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PAIN CONTROL DURING WOUND CARE FOR COMBAT-RELATED BURN INJURIES USING CUSTOM ARTICULATED ARM MOUNTED VIRTUAL REALITY GOGGLES

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We describe the first two cases where virtual reality was added to usual pain medications to reduce excessive pain during wound care of combat-related burn injuries. Patient 1 was a 22 year old male who suffered 3rd degree burns on 32% of his body, including his right hand, during a roadside bomb terrorist attack in Iraq. The nurse administered wound care to half of the right hand during VR and the other half of the same hand during no VR (treatment order randomized). This patient was the first to use a unique custom articulated robotic-like arm mounted VR goggle system. Three 0-10 graphic rating scale pain scores for each of the two treatment conditions served as the primary dependent variables. The patient reported less pain when distracted with VR. "Time spent thinking about pain" dropped from 100% during no VR to 15% during VR, “pain unpleasantness” ratings dropped from “moderate” (6/10) to “mild” (4/10). Wound care was "no fun at all" (0/10) during no VR but was "pretty fun" (8/10) during VR. However, Patient 1 reported no reduction in worst pain during VR. Patient 2 suffered 2nd and 3rd degree burns when his humvee was hit by a terrorist's rocket propelled grenade in Iraq. During his wound care debridement, "time spent thinking about pain" was 100% (all of the time) with no VR and 0 (none of the time) during VR, "pain unpleasantness" ratings dropped from "severe" (7/10) to "none". Worst pain dropped from "severe" (8/10) to mild pain (2/10). And fun increased from zero with no VR to 10 (extremely fun) during VR. Although preliminary, using a within-subjects experimental design, the present study provided evidence that immersive VR can be an effective adjunctive nonpharmacologic analgesic for reducing cognitive pain, emotional pain and the sensory component of pain of soldiers experiencing severe procedural pain during wound care of a combat-related burn injury.

Introduction.

U.S. soldiers injured in Iraq with significant burns are treated at the U.S. Army Institute of Surgical Research (USAISR) at Brooke Army Medical Center in San Antonio, TX. The mean length of inpatient stay for burn patients at this medical center is approx 25 days. (Kauvar et al.) Recovery often involves extensive outpatient physical therapy rehabilitation. Soldiers often move to San Antonio to continue their outpatient physical therapy for six months, a year or longer. Currently, wounded warfighter inpatients with severe burn wounds may have their bandages removed each day, so the wound can be inspected, cleaned and kept free of infection. Wounded warriors with severe burns remain conscious during daily wound care. Typically, they receive strong short-acting opioid analgesics and anxiolytics about twenty minutes prior to debridement (cleaning of dead skin from their healing burn wound). Despite early, aggressive

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use of opioid analgesics, patients frequently experience severe to excruciating pain during daily burn wound care. (Carrougher et al.) Excessive pain can increase the amount of time it takes caregivers to complete the wound care, and can increase how long the patient remains in the hospital before discharge. Clinical and laboratory studies of civilians have shown large drops in subjective pain during virtual reality, (Hoffman et al., 2008 & Hoffman, 2004) and fMRI results with healthy volunteers show reductions in pain-related brain activity during VR analgesia. (Hoffman et al., 2004) If VR reduces procedural pain in patients with combat-related injuries, this would be a valuable advance in combat casualty care with potential widespread military applications in the future. The two patients in this case report are the first to quantify whether VR distraction can reduce high levels of subjective pain reports in soldiers with combat-related burn injuries undergoing wound care and dressing change. Both patients used a unique articulated robotic-like arm that allowed the VR goggles to be placed near the patient 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 1A and 1B).

