

## Study of gender differences in VR response following cardiac surgery.

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### Abstract

**Cardiac and other invasive surgical procedures cause significant anxiety and stress to patients and their family members. In this study Virtual Reality (VR) was used as a method to reduce stress, anxiety and pain in patients undergoing surgical procedures. This study compared a cohort of patients in the interval prior to and successive to the surgery, differentiating the responses achieved by males and females and comparing the effectiveness. The results are encouraging: they demonstrate the efficacy of VR treatment and the safety of the method and detection of differences in the responses based on gender.**

**Keywords:** Gender differences, Cardiac surgery, Anxiety, Stress, Surgery.

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### Introduction

Despite the progress in anesthesia and surgical methods, a common problem in surgical procedures using local or regional anesthesia is that many patients experience high levels of anxiety both before and during the operation. Their anxiety often arises from a lack of information or knowledge about medical procedures and they presume that such procedures will cause them pain and discomfort. Local and regional anesthesia 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 that 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 to be more distressing than it really is. Therefore, anxiety is a common problem for patients who undergo surgical procedures, often associated with a number of negative behaviors during and after the surgical experience.

Analgesics have been the mainstream solution for alleviating pain in the past. However, medications are often ineffective; some patients may experience high levels of pain after surgery, resulting in a high intake of extra analgesics, longer hospitalization, and slower recovery. Since drug treatments alone have frequently proven to be inadequate in reducing stress and anxiety in surgical contexts, there has been an increased interest in non-invasive supplementary medical therapies, including music [1,2] relaxation, guided imagery, hypnosis, etc., to reduce pain and tension during pre and post

operative phases. Different experimental studies have shown that distraction techniques are effective in reducing pain and related anxiety. Management of procedure-related distress commonly includes the use of distraction techniques that intend to divert attention away from the procedure and instead focus attention on an activity or task [3,4]. Prior research has shown Virtual Reality (VR) distraction to be beneficial for patients who are undergoing painful medical procedures [5-8]. It has also been shown that VR can be used in a sustained manner with positive results.

Virtual environments are safe alternatives to medications, as they eliminate risk of dependence on drugs and cause minimal side effects. These advances have shifted towards using distraction and hypnosis techniques to treat pain [9]. Demonstrated in its utility as a distraction technique, VR can be considered as an innovative form of e-health therapy gaining further recognition as a means of attenuating pain during medical procedures. VR reduces distress and pain perception by providing a form of immersive distraction that taxes the patient's limited attention capacity, resulting in the withdrawal of attention from the real, noxious, external stimulus with a subsequent reduction in pain and stress [10]. This technology allows the patient to explore and manage several situations inspired to daily experiences, using the real correspondent behaviors in a more controlled, safe and low-cost setting than in real life situations. In the last few years VR has been applied for the assessment and rehabilitation of several psychological diseases like Post-Traumatic Stress Disorder [11], anxiety [12], and eating disorders [13]. Furthermore, VR has been applied in neuropsychological domains like neglect

[14], executive functions [15] and cognitive rehabilitation of schizophrenia [16]. Therefore, these advanced systems interact at many levels with the VE, stimulating sights, sounds, and motion to encourage immersion in the virtual world to enhance distraction from pain [17].

Finally, different studies have demonstrated that VR can significantly reduce subjective pain intensity ratings and pain-related brain activity. Virtual reality has been shown to be effective in decreasing pain intensity and anxiety in the treatment of burns [18-20] and surgery [21-24], as well as in dental procedures [25]. In one controlled study, adult burn patients undergoing physical therapy reported less pain while immersed in VR than those who only participated in standard physical therapy [20]. Evidence shows that VR is effective in reducing pain in children with cancer. As chemotherapy-related symptom distress was reduced significantly immediately after using VR during treatment [26-28]. Another clinical study observed that dental patients undergoing plaque removal below their gum line experienced considerable reduction in pain when using VR compared to participants that watched a movie and to participants that did not have any type of distraction [29]. In a study conducted by Johnston in 1980, the natural course of anxiety before and after surgery was examined using the State Trait Anxiety Inventory in 4 studies involving 136 surgical patients. The results suggested that high levels of anxiety were experienced before admission to hospital, between admission and surgery and following surgery, and were not restricted to the immediate pre-operative period [30].

## Methods

A group of 22 patients, composed of 7 women and 15 men underwent cardiac surgical interventions. They were given a VR treatment session before the surgery, and another VR session immediately following surgery. The VR scenarios used were “Enchanted Forest” and “Cliff”, developed at The Virtual Reality Medical Center, La Jolla, California. The worlds help evoke relaxation and deep breathing [31]. To evaluate the patients’ responses, both objective and subjective parameters were monitored. Objective measures included: heart rate, breathing rate, arterial blood gas analysis (pH, bicarbonates, CO<sub>2</sub>, FiO<sub>2</sub>, saturation of O<sub>2</sub>) and blood pressure values (systolic, diastolic, mean arterial pressure). A Likert scale was used to provide a subjective measure in reference to the pain experienced [32].

The Virtual Reality scenarios were presented through an eMagin Headmounted Display (HMD) that displayed 3D stereoscopic color images with a resolution of 1024 × 768 pixels. The auditory effects were delivered through binaural headphones. The computer was a Pentium IV, 3 GHz, 2 GB Ram, NVIDIA QuadroFX 4500 512 MB DDR3 Graphics card. Virtual scenarios were modeled and animated using 3D StudioMax, Adobe Photoshop and Maya. Navigation was conducted with a Logitech Joypad [31,32].

## Results

Figure 1 describes differences between the B (before) and A (after) values are shown, separated according to gender of the patients.

