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Abstract

Two patients received virtual reality (VR) to distract them from high levels of pain during burn injury wound care. The first was a 16 year old male with a deep flash burn on his right leg requiring surgery and staple placement. On two occasions, the patient spent some of his wound care in VR, and some playing a video game. Five 100 mm visual analog pain scores were measured during his first session of wound care. These pain scores decreased 93 mm, 80 mm, 86 mm, 80 mm and 66 mm during VR treatment compared to the video game control condition. For the second session involving staple removal, scores also decreased. The second patient was a 17 year old male with 33.5% total body surface area deep flash burns on his face, neck, back, arms, hands and legs. He had difficulty tolerating wound care pain with traditional opioids alone and showed dramatic drops in pain ratings during VR compared to the video game (e.g., a 47 mm drop in pain intensity during woundcare). We contend that virtual reality merits further empirical research as a uniquely attention-capturing medium capable of maximizing the amount of attention drawn away from the "real world". Since pain requires attention, patients immersive in VR may experience less pain during painful procedures.

Virtual Reality as an adjunctive pain control during burn wound care in adolescent patients: A case report.

For daily burn wound care procedures, opioid analgesics alone are often inadequate. Since most burn patients experience severe to excruciating pain during wound care, analgesics that can be used in addition to opioids are needed (Perry et al., 1981; Choiniere et al., 1989; Everett, et al., 1990; Patterson, 1992;1995, Patterson et al., 1992; 1997). This case report provides the first evidence that entering an immersive virtual environment can serve as a powerful adjunctive, nonpharmacologic analgesic.

We predicted that because immersive VR is uniquely distracting, it would reduce burn pain (measured using the pain-related measures described below) compared to a 2-D video game control condition. Since the degree of pain reported during hospitalization is associated with the degree of postdischarge mental and physical dysfunction (Ptacek, et al., 1995), improved burn wound pain management may have practical as well as humane purposes.

Method.

For the first session, in addition to their standard pharmacologies, each patient spent 3 minutes in VR and 3 minutes playing a video game during wound care. The order in which the treatments were administered was randomized and counterbalanced such that across subjects each distraction treatment had an equal chance of occurring first or second for each patient. Pain and presence ratings, the primary dependent variables, were administered after each experimental treatment during a brief pause in wound care. At each pause (once after wound care with VR, and once after wound care while playing

the video game), patients completed several retrospective 100 mm Visual Analog Scales (i.e., VAS, Huskisson, 1974; Gift, 1989). Patients rated A) how much time they spent thinking about their pain and/or burn wound.[1] B) how UNPLEASANT was wound care[2,] C) how much their wound BOTHERED them[3,] D) their WORST PAIN[4], E) AVERAGE PAIN[5], F) ANXIETY[6]. After wound care, patients in the VR condition were also asked the following ratings using visual analog scales: G) To what extent (if at all) did you feel nausea as a result of experiencing VR?[7] H) While experiencing VR, to what extent did you feel like you went into the virtual world?[8] I) How real did the objects in the virtual world seem to you?[9] Patients also filled out appropriate simulator sickness, presence and realism ratings after the video game control condition. Hendrix and Barfield (1995) describe several studies showing the reliability of a similar subjective measure of presence.

Procedure.

Experimental condition

A Silicon Graphics Octane MXE with Octane Channel Option[10] coupled with a wide field-of-view head mounted visual display was the primary system used to create an immersive, 3-D, interactive, computer-simulated environment[11] A stationary Polhemus low energy source detected by movable Polhemus 6df sensors was used to measure the position of the user's head and hand position. The patient experienced SpiderWorld, a modified version of Division Ltd's DVS-3.1.2 KitchenWorld[12] complete with countertops, a window, and 3-D cabinets that could be opened. Patients could pick up numerous virtual objects with their 3-D mouse. Using tactile augmentation (Hoffman et

al, 1996; Carlin et al., 1997; Hoffman, 1998), patients could "physically" touch the furry body of a virtual Guyana bird-eating tarantula with wiggling legs.

Control condition. A Ninetendo 64 advanced video game with a 64-bit graphics chip, real-time rendering and CD-quality sound, served as the control condition. For "Wave Race 64", patients competed in a jet ski race, maneuvering their craft through the wavy water using a joystick. For "Mario Kart 64", patients maneuvered their race car around a slick icy racetrack. We expected these games to be more engaging than other conventional distractors previously used (e.g., passive video tapes), because the user was actively involved in the task (first person experience).

Case 1.

Patient history.

The patient was a 16 year old male, hospitalized in a major regional burn center. He had 5% total body surface area (TBSA) deep flame/flash burn to his lower right leg sustained from ignited gasoline. For his first experimental session, he used 12 milligrams of oral hydromorphone (Dilaudid) during wound care, representing 1.6 opioid equivalents (OE) (Carrougher et al., 1998). The following day this patient was taken to surgery for excision and autografting of his burn wound. His second wound care studied (the following week) was the first wound care he received after his skin graft surgery. It involved a dressing change with staple and hypofix tape removal. For this procedure, the patient was given hydrocodone and acetaminophen (Vicodin), representing 0.59 OE.

Results for Patient One.

According to 100 mm VAS pain ratings for session 1 (see Table 1), VR was dramatically more effective than the video game control condition as a nonpharmacologic pain analgesic. For his second session, patient 1 was tested during staple removal from his grafted burn wound. Six staples were removed during VR, and 5 were removed while he played the video game Mario Cart 64. As shown in Table 2, VR was considerably more effective than the video game control condition as a nonpharmacologic pain analgesic.

