Virtual reality on mobile phones to reduce anxiety in outpatient surgery

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Abstract: When undergoing ambulatory surgical operations, the majority of patients experience high levels of anxiety. Different experimental studies have shown that distraction techniques are effective in reducing pain and related anxiety. Since Virtual Reality (VR) has been demonstrated as a good distraction technique, it has been repeatedly used in hospital contexts for reducing pain in burn patients, but it has never been used during surgical operations. With the present randomized controlled study we intended to verify the effectiveness of VR in reducing anxiety in patients undergoing ambulatory operations under local or regional anaesthesia. In particular, we measured the degree to which anxiety associated with surgical intervention was reduced by distracting patients with immersive VR provided through a cell phone connected to an HMD compared to a no-distraction control condition. A significant reduction of anxiety was obtained after 45 minutes of operation in the VR group, but not in the control group and, after 90 minutes, the reduction was larger in the experimental group than in other one. In conclusion, this study presents an innovative promising technique to reduce anxiety during surgical interventions, even if more studies are necessary to investigate its effectiveness in other kinds of operations and in larger numbers of patients.

Introduction

In the last 50 years there have been significant advances in anaesthesia and surgical methods, which have created the possibility of performing procedures with greater precision, predictability, speed, safety, and often without pain. However, despite these progresses, a common problem that still involves surgical operations using local or regional anaesthesia is that a lot of patients experience high levels of anxiety before and during the operation, since they usually do not know enough about medical procedures and they presume that such procedures will cause them pain and discomfort. Local and regional anaesthesia are techniques used to render part of the body insensitive to pain without affecting consciousness; this means that during the operation patients can perceive everything is happening around them: they can see doctors and nurses moving around, hear their voices and comments and so on. Patients with high levels of anxiety usually perceive the procedure more distressing than it really is. This causes a lack of cooperation during the operation, which in turn may cause stress on the operating surgeon, impairing his or her surgical performance and leading to longer operative times. Moreover, in the worst cases patients demonstrate their avoidance behaviour by not attending their appointments.

Different experimental studies have shown that cognitive factors such as attention can influence the subjective experience of pain and fear of pain (Andrasik, Flor, & Turk, 2005; Eccleston & G., 1999; Melzack & Wall, 1965). In particular, distraction techniques have been demonstrated to be effective in reducing pain and related anxiety (Fernandez & Turk, 1989; Tan, 1982). Unfortunately, these techniques have been primarily used in artificial context such as research laboratories and their effectiveness may not be generalized to more complex clinical settings. Moreover, the more complex and uncontrollable the critical situations, the more difficult it is to obtain an effective distraction. For these reasons it is necessary apply distraction techniques, effective in different contexts and clinical procedures.

Hoffman and coll. have recently shown the potential of immersive virtual reality (VR) in reducing pain during the wound caring on conscious patients with severe burn injuries, which is widely considered one of the most painful medical pro-
c edures (Hoffman, 2004; Hoffman, Patterson, & Carrouthger, 2000; Hoffman, Patterson et al., 2004; Hoffman et al., 2008; Hoffman et al., 2006; Hoffman et al., 2007; Patterson, Hoffman, Palacios, & Jensen, 2006; Sharar et al., 2007).

The illusion of going into the 3-dimensional computer generated world (known as presence) provoked by VR immersion is thought to be especially effective in moving attention away from the real world situations to the virtual environment. Researchers have demonstrated that patients who experience a stronger illusion of going into the virtual world representing an icy, cool 3-dimensional virtual environment (the SnowWorld) will be more distracted by VR, and will thus report more pain reduction than those who experience a less compelling illusion of presence in the virtual world (Hoffman, Sharar, & Coda, 2004). VR has also been used for reducing anxiety and stress in individuals exposed to critical real-life situations, such as university students performing examinations (Riva, Grassi, Villani, Gaggioli, & Preziosa, 2007) and commuters travelling every day in very uncomfortable situations (Riva, Preziosa, Grassi, & Villani, 2006). Also in these cases, a relaxing VR environment helps subjects to move their attention from a disturbing condition to a relaxing experience.