	Female			Male		
	Before	After	Result	Before	After	Result
pH	7,415	7,413	▼	7,427	7,450	▲
Bicarbonate	23,483	23,463	▼	28,587	29,160	▲
CO2	37,167	33,500	▼	35,200	35,333	▲
FiO2	87,833	79,500	▼	72,400	79,333	▲
BR	19,5	14,5	▼	17,733	16,867	▼
HR	87,71	85,29	▼	80,00	79,47	▼
Saturation	95,86	95,71	▼	92,93	92,25	▼
Systolic	117,57	121,29	▲	118,40	124,67	▲
Diastolic	72,57	73,14	▲	72,20	71,80	▼
Mean Art Press	87,57	89,19	▲	87,60	89,42	▲
Likert	8,43	5,00	▼	7,80	3,00	▼

**Figure 1.** Differences between the B (before) and A (after) values are shown, separated according to gender of the patients.

(after) values, separated according to gender of the patients. The behavior is the opposite between the two sexes in 6 of the 11 cases. In particular it is the opposite in all four detections regarding Arterial Blood Gas analysis.

**Focus on ABG analysis**

In women, we see a marked reduction of CO<sub>2</sub> and FiO<sub>2</sub>, while bicarbonate and pH values show marginal changes. Breathing Rate (BR), a factor that can drastically influence the acid/base equilibrium, shows a significant reduction of the respiratory rate. This could cause an acidification of the blood, due to retention of CO<sub>2</sub>, but this seems not to be the case. In females, even with a reduction of 25% of their respiratory rate, there is no increase of the CO<sub>2</sub> values; rather we identified a significant reduction. Furthermore, nothing suggests a change in metabolic parameters regarding the acid/base equilibrium, since the bicarbonate is stationary in physiological values.

Male patients behave differently in that they exhibit an increase in their pH value of 0,023. The differences between B and A are not high in these patients, except for the FiO<sub>2</sub> value which has a significant increase over time. Breathing rate decreased by 0.866 while CO<sub>2</sub> increased by 0.133 and bicarbonate value increased by 0.573, suggesting that in male

patients there are no significant changes in the main factors of acid/base equilibrium (Figure 2).

**Other objective measures**

Heart rate, oxygen saturation and blood pressure show no difference between genders. The behavior is almost equal indeed, with the exception of diastolic pressure, which increases in females and decreases in males. The heart rate decreases more in females (-2,51 acts/min) than in males (-0,53 acts/min), indicating relaxation in both genders after the procedure.

The saturation remains almost unvaried in both sexes (a very little decrease can be noticed), staying in optimal physiological range in women, and a little below the normal range in men. The pressure values behave in a similar way, with the exception of the diastolic pressure:

- Systolic pressure increases in both sexes, but more in men. Women experience an increase of 3,75 mm Hg, while men have a more substantial increase, which is 6,27 mm Hg;
- Diastolic pressure increases in women while it decreases in men;
- Mean arterial pressure increases in both sexes in almost



Figure 2. Breathing rate.

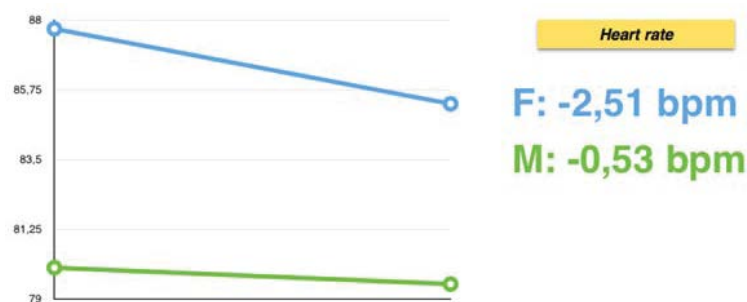


Figure 3. Heart rate.



Figure 4. Likert scale.

the same amount: 1,62 for women and 1,82 for men.

Males and females had similar mean arterial pressure values; however, men had higher systolic pressure when compared to women. We noted that diastolic pressure decreases in men while it remains stable in women (Figure 3).

#### **Likert scale (pain)**

There's a clear and impressive decrease of the Likert values in both sexes. We have a -3,43 in women and -4,80 in men, suggesting that there is a significant decrease in pain perception in both male and female subjects (Figure 4).

#### **Discussion**

Very few studies have examined gender differences in physiological responses to VR. In this study we show that VR is an effective medium to reduce stress and anxiety in patients undergoing cardiac surgery. Some studies on gender differences in pain threshold have produced interesting results. For example, an investigation of gender differences in experimental pain threshold detected significantly lower tolerance in females than males [33]. In this study, 240 participants (120 males and 120 females) received gradually increasing amounts of pressure in the dorsal interosseous muscle. In comparing time of tolerance and the average amount of pressure applied to each subject, the experimenters concluded that females exhibit lower thresholds.

Interesting differences in physiological response will be further investigated in future studies. We are as of yet unable to correlate gender differences in physiological response to clinical outcome. Our study suggests we further study these differences, as we continue to promote individualized therapy for all patients. Additional studies support the notion of gender differences in perceived pain. Bingefors and Isacson found major differences in reported pain between 5,000 males and females in Uppland, Sweden. Surveying the population about pain problems that effect their work, daily living, and social life, the researchers concluded that the prevalence of pain conditions was higher among women than men [34]. Comparisons of genders in thermal sensitivity also report variations between males and females in thermal sensation response [35]. These examples suggest gender differences in pain and highlight an increasing need for effective, accessible, and easy to use devices that control pain perception.

#### **Conclusion**

This brief study confirms the efficacy of VR in helping patients reduce stress before, during and after medical and surgical procedures. We anticipate additional positive effects in reducing these often harmful symptoms that can affect both quality of life and activities of daily living. We are interested in continued investigation and are working toward making this intervention more effective, less expensive and available across platforms to include mobile healthcare and behavioral health.

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