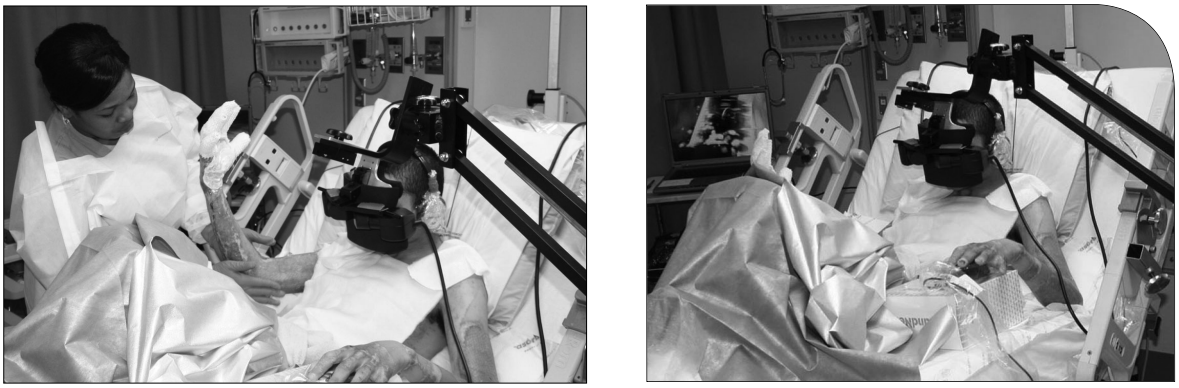


Figure 1A and 1B. U.S. Army soldier receiving immersive Virtual Reality to reduce his pain during severe burn wound care, using our unique articulated arm mounted VR goggles designed by Hoffman and Magula, that hold the displays near the patient's eyes. Photos and copyrights Hunter Hoffman, U.W.

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 was harvested from unburned portions of his body and transplanted as skin grafts to many of his severe burn wounds. In keeping with the standard practice, continuous wound care and frequent dressing changes were required to optimize the healing process.

A 10 minute segment of wound care to the patient's right hand, identified from previous days' procedures as being

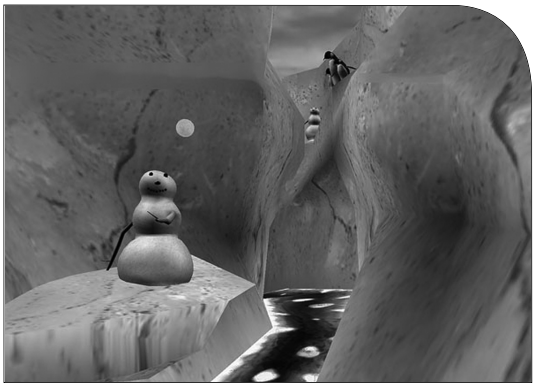
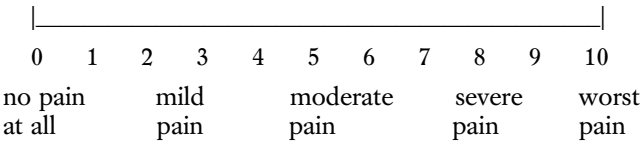


Figure 2. A snapshot of SnowWorld (the virtual world burn patients interact with during wound care). Image by worldbuilder Ari Hollander, www.imprintit.com, copyright Hunter Hoffman, UW., www.vrpain.com.

excessively painful, was divided into two equivalent five minute wound care segments. Pre-medication with two percocet tablets by mouth approximately 20 minutes prior to wound care served as the opioid analgesic for this session. During one of the five-minute sessions he received no VR distraction (i.e., standard pre-medication only). During the other five-minute treatment session, the participant looked into the articulated arm mounted VR goggles and underwent wound care while experiencing immersive, interactive VR (randomized to receive VR first or second).

During two brief pauses in the wound care procedure (once after each five minute wound care period), the patient completed three subjective pain ratings using Graphic Rating Scales (GRS) labeled 0 – 10 with respect to the preceding 5 minutes of wound care. "Please indicate how you felt during the past five minute session by rating your response on the following scales." Each question was accompanied by a pictorial example of the labeled graphic rating scale such as the "worst pain" rating shown below.

How much TIME did you spend thinking about your pain during the past five minutes? I thought about my pain during Virtual Reality 0 = none of the time, 1-4 = some of the time, 5 = half of the time, 6-9 = most of the time, and 10 = all of the time. How UNPLEASANT was you pain during the Virtual Reality (a similar 10-cm line with numeric and word descriptors beneath it: 0 = not unpleasant at all, 1-4 = mildly unpleasant, 5-6 = moderately unpleasant, 7-9 = severely unpleasant, and 10 = excruciatingly unpleasant)? Rate your WORST PAIN during the past 5 minutes.



How much FUN did you have during Virtual Reality (10-cm line with numeric and verbal descriptors: 0 = no fun at all, 1-4 = mildly fun, 5-6 = moderately fun, 7-9 = pretty fun, 10 = extremely fun)? To what extent (if at all) did you feel NAUSEA for any reason during Virtual Reality (10-cm line with numeric and verbal descriptors: 0 = no nausea at all, 1-4 = mild nausea, 5-6 = moderate nausea, 7-9 = severe nausea, and 10 = vomit)? While experiencing the virtual world, to what extent did you feel like you WENT INSIDE the computer-generated world (10-cm line with numeric and verbal descriptors: 0 = I did not feel like I went inside at all, 1-4 = mild sense of going inside, 5-6 = moderate sense of going inside, 7-9 = strong sense of going inside, 10 = I went completely inside the virtual world)? After wound care with no VR, each patient was asked the same questions but "during Virtual Reality" was replaced by "without Virtual Reality". After-wound care with no VR, patients were not asked the question about presence.