Immersive VR can be provided using a computer or an advanced personal digital assistant (PDA) or mobile phone (Preziosa, In press) connected to an head mounted display (HMD), a display device worn on the head or as part of a helmet that allows a stereoscopic vision. The HMD blocks the user’s view of the real world, and, on the contrary, presents patients with a view of a computer generated world. The helmet and headphones exclude sights and sounds from the hospital environment, providing converging evidence from the virtual world to multiple senses (both sight and sound). VR has been repeatedly used in hospital contexts for reducing pain in burn patients, but it has never been used during surgery. With the present randomized controlled study we intended to verify the effectiveness of VR in reducing anxiety in patients undergoing ambulatory operations under local or regional (epidural) anaesthesia. Using a controlled experimental design, we tested the degree to which anxiety associated with surgery was reduced by distracting patients with immersive VR compared to a no-distraction control condition. In many cases this kind of operation provokes moderate pain and high level of anxiety, associated to physiological responses such as increasing of blood pressure and heart rate that can interfere with the surgical procedures. These symptoms are usually reduced with medical treatments that increase operation costs and often produce side effects. The other relevant innovation of this study regards the introduction of mobile phones in the operation room. Patients will be immersed in a relaxing environment wearing an HMD connected to a small Nokia phone. No computers, neither big screens or projections, are necessary to provide patients with VR.

Method

Subjects

Twenty one patients, 14 females and 7 males, aged between 17 and 81 years (mean = 49.6 ± 18) participated in the study. All patients underwent an ambulatory surgical operation at the General and Regional Hospital No. 25 of the IMSS in Mexico City (for a detailed list of the performed operations see tab.1). Patients were randomly divided in two groups: the experimental group (N = 11; 8 females and 3 males; mean age = 44.4 ± 13.5) and the control group (N = 10; 6 female and 4 males; mean age = 55.4 ± 21.2). The age difference between the two groups was not significant.

Immediately before the operation, patients included in the experimental group were instructed about the use of the HMD and VR and were asked to sign an informed consent.

Technical equipment

- Nokia N95: a mobile phone with up to 160 MB of internal memory. Display: Large 2.6” QVGA (240 x 320 pixels) TFT display with ambient light detector and up to 16 million colours. Operating system: Symbian OS; User Interface: S60 3rd edition; Dedicated Media Keys; Multimedia Menu. Mobile video: Video resolutions: up to VGA (640x480) at 30 fps; video clip length: limited by available memory; video file format .mp4. Music features: Digital music player - supports MP3/ AAC/AAC+/eAAC+/WMA/M4A with playlists and equalizer; Integrated handsfree speaker. Connectivity: USB 2.0 via Mini USB interface and mass storage class support to support drag and drop functionality; Nokia PC Suite connectivity with USB, Infrared and Bluetooth wireless technology.

- HMD Vuzix iWear AV 920: Twin high-resolution 640x480 (920,000 pixels) LCD
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<tr>
<th>Case Number</th>
<th>Group</th>
<th>Sex</th>
<th>Age</th>
<th>Anesthesia</th>
<th>Surgery</th>
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*Tab.1: Epidemiological and clinical characteristic of the sample*

displays equivalent to a 62" screen viewed from 9 feet; iWear® 3D enabled for automatic 2D/3D control; no buttons required; Visor weighs 2.9 ounces; Can be worn with or without prescription eyeglasses; Removable, integrated speakers that can be upgraded or removed to allow you to plug in your own headsets; AccuTilt™ viewer pivots up to 15 degrees for comfortable viewing angle; Soft, comfortable, hypo-allergenic nosepiece extends up to 3/8"; Custom fit headstrap; Integrated rechargeable lithium ion battery allows approximately five hours of continuous operation; 60 Hz progressive scan update rate.
Virtual environment
A pre-recorded video of the Green Valley, a very relaxing environment showing a mountain landscape around a calm lake is presented together with the relaxing music and soft sounds (birds’ songs, water flowing, etc) (see fig.1). Patients have the impression to walk around the lake, they can observe the nature and virtually sit on a comfortable deck chair, in order to become easily relaxed.

![Fig.1: A screenshot from the Green Valley](image)

Measures of anxiety
The patients’ self-ratings of anxiety were the primary dependent variables. Ratings were administered immediately before (T0), after 45 minutes (T1) and after 90 minutes of operation (T2). Measurement at T1 and T2 were taken during a brief (approximately 2 minutes) pause in operation. Patients gave ratings using 0-10 visual analogue scale for anxiety (VAS-A) (see fig.2).

