Using virtual reality to control preoperative anxiety in ambulatory surgery patients: A pilot study in maxillofacial and plastic surgery

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ABSTRACT

Introduction: Preoperative anxiety may lead to medical and surgical complications, behavioral problems and emotional distress. The most common means of prevention are based on using medication and, more recently, hypnosis. The aim of our study was to determine whether a virtual reality (VR) program presenting natural scenes could be part of a new therapy to reduce patients' preoperative anxiety. Materials and methods: Our prospective pilot study consisted of a single-blind trial in skin cancer surgery at the Henri-Mondor teaching hospital in France. In the outpatient surgery department, 20 patients with a score of >11 on the Amsterdam preoperative anxiety and information scale (APIAS) were virtually immersed into a natural universe for 5 minutes. Their stress levels were assessed before and after this experience by making use of a visual analog scale (VAS), by measuring salivary cortisol levels, and by determining physiological stress based on heart coherence scores. Results: The VAS score was significantly reduced after the simulation (P < 0.009) as was the level of salivary cortisol (P < 0.04). Heart coherence scores remained unchanged (P = 0.056). Discussion: VR allows patients to be immersed in a relaxing, peaceful environment. It represents a non-invasive way to reduce preoperative stress levels with no side effects and no need for additional medical or paramedical staff. Our results indicate that VR may provide an effective complementary technique to manage stress in surgery patients. Randomized trials are necessary to determine precise methods and benefits.

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1. Introduction

Virtual reality (VR) has been used with success in a number of fields in healthcare, such as simulation-based medical teaching. There is currently a great deal of interest in VR, particularly to address anxiety disorders including phobias and post-traumatic stress [1–4].

The waiting period preceding a healthcare procedure (bandaging, removing stitches, collecting a blood sample) or a surgical procedure often gives rise to undesirable psychological reactions such as anxiety, anguish, stress, fear, distress and actual phobias. For the patient, hospitalization in general and surgery in particular constitute negative stress factors, regardless of the specialty [5–8] and the disease being treated.

Among adults, the prevalence of preoperative anxiety in connection with a surgical procedure or anesthesia ranges from 60 to 80%, and context plays an important role [9,10]. For example, anxiety is greater in aesthetic surgery than in reconstructive surgery [11].

The primary risk factors for preoperative anxiety in adults are: cancer, smoking, psychiatric disorders (in particular anxiety and depression), moderate to intense preoperative pain, and relatively major surgery [12].

Patients with high levels of preoperative anxiety experience a slower, more complicated and more painful postoperative wakeup [13–15].

A conventional approach to reducing this type of anxiety is based on a preventive strategy using drugs (antihistamines and benzodiazepines) or hypnosis, or a combination of the two. VR may be a new way to address our patients’ anxiety during the waiting period just prior to a surgical procedure.

Oral and maxillofacial surgery is a specialty where numerous procedures can be performed under local anesthesia, in the office
of the surgeon. It is a specialty where surgeons can take care of pediatric as adult patients, and the need for fast and easy medical devices to prevent preoperative anxiety of our patient is mandatory.

The objective of our study was to determine whether a VR program containing natural scenes could decrease preoperative anxiety levels in patients who were candidates for ambulatory skin cancer surgery in a university hospital.

2. Materials and methods

We conducted a pilot, monocentric, prospective and single-blind study. We evaluated the effects of VR by administering psychological tests, measuring salivary cortisol and determining a heart coherence score.

2.1. Patients

Our study enrolled 20 patients (10 men, 10 women) with an average age of 56.9 years (Table 1).

Inclusion criteria were an anticipated high stress level during the surgical procedure as assessed by the French version of the Amsterdam preoperative anxiety and information scale (APAIS) > 11. Exclusion criteria were pregnancy, breastfeeding, impaired cognitive function, and an age of < 18 years.

After receiving information about how the study would be conducted, each patient was required to give his or her written consent to participate in the study.

This study received prior approval by a local institutional review board (Comité de protection des personnes).