Such pain rating scales have been shown to be valid through their strong associations with other measures of pain intensity, as well as through their ability to detect treatment effects. (Jensen, 2003 & Jensen et al., 2001) The specific measures used in the current study were designed to assess the cognitive component of pain (amount of time spent thinking about pain), the affective component of pain (unpleasantness), and the sensory component of pain (worst pain). Affective and sensory pain are two separately measurable and sometimes differentially influenced components of the pain experience. (Gracely et al., 1978) Gracely et al., have shown ratio scale measures such as the labeled Graphic Rating Scales used in this study to be highly reliable. In addition, a GRS rating of 'fun' during wound care was measured. (Hoffmann et al., 2008)

Patient 2, a 21-year-old male, was injured when his humvee was hit by a terrorist's rocket propelled grenade in Iraq. The explosion caused 2nd and 3rd degree burns on 15% of his body: lower back, flank, buttox, bilateral hands, bilateral upper arms. A 12-minute segment of wound care to the patient's left and right arms identified from previous days'

procedures as being excessively painful was divided into two equivalent six-minute wound care segments. Pre-medication with one fentanyl lollypop (400 mic) and two percocet tablets by mouth approximately 20 minutes prior to wound care served as the opioid analgesic for this session. During one of the six-minute wound care sessions he received no VR distraction (i.e., standard pre-medication pharmacologies only). During the other six minute wound care session the participant looked into the articulated arm mounted VR goggles and underwent wound care while experiencing immersive, interactive VR (randomized to receive VR first or second). During two brief pauses in the wound care procedure (once after each six minute wound care period), the patient completed three subjective pain ratings using Graphic Rating Scales (GRS) labeled 0 – 10 with respect to the preceding 6 minutes of wound care, using the same measures described above for patient 1.

For both patients, the VR system consisted of a Voodoo Envy laptop with NVIDIA GForce Go 7900 GTX (512 MB) video card; Intel Core 2 Duo (T7400) CPU @ 2.16 GHz, 2 GB RAM @ 994 MHz. While in High Tech VR, each subject followed a pre-determined path, "gliding" through an icy 3-D virtual canyon (Figure 2). He 'looked' around the virtual environment and aimed via a mouse. He pushed a mouse trigger button to shoot virtual snowballs at virtual snowmen, igloos, and penguins (see www.vrpain.com). Each subject saw the sky when he looked up, a canyon wall when he looked to the left or right, a flowing river when he looked down, and heard sound effects (e.g., a splash when a snowball hit the river) mixed with background music by recording artist Paul Simon. Participants looked into a pair of Rockwell Collins SR-80 VR goggles (see www.imprintit.com) with a custom made neoprene blinder on top and sides, which largely blocked his view of the real world. These VR goggles afforded approximately 80° diagonal field of view for each of the rectangular eyepieces with 100% overlap between the right and left eye images. The goggles were held in place near the patient's eyes by a custom made articulated arm mounting system.

Results

As shown in Figure 3 below, Patient 1 reported less pain when distracted with VR (e.g., "time spent thinking about pain" dropped from "all the time" during no VR to "some of the time" 1.5 (15%) during VR, "pain unpleasantness"