![Fig.2: VAS-A. Patients were asked to answer the following question: Please indicate how much anxiety you are experiencing now (0 is no anxiety at all, 10 is the maximum level of anxiety you can experience)](image)

Experimental procedure
Patients in the experimental group wore the HMD and the headphones connected to the Nokia N95 few minutes before the anaesthetic injection (see fig.3). The total length of the virtual relaxing presentation was 90 minutes - that was more or less the duration of the intervention. Patients in the control group did not receive any kind of virtual exposure.

(a)

![Fig.3: (a) Cyst resection on the head; (b) Lipoma resection on the abdomen wall](image)

Results
At T0 all patients were asked to rate their level of anxiety on a scale of 0-10. Statistical analysis show that the level of anxiety did not differ between the two groups (t = 0.547, df = 19, p = 0.59). After 45 minutes the anxiety level significantly decreased in the VR group (t = 3.57, df = 10, p < 0.05), but not in the control group (t = 0.73, df = 9, p = 0.48), while after 90 minutes it decreased in both groups (t = 4.74, df = 10, p < 0.01; t = 2.37, df = 9, p < 0.05) (see fig.4). Moreover, comparing the two groups, we observed that the reduction of anxiety between T0 and T2
was higher in the VR group (mean: 5.27 ± 3.69) than in the control group (mean: 2.2 ± 2.94) (t = 2.1, df = 19, p < 0.05).

No differences were found in anxiety reduction between males and females (t = 1.39, df = 19, p = 0.18). No correlations were found in the two groups between age and the decrease of anxiety (VR group: r = -0.115, n = 11, p = 0.735; control: r = 0.36, n = 10, p = 0.31).

![Graph](image_url)

*Fig.4: The graph represents the decreasing of anxiety along time in the two groups of patients*

**Discussion**

The present study provides preliminary evidence that entering a virtual relaxing environment can help to reduce anxiety during surgical interventions performed under local or regional anaesthesia. A significant reduction of anxiety was obtained after 45 minutes of operation in the VR group, but not in the control group and, after 90 minutes, the reduction was larger in the experimental group than in other one. These results can be explained by the positive effect of virtual immersion on relaxation, and not only by the fact

that patients realized that the operation was going to be concluded. Moreover, the lack of correlation between age and anxiety decrease means that VR exposure is equally effective in all patients, no matter how old they are.

VR systems provide computer-generated sensory inputs to several senses (in our case sight and sound) which make the presented virtual world difficult for the brain to ignore. Inducing the illusion of going into the virtual environment, immersive VR is more effective than other cognitive methods in distracting patients from their worries. Moreover, differing from other forms of distraction, the HMD prevents patients from looking at the real world. The impossibility to see the doctors and the surgery room may be one important advantage of VR. In a surgical setting, reduction of anxiety is important for different reasons: (1) patients undergo operation in a more relaxed way; (2) their physiological parameters remain more stable during the intervention; (3) no extra pharmacological medications are needed in order to calm patients. With VR we can obtain these advantages without side effects, using very small and easy to install equipment. Since these data demonstrate that even small cell phones are suitable for VR immersion, in the future studies we are going to provide them to the patients before operations. We intend to give patients the possibility to practice relaxation abilities in a non-immersive way (without the HMD) with the same virtual environment they will see during the operation in order to help them to become more quickly and easily relaxed.

The substantial limitations of this study are the quite small sample size, the lack of a blind experimental condition and the lack of the possibility to actively interact with the virtual environment. The latter feature could be relevant to increase the sense of presence, that is the impression to be immersed in the virtual environment, but it is difficult to be introduced in a surgical setting where patients are usually lying down and asked not to move.

In conclusion, this study presents an innovative and promising technique to reduce anxiety during surgical interventions, even if more studies are necessary to investigate its effectiveness in other kinds of operations and in larger numbers of patients.

**References**


weightlessly, eliminating the need for the patient to put on a VR helmet and reducing the amount of surface contact needed with the patient (see Figure 1).

**Subject**

Patient 1 was a U.S. Army soldier medically evacuated from Iraq to USAISR after suffering severe burns covering 32% of his body approximately 45 days prior to this intervention. While a passenger in a vehicle that was attacked by an improvised explosive device (roadside bomb), he experienced full thickness burns on his hands, arms, anterior and posterior chest and distal thighs. In the following weeks, donor skin