2.1.1. Preparation of the patient

2.1.1.1. Positioning the patient. The room in which the study was conducted was isolated, bright and calm. Before beginning the study, patients were first greeted and prepared by the paramedical team to ensure a smooth ambulatory care experience. While patients were waiting in the hospital room, wearing a hospital gown before being taken to the operating room, we asked them to take part in our study. Patients were invited to sit in an adjustable chair that could recline to become a lounge chair. Staff offered a blanket and sought to ensure the patient was comfortable (Fig. 1).

Three tests were administered to patients before and after undergoing VR immersion.

2.2. Conduct of the study

- Psychological test: for the initial evaluation, we used a self-assessment scale of preoperative anxiety based on the Amsterdam preoperative anxiety and information scale (APAIS) [16]. This is an instrument for use by adults that combines patients’ assessment of their anxiety with an evaluation of their expectations concerning a desire for information about the surgery. All patients with a score of 11 or above were included in our study (Table 1). The test consists of six questions that were developed and validated to evaluate a patient’s preoperative anxiety. This global index includes three separate areas: anxiety about anesthesia, anxiety about surgery, and the desire for information. The items are rated on a five-point Likert scale from “not at all” to “extremely” [17,18]. Next, we used a visual analog scale (VAS) with self-assessment before and after the immersive VR experience in order to evaluate preoperative anxiety and ask patients to rate their level of anxiety on a scale specifically adapted for this purpose. Each patient obtained a score between 0 and 10;
- Biological test: salivary cortisol was measured using a Salivette® swab (SarstedT™) to ensure that collected saliva samples were reproducible. Samples were stored at 4 °C until they underwent analysis by an outside laboratory (Cerba®). We measured cortisol levels using liquid chromatography combined with mass spectrometry, an excellent non-invasive marker of the corticotropic axis [19]. This is a sensitive test with levels that can change in a matter of minutes after experiencing an anxiety-provoking or a relaxing stimulus [20,21]. We consistently measured salivary cortisol levels last, i.e., right before VR immersion and as long as possible after VR immersion; and
- Physiological test: measurement of heart coherence (HC) with a finger pulse oximeter was performed using Max Pulse® software (version 1.0.0.6.1.3) and a Samsung Electronics® computer, Intel Atom N270, 1.60 GHz, 0.99 Go memory (Fig. 2(a) et (b)). We were thus able to obtain the heart coherence score of each patient over a period of 3 minutes before and after the utilization of VR. The score was calculated based on the extreme heart rate scores, the periods of heart rate variability (between periods of disorganization or incoherence, and those of organization or coherence), and the average of all measurements recorded every 3 seconds. A low score corresponded to a more efficient heart coherence state in connection with diminished anxiety levels [22].

2.3. VR test

After completing the first three tests, the patient put on the VR glasses. The system consisted of VR glasses (Oculus®) and an audio

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headset (Oculus Rift®) connected to a LDLC® computer enhanced with an Intel Core i7-4790 K processor, 4.00 GHz, 8.00 Go memory, and a high-performance NVIDIA® GeForce GTX 1060 6 GB graphics card. The components were kept in a Zalman® tower computer case (Fig. 3(a) et (b)).

The prototype VR software we used for this study was specially developed by the company Diacalm® for the purposes of relaxation. The patient was immersed in a peaceful setting—a beach in the Caribbean—with audio features and sounds from nature, in order to be completely isolated from the real world for 5 minutes. The lead evaluator followed the patient’s 360° rotation in this virtual world on the computer screen (Fig. 4).

2.4. Statistical method

For the statistical analysis, we used an unpaired t test and analysis of variance for repeated measures. This test allows the comparison of two measurements (before and after) of a quantitative variable for the same subjects. We used the Prism®, Version 5 (GraphPad, USA) software with a selected statistical P value < 0.05.

3. Results

- Psychological test (VAS): patients’ anxiety scores decreased by 0 to 2 points (out of 10 points) after VR immersion, according to the VAS. The average of all scores decreased from 3.3 before the VR test to 2.85 after the VR test, a significant difference (P < 0.009) (Table 2);
- biological test (salivary cortisol): the average salivary cortisol concentrations dropped from 14.55 before the VR test to 12.86 after the VR test, a significant difference (P < 0.005) (Table 2);
- physiological test (heart coherence): the average of all scores went from 50.6 before the VR test to 46.9 after the VR test. The difference between these 2 averages was not significant (P = 0.056) (Table 2).