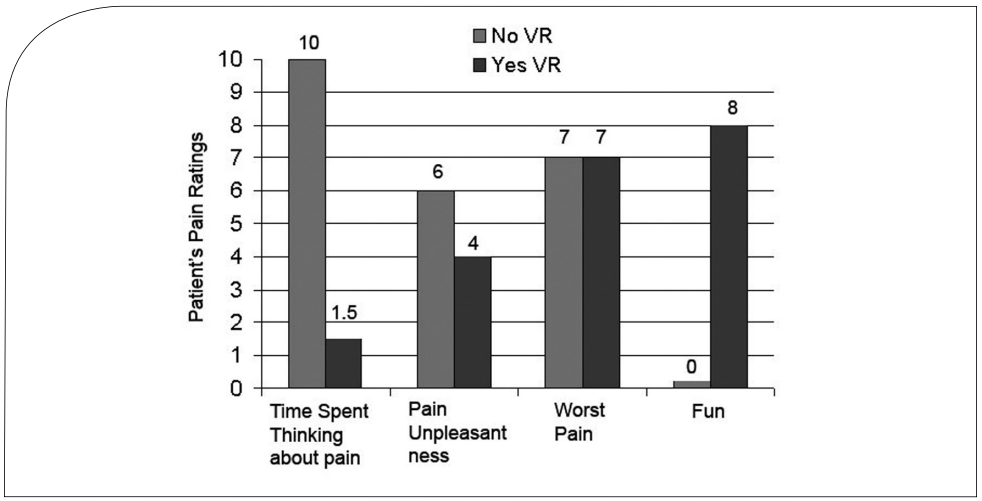


Figure 3. Patient 1 reported large reductions in amount of time thinking about pain during VR (shown in blue) compared to no VR (shown in red) during severe burn wound care of burn injury resulting from an Improvised Explosive Device (roadside bomb) attack/explosion.

ratings dropped from “moderate” (6/10) to “mild” (4/10). VR did not reduce Worst pain (0% drop) in Patient 1. Wound care during VR was "pretty fun" (8/10) vs. "no fun at all" (0/10) during no VR and the patient reported having a "moderate sense of going inside the computer-generated world" (6/10).

As shown in Figure 4 below, Patient 2 reported that during his wound care debridement, Time spent thinking about pain was 100% with no VR and 0 with VR, "pain unpleasantness" ratings dropped from "severe" (7/10) with no VR to "none" during VR. Worst pain dropped from "severe" (8/10) with no VR to mild pain (2/10) during VR. And fun increased from zero with no VR to 10 during VR. Patient 2 reported having "a strong sense of going inside the computer-generated world" (8/10). Both patients and their wound care nurses noted that they would prefer VR be available for subsequent dressing changes as they found it to be helpful as an adjunctive modality for pain control. Patient 2 was very determined to continue playing SnowWorld as long as possible. And the wound care nurse of patient 1 spontaneously remarked she was pleasantly surprised to see that when in VR, the patient was not pulling his hand away from her as she worked on his hand, a "protective" behavior he consistently exhibited during daily wound care of his hand with No VR.

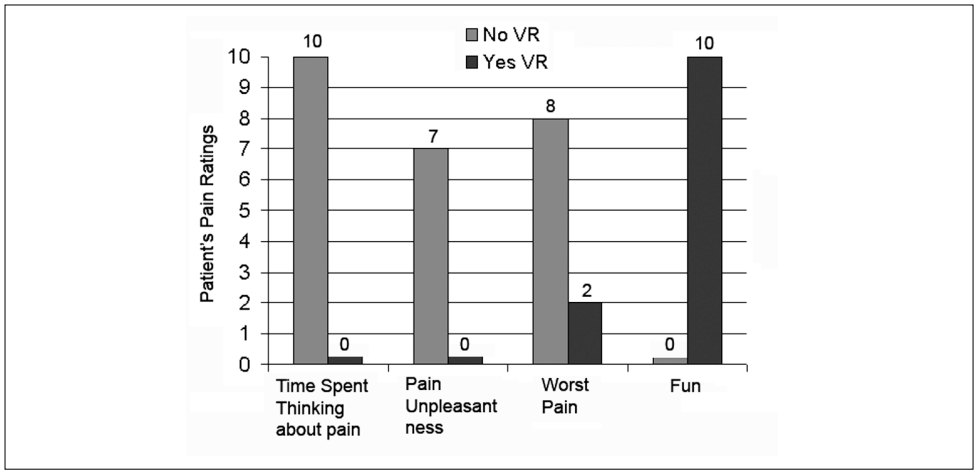


Figure 4. Patient 2 reported large reductions in pain during VR (shown in blue) compared to no VR (shown in red) during burn wound care of a severe burn injury resulting from a rocket-propelled grenade attack/explosion.

Discussion

The results of these two case studies demonstrate that immersive VR reduced the reported amount of time patients with a combat-related burn injury spent thinking about their pain and VR reduced pain unpleasantness. VR did not reduce patient one's worst pain rating during his burn wound care. But VR did reduce patient two's worst pain from severe (a rating of 8) down to mild (a rating of 2). Although case studies are scientifically inconclusive and controlled studies are needed, these results provide the first available evidence that VR can reduce severe acute pain during medical procedures (wound care and dressing changes) in patients with combat-related burn injuries. Because excessive acute pain during medical procedures for combat-related injuries remains a widespread medical problem, and our preliminary results support the notion that VR might prove valuable for pain control in combat trauma patients, additional research on this modality with this patient population is warranted.

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