic solution, what is lagging at this time is its widespread implementation or adoption into standard practice. The results of this project are similar to the work of Schwartz and colleagues who conducted a quality improvement project demonstrating reductions of perioperative pain and anxiety in the context of children who suffered from burns [24]. As much of the literature about VR includes literature reviews, methods papers and research studies, this quality improvement paper contributes by bringing attention to implementation science and evidence-based practice in the nursing context of VR in the perioperative setting.

4.1. Limitations

This quality improvement project was limited in several ways. The project was conducted over six weeks which limited the number of participants obtained. Further, as this quality improvement project was not a formal research study, the results are not generalizable. There was no comparative

cohort so it remains unknown how the VR would have compared to the traditional standard of care. All participants were male, but the veteran population is mostly male. Lastly, individuals who may have benefitted from the VR may not have fit the inclusion criteria of this project and may not have been invited to participate (i.e., those not under monitored anesthesia care). The target population was quite narrow as it was only a pilot project.

4.2. Lessons Learned

Certain challenges arose during the implementation of this project. They included the frequent correction of the orientation view shown on the headset. Patients reported the picture view being off center, sideways or diagonal right after placement of the headset in the OR which took time to readjust. These orientation problems only occurred with the patient lying down. Re-centering the device was difficult with the patient lying flat on the OR table. Fixing the problem took time away from actually starting the VR experiences. For this reason, it is recommended to have a designated person present who is trained in use of the device for successful implementation.

The operating room environment is a dynamic environment with time constraints, so having a designated person available was helpful for successful recruitment of patients pre-operatively and to provide assistance intraoperatively. VR experiences ranged from six to thirty minutes so length of the procedure should be taken into consideration when deciding whether or not to use VR. Some patients were able to navigate through the device to find additional virtual experiences, but others required assistance to navigate to other virtual experiences which required removal of the headset and resulted in time spent re-centering the device.

Concerns were raised regarding physician–patient interaction and being able to follow instructions during some surgical procedures. However, it was observed that patients were still able to interact with their surgeon. Patients appeared to have no problems following commands when prompted during their surgery.

Of note, although VR is a new and exciting technology, it may not be for everyone. Reasons patients decided against the use of VR included the patients wanting to sleep during their procedure and others who preferred to stay aware of their surroundings. Based on these anecdotal findings, it was apparent that patients should still be offered choices regarding their preference of use of VR or traditional methods.

4.3. Impact

Application of VR can have a significant impact on nursing practice by providing a non-pharmacologic solution to reduce the pain and anxiety that often accompany surgical procedures. A primary impact is the enhancement of patient satisfaction by providing positive, customizable experiences that empower patients through offering them choices. Second, the use of VR may lead to the sparing of opioids and sedation, thereby decreasing side effects. Third, with decreased medications, therein lies potential for reduced postoperative recovery times and decreased healthcare related costs. Additionally, findings from this project may inspire other clinical settings and patient populations to use VR as a non-pharmacologic solution.

Further research is recommended to explore perioperative use of VR in obstetrics during labor with epidural placement, pediatrics for preoperative anxiety use, adults for preoperative anxiety reduction, preoperative use for venipuncture, postoperatively for peripheral nerve block placement and in other appropriate surgical and non-surgical situations where the patient is wide awake. Perhaps, in the future, the integration of immersive VR to improve the patient experience will become standard practice.

5. Conclusions

This quality improvement project supported the implementation of immersive VR in the perioperative setting to reduce adult patient anxiety and pain. VR is a viable non-pharmacologic intervention that research has supported to be effective, yet it has not been widely integrated into mainstream clinical practice. This project serves to advance evidence-based practice in the perioperative clinical setting. Future efforts are warranted to increase the diffusion and adoption of VR to improve patient care.

Conflicts of Interest: The authors declare no conflict of interest.

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