Results are resumed in Fig. 5. No adverse events were observed.
4. Discussion

Our VR system seems to reduce preoperative anxiety, particularly with respect to the psychological and biological evaluation factors.

Preoperative anxiety has harmful consequences. It increases postoperative complications [4-8], behavioral disorders and emotional disturbance [12-15]. VR is a simple, non-invasive technique that is both reproducible and affordable for a surgery department. Although our test lasted for a short amount of time and provided only one virtual universe (a desert beach), the effect on our patients was positive.

The psychological test and measurement of salivary cortisol levels led to a state of emotional stability and rest after immersion into VR, with a tendency towards decreased anxiety levels and increased stress resistance thresholds.

There is no psychological test to specifically evaluate preoperative anxiety before and after the immersive VR experience. We decided to use a VAS, which is correlated with the State-Trait Anxiety Inventory (STAI) among adults [23,24]. STAI is considered to be the gold standard in English-speaking countries for the evaluation of anxiety, but it was not suitable for utilization in our clinical setting.

Measuring salivary cortisol levels provided an indicator of patients’ biological stress levels. The advantage of this technique is that we were able to collect samples in a non-invasive way, without influencing our results [25]. Nonetheless, certain salivary cortisol scores were particularly high, such as for patient n°14 (P14) following VR immersion, which may be explained by the presence of blood when the sample was collected, artificially increasing salivary cortisol levels. When patients who are at risk for advanced periodontal disease chew the Salivate® swab, bleeding of the gums may be observed. This is what happened with our patient.

The results of the heart coherence score were not statistically significant. We think this is due to a bias when the second measurement was taken, after VR immersion. Instead, it should have been measured during the VR experience, when the patient’s respiratory rate slows and becomes regular (corresponding to a relaxed state). At that point, the conditions would have been right to enter into a state of heart coherence. Since the second measurement took place after the patient had returned to reality and was aware that he or she was speaking to a doctor and was about to undergo surgery, we probably lost the immediate benefit of the VR experience in terms of resistance to psychological stress. However, the improvement in the patient’s perception and the overall decrease in salivary cortisol scores confirm the positive psychological and biological dimensions of reducing preoperative anxiety.

With respect to the time required for our study (approximately 45 minutes/patient), we did not disturb the workflow of the operating room, nor did we impact the way patients are greeted by the outpatient surgery department’s paramedical team. The time which patients spend waiting before undergoing an operation, which is often idle time, could be put to good use by adopting this technology in order to help patients relax. It would require few additional paramedical staff members compared to other psychological strategies, such as hypnosis.

To reduce preoperative anxiety, using hypnosis alone is described as being more effective than pharmacological interventions, such as Midazolam [26]. Despite the potential reduction in postoperative behavioral disorders [27,28], hypnosis is difficult to organize on a routine basis because it is often time-consuming and requires qualified, available personnel.

The entire VR system can be reused indefinitely with no additional cost and no need for highly-trained personnel. Patients are able to manage the use of VR on their own, which reduces the cost of this approach compared to hypnosis or medication.

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Results: $P < 0.009$ $P < 0.005$ $P > 0.005$ ($P = 0.056$)

VAS: visual analog scale; VR: virtual reality.

a. Salivary cortisol.

b. Heart coherence score.

Fig. 5. Results of the three evaluations.

5. Conclusion

VR offers an innovative strategy to manage preoperative anxiety, and our preliminary results were satisfactory despite the currently limited capacity of our system. Thanks to the many different possible themes patients can choose from to help them relax, improved graphics, and the addition of olfactory and musical features, as well as the ease with which VR glasses and a headset can be used from a hospital bed, VR holds the potential to effectively manage preoperative anxiety for numerous patients. Moreover, it does not negatively impact the work of healthcare teams, regardless of the medical specialty. A final consideration: one can easily imagine setting automatic personal preferences regarding graphics, smells, and sounds directly on a patient’s Facebook profile. Clearly, this technique is still in its infancy, and randomized studies will be useful to determine its exact benefits and to improve the algorithms.

Disclosure of interest

The authors declare that they have no competing interest.

References