The patient returned for a third VR experience one week later (no wound care involved). He entered VR to determine whether his sense of presence would continue to drop with each treatment due to a reduction in the novelty of VR, and also to determine whether simulator sickness became a problem for longer exposures to SpiderWorld. The patient explored SpiderWorld for 10 continuous minutes. Presence in VR was 96 mm out of 100 (where 100 = high presence). Simulator sickness was rated zero. Pain measures were not administered since the patient was no longer having trouble with pain. The video game condition was not used during this session.

Case 2.

Patient history.

The second patient was a 17 year old male hospitalized at the same center. He had deep flash burns to his face, chest, back, stomach, upper legs, and both sides of his right arm, covering 33.5% of his total body surface area. He required skin grafting to his neck, chest and stomach. Donor skin was harvested from the uninjured portion of his back and the calves of his legs. As indicated by the staff, he experienced unusually high levels of pain during wound care. He used 14 milligrams of oral hydromorphone

(Dilaudid) during the dressing change procedure, representing 1.86 OE. Wound care was restricted to removal of the adherent dressing over his fragile donor site (back area), thus he was unable to observe the wound care.

Results for Case 2.

As shown in Table 3, Patient 2 showed a drop in pain and anxiety while in VR compared to the video game control. The patient care nurse removed equal amounts of dressing from areas of newly healed and sensitive donor site skin from the same area of the patient's back during VR and the video game. She reported that the patient was "unaffected by what I was doing to his wound" while in VR, and the patient was "more aware, and he flinched often" in the video game condition.

Discussion.

These two cases provide preliminary evidence that entering a virtual environment can help control burn pain and reduce the amount of time spent thinking about pain during wound care. Simulator sickness was not a problem in this study but should be monitored closely in any medical use of VR. Presence remained high for three immersions with no sign of habituation for patient 1. The second patient had a large severe burn and experienced considerable difficulty with his wound care pain. Both patients showed dramatic drops in wound care pain during VR compared to the video game control condition.

Underutilization of opioid analgesics is a problem that contributes to inadequate acute pain management (Melzack, 1990). Unfortunately, higher doses of such agents increase the likelihood of side effects like respiratory failure, nausea, encephalopathy, and constipation. Health care professionals also may worry (albeit unnecessarily) that

patients will become addicted (Melzack, 1990) and must take into consideration the often large number of medications involved for a single patient. (Patient 2 experienced over 30 wound care procedures). As such, nonpharmacologic pain modalities have an important role in managing burn injuries. The potential applications of VR to pediatric populations is particularly appealing since children are severely undertreated for acute pain and anxiety (Melzack, 1990).

This report involves two case studies and the substantial limitations of this methodology are well known (Campbell and Stanley, 1963). Although case studies are a good vehicle for presenting innovative techniques, evidence for effectiveness requires converging results from larger, more generalizable, carefully controlled studies (e.g., to reduce the viability of a placebo/demand characteristic explanation). If controlled experiments show VR has analgesic effects, research will be needed to assess whether VR remains effective for pain management with repeated use and to determine how to maximize longevity. Because burn injuries offer a paradigm for management of acute pain in general, the results of such investigations will likely be generalizable to other causes of acute pain.

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Footnotes.

1. where 0 = zero minutes, and 10 = the entire time

2. where 0 = not at all unpleasant, and 10 = the most unpleasant

3. where 0 = not at all bothersome, and 10 = the most bothersome

4. where 0 = no pain and 10 = worst pain

5. where 0 = no pain and 10 = worst pain

6. where 0 = no anxiety and 10 = highest anxiety

7. where 0 = none and 10 = very much (adapted from Kennedy, et al. , 1992).

8. where 0 = I did not feel like I went into the virtual world at all, 10 = I went completely into the virtual world.

9. where 0 = completely fake, 10 = indistinguishable from a real object

10. Silicon Graphics, Inc. 2011 N. Shoreline Blvd. Mountain View, CA 94043 USA (650)960-1980 http://www.sgi.com/

11. A Division Provision 100, maunfactured by Division Hardware Ltd (no longer in business) was also used for some of the treatments.

12. Division Incorporated, 1400 Fashion Island Blvd, Suite 510, San Mateo, CA 94404, http://www.division.com/

Table 1.Patient 1, session 1 (see method section for labels).

	A	B	C	D	E	F	G	H	I
Video game	95 mm	80 mm	87 mm	82 mm	87 mm	59 mm	0 mm	17 mm	11 mm
Virtual Reality	02 mm	0 mm	01 mm	02 mm	21 mm	01 mm	0 mm	100	55 mm

Table 2. Patient 1, session 2

	A	B	C	D	E	F	G	H	I
Video game	91 mm	85 mm	86 mm	79 mm	71 mm	87 mm	0 mm	11 mm	02 mm
Virtual Reality	38 mm	58 mm	07 mm	49 mm	40 mm	55 mm	0 mm	81 mm	71 mm

Table 3. Patient 2.

	A	B	C	D	E	F	G	H	I
Video game	88 mm	96 mm	77 mm	77 mm	73 mm	30 mm	0 mm	0 mm	18 mm
Virtual Reality	27 mm	41 mm	38 mm	30 mm	38 mm	03 mm	0 mm	43 mm	35